

**SECTION 700 MATERIALS DETAILS**



## Section 701 - Cement, Grout, & Mortar

### 701.01 Cement

Cement shall meet the requirements of the following specifications:

- (a) Portland cement . . . . . AASHTO M 85
- (b) Blended hydraulic cements  
excluding Types S and SA . . . . . AASHTO M 240
- (c) Masonry cement . . . . . AASHTO M 150

Fly ash or pozzolan may be substituted for Portland cement providing that the proportions of cement and fly ash or pozzolan conform to the requirements of Sections 552 or 602.

When blended cement (AASHTO M 240) is proposed for use, all requirements for fly ash modified concrete in the applicable sections shall apply.

Fly ash or pozzolan materials shall conform to the requirements of Subsection 712.04.

The product of only one manufacturing plant and only one brand of any one type of Portland cement shall be used on the project.

The cement shall be stored and protected against dampness. Cement that for any reason has become partially set or that contains lumps of caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used.

### 701.02 Grout

Grout shall be packaged and ready for use with the addition of water at the construction site. Each bag shall be stamped to show the latest date at which it may be used. The product shall consist of a hydraulic cementitious system, graded and processed natural fine aggregate and additional technical components meeting the following:

- (a) Free of inorganic accelerators, including chlorides.
- (b) Free of oxidizing catalysts.
- (c) Free of gas-producing agents.
- (d) The grout, when mixed to 130 percent flow on flow table (ASTM C 230 at 10 drops), shall not reduce in linear dimension when tested in accordance with ASTM C 157. Measurements shall be taken at 72 hours and 7 days.
- (e) No bleeding shall be present for the first 2 hours after mixing when mixed to 130 percent flow on flow table (ASTM C 230 at 10 drops), as tested in accordance with ASTM C 232.
- (f) Provide performance characteristics at 115 to 120 percent flow on flow table (ASTM C 230 at 10 drops), and minimum strength of grout shall be as follows when tested in accordance with ASTM C 109:

- 72 hours - 3,500 psi
- 7 days - 5,500 psi
- 28 days - 7,000 psi

(g) Manufacturer must state that the product is designed to be mixed, placed, and cured at atmospheric temperatures of 40 °F to 90 °F. Products proposed by the contractor for use shall be submitted for Engineer's approval and shall be accompanied by manufacturer's submittals substantiating all requirements of this

701.03  
Mortar

section, including (1) graphs or charts showing the time, temperature, and humidity curing requirements to achieve the specified grout strengths; and (2) recommendations for storage, mixing, application, and curing procedures.

Mortar shall be packaged and ready for use with the addition of water at the construction site. Each bag shall be stamped to show the latest date at which it may be used. The product shall consist of a cementitious system made up of:

- (a) Natural 3/8-inch maximum size aggregate, meeting ASTM C 33 except for grading, which shall be accomplished by blending of sieve sizes to get the optimum density.
- (b) Metallic aggregate free from nonferrous material, soluble alkaline compounds, and visible rust.
- (c) Water reducers, workability agents, air-entraining agents and catalysts.

The materials shall be blended to minimize bleeding, increase workability, resist exposure to freeze-thaw cycles and deicing salts, and shall prevent shrinkage within and at the perimeter of the patch, keyway, or other area to be filled.

The minimum compressive strength of the mortar, as tested by ASTM C 109 for a 3-inch slump, shall be:

24 hours - 5,000 psi  
7 day - 9,000 psi  
28 days - 10,000 psi

The durability of the products when tested at 300 cycles, ASTM C 666 procedure A, shall be:

<u>Submerged in:</u>	<u>DF (%)</u>
Water . . . . .	98
5% CaCl <sub>2</sub> . . . . .	95
5% NaCl . . . . .	85

The scaling resistance shall have a rating of 3-Moderate Scaling after 50 cycles when tested according to ASTM C 672.

The manufacturer must certify that the product is compatible for work that is 1 inch or more in depth and over 1 inch in width; and where the mixing, placing, and curing temperatures may range from 40 °F to 90 °F.

Products proposed by the contractor for use shall be submitted for Engineer's approval and shall be accompanied by manufacturer's submittals substantiating all requirements of this Section, including (1) graphs or charts showing the time, temperature, humidity, and curing requirements to achieve mortar strengths equal to the adjacent concrete; and (2) complete recommendations for storage, mixing, application, and curing procedures.

## Section 702 - Bituminous Materials

702.01  
Asphalt Cements

Asphalt cement shall meet the requirements of AASHTO M 20 for penetration-graded asphalt cement and AASHTO M 226 for viscosity-graded asphalt cement.

702.02  
Liquid Asphalts

Liquid asphalts shall meet the requirements of the following specifications:

- (a) Rapid curing liquid asphalts . . . . . AASHTO M 81
- (b) Medium curing liquid asphalts . . . . . AASHTO M 82

702.03  
Emulsified Asphalts

Emulsified asphalts shall meet the requirements of the following specifications:

- (a) Emulsified asphalt (anionic) . . . . . AASHTO M 140
- (b) Emulsified asphalt (cationic) . . . . . AASHTO M 208

CMS-2S: Shall comply with requirements of CMS-2, except that oil distillate by volume of emulsion shall be 12 to 20 percent, and the distillation residue shall have a minimum value of 60 percent.

CMS-3: Shall comply with requirements of CMS-2, except that oil distillate by volume of emulsion shall have a maximum value of 4 percent and the distillation residue shall have a minimum value of 68 percent.

702.04  
Bituminous  
Dust Palliatives

Bituminous dust palliatives shall meet the requirements listed in table 702-1.

Table 702-1.--Bituminous dust palliatives.

General Requirements	ASTM Method	D0-1 Forest Service Dust Oil			D0-2 Medium		D0-3 Heavy		D0-4 Clarified Dust Oil	D0-6	D0-6P	D0-8
		Light	Medium	Heavy	Medium	Heavy						
Flash Point:												
Tag Open-Cup, °F, Min.	D 1310	125	125	125				200	150	150	-	-
Cleveland Open-Cup, °F, Min.	D 92	-	-	-				-	-	-	212	-
Viscosity:												
Kinematic, @ 100°F, cSt	D 2170	40-70	90-125	135-200				20-100	75-150	25-50	-	50
Saybolt Furo1, @ 77°F, SFS, Max.	D 88	0.	0.5	0.5				0.	25	25	-	50
Water, % Max.	D 95	0.	0.5	0.5				0.	25	25	-	50
Asphaltenes, %	D 244	3-6	4-8	5-10				0-5	5-15	5-15	-	5-10
Saturates, % Min.	D 2006-70	25	25	25				10	25	25	-	8
24 Hour Settlement, %	D 2006-70	25	25	25				10	25	25	-	8
Sieve Test, % Max.	D 244	-	-	-				-	2.0	2.0	-	2.0
Distillation Tests	D 244	-	-	-				-	-	-	-	0.1
Total Distillate to 550° F, Max % by Volume	D 244	35	30	30				5	-	-	-	50
Total Distillate to 680° F, Max. % by Volume	D 402	-	-	-				-	-	-	-	-
Oil Distillate, % by Volume	D 244	-	-	-				-	-	10-20	-	5
Total Residue, % by Weight	D 244	-	-	-				-	60	55	-	45
Tests on Residue from Distill.												
Viscosity, Kinematic, @ 100°F, cSt	D 2170	75-250	200-600	500-1500				20-150	200-600	150-450	-	250-1200
Viscosity, Kinematic, @ 122°F, cSt	D 2170	98	98	98				98	96	96	-	98
Solubility in Trichloroethylene, % Min.	D 2042	-	-	-				-	-	-	-	-
Ductility, CM Min.	D 113	-	-	-				-	-	-	-	-

702.05  
Application  
Temperatures

Bituminous materials shall be applied within the temperature ranges indicated in table 702-2.

Table 702-2.--Application temperatures--degrees Fahrenheit (°F).

Type and Grade of Asphalt	Temperature ranges (min-max.)		
	Surface Treatments (Spray)	Central mixing plant (b)	Road Mixing
<b>Cutbacks:</b>			
MC 30	85 - (a)	60 - 105	60 - 105
RC-MC 70	120 - (a)	90 - 155	65 - (a)
RC-MC 250	165 - (a)	135 - 175(c)	105 - (a)
RC-MC 800	200 - (a)	165 - 210	135 - (a)
RC-MC 3000	230 - (a)	180 - 240	180 - 240
<b>Emulsions:</b>			
RS-1	70 - 140	50 - 160	50 - 160
RS-2	125 - 185	50 - 160	50 - 160
MS-1, MS-2, MS-2h	70 - 160	50 - 160	70 - 160
HFMS-1, 2, 2h, 2s	70 - 160	50 - 160	70 - 160
SS-1, SS-1h	50 - 160	50 - 160	50 - 160
CRS-1, CRS-2	125 - 185	50 - 160	50 - 160
CMS-2, CMS-2h	50 - 160	50 - 160	70 - 160
CSS- , CSS-1h	50 - 160	50 - 160	70 - 160
<b>Asphalt cements:</b>			
All grades 350 max.		As required to achieve a kinematic viscosity of 150 - 300 centistokes	

Notes:

- (a) Maximum temperature shall be below that at which fogging occurs.
- (b) Temperature of mix immediately after discharge.
- (c) Temperature may be above flash point. Precautions shall be taken to prevent fire or explosion.

Material shall meet the requirements of the following specifications:

- (a) Primer for use with asphalt . . . . . AASHTO M 116
- (b) Asphalt for mop coat . . . . . AASHTO M 115  
Type II
- (c) Waterproofing fabric . . . . . AASHTO M 117

Fabric shall be waterproofed with asphalt, in agreement with the material specified for primer and mop coats.

(d) Mortar material shall meet the requirements of Subsection 705.05, except the mortar shall be uniformly mixed to spreading consistency in the proportion of one part Portland cement to three parts fine aggregate.

702.06  
Material for  
Damp-proofing &  
Waterproofing  
Concrete & Masonry  
Surfaces

(e) Asphalt plank shall meet the requirements of AASHTO M 46 (ASTM D 517). Unless otherwise SHOWN ON THE DRAWINGS, planks shall be 1.25 inches thick and may be from 6 to 12 inches in width, but all pieces for one structure shall be of the same width, except such closers as may be necessary. The length shall permit the laying of the planks to the best advantage on the surface to be covered but shall not be less than 3 nor more than 8 feet.

(f) Asphalt roll roofing shall meet the requirements of ASTM D 224, 65-pound grade.

702.07  
Membrane Material  
for Waterproofing  
Bridge Decks

Bridge deck waterproofing membrane shall be mesh-reinforced, self-sealing, rubberized-asphalt preformed membrane having the following properties:

Thickness . . . . .	65 mils . . . . .	_____
Permeance-perms (grains/ sq ft/hr/in Hg) . . . . .	0.10 . . . . .	ASTM E 96 Method B
Tensile strength . . . . .	50 lb/in . . . . .	ASTM D 882 modified for 1-inch opening
Puncture resistance (mesh) . . . .	200 lb . . . . .	ASTM E 154
Pliability 1/4-inch mandrel, 180° Bend at -15 °F . . . . .	no cracks in mesh or rubberized asphalt	ASTM D 146

Primer and mastic shall be as recommended by the manufacturer and compatible with the membrane.



## Section 703 - Aggregates

703.01  
Fine Aggregate

(a) Structural Concrete. Fine aggregate shall meet the requirements of AASHTO M 6, except that:

(1) The soundness test is not required.

(2) There shall be no deleterious substances in excess of the following percentages:

Clay lumps and friable particles . . . . .	3.0
Coal and lignite, as defined in 7.1.6 of AASHTO M 80 . . .	1.0
Material passing the Number 200 sieve . . . . .	7.0

(3) Fine aggregate shall not contain any materials that are deleteriously reactive with the alkalis in the cement in an amount sufficient to cause excessive expansion of mortar or concrete, except that if such materials are present in injurious amounts, the fine aggregate may be used with a cement containing less than 0.6 percent alkalis calculated as sodium oxide or with the addition of a material that has been shown to prevent harmful expansion due to the alkali-aggregate reaction (see AASHTO M 80).

(4) The Minimum Sand Equivalent determined by AASHTO T 176 (Alternative method Number 2) shall be 75.

Lightweight aggregate, if required or permitted by the SPECIAL PROJECT SPECIFICATIONS, shall meet the requirements of AASHTO M 195.

(b) Granular Backfill Filter Material. Granular backfill filter material for underdrains and drainage blankets shall be permeable, shall meet the gradation SHOWN ON THE DRAWINGS, and shall meet the quality requirements for crushed aggregate base shown in table 703-3 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

(c) Aggregate for minor concrete structures shall meet the requirements of AASHTO M 80 and M 6. Coarse aggregate size shall be as SHOWN ON THE DRAWINGS.

703.02  
Coarse Aggregate

Coarse aggregate for concrete shall meet the requirements of AASHTO M 80, aggregate Class A, with the following modifications and additions unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

(a) Gradation shall meet the requirements of table 703-1 for the specified classes of concrete.

(b) Subsection 6.3 of AASHTO M 80 is deleted.

(c) The following words are deleted from the first sentence of 6.2 of AASHTO M 80: ". . . that will be subject to wetting, extended exposure to humid atmosphere, or contact with moist ground. . . ."

Lightweight aggregate, if required or permitted by the SPECIAL PROJECT SPECIFICATIONS, shall meet the requirements of AASHTO M 195.

703.03  
Reserved

703.04  
Aggregate for Road  
Mix Bituminous  
Base

Aggregates for road mix bituminous base construction shall be crushed stone, crushed slag, or crushed or natural gravel meeting the quality requirements of table 703-3 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

The gradation shall be as described in the SPECIAL PROJECT SPECIFICATIONS. When crushed gravel is used, not less than 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face.

Table 703-1.--Coarse aggregate requirements for structural concrete.

AASHTO M 43 Size Number	Nominal Size Range	Percentage by Weight Passing Square Mesh Sieve Size (AASHTO T 27)										
		3 in	2-1/2 in	2 in	1-1/2 in	1 in	3/4 in	1/2 in	3/8 in	No. 4	No. 8	
7	1/2 in --No. 4	--	--	--	--	--	100	90--100	40--70	0--5	0--5	
67	3/4 in --No. 4	--	--	--	--	100	90--100	--	20--55	0--10	0--5	
57	1 in --No. 4	--	--	--	100	95--100	--	25--60	--	0--10	0--5	
467	1-1/2 in --No. 4	--	100	95--100	--	35--70	--	10--30	10--30	0--5	--	
357	2 in --No. 4	--	95-100	100	35--70	10--30	--	--	--	0--5	--	
4	2-1/2 in --No. 4	--	--	100	90--100	20--55	0--15	--	0--5	0--5	--	
3	1-1/2 in --3/4 in	--	100	95--100	35--70	0--15	--	0--5	--	--	--	
2	2 in --1 in	100	90--100	35--70	0--15	--	--	--	--	--	--	
	2-1/2 in --1-1/2 in	100	90--100	35--70	0--15	--	0--5	--	--	--	--	

703.05  
(Reserved)

703.06  
Aggregate for Base  
or Surface Courses

Aggregate materials shall conform to the requirements shown below unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

(a) Pit-Run Aggregate. Pit-run aggregates shall consist of native materials of a size and grading that can be taken directly from the source and placed on the road without crushing or screening. No gradation, other than a maximum size, will be required. The maximum size shall be as shown in the SCHEDULE OF ITEMS.

(b) Grid-Rolled Aggregate. Grid-rolled aggregate shall consist of native materials of a quality that can be taken directly from the source, without crushing or screening, and broken down on the road by grid-rolling. No gradation other than a maximum size will be required. The maximum size shall be as shown in the SCHEDULE OF ITEMS.

(c) Screened Aggregate. Material shall consist of gravel, talus, rock, sand, shale, or other suitable material, and be reasonably hard and durable and reasonably free of organic material, mica, clay lumps, or other deleterious materials. The gradation requirements shall be as shown on the SCHEDULE OF ITEMS.

(d) Crushed Aggregate. Aggregate for crushed base or surface courses shall be crushed stone, slag, or gravel meeting the requirements shown in table 703-3 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS, the crushed aggregate gradation shall meet the requirements of table 703-4 for the grading shown in the SCHEDULE OF ITEMS. Aggregate shall be well graded from coarse to fine within the gradation band.

Table 703-3.--Crushed aggregate quality requirements for base or surface courses.

Description	AASHTO Test Method	Requirement	
		Base	Surfacing
Percent Wear	T 96	40 max.	40 max.
Durability Index, Coarse and Fine	T 210	35 min.	35 min.
Liquid Limit	T 89	25 max.	35 max.
Plasticity Index	T 90	6 max.	2--9 max.
Dust Ratio: $\frac{\% \text{ Passing No. 200}}{\% \text{ Passing No. 30}}$	T 11 T 27	2/3 max.	2/3 max.
Sand Equivalent (Alternative Method Number 2)	T 176	35 min.	--

When crushed gravel is used, at least 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face. Naturally fractured faces may be included in the 50 percent requirement, provided the roughness and angularity produce strength characteristics equivalent to mechanically fractured faces.

Table 703-4.--Crushed aggregate grading requirements for base or surface courses.

Sieve	Percent Passing (AASHTO T 11 and T 27)				
	Grading A	Grading B	Grading C	Grading D	Grading E
3-Inch	100				
2-Inch	65-95	100			
1-1/2-Inch			100		
1-Inch		60-90		100	
3/4-Inch	40-75		60-90	70-98	100
1/2-Inch		44-70			70-98
No. 4	22-45	28-50	30-55	36-60	44-70
No. 8	16-34	20-41	22-43	25-47	30-54
No. 30	8-22	9-26	11-27	12-31	15-34
No. 200	2-10 <sup>a</sup>	3-12 <sup>a</sup>	3-15 <sup>a</sup>	3-15 <sup>a</sup>	3-15 <sup>a</sup>
Sieve	Grading F	Grading G	Grading H	Grading J	Grading K
3-Inch	100				
2-Inch	65-95	100			
1-1/2-Inch			100		
1-Inch		50-85		100	
3/4-Inch	28-70		55-90	70-98	100
1/2-Inch		27-60			65-95
No. 4	10-35	15-40	20-48	25-55	33-60
No. 8				16-40	21-42
No. 30			5-20	6-22	8-24
No. 200	0-10 <sup>a</sup>	0-12 <sup>a</sup>	0-15 <sup>a</sup>	0-15 <sup>a</sup>	0-15 <sup>a</sup>
Sieve	Grading L	Grading M	Grading N	Grading O	
6-Inch	100				
4-Inch		100			
3-Inch			100		
2-Inch				100	
1-1/2-Inch					
1-Inch					
3/4-Inch					
1/2-Inch					
No. 4		15-45	15-45		
No. 8					
No. 30					
No. 200					

<sup>a</sup>For untreated base used under bituminous materials, Sections 403, 404, 405, 406, and 410, the maximum percent passing the Number 200 sieve shall be eight. For surfacing, the minimum percent passing the Number 200 sieve shall be six.

703.07  
Aggregate for Hot  
Bituminous Pavement

Aggregates for hot bituminous pavement shall be crushed stone, slag, or gravel meeting the quality requirements shown in table 703-5, unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

When crushed gravel is used, at least 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one mechanically fractured face.

The pavement aggregate gradation shall meet the requirements of table 703-6 for the grading shown in the SCHEDULE OF ITEMS unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Table 703-5.--Crushed aggregate quality requirements for hot bituminous pavement.

Description	AASHTO Test Method	Requirement
Percent Wear	T 96	40 max.
Durability Index, Coarse and Fine	T 210	35 min.
Sand Equivalent (Alternative Method Number 2)	T 176	45 min.
Stripping Test	T 182	Min. 95% coated <sup>a</sup>

<sup>a</sup>An approved chemical additive may be used to meet this requirement.

Table 703-6.--Crushed aggregate grading requirements for hot bituminous pavement.

Sieve	Percent Passing (AASHTO T 11 and T 27)			
	Grading A	Grading B	Grading C	Grading D
1-1/2-Inch	100			
1-Inch	95-100	100		
3/4-Inch	78-95	95-100	100	
1/2-Inch		68-86	95-100	100
3/8-Inch	54-75	56-78	74-92	95-100
No. 4	36-58	38-60	48-70	75-90
No. 8	25-45	27-47	33-53	62-82
No. 16		18-37	22-40	38-58
No. 30	11-28	13-28	15-30	22-42
No. 50		9-20	10-20	11-28
No. 200	0-8	4-8	4-9	2-10

703.08  
(Reserved)

703.09  
(Reserved)

703.10  
Aggregate for  
Cold Bituminous  
Pavement

Aggregates for cold bituminous pavement shall be crushed stone, slag, or gravel meeting the quality requirements shown in table 703-7 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

When crushed gravel is used for dense- or intermediate-graded cold bituminous pavement, at least 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face. At least 70 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face for open-graded cold bituminous pavement. Naturally fractured faces may be included in the percentage requirement provided the roughness and angularity produce strength characteristics equivalent to mechanically fractured faces.

Aggregate gradation shall meet the requirements of Table 703-8 for the grading shown in the SCHEDULE OF ITEMS unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Table 703-7.--Crushed aggregate quality requirements for cold bituminous pavement.

Description	AASHTO Test Method	Requirement
Percent Wear	T 96	40 max.
Durability Index, Coarse and Fine	T 210	35 min.
Sand Equivalent (Alternative Method Number 2)	T 176	35 min.
Stripping Test	T 182	min. 95% coated

Table 703-8.--Crushed aggregate grading requirements for cold bituminous pavement.

Sieve	Percent Passing (AASHTO T 11 and T 27)			
	Dense-Graded	Intermediate-Graded	Open-Graded	Top Dressing
1-Inch	100	100	100	
3/4-Inch	80-100	70-100	70-90	
1/2-Inch	60-85	50-70	40-70	
3/8-Inch				100
No. 4	35-60	15-35	0-10	
No. 8	23-44	11-23	0-7	
No. 16				30-60
No. 30	9-25	3-12	0-5	
No. 200	2-8	0-3	0-2	0-4

703.11  
Aggregate for  
Road Mix Bituminous  
Pavement

Aggregates for road mix bituminous pavement shall be crushed stone, slag, or gravel meeting the quality requirements shown in table 703-9 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Table 703-9.--Crushed aggregate quality requirements for road mix bituminous pavement.

Description	AASHTO Test Method	Requirement
Percent Wear	T 96	40 max.
Durability Index, Coarse and Fine	T 210	35 min.
Stripping Test	T 182	min. 95% coated <sup>a</sup>
Sand Equivalent (Alternative Method Number 2)	T 176	35 min.

<sup>a</sup>An approved chemical additive may be used to meet this requirement.

When crushed gravel is used, at least 50 percent by weight of the particles retained on the Number 4 sieve shall have at least one fractured face. Naturally fractured faces may be included in the 50 percent requirement provided the roughness and angularity produce strength characteristics equivalent to mechanically fractured faces.

Aggregate gradation shall meet the requirement of table 703-10 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Table 703-10.--Crushed aggregate grading requirements for road mix bituminous pavement.

Sieve	Percent Passing (AASHTO T 11 and T 27)
1-Inch	100
3/4-Inch	80-100
1/2-Inch	60-85
No. 4	35-60
No. 8	23-44
No. 30	9-25
No. 200	2-8

703.12  
(Reserved)

703.13  
Aggregate for  
Surface Treatments

Crushed stone shall consist of clean, tough, durable fragments, free from an excess of flat, elongated, soft, or disintegrated pieces and free from stone coated with dirt or other objectionable matter. Aggregate shall meet the quality requirements shown in table 703-11 unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

Aggregate for bituminous surface treatments shall meet the requirements of table 703-12 for the grading shown in the SCHEDULE OF ITEMS unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS.

703.14  
Blotter

Unless shown otherwise in the SPECIAL PROJECT SPECIFICATIONS, aggregate for blotter material shall meet the gradation requirements shown in table 703-13 and shall be granular material free from organic matter and other deleterious materials with a minimum sand equivalent value of 45 measured by AASHTO T 176, Alternate Method Number 2.

Table 703-11.--Crushed aggregate quality requirements for surface treatments.

AASHTO Description	Test Method	Bituminous Surface Treatment Section 410
Percent wear	T 96	40 max.
Stripping Test <sup>a</sup>	T 182	min. 95% coated <sup>a</sup>
Durability Index	T 210	35 min.
One Mechanically Fractured Face, by Weight of Plus No. 8		50% min.

<sup>a</sup>An approved chemical additive may be used to meet this requirement.

703.15  
Bed Course Material  
& Mineral Filler

(a) Bed course material for sidewalks, paved waterways, and curbing shall consist of cinders, sand, slag, gravel, crushed stone, or other material specified in the SPECIAL PROJECT SPECIFICATIONS.

(b) Bed course material for slope protection shall be a free draining material consisting of sand, gravel, cinders, slag, crushed stone, or other material specified in the SPECIAL PROJECT SPECIFICATIONS.

(c) Mineral filler shall meet the requirements of AASHTO M 17.

Table 703-12.--Crushed aggregate grading requirements for surface treatments.

Sieve	Percent Passing (AASHTO T 11 and T 27)				
	Grading 6	Grading 6A	Grading 7	Grading 7A	Grading 7B
1-Inch	100	100			
3/4-Inch	90-100	95-100	100	100	100
1/2-Inch	20-55	0-20	90-100	95-100	70-98
3/8-Inch	0-15	0-5	40-70	0-30	
1/4-Inch				0-5	
No. 4	0-5		0-15		44-70
No. 8			0-5		30-54
No. 16		0-0.5		0-0.5	
No. 30					15-34
No. 200	0-2		0-2		0-2
Sieve	Grading 8	Grading 8A	Grading 9	Grading 9A	
1-Inch					
3/4-Inch					
1/2-Inch	100	100			
3/8-Inch	85-100	95-100	100		
1/4-Inch		0-40		100	
No. 4	10-30	0-5	85-100	95-100	
No. 8	0-10		10-40	0-40	
No. 16	0-5	0-0.5	0-10	0-0.5	
No. 30			0-5		
No. 200	0-2		0-2		

Table 703.13--Requirements for grading blotter material.

Sieve	Percent Passing (AASHTO T 11 and T 27)	
	Grading A	Grading B
3/8	100	100
No. 4	85-100	
No. 16	30-80	
No. 200	0-4	



## Section 704 - Masonry Units

704.01  
Clay or Shale Brick

Brick shall meet the requirements of the following specifications:

Sewer Brick . . . . . AASHTO M 91, Grade SM  
Building Brick . . . . . AASHTO M 114, Grade SW

The grade shall be as SHOWN ON THE DRAWINGS.

704.02  
Concrete Brick

Concrete brick shall meet the requirements of ASTM C 55, Grade A.

704.03  
Concrete Masonry

Solid blocks shall meet the requirements of ASTM C 139 or ASTM C 145, grades as specified. Hollow blocks shall meet the requirements of ASTM C 90, grades as specified.

Dimensions and tolerances shall be as SHOWN ON THE DRAWINGS.

## Section 705 - Joint Materials

705.01  
Joint Fillers

Poured filler for joints shall meet the requirements of AASHTO M 173 or as SHOWN ON THE DRAWINGS.

Preformed filler for joints shall meet the requirements of AASHTO M 33, AASHTO M 153, or AASHTO M 213 and shall be punched as SHOWN ON THE DRAWINGS to admit the dowels. The filler for each joint shall be furnished in a single piece according to the depth and width required for the joint. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely and held in position by stapling or other positive fastening approved by the Engineer.

705.02  
Joint Mortar

Pipe joint mortar shall consist of one part Portland cement and two parts sand, with water added as necessary to obtain the required consistency. Portland cement and sand shall meet the requirements of Subsections 701.01 and 703.01(a), respectively. Mortar shall be used within 30 minutes after its preparation.

705.03  
Rubber Gaskets

Ring gaskets for rigid pipe shall meet the requirements of AASHTO M 198. Continuous flat gaskets for flexible metal pipe shall meet the requirements of ASTM D 1056, with grade RE 41 used for bands with projections or flat bands and grade RE 43 used for corrugated bands. When used with metal pipe with annular reformed ends, the ring gasket shall be one-fourth greater in diameter than the depth of the corrugation. Gasket thickness for bands with projections or flat bands shall be 1/2 inch greater than the nominal depth of the corrugation and shall be 3/8 inch for corrugated bands. For pipe with flanged ends, a butyl rubber strip gasket shall be placed inside the channel band.

705.04  
Oakum

Oakum, for joints in bell and spigot pipe, shall be made from either hemp (*Cannabis sativa*) line, Benares Sunn fiber, or from a combination of these fibers. The oakum shall be thoroughly corded and finished and free from lumps, dirt, and extraneous matter.

705.05  
Mortar for Masonry  
Beds & Joints

(a) Composition. Masonry mortar shall be composed of one part Portland cement or air-entraining Portland cement and two parts fine aggregate by volume to which hydrated lime has been added in an amount equal to 10 percent of the cement by weight. Instead of air-entraining cement, Portland cement may be used with an air-entraining admixture in accordance with Section 602.

For masonry walls not exceeding 6 feet in height, a mortar composed of one part masonry cement and two parts fine aggregate by volume may be substituted for the above mixture of Portland cement, lime, and fine aggregate.

(b) Materials. Type I or Type IA air-entraining Portland cement, meeting the requirements of AASHTO M 85, may be used, except when the contract contains an item for concrete under Section 602, the contractor may use the same type as is used for that work.

Masonry cement shall meet the requirements of AASHTO M 150.

Fine aggregate shall meet the requirements of AASHTO M 45.

Hydrated lime shall meet the requirements for residue, popping and pitting, and water retention shown for Type N in ASTM C 207.

Water shall meet the requirements of Subsection 712.01.

Air-entraining agents shall meet the requirements of Subsection 711.02.

705.06  
(Reserved)

705.07  
Rubber Waterstops

Rubber waterstops may be molded or extruded and shall have a uniform cross section, free from porosity or other defects, conforming to the nominal dimensions SHOWN ON THE DRAWINGS. An equivalent standard shape may be furnished, if approved by the Engineer.

The waterstop may be compounded from natural rubber, synthetic rubber, or a blend of the two, together with other compatible materials which will produce a finished waterstop meeting the requirements tabulated in table 705-1. No reclaimed material shall be used. The contractor shall furnish a certificate from the manufacturer to show the general composition of the material and values for the designated properties in table 705-1. The contractor shall also furnish samples, in lengths adequate for making designated tests, as ordered by the Engineer.

Table 705-1.--Required properties and test methods, finished rubber waterstop.

Property	Federal Test Method Standard No. 601	Requirement
Hardness (by Shore Durometer)	3021	60 to 70
Compression Set	3311	30% max.
Tensile Strength	4111	2,500 psi min.
Elongation at Breaking	4121	450% min.
Tensile Stress at 300% Elongation	4131	900 psi min.
Tensile Strength After Aging	7111	80% original min.

705.08  
Plastic Waterstops

Plastic waterstops shall be fabricated with a uniform cross section, free from porosity or other defects, to the nominal dimensions SHOWN ON THE DRAWINGS. An equivalent standard shape may be furnished, if approved by the Engineer.

The material from which the waterstop is fabricated shall be homogeneous elastomeric, plastic compound of basic polyvinylchloride and other material that, after fabrication, will meet the requirements of table 705-2. No reclaimed material shall be used. The contractor shall furnish a certificate from the manufacturer showing values for the designated properties in table 705-2. The contractor shall furnish samples, in lengths adequate for making designated tests, as requested by the Engineer.

705.09  
Flexible Plastic Gaskets

Flexible plastic gaskets shall conform to AASHTO M 198, Type B, shall be produced from blends of refined hydrocarbon resins and plasticizing components reinforced with inert mineral filler, and shall contain no solvents. The gasket joint sealer shall be supplied in extruded rope form of suitable cross section and size as to fill the joint space when the pipes are joined.

705.10  
Bituminous Mastic

Bituminous mastic joint sealing material shall be a smooth, uniform mixture of bituminous cement, solvent, and mineral filler. The mineral filler shall consist essentially of short fiber asbestos. The mixture shall be readily applicable by means of a trowel or caulking gun without pulling or drawing, and shall not sag or flow when applied to metal, concrete, or vitrified clay surfaces.

The compound shall be capable of withstanding freezing and shall not exhibit any tendency to separate or otherwise deteriorate while in storage.

Table 705-2.--Required properties and test methods, finished plastic waterstop.

Property	Federal Test Method Standard No. 406	ASTM Equivalent	Requirement
Tensile Strength	1011	D 638	Minimum 1,400 psi
Elongation at Breaking	1011	D 638	Minimum 250 percent
Hardness (Shore Durometer)	1082	D 1706	60 to 75
Specific Gravity	5011		Maximum $\pm 0.02$ from manufacturer's value
Resistance to Alkali (7 days using 10 percent NaOH)	7011	D 543	Maximum weight change: -0.10 percent to +0.25 percent. Maximum hardness change $\pm 5$ (Shore); maximum tensile strength decrease: 15 percent
Water Absorption (48 hours)	7031	D 570	Maximum 0.5 percent
Cold Bending	(a)	(a)	No cracking
Volatile Loss	6081	D 1203	Not more than manufacturer's value

(a) = The cold bend test will be made by subjecting a 1-inch by 6-inch by 1/8-inch strip of plastic waterstop to a temperature of -20 °F for 2 hours. The strip will immediately thereafter be bent 180 degrees around a rod of 1/4-inch diameter by applying sufficient force to hold the sample in intimate contact with the rod. The sample will then be examined for evidence of cracking. At least three individual samples from each lot will be tested and the result reported.

When applied to a tinned panel or glass plate, in a layer 1/16 to 1/8-inch thick, and cured at room temperature for 24 hours, the compound shall set to a tough, plastic coating and shall not shrink, crack, or loosen from the surface.

In addition, the material shall comply with the requirements of the following table:

	Min.	Max.
Grease Cone Penetration (ASTM D 217 Unworked, 150 gm., 25 °C., 5 sec.) 0.10 mm...	175	250
Weight per gal, lbs.....	9.75	---
Non-Volatile (10 gm, 105 °C - 110 °C., 24 hrs), pct.....	75	---
Ash (by ignition), pct.....	25	45

705.11  
Preformed Plastic  
Sealing Compound

Preformed plastic sealing compounds for concrete pipe joints shall meet the requirements of AASHTO M 198.

## Section 706 - Concrete, Clay, Plastic, & Fiber Pipe

- 706.01  
Nonreinforced  
Concrete Pipe
- Nonreinforced concrete pipe shall meet the requirements of AASHTO M 86.
- 706.02  
Reinforced  
Concrete Pipe
- Reinforced concrete pipe shall meet the requirements of AASHTO M 170 or AASHTO M 242. Elliptical pipe shall meet the requirements of AASHTO M 207. Pipe wall design and the use of elliptical reinforcement in circular pipe are optional. Reinforced concrete arch culvert pipe shall meet the requirements of AASHTO M 206.
- Precast reinforced concrete end sections shall meet the requirements of the cited specifications as applicable. Reinforced concrete D-load pipe shall meet the requirements of AASHTO M 242.
- 706.03  
Perforated  
Concrete Pipe
- Perforated concrete pipe shall meet the requirements of AASHTO M 175.
- 706.04  
Drain Tile
- Drain tile shall meet the requirements of AASHTO M 178 or AASHTO M 179.
- 706.05  
Porous Concrete Pipe
- Porous concrete pipe shall meet the requirements of AASHTO M 176.
- 706.06  
Vitrified Clay-Lined  
Reinforced Concrete  
Pipe
- Manufacturer's designs for fully lined or half lined pipes of the specified strength classes shall be submitted for approval. The applicable requirements of AASHTO M 170 and AASHTO M 65 shall govern. Liner or liner elements shall be clay of first quality, sound, thoroughly and perfectly burned, without warps, cracks, or other imperfections, and fully and smoothly salt glazed.
- 706.07  
Clay Pipe
- Clay pipe shall meet the requirements of AASHTO M 65, for pipe with full circular cross section. When specified, the bell shall have integral spacer lugs to provide for an annular opening and self-centering feature.
- 706.08  
Perforated Vitrified  
Clay Pipe
- Perforated vitrified clay pipe shall meet the requirements of AASHTO M 65 for circular, unperforated or perforated pipe.
- 706.09  
Cradle Invert  
Clay Pipe
- Cradle invert clay pipe shall meet the applicable requirements of AASHTO M 65.
- 706.10  
Asbestos Cement Pipe
- Asbestos cement pipe shall meet the requirements of AASHTO M 217.
- 706.11  
Perforated Asbestos  
Cement Pipe
- Perforated asbestos cement pipe shall meet the requirements of AASHTO M 189.
- 706.12  
Bituminized-Fiber  
Pipe
- Bituminized-fiber pipe shall meet the requirements of AASHTO M 177, ASTM D 1861, or ASTM D 1862.
- 706.13  
Perforated  
Bituminized-  
Fiber Pipe
- Perforated bituminized-fiber pipe shall meet the requirements of AASHTO M 177. Type I or Type II couplings may be furnished.
- 706.14  
Reinforced Concrete  
Arch Culvert, Storm  
Drain, & Sewer Pipe
- Reinforced concrete arch culvert, storm drain, and sewer pipe shall meet the requirements of AASHTO M 206.

- 706.15 Reinforced concrete elliptical culvert, storm drain, and sewer pipe shall meet the requirements of AASHTO M 207.  
Reinforced Concrete Elliptical Culvert, Storm Drain, & Sewer Pipe
- 706.16 Reinforced concrete D-load culvert, storm drain, and sewer pipe shall meet the requirements of AASHTO M 242.  
Reinforced Concrete D-Load Culvert, Storm Drain, & D Sewer Pipe
- 706.17 Polyvinylchloride (PVC) sewer and drain pipe shall meet the requirements of ASTM D 3034.  
Polyvinylchloride (PVC) Sewer & Drain Pipe
- 706.18 Corrugated polyethylene (PE) drainage pipe shall meet the requirements of AASHTO M 252.  
Corrugated Polyethylene (PE) Drainage Pipe
- 706.19 Acrylonitrile-butadiene-styrene (ABS) sewer pipe and fittings shall meet the requirements of AASHTO M-264 and M-265.  
Acrylonitrile-Butadiene-Styrene (ABS) Sewer Pipe & Fittings
- 706.20 Corrugated polyethylene (PE) pipe for culverts 12 through 24 inch diameter shall meet the requirements of AASHTO M 294.  
Corrugated Polyethylene (PE) Pipe for Culverts

## Section 707 - Metal Pipe

707.01  
Corrugated  
Steel Pipe &  
Pipe Arches

- (a) Riveted Pipe and Pipe Arches. These pipes shall meet the requirements of AASHTO M 36.
- (b) Welded Pipe and Pipe Arches. Corrugated metal pipe and pipe arches fabricated by resistance spot welding shall meet the applicable requirements of AASHTO M 36.
- (c) Helical Pipe. Helically corrugated pipe with continuous lock or welded seams shall meet the applicable requirements of AASHTO M 36.
- (d) Coupling Bands. Coupling bands shall meet the requirements of AASHTO M 36.
- (e) Special Sections. Special sections such as elbows, tees, wyes, etc., shall be the same thickness as the conduit to which they are joined and meet the applicable requirements of AASHTO M 36.
- (f) Flared End Sections. Flared end sections for inlet and outlet ends of pipe and pipe arch culverts shall meet the applicable requirements of AASHTO M 36. End sections shall be fabricated in accordance with the details and dimensions SHOWN ON THE DRAWINGS, except minor variations may be accepted to permit the use of the manufacturer's standard methods of fabrication.

707.02  
Bituminous-Coated  
Corrugated  
Steel Pipe &  
Pipe Arches

These conduits and their coupling bands shall meet the requirements of AASHTO M 190. The coating shall be Type A, B, C, or D as shown in the SCHEDULE OF ITEMS. Coupling bands shall be fully coated with bituminous material. Pipe shall be made from material conforming to AASHTO M 218 zinc coated, AASHTO M 274 aluminum coated, or AASHTO M 289 aluminum-zinc coated.

Special sections, such as elbows and prefabricated flared end sections, shall meet the applicable requirements of AASHTO M 190. Coating and invert paving shall be of the type specified. Flared end sections shall meet the requirements of AASHTO M 243 or M 190 for the coating specified. The Engineer may waive the imperviousness test for coated pipe if no separation of coating from metal is observed.

When asbestos-bonded bituminous coating is specified, the above requirements shall apply; in addition, the special process of embedding asbestos fiber in the molten metallic bonding medium shall be used to bond the bituminous coating. Asbestos-bonded corrugated metal pipe shall be fabricated in accordance with AASHTO M 36 using asbestos-bonded sheets of base metal specified therein. Both sides of the metal sheets shall be coated with a layer of asbestos fibers pressed into the molten zinc bonding medium. Immediately after the metallic bond has solidified, the asbestos fibers shall be thoroughly impregnated with a bituminous saturant. The finished sheets shall be uniformly coated and free from blisters. After fabrication, the culvert sections shall be treated as specified for Type A, B, or C in accordance with AASHTO M 190. Coupling bands shall meet the requirements of AASHTO M 36.

707.03  
Polymeric-  
Precoated Steel  
Pipe, Pipe Arches,  
& Underdrains

- (a) Pipe shall meet the requirements of AASHTO M 245.
- (b) Coupling bands shall meet the requirements of AASHTO M 245 and M 246. Coating shall be Type A or B as shown in the SCHEDULE OF ITEMS.
- (c) Special sections such as elbows, tees, wyes, etc., shall be the same thickness as the conduit to which they are joined.

(d) Flared end sections for attachment to the inlet and outlet ends of pipe and pipe arch culverts shall meet the applicable requirements of AASHTO M 243 and M 246. End sections shall be fabricated in accordance with the details and dimensions SHOWN ON THE DRAWINGS, except that minor variations may be accepted to permit the use of the manufacturer's standard methods of fabrication.

- 707.04  
Corrugated  
Steel Pipe for  
Underdrains, Plain  
Galvanized or  
Precoated
- Plain galvanized pipe shall meet the requirements of AASHTO M 36.  
Precoated underdrains shall meet the requirements of AASHTO M 245.
- 707.05  
Bituminous-Coated  
Steel Pipe  
for Underdrains
- Pipe shall meet the requirements of AASHTO M 36 and shall be coated with bituminous material to meet the requirements of AASHTO 190, Type A coating, except that minimum coating thickness shall be 0.03 inch. Coupling bands shall be fully coated. The specified minimum diameter of perforations shall apply after coating. The Engineer may waive the imperviousness test if no separation of coating from metal is observed.
- 707.06  
Corrugated  
Aluminum Alloy  
Culvert Pipe &  
Pipe Arches
- Pipe shall meet the requirements of AASHTO M 196.
- 707.07  
Corrugated Aluminum  
Alloy Pipe for  
Underdrains
- Pipe shall meet the requirements of AASHTO M 196.
- 707.08  
Bituminous-Coated  
Corrugated Aluminum  
Alloy Culvert Pipe  
& Pipe Arches
- Pipe shall meet the requirements of AASHTO M 196 and shall be coated with bituminous material meeting the requirements of AASHTO M 190.
- 707.09  
Bituminous-  
Coated Corrugated  
Aluminum Alloy  
Pipe Underdrains
- Pipe shall meet the requirements of AASHTO M 196 and shall be coated with bituminous material meeting the requirements of AASHTO M 190.
- 707.10  
Structural Steel  
Plate for Pipe, Pipe  
Arches, & Arches
- The plates and bolts and nuts for connecting plates shall meet the requirements of AASHTO M 167.
- 707.11  
Full Bituminous-  
Coated Structural-  
Plate Pipe, Pipe  
Arches, & Arches
- Plates shall meet the requirements of AASHTO M 167 and shall be coated with bituminous material meeting the requirements of AASHTO M 243.
- 707.12  
Aluminum Alloy  
Structural Plate  
for Pipe, Pipe  
Arches, & Arches
- Plates and the bolts and nuts for connecting plates shall meet the requirements of AASHTO M 219.
- 707.13  
Aluminum-Coated  
Type 2  
Corrugated Steel  
Pipe & Pipe Arches
- (a) Pipe and coupling bands shall meet the requirements of AASHTO M 36 except that they shall be made from material meeting the requirements of AASHTO M 274.
- (b) Special sections such as elbows, tees, and wyes shall be the same thickness as the conduit to which they are joined and shall meet the applicable requirements of AASHTO M 36 and M 274.



707.14  
Aluminum-Zinc-Alloy-  
Coated Corrugated  
Pipe and Pipe Arches

(a) Pipe and coupling bands shall meet the requirements of AASHTO M 36 except that they shall be made from material meeting the requirements of AASHTO M 289.

(b) Special sections such as elbows, tees, and wyes shall be the same thickness as the conduit to which they are joined and shall meet the applicable requirements of AASHTO M 36 and M 289.

707.15  
Bituminous-Coated  
Polymeric-Precoated  
Steel Pipe, Pipe  
Arches, & Underdrains

These conduits and their coupling bands shall meet the requirements of AASHTO M 190. The coating shall be Type A, C, or D, or invert paved only, or 100 percent paved only. Pipe shall be made from material conforming to AASHTO M 245 Polymeric Precoated Steel Pipe.

## Section 708 - Paints

708.01  
(Reserved)

708.02  
Paint for Timber  
Structures

Paint for timber structures shall be white or as SHOWN ON THE DRAWINGS and shall meet the requirements of AASHTO M 70, Type I, Class B. The paint as specified is intended for use in covering previously painted surfaces. When applied to unpainted timber, turpentine and linseed oil shall be added as required by the character of the surface in an amount not to exceed 1 pint each per gallon of the paint.

708.03  
Paint for Steel  
Structures

(a) General. All paint furnished shall be shipped in strong, substantial containers, plainly marked with the name, weight, and volume of paint content, together with the color, formula, and the name and address of the manufacturer. Paint systems shall be of the type SHOWN ON THE DRAWINGS. Except as otherwise required in the cited specifications, all paint shall meet the following requirements:

(1) The paint shall not show excessive settling in a freshly opened full can and shall easily be redispersed with a paddle to a smooth, homogeneous state. The paint shall show no curdling, livering, caking, or color separation and shall be free from lumps and skins.

(2) The paint as received shall brush easily, possess good leveling properties, and show no running or sagging tendencies when applied to smooth steel vertical surfaces.

(3) The paint shall not form a skin within 48 hours in a three-quarters filled closed container.

(4) The paint shall dry to a smooth uniform finish, free from roughness, grit, unevenness, and other surface imperfections. It shall show no streaking or separation when flowed on clean glass.

(5) The paint shall show no thickening, curdling, gelling, or hard caking after 6 months storage in a full, tightly covered container at a temperature of 70 °F.

(b) System 1--Vinyl Paint System.

(1) Vinyl wash primer shall meet the requirements of MIL-P-15328.

(2) Vinyl intermediate coat shall meet the requirements of MIL-P-15929, MIL-P-15930, or SSPC-Paint-8 or -9.

(3) Third and fourth coats shall be the same as the intermediate coat.

(4) Final coat shall be the same as the intermediate coat or SSPC-Paint-8 or -9 or Fed. Spec.--TT-P-615 to obtain the specified finish color.

(c) System 2--Epoxy-Polyamide Paint System

(1) Primer coat shall meet the requirements of MIL P-24441, Formula 150 and the color as specified.

(2) Intermediate coat and third coat shall meet the requirements of MIL-P-24441, using contrasting color sequences.

(3) Final coat shall meet the requirements of SSPC-Paint-8 or -9 or Fed. Spec.-TT-P-615 to obtain the specified final coat, and shall be applied in accordance with the recommendations of the manufacturer of the undercoat. The entire paint system shall be supplied by the same manufacturer.

(d) System 3--Inorganic Zinc Silicate System.

(1) Primer coat shall be an inorganic zinc silicate paint of the two-component self-curing type that, when mixed, cures without the use of a separate curing solution, and shall have the properties described herein.

a. Pigment. The zinc pigment component shall meet the requirements of ASTM D 520 for Type II. The average particle size of the zinc powder shall not exceed 10 microns as determined by the Fisher sub-sieve sizer.

b. Vehicle. The vehicle component shall consist primarily of an alkyd silicate in an appropriate alcohol solvent. Total solids, by content, shall be determined by drying the sample to a constant weight at 100 °C.

c. Mixed Paint. Mixed paint shall meet the following requirements:

1. The zinc portion shall be at least 75 percent by weight of the total solids of the dried coating.

2. The total solids, when heated at 100 °C for 3 hours, shall be not less than 72 percent by weight.

3. The paint shall tolerate up to 1 percent water contamination without gelation.

4. The usable pot life of the mixed paint shall be not less than 12 hours at 77 °F. There shall be no hard settling that cannot be easily redispersed during this period.

5. The inorganic zinc coating shall be formulated to produce a distinct contrast in color with blast-cleaned metal surfaces and with the topcoat.

d. Resistance Tests. Test panels of steel meeting the requirements of ASTM D 609, having dimensions of 2 by 5 by 0.125 inches, shall be prepared by blast cleaning leaving all surfaces with a dense and uniform anchor pattern of not less than 1.5 mils, measured with an approved surface profile comparator or Testx-press tape. A 3- to 4-mil coating (dry thickness) shall then be applied to the test panels in accordance with the manufacturer's current printed instruction. The coating shall be cured as recommended by the manufacturer. Each of the following tests shall be performed on a minimum of three panels. The material will not be accepted if any individual test panel fails any of the following tests:

1. Fresh Water Resistance. Panels shall be scribed down to base metal with an X of at least 2-inch legs and shall be immersed in fresh tap water at 75 °F, plus or minus five degrees. The panels shall show no rusting, blistering, or softening when examined after 30 days.

2. Salt Water Resistance. Panels shall be scribed down to base metal with an X of at least 2-inch legs and immersed in five percent sodium chloride at 75 °F, plus or minus five degrees and examined at 7, 14, and 30 days. The sodium chloride solution shall be replaced with fresh solution after each examination.

3. Weathering Resistance. Panels shall be tested in accordance with ASTM G 23, Type D. The panels shall be placed on test at the beginning of the wet cycle. After 1,000 hours of continuous exposure, the coating shall show no rusting, loss of adhesion to the steel test panel, or blistering.

4. Weather and Salt Fog Resistance. Panels shall be tested in the weatherometer as specified in Part 3 above for 300 hours. After this period the panels shall be removed and scribed with an X of at least 2-inch legs down to base metal. The test panels shall then be tested in accordance with ASTM B 117. After 1,000 hours of continuous exposure, the coating shall show no loss of bond, nor shall it show rusting or blistering beyond 1/16 inch from the center of the scribe mark.

5. Resistance to Elevated Temperatures and Thermal Shock. Panels shall be exposed to a temperature of 500 °F for 1 hour, then quenched immediately in water 65 °F plus or minus five degrees. Panels subjected to this test shall show no blistering or flaking of the coating.

6. Adhesion Panels. Adhesion panels shall be tested in accordance with ASTM D 3359 and shall attain a rating of three or greater.

7. Mud Cracking Resistance. The coating, when applied to test panels as provided above, to a 5- or 6-mil dry film thickness shall not show mud cracking when viewed under 10 power magnification.

e. Manufacturer and Brand Name Approved for Inorganic Zinc Primer. Prior to approval and use of inorganic zinc, the contractor shall submit in triplicate to the Engineer a certified test report from an approved independent testing laboratory showing specific test results meeting all quantitative and resistance test requirements of these specifications. The certified test report shall also contain the exact ratio, by weight, of the pigment component to the vehicle component of the paint used for the tests, the lot tested, the manufacturer's name, brand name of paint, and date of manufacture. Upon approval by the Engineer of this certified test report, further resistance tests will not be required, except as hereinafter noted, of that manufacturer for that brand name of paint for a period of 2 years from the date of test completion. New certified test results shall be submitted any time the manufacturing process or the paint formulation is changed, and may be required by the Engineer when sampling and testing of material offered for use indicates nonconformance to any of the requirements specified.

(2) Intermediate coat shall be applied as recommended by the manufacturer in a single application employing multiple spray passes. The color of the intermediate coat shall contrast with both the primer and final coat. The tie coat shall meet the requirements of MIL-P-15328, or MIL-P-24441, Formula 150.

(3) Final coat shall be applied as recommended by the manufacturer in a single application employing multiple spray passes. The final coat shall meet the requirements of SSPC-PC-8 or -9. For MIL-P-24441 intermediate coat see System 2, Final Coat.

The contractor shall submit final coat color chips for approval of color by the Engineer.

(e) System 4--Alkyd-Oil Basic Lead Silico-Chromate System.

(1) Primer coat shall meet the requirements of Fed. Spec.-TT-P-615 or AASHTO M 229.

(2) Intermediate coat shall be the same as the prime coat but tinted to contrast with both the prime coat and the final coat.

(3) The contractor shall submit final coat color chips for approval of the color by the Engineer.

(f) System 5--Organic Zinc-Rich Paint System.

(1) Prime coat shall meet the following requirements:

a. Description. This specification covers a one-package, thermoplastic, organic zinc-rich primer whose mechanism of drying is that of solvent release. It is intended for use only on blast-cleaned open steel structures exposed to the air.

b. Composition. The composition of the organic zinc-rich paint is specified in the following tables.

The average particle size of the pigment shall not exceed nine microns as determined by the Fisher Sub-Sieve Sizer. The red iron oxide must first be ground into a portion of the vehicle to provide a Hegman grind sufficient to produce the specified color of the finished paint.

The necessary additives to prevent gas formation in the containers during storage shall be incorporated into the formulated paint.

c. Infrared Characteristic Curve of Primer Vehicle. When dried upon a potassium bromide disc, a film of the primer shall have infrared absorption maximums at the same wavelengths and to the same relative degree as that shown by the curve on file.

The composition of the extracted zinc dust pigment shall match the X-ray diffraction curve on file.

Table 708-1.--Pigment ingredients (62.3 percent of composition weight, minimum).

Ingredient	Specification	Parts by Weight of Pigment	
		Type I Red Tint	Type II Gray Tint
Zinc Dust	ASTM D 520	95.0 min.	95.0 min.
Red Iron Oxide <sup>a</sup>	_____	1.5 max.	_____
Zinc Oxide	ASTM D 3280	_____	1.5 max.
Thixotropes and Additives	_____	3.5 max.	3.5 max.

<sup>a</sup> Fe<sub>2</sub>O<sub>3</sub> 98.5 percent minimum; oil absorption, 21; fineness through 325 mesh screen, 99 percent minimum; and specific gravity, 5.15.

Table 708-2.--Vehicle ingredients (37.7 percent of composition weight, maximum).

Ingredients	Specification	Parts by Weight of Vehicle
Polyaryl Ether <sup>a</sup>	_____	19.0
Ethylene Glycol Monoethyl Ether Acetate	MIL-E-7125	66.8
Toluene	Fed. Spec.-TT-T-548	14.2

<sup>a</sup>A polyhydroxy polyalkaryl polyether of the following properties:  
 Specific gravity . . . . . 1.18  
 Viscosity of 49 percent solids in methyl ethyl ketone,  
 Brookfield RVF, 20 rpm No. 5 spindle . . . . . 5,500 to 7,700 cps  
 Reduced viscosity (0.2 g/100 ml.  
 dimethylformamide) . . . . . 0.4 to 0.6  
 Ultimate tensile strength . . . . . 9,000 to 9,500 psi  
 Ultimate tensile elongation . . . . . 50 to 100 percent  
 Softening temperature . . . . . 212 °F  
 Bulking value . . . . . 9.83 lbs. per gal.

d. Characteristics of Paint:

The paint shall, in addition to the preceding composition, meet the following requirements:

Volatiles at 105 °C, percent by weight . . . . . 28-32  
 Weight per gallon, pounds . . . . . 17.2-18.0  
 Viscosity, KU at 77 °F . . . . . 100-120  
 Metallic zinc, percent by weight of extracted  
 pigment by Federal Test Method Standard  
 No. 141, Method 7221 . . . . . 90.2 min.  
 Dry time at 77°F, 50 percent relative  
 humidity, 6-mil wet thickness:  
 Set to touch, hours . . . . . 3/4 max.  
 Dry hard, hours . . . . . 5 max.  
 Storage life, years . . . . . 1 min.

e. Properties of Cured Coating. When applied to a plate glass panel with a 6-mil gap clearance doctor blade and cured for 15 days at 77 °F plus or minus five degrees, and 50 percent relative humidity, plus or minus 5 percent, the coating shall have the following properties:

Pencil hardness . . . . . B min.  
 Color (for Type I only) . . . . . Not lighter than  
 Federal Standard  
 Color 31575

When applied by air or airless spray to a minimum dry film thickness of 1.5 mils on blast-cleaned steel having an anchor profile pattern of 1.0 to 1.5 mils, the mixed paint shall completely wet the surface of the steel with no evidence of dry spray particles or sagging.

When applied to a wet film thickness of 6 mils on a metal panel corresponding to Fed. Spec.-QQ-S-698, the panel being previously cleaned by blast cleaning to produce a 1.0- to 1.5-mil anchor pattern, and cured for 15 days at a relative humidity of 50, plus or minus 5 percent, and tested in accordance with the Conical Mandril Test, Federal Test Method Standard No. 141, Method 6222, there shall be no loosening of the film above the point of the longest continuous crack.

When a steel panel is blast cleaned to white metal and coated with 3- to 4-mils dry film thickness of this coating and cured for 15 days at 75 °F plus or minus two degrees and 50 percent relative humidity plus or minus 5 percent and diagonally scribed to expose base steel, there shall be no underfilm corrosion on the surface of the panel extending beyond the scribed lines after 1,000 hours when tested in accordance with ASTM B 117.

Prior to use, the paint shall be thinned with not more than one part of thinner to four parts of paint using a power-agitated stirrer. The thinner shall consist of a mixture of 82 percent by volume of ethylene glycol monoethyl ether acetate and 18 percent by volume of toluene.

(2) Intermediate coat shall be the same as the prime coat tinted to contrast with both the prime coat and the vinyl wash coat.

(3) Vinyl wash tie coat shall meet the requirements of MIL-P-15328.

(4) Final coat shall meet the requirements of SSPC-Paint-8 or -9, or Fed. Spec.-TT-P-615 with the color as specified.

(g) Sampling and Testing. Unless otherwise specified, sampling will be performed in accordance with Federal Test Method Standard No. 141, Method 1022.

The paint will be tested in accordance with methods of Federal Test Method Standard No. 141, as follows:

<u>Test</u>	<u>Method # 141</u>	<u>ASTM Method</u>
Percentage of Pigment	4021	--
Isolation of Vehicle	4032	D 2698
Nonvolatile in Vehicle	4053 <sup>a</sup>	--
Phthalic Anhydride		D 563
Uncombined Water	4081	D 1364
Consistency: Krebs-Stormer		D 562
Coarse Particles and Skins		D 185
Weight per Gallon		D 1465
Set to Touch Time	4061	--
Condition in Container	3011	--
Brushing Properties	2141, 4321	--
Skimming	4141	--
Rosin and Resin Derivatives	--	D 1542
Storage Stability	4142	--
Dry Through Time	4061	--
Fineness of Grind		D 1210

<sup>a</sup>A gravity convection oven may be used to determine the non-volatile content of the supercentrifuged vehicle if the procedure outlined in ASTM D 2369 is modified as follows: Weigh accurately from 0.8 to 1.2 gram of sample (by difference), heat for one hour, cool and weigh. Use the lower value to calculate the percentage of nonvolatile matter.



## Section 709 - Reinforcing Steel & Wire Rope

### 709.01 Reinforcing Steel

Reinforcing steel shall meet the following requirements:

- (a) Deformed and plain billet steel bars for concrete reinforcement . . . . . AASHTO M 31
- (b) Low-alloy steel deformed bars for concrete reinforcement . . . . . ASTM A 706
- (c) Metal chair supports. All supports not covered by at least 1/2 inch of concrete shall meet one of the following:
  - (1) Hot-dipped galvanized . . . . . AASHTO M 232
  - (2) Stainless steel . . . . . ASTM A 493, Type 430
  - (3) Plastic coated . . . . . As approved by Engineer
- (d) Fabricated steel bar or rod mats for concrete reinforcement . . . . . AASHTO M 54
- (e) Welded steel wire fabric for concrete reinforcement . . . . . AASHTO M 55
- (f) Welded deformed steel wire fabric for concrete reinforcement . . . . . AASHTO M 221
- (g) Dowel and tie bars . . . . . AASHTO M 31
- (h) Epoxy coated reinforcing bars . . . . . AASHTO M 284
- (i) Galvanized reinforcing bars . . . . . ASTM A 767

Tie bars shall be deformed bars. Dowel bars shall be plain round bars, and shall be free from burring or other deformation restricting slippage in the concrete. At least one-half the length of each dowel bar shall be painted with one coat of approved tar paint before delivery to the work site.

The sleeves for dowel bars shall be metal of an approved design to cover 2 inches, plus or minus 1/4 inch, of the dowel. The sleeve shall have a closed end with a stop to hold the end of the sleeve at least 1 inch from the end of the dowel bar. Sleeves shall be designed so they will not collapse during construction.

### 709.02 Wire Rope or Wire Cable

The wire rope or wire cable shall meet the requirements of AASHTO M 30.

### 709.03 Prestressing Reinforcing Steel

Prestressing reinforcing steel shall be high-tensile wire meeting the requirements of AASHTO M 204, high-tensile wire strand or rope meeting the requirements of AASHTO M 203, or high-tensile alloy bars cold stretched to a minimum of 130,000 psi. The resultant physical properties shall be as follows:

- Minimum ultimate tensile strength . . . . . 145,000 psi followed by stress relieving
- Minimum yield strength, measured by the 0.7 percent extension under load method shall not be less than . . . . . 130,000 psi
- Minimum modulus of elasticity . . . . . 25,000,000 psi
- Minimum elongation in 20 bar diameters after rupture . . . . . 4 percent
- Diameter tolerance . . . . . +0.03 inch  
-0.01 inch

## Section 710 - Fence & Guardrail

- 710.01  
Barbed Wire Galvanized barbed wire shall meet the requirements of ASTM A 121. Aluminum coated barbed wire shall meet the requirements of ASTM A 585, with Type I (Aluminum Coated) or Type II (Aluminum Alloy) barbs at the option of the manufacturer.
- 710.02  
Woven Wire Galvanized woven wire fence shall meet the requirements of ASTM A 116. Aluminum coated woven wire fence shall meet the requirements of ASTM A 584.
- 710.03  
Chain Link Fence Chain link fabric and the required fittings and hardware shall meet the requirements of AASHTO M 181. Galvanized coiled spring steel tension wire shall be 7 gauge, meeting the requirements of ASTM A 641, hard temper with Class 3 coating.
- 710.04  
Metal Beam Rail Steel rail elements shall be corrugated sheet steel beams meeting the requirements of AASHTO M 180 for the class and type SHOWN ON THE DRAWINGS.
- 710.05  
Timber Rail The timber rail shall be cut from dry, well-seasoned, and dressed timber stock, meeting the requirements of AASHTO M 168 for the grade and species SHOWN ON THE DRAWINGS.
- Preservative treatment shall meet the requirements of Subsection 716.03.
- Rustic rails shall be straight, sound, and free of injurious defects and shall be cut from live trees not less than 30 days but not more than 1 year before use. They shall be stripped of bark before seasoning or shall be stored under water. Immediately before the logs are used in the work, all knots and projections shall be trimmed smooth and, if water cured, all bark shall be peeled. Slight curvature or "wind" that will give a pleasing appearance to the structure will be permitted.
- 710.06  
Fence Posts Wood post details and dimensions shall be as SHOWN ON THE DRAWINGS. All wood posts shall be of sound, seasoned wood, peeled and with ends cut as SHOWN ON THE DRAWINGS. The posts shall be straight and all knots trimmed flush with the surface. Where treated posts are called for, the kind and type of treatment shall meet the requirements SHOWN ON THE DRAWINGS. The requirements for peeling may be omitted for red cedar posts or bracing.
- All dimension timber and lumber required for fences or gates shall be sound, straight, and reasonably free from knots, splits, and shakes. The species and grades shall be as SHOWN ON THE DRAWINGS and shall be dressed and finished on four sides.
- Concrete posts shall be made of concrete meeting the requirements of Section 602, Method A or B. Steel reinforcement, as SHOWN ON THE DRAWINGS, shall meet the requirements of Section 709.
- Steel posts for line-type fencing shall be manufactured in accordance with ASTM A 702 and galvanized in accordance with AASHTO M 111 (ASTM A 123), except that tubular steel posts shall be galvanized in accordance with ASTM A 120. Fittings, hardware, and other appurtenances shall be galvanized in accordance with ASTM A 120, by current standard practice, and be of standard commercial grade. Weathering steel posts shall meet the requirements of AASHTO M 222.
- Aluminum alloy posts shall meet the requirements of AASHTO M 181.

710.07  
Guardrail Posts  
& Blocks

Railing posts shall be of wood or steel as SHOWN ON THE DRAWINGS and shall meet the following requirements:

(a) Wood posts and blocks shall be fabricated from timber species meeting the requirements of AASHTO M 168. The species, diameter or section, length, and treatment shall be as SHOWN ON THE DRAWINGS. Treated posts shall be fabricated or framed before treatment. Timber preservatives shall meet the requirements of Subsection 716.03.

(b) Steel posts shall be copper bearing steel of the section, length, and grade as SHOWN ON THE DRAWINGS. Steel shall meet the requirements of AASHTO M 183 unless otherwise SHOWN ON THE DRAWINGS. The posts shall be galvanized, shop painted, or left bare as SHOWN ON THE DRAWINGS.

(c) Box beam posts shall be of the section and length SHOWN ON THE DRAWINGS. Posts, base plates, splice plates, anchor plates, and plate material for soil-bearing plates and rail connections shall meet the requirements of AASHTO M 183 unless otherwise SHOWN ON THE DRAWINGS and shall be galvanized in accordance with AASHTO M 111.

710.08  
Guardrail Hardware

All bolts, nuts, washers, and other fittings for beam-type guardrail shall be steel and of a quality adequate to develop the specified strength of rail splices. All fittings shall be galvanized to meet the requirements of AASHTO M 232.

All bolts, nuts, and washers for metal beam rail shall meet the requirements of AASHTO M 180. Nuts shall not be tapped oversize more than 1/32 inch. Nuts, bolts, and washers for box beam rail shall be as SHOWN ON THE DRAWINGS.

(a) Interchangeability. Bolts, nuts, and other fittings shall be interchangeable with similar parts.

(b) Qualifying and Duplication Tests. The bolts, nuts, and other fittings shall be subjected to qualifying tests to determine conformance with specifications. At least one test will be required on the materials furnished by each manufacturer of the materials. Materials required by the Forest Service for tests shall be furnished without cost.

Once the fittings produced by a manufacturer have qualified under test, the similar products of this manufacturer will be subject to subsequent inspection and testing at any time to ensure that the materials are duplicates of those tested. Subsequent inspections and testing may consist of visual inspection, tests on the physical properties of the metal, tests of the galvanizing, and verification of design. When subsequent inspection and testing provide reason to question the duplication, the contractor shall furnish fittings for a new qualifying test prior to use of the materials.

Cable and fittings for anchors shall meet the requirements of AASHTO M 30 for Type II cable.

Rods for anchors shall meet the requirements of AASHTO M 183. All other fittings shall develop the strength of the rod.

All fittings and rods shall be galvanized in accordance with AASHTO M 111.

710.09  
Box Beam Rail

Steel beam rail elements shall meet the requirements of ASTM A 500, Grade B, or ASTM A 501 and shall be galvanized after fabrication in accordance with AASHTO M 111, except when corrosion-resistant steel rail elements are specified. In this case, rail elements shall be made of steel meeting the dimensional and mechanical requirements of ASTM A 500, Grade B, or ASTM A 501 and having an atmospheric corrosion-resistance approximately two times that of carbon structural steel with copper, and shall not be painted or galvanized. Posts shall meet the requirements of Subsection 710.07 and hardware of Subsection 710.08.

## Section 711 - Concrete Curing Materials & Admixtures

### 711.01 Curing Materials

Curing materials shall meet the following requirements:

- (a) Burlap cloth made from jute or kenaf . . . . . AASHTO M 182
- (b) Sheet materials for curing concrete . . . . . AASHTO M 171
- (c) Liquid membrane-forming compounds for curing concrete . . . . . AASHTO M 148

### 711.02 Air-Entraining Admixtures

Air-entraining admixtures shall meet the requirements of AASHTO M 154.

### 711.03 Chemical Admixtures

Water-reducing, set-retarding, and set-accelerating admixtures shall meet the requirements of AASHTO M 194.

### 711.04 Carbon Black

Emulsified carbon black shall be a uniform colloidal dispersion of standard carbon gas black in a liquid medium. At least 25 percent by weight shall be carbon black. The product shall be free of lampblack, mineral black, silicas, asbestine, talc, boneblack, or other fillers. It shall be free of substances deleterious to the strength, durability, or appearance of concrete. Addition of carbon black, at the specified rate, to concrete of the proportions and air content to be used in the work shall not reduce the compressive strength by more than 5 percent. Emulsified carbon black shall be so finely processed and dispersed that when 1 part is stirred into 10 parts of water, and the mixture left standing without agitation for 72 hours, the resulting liquid will remain uniformly colored from top to bottom. The emulsified carbon black shall be delivered on the job in sealed containers plainly marked with the manufacturer's name and address, together with the trade name of the product and a statement indicating whether or not addition of an air-entraining admixture to the carbon black has been made.

## Section 712 - Miscellaneous

- 712.01  
Water
- (a) Water used in mixing, curing, or other applications shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable matter, or any other substance injurious to the finished product. Water shall be tested in accordance with and shall meet the requirements of AASHTO T 26.
- (b) Water known to be of potable quality may be used without further testing.
- 712.02  
Calcium Chloride  
& Sodium Chloride
- Calcium chloride shall meet the requirements of AASHTO M 144.
- Sodium chloride shall meet the requirements of AASHTO M 143.
- 712.03  
Hydrated Lime
- Hydrated lime shall meet the requirements of ASTM C 207, Type N.
- 712.04  
Stone Curbing
- (a) Stone Curb. The stone for stone curb items shall meet the requirements for size and shape specified and shall also meet the following requirements:
- Stone curb shall be approved limestone, sandstone, or granite from acceptable sources. Stone material shall be as SHOWN ON THE DRAWINGS. The exposed faces of stone curb shall be free from drill holes.
- All vertical stone curb shall have a top surface sawed or pointed to an approximate true plane with no depression or projection on that surface of over 1/4 inch. The front and back arris lines shall be pitched straight and true. There shall be no projection or depression on the back surface that would exceed a batter of 1 inch horizontal on 3 inches vertical.
- The front exposed face vertical stone curb shall be sawed, pointed, or smooth quarry split, as SHOWN ON THE DRAWINGS, and shall be formed to an approximately true plane. The remaining face distance shall have no projections or depressions greater than 1 inch from the plane of the exposed face noted above.
- The ends of vertical stone curb shall be square with the planes of the top, back, and face finished so that when the sections are placed end to end as closely as possible, no space more than 1/2 inch shall show in the joint for the full width of the top surface and for the entire exposed front face. The remainder of the end may break back no more than 4 inches from the plane of the joint. The joints of circular or curved stone curb shall be cut on radial lines.
- The minimum length of any segment of vertical stone curb shall be as SHOWN ON THE DRAWINGS. When required for driveways, crossings, closures, or for other reasons, a depressed or modified section of curb as SHOWN ON THE DRAWINGS shall be furnished by the contractor.

(b) Slope Stone Curb. Slope stone curb shall meet the requirements of stone curb except as follows:

The maximum allowable projection or depression on a horizontal top surface shall be 1/2 inch; on other exposed faces the maximum allowable projection or depression shall be 1 inch.

For unexposed surfaces, the maximum allowable projection or depression from a true plane on a 2-foot length shall be 3 inches.

The maximum allowable space showing on exposed faces between adjacent segments of slope stone curb shall be 3/4 inch.

The minimum length of any segment of slope stone curb shall be 2 feet.

712.05  
Precast Concrete  
Curbing

Precast concrete curbing shall consist of precast Portland cement concrete curb units constructed to the lengths, shapes, and other details SHOWN ON THE DRAWINGS. Steel reinforcement shall meet the requirements of Subsection 709.01. Concrete shall attain a minimum 28-day compressive strength of 3,000 psi as determined in accordance with AASHTO T 22.

When required for driveways, crossing, closures, or for other reasons, a depressed or modified section or curb as SHOWN ON THE DRAWINGS shall be furnished by the contractor.

712.06  
Precast Concrete  
Units

Precast concrete units shall be cast in substantial permanent steel forms. The structural concrete used shall attain a minimum 28-day compressive strength of 3,000 psi as determined in accordance with AASHTO T 22. Air-entrained concrete shall have an air content of 6 percent plus or minus 2 percent by volume. The precast units shall be cured in accordance with AASHTO M 170. Water absorption of individual cores taken from such units when tested in accordance with AASHTO T 33 shall not exceed 8 percent. Additional reinforcement shall be provided as necessary to provide for handling of the precast units.

A sufficient number of cylinders shall be cast from the concrete for each unit to permit compression tests at 7, 14, and 28 days, and to allow for at least two cylinders for each test. If the strength requirement is met at 7 or 14 days, the units will be certified for use from the date of casting. If the strength requirement is not met at 28 days, all units made from that batch or load will be rejected.

Cracks in units, honeycombed or patched areas in excess of 30 square inches, excessive water absorption, and failure to meet strength requirements will be cause for rejection. Precast reinforced concrete manhole risers and tops shall meet the requirements of AASHTO M 199.

712.07  
Frames, Gratings,  
Covers, & Ladder  
Rungs

Metal units shall be as SHOWN ON THE DRAWINGS and shall meet the following requirements:

(a) Metal gratings and covers that are to rest on frames shall bear on them evenly. They shall be assembled before shipment and marked so the same pieces may be reassembled readily in the same position when installed. Inaccuracy of bearings shall be corrected by machining, if necessary. A frame and the grating or cover to be used with it shall constitute one pair.

(b) All castings shall be uniformly coated with asphalt varnish meeting the requirements of Fed. Spec.-TT-V-51.

(c) Gray iron castings shall meet the requirements of AASHTO M 105. Strength class shall be as SHOWN ON THE DRAWINGS.

(d) Carbon-steel castings shall meet the requirements of AASHTO M 103. Grade shall be as SHOWN ON THE DRAWINGS.





712.10  
Epoxy Resin  
Adhesives

Epoxy resin adhesives shall meet the requirements of AASHTO M 234 and M 235. Class I adhesives shall be used to bond fresh concrete to cured concrete. Class II adhesives shall be used to bond cured concrete to cured concrete and as a binder in epoxy resin concrete and mortar to repair defects in cured concrete. Class II adhesives, to be used in exposed epoxy mortar or epoxy concrete, shall be a uniform, concrete gray color when thoroughly mixed. Manufacturer's certification shall be furnished prior to its use in the work.

712.11  
Magnesium Chloride

Magnesium chloride shall be a brine consisting of water and magnesium chloride.

(a) Chemical Analysis.\* The chemical analysis shall meet the following requirements:

Chemical	Percent by Weight of Brine
Magnesium Chloride	7.0 minimum
Sulfate	20.0 minimum
Nitrate	4.3 maximum
	5.0 maximum

The pH shall be between 4.5 and 10.0. The solids shall be at least 30 percent by weight of the brine.

(\*Copy of test procedures available upon request from USDA Forest Service, Pleasant Hill Engineering Center, 2245 Morello Avenue, Pleasant Hill, CA 94523.)

(b) Temperature. The temperature of the material shall be 40 °F or above when it is applied.

(c) Certification. When each load of magnesium chloride is delivered, the contractor shall furnish the Engineer with a completed Certificate of Compliance conforming to the format as shown in figure 712-2. A separate Certificate of Compliance will not be required if the Bill of Lading contains the required information.

CONSIGNEE _____	DESTINATION _____
DATE _____	NET WEIGHT _____
IDENTIFICATION _____ (Truck No., Car No., Etc.)	SOURCE _____ (Mfg. & Location)
This shipment of magnesium chloride identified above and covered by this Certificate of Compliance complies with Forest Service Standard Specifications as modified by SPECIAL PROJECT SPECIFICATIONS applicable to this project.	
	PRODUCER _____
	SIGNED _____ Producer's Representative

Figure 712-2.--Sample Certificate of Compliance.

712.12  
Bonding Agents

Bonding agents shall meet the requirements SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS.

712.13  
Delineators

The delineator reflector shall be Type 1 or Type 2 as SHOWN ON THE DRAWINGS. The reflectors shall be amber or crystal and ready for mounting.

The delineator element shall consist of a sealed optical system complete with aluminum housing and assembly hardware as SHOWN ON THE DRAWINGS. The post-mounting hardware shall consist of all bolts, nuts, plain or lock washers, fastening plates, and brackets as SHOWN ON THE DRAWINGS.

712.14  
Fly Ash & Pozzolan  
Cement Substitutes

Fly ash and raw or calcined pozzolan, for use with Portland cement, shall conform to the requirements of ASTM C 618, either Class F or Class C, except the maximum loss at ignition for either Class shall be 1.5 percent, unless otherwise specified in the contract.

The use of fly ash produced by plants, which utilizes compounds of sodium, ammonia, or sulfur, such as soda ash, to control stack emissions, shall be prohibited for use in structural concrete.

The contractor shall furnish certificates and test results substantiating that the material conforms to the above requirements.

## Section 713 - Roadside Improvement Materials

### 713.01 Topsoil

Topsoil shall consist of loose, friable, sandy loam, free of admixture of subsoil, refuse, stumps, roots, rocks, brush, weeds, or other material that would be detrimental to the development of vegetative growth. Topsoil, as used herein, shall mean that portion of the soil profile defined technically as the "A" horizon by the Soil Science Society of America.

Topsoil shall have a grading analysis as follows:

<u>Sieve Designation</u>	<u>Percentage by Weight Passing Square Mesh Sieve</u>
1"	100
1/4"	97-100
No. 10	80-100

The minimum and maximum pH values shall be 5 and 8, respectively.

Topsoil shall contain a minimum of 3 percent and a maximum of 20 percent organic matter as determined by loss on ignition of samples oven dried to constant weight at 212 °F.

Topsoil shall consist of the following particle sizes:

<u>Material</u>	<u>Size</u>	<u>Percent in Topsoil</u>	
		<u>Min.</u>	<u>Max.</u>
Sand	0.075-2 mm	20	75
Silt	0.002-0.075 mm	10	60
Clay	0.002 mm or less	5	30

Prior to stripping, topsoil shall have demonstrated by the occurrence upon it of healthy crops, grass, or other plant growth, that it is of good quality and reasonably free draining. All testing will be at the expense of the Government. The contractor will be reimbursed for materials provided to improve the pH, organic matter, or other quality of the onsite topsoil when requested by the Engineer.

### 713.02 Agricultural Limestone

Agricultural limestone shall be a calcic or dolomitic ground limestone containing not less than 85 percent of total (calcium and magnesium) carbonates.

Rates of application shall be specified in the SPECIAL PROJECT SPECIFICATIONS.

Limestone shall meet the following sieve analysis: at least 40 percent passing a No. 100 sieve and at least 95 percent passing a No. 8 sieve.

Granulated slag or other approved natural sources of lime may be used, provided the application rate is adjusted to equal the total neutralizing power of the specified ground limestone.

### 713.03 Fertilizer

Fertilizer shall be a standard commercial grade and provide the minimum percentage of available nutrients specified in the SPECIAL PROJECT SPECIFICATIONS.

Fertilizer shall be furnished in new, clean, and sealed containers with the name, weight, and guaranteed analysis of contents clearly marked. Fertilizer failing to meet the specified analysis may be used providing sufficient materials are applied to supply the specified nutrients without additional cost to the Government.

A liquid form of fertilizer containing the minimum percentage of available nutrients may be used.

713.04  
Seed

The kinds of grass, legume, and cover-crop seed furnished shall be those stipulated in the SPECIAL PROJECT SPECIFICATIONS. Seed shall meet the requirements of Federal Specification-JJJ-S-181.

Seed shall be furnished separately or in mixture in standard containers with (1) seed name; (2) lot number; (3) net weight; (4) percentages of purity and of germination (in case of legumes, percentage of germination to include hard seed); and (5) percentage of maximum weed seed content clearly marked for each kind of seed. Unless otherwise stated in the SPECIAL PROJECT SPECIFICATIONS, the contractor shall furnish the Engineer duplicate signed copies of a statement by the vendor, certifying that each lot of seed has been tested by a recognized laboratory for seed testing within 6 months of date of delivery. This statement shall include (1) name and address of laboratory, (2) date of test, (3) lot number for each kind of seed, and (4) results of tests as to name, percentages of purity and of germination, and percentage of weed content for each kind of seed furnished, and, in case of a mixture, the proportions of each kind of seed. Legume seed shall be inoculated with approved cultures in accordance with the instructions of the manufacturer.

713.05  
Mulch

(a) Wood Chips. Wood chips shall be obtained from green hardwood. They shall be 1/8 inch nominal thickness with 50 percent having an area of not less than 1 square inch, and not more than 6 square inches. All wood chip mulch shall be free of leaves, twigs, shavings, bark, or materials injurious to plant growth. Wood chips from elm trees will not be used when State or Federal regulation prohibits such use, or when the trees are diseased.

(b) Straw. Straw for mulching shall be from grain crops that are free from noxious weeds, mold, or other objectionable material. Straw mulch shall be in an air-dry condition and suitable for placing with mulch blower equipment.

(c) Hay. Grass hay shall be of approved herbaceous mowings, free of noxious weeds, mold, or other objectionable material. Grass hay shall be in an air-dry condition and suitable for placing with mulch blower equipment.

(d) Wood Cellulose Fiber. Natural wood cellulose fiber mulch shall be produced from clean, whole-wood chips and have the property of dispersing readily in water. The material shall contain no weed seed and shall be heat-processed to eliminate factors that inhibit growth and germination. The material shall have no toxic effect when combined with seed or other materials and shall have the following physical and chemical properties:

Moisture Content . . . . .	7-13%
Organic Matter (Oven-dried Basis) . . . . .	99.1% minimum
Ash Content . . . . .	0.9% maximum
pH @ 3% Concentration . . . . .	4.7 to 7.0 pH
Water-holding Capacity . . . . .	200% by weight on oven dry basis

The material shall readily blend with water, grass seed, fertilizer, and other additives to form a homogeneous slurry or mixture capable of application with power spray equipment. A colored dye that is noninjurious to plant growth and that fades rapidly with exposure to light may be used. Wood cellulose fiber shall be packaged in new, labeled containers in an air-dry condition.

(e) Sawdust. Sawdust shall be obtained from wood that has not been subjected to conditions that would cause the sawdust to lose its value or usefulness as a mulch. Sawdust shall not contain any toxic substances and shall be aged.

(f) Peat Moss. Peat moss shall be a granulated sphagnum peat moss nearly free of woody substances consisting of at least 75 percent of partially decomposed stems and leaves of sphagnum and essentially brown in color. The texture may vary from porous fibrous to spongy fibrous and shall be free of sticks, stones, and mineral matter. Peat moss shall be in an air-dry condition, show an acid reaction of 3.5 pH to 5.5 pH, and meet State and Federal regulations.

(g) Peat Humus. Peat humus shall be natural peat or peat humus from fresh water-saturated areas, consisting of sedge, sphagnum, or reed peat and be of a physical condition that will pass through a 1/2-inch mesh screen. The humus shall be free of sticks, stones, roots, and other objectionable materials. Samples taken at the source of supplies shall have the following characteristics when analyzed:

Acidity range . . . . . 4.0 to 7.5 pH.  
Minimum water absorbing ability . . . . . 200 percent by weight on  
oven-dry basis  
Minimum organic content . . . . . 60 percent when dried at 105 °C

Freshly excavated peat, if saturated with water, shall be stored for a sufficient length of time to condition it for workability.

(h) Grass Straw Cellulose Fiber. Natural or cooked straw (grass processed to remove seed) cellulose fiber shall have the property of dispersing readily in water and shall have no toxic effect when combined with seed or other materials. The processed fiber shall contain no growth inhibiting factors or weed seed. The homogeneous slurry or mixture shall be capable of application with power spray equipment. A green colored dye that is noninjurious to plant growth may be used. The fiber shall be packaged in new, labeled containers, shall be of uniform weight (plus or minus 5 percent) in an air-dry condition, and shall bear the name of the manufacturer and the air-dry weight content. The fiber shall meet the following characteristics when tested:

Acidity range . . . . . 6.5 - 7.5 pH  
Moisture content (packaged fiber) . . . . . 8 - 12%  
Organic Matter . . . . . 90.0 - 100.0%  
Ash Content . . . . . 0.0 - 10.0%

The contractor shall submit a Certificate of Compliance from the supplier that states their product meets all of the foregoing requirements, based on laboratory and field tests.

(i) Other. Mulch products made of other materials intended for this purpose shall be as specified in the SPECIAL PROJECT SPECIFICATIONS.

713.06  
Plant Materials

(a) Quality of Plant Materials. All plants shall be first-class representatives of their normal species or varieties unless otherwise specified as "street-tree," "extra heavy," "clump," and other of like import, according to the particular exception. All plants shall be nursery-grown stock that has been transplanted or root-trimmed two or more times, according to the kind and size of plants. The branch system shall be of normal development and free of disfiguring knots, sun-scald, injuries, abrasions of the bark, dead or dry wood, broken terminal growth, or other objectionable disfigurements. Trees shall have reasonably straight stems and shall be well branched and symmetrical in accordance with their natural habits of growth.

(b) Plant Names. All scientific and common plant names and types specified shall meet the requirements in the edition of "Standardized Plant Names," as adopted by the American Joint Committee on Horticultural Nomenclature, that is in effect at the time of advertisement. All plants delivered shall be true to name and legibly tagged with the names and sizes of materials. Substitution of a plant or plants of a different variety than the plant material specified shall be subject to approval by the Engineer. An approved substitute plant shall be of a value at least equal to the respective specified plant.

(c) Grading Standards. Grading of plants shall meet the requirements of the "American Standard for Nursery Stock," as approved by the United States of America Standards Institute, in effect at the time of advertisement.

(d) Nursery Inspection and Plant Quarantine. All plants shall be free from plant diseases and insect pests. All shipments of plants shall comply with all nursery inspection and plant quarantine regulations of the States of origin and destination, as well as with Federal regulations governing interstate movement of nursery stock. A valid copy of the certificate of inspection shall accompany each package, box, bale, or carload.

(e) Balled and Burlapped Plants. Balled and burlapped plants shall be dug to retain as many fibrous roots as possible. The soil in the ball shall be the original and undisturbed soil in which the plant has been grown. The plant shall be dug, wrapped, transported, and handled so the soil in the ball will not be loosened and cause stripping of the small and fine feeding roots, or cause the soil to drop away from the roots.

713.07  
Erosion Control Net  
& Blanket Material

All erosion control materials shall be made of new material, clean, sound, free of rips or tears, and furnished in lengths of at least 200 feet.

(a) Burlap. Burlap shall be of standard weave with a weight of 3.5 to 5.0 ounces per square yard.

(b) Jute Mesh. Jute mesh shall be of a uniform, plain weave with warp and weft yarns of approximately the same size. The physical requirements shall be:

- (1) Width of 45 to 48 inches, plus or minus 1 inch.
- (2) 78 warp ends per width.
- (3) 41 weft ends per yard.

The weight of cloth shall average 1.80 pounds per running yard with a 5 percent minimum tolerance to an average of 1.22 pounds per running yard with a 5 percent minimum tolerance at standard atmospheric conditions.

(c) Woven Paper or Sisal Mesh Netting. Woven paper or woven sisal mesh netting shall be woven from twisted yarns available in rolls at least 45 inches wide. Mesh shall have a 3-inch by 3-inch maximum opening. Shrinkage after wetting shall not exceed 20 percent of the surface area. Netting shall have a minimum dry weight of 0.8 pound per square yard, plus or minus 10 percent.

(d) Excelsior Blanket. Excelsior blanket shall consist of a machine produced mat or curled wood excelsior of 80 percent 6-inch or longer fiber length with consistent thickness and the fiber evenly distributed over the entire area of the blanket. Fiber dimensions shall be 0.021 by 0.042 inch plus or minus 25 percent. Average weight per square yard to be 0.975 pounds plus or minus 10 percent at time of manufacture.

713.08  
Miscellaneous

(e) Photodegradable Plastic Mesh Netting. Material shall be extruded, rectangular mesh and weigh approximately 3.0 pounds per 1,000 square feet, (plus 1/2 pound) and have a mesh opening and color as SHOWN ON THE DRAWINGS.

(a) Water. Water used in the planting or care of vegetation shall be free of oils, acids, alkalies, salts, or any substance injurious to plant life. Water sources shall be approved by the Engineer.

(b) Stakes for Bracing and Anchoring. Stakes for bracing or supporting trees shall be of wood, free of knots, rot, cross-grain, or other defects that would impair the strength of the stake. Stake size, length, and type shall be as SHOWN ON THE DRAWINGS.

(c) Ties. Tree ties shall be chain-type plastic green or black, approximately 1 inch wide and 1/8 inch thick; elastic belt webbing, 3/4 inch wide; or flexible tubing approximately 3/8 inch in diameter. Wire shall not be used as tree ties.

(d) Wrapping Material. Wrapping material for trees shall be an approved waterproof paper triple lamination 30-30-30 in 4-inch wide rolls, or an approved burlap in 6-inch wide rolls.

(e) Twine. Twine used for tying wrapping on trees shall be of approved quality. Two-ply twine shall be used for trees 3 inches and less in diameter, and three-ply twine for trees over 3 inches in diameter.

(f) Antidesiccant. Antidesiccant shall be an approved emulsion that will provide a film over plant surfaces permeable enough to permit transpiration. Antidesiccant shall be used only after approval by the Engineer.

(g) Tree Wound Dressing. Dressing for treating tree wounds or cuts shall be:

(1) An approved black asphaltum base antiseptic paint.

(2) An approved black paint consisting of Bordeaux mixture, raw linseed oil, and lampblack.

(3) An approved black paint consisting of zinc oxide, raw linseed oil, and lampblack.

(h) Staples. Staples shall be made of wire, 0.091 inch in diameter (11 gauge) or greater, "U" shaped with a 1 inch wide throat, and legs not less than 6 inches in length.

713.09  
(Reserved)

713.10  
Sod

Sod shall be living, vigorously growing, and predominantly of the grass and thickness specified in the SPECIAL PROJECT SPECIFICATIONS, having a dense root system contained in suitable sod and reasonably free from noxious weeds and grasses. When the sod is cut, its top growth shall not be more than 3 inches in height and it shall have a minimum of 1 inch of soil and root zone backing. Sod from other than commercial sources will be inspected by the Engineer at the source and shall not be cut prior to approval.

713.11  
Pegs for Sod

Pegs shall be of sound wood, at least 8 inches long, square or round and have a cross sectional area of approximately 1 square inch.

## Section 715 - Piling

715.01 Untreated timber piles shall meet the requirements of AASHTO M 168.  
Untreated Timber  
Piles

715.02 Treated timber piling shall be Douglas fir, larch, southern yellow  
Treated Timber pine, Norway pine, or red oak meeting the requirements of AASHTO  
Piles M 168 and M 133. Preservative treatment shall be in accordance  
with Subsection 716.03.

One copy of the following Certificates of Compliance shall be furnished to the Engineer upon delivery of the piling to the work site:

(a) Supplier certification of species, and meeting the requirements of AASHTO M 168.

(b) Certificate of treatment, including type of treatment, retention (Assay Method), and penetration.

The compliance certifications shall be made by a qualified testing and inspection agency. The certification may be made by the supplier when the piling is stamped or branded with the American Wood Preservers Bureau (AWPB) quality mark.

715.03  
(Reserved)

715.04 (a) Shells Driven Without a Mandrel. Shells for cast-in-place  
Steel Shells concrete piles shall have a minimum 12-inch diameter at cutoff and a minimum 8-inch diameter tip; made from not less than 7-gauge (0.1792 inch in thickness) plate stock meeting the requirements of AASHTO M 183. Shells may be spirally welded or longitudinally welded and may be tapered or constant in section. Tips shall be sealed as SHOWN ON THE DRAWINGS.

(b) Shells Driven With a Mandrel. The shell shall be able to withstand driving without injury and resist harmful distortion or buckling due to soil pressure or the driving of adjacent piles after being driven and the mandrel removed. Butt and tip dimensions shall be as SHOWN ON THE DRAWINGS. The piles shall be water-tight to provide for placing of concrete in the dry.

715.05 (a) Filled Steel Pipe. Steel pipe to be driven as piles and  
Steel Pipes filled with concrete shall meet the requirements of ASTM A 252, Grade 2. Closure plates for closed end piles shall meet the requirements of AASHTO M 183. Conical points shall be inside or outside flanged as SHOWN ON THE DRAWINGS; they shall be cast steel and taper at approximately 60 degrees; cast steel shall meet the requirements of ASTM 27 Grade 65/35.

(b) Unfilled Steel Pipe. Steel pipe for piles to be driven and not filled with concrete after driving shall meet the requirements of ASTM A 252, Grade 2, with chemical requirements meeting ASTM A 53, Grade B. Cast steel for open-end cutting shoes shall meet the requirements of ASTM A 148 Grade 90/60.

715.06 Steel H-Piles shall be rolled steel sections of the weight and  
Steel H-Piles shape SHOWN ON THE DRAWINGS. They shall be structural steel meeting the requirements of AASHTO M 183. Copper-bearing structural steel shall contain not less than 0.20 percent nor more than 0.35 percent of copper. Steel manufactured by the acid-bessemer process shall not be used.

715.07 Steel sheet piles shall meet the requirements of AASHTO M 202  
Sheet Piles or M 223. All other sheet piles, except cold-formed lightweight steel sheeting, shall meet the requirements prescribed above.



Cold-formed lightweight steel sheeting shall be made from steel meeting the requirements of ASTM A 569 or A 526. The joints shall be practically water-tight when the piles are in place.

715.08  
Pile Shoes

Pile shoes shall be as SHOWN ON THE DRAWINGS.

## Section 716 - Material for Timber Structures

- 716.01  
Structural Timber  
& Lumber
- Structural timber and lumber shall meet the requirements of AASHTO M 168.
- Lumber shall be of the kinds and grades SHOWN ON THE DRAWINGS.  
Round poles and posts shall be of the kinds SHOWN ON THE DRAWINGS.
- 716.02  
Hardware &  
Structural Steel
- Machine and carriage bolts, drift pins, and dowels shall meet the requirements of ASTM A 307. All hardware shall be galvanized in accordance with AASHTO M 232.
- All structural steel shapes, rods, glued laminated deck panel dowels, and plates shall be structural steel meeting the requirements of AASHTO M 183. Galvanizing shall be in accordance with AASHTO M 111.
- Bolts shall have square or hexagonal heads and nuts. Nails shall be cut or round nails of standard form. Spikes shall be cut, round, or boat, as SHOWN ON THE DRAWINGS.
- Washers shall be malleable iron castings. Plain or cut washers shall be American Standard Plain Washers.
- Ring or shear plate timber connectors shall be of approved design meeting the requirements of Article 2.20.1(f), AASHTO's "Standard Specifications for Highway Bridges."
- 716.03  
Preservative  
Treatments
- Timber preservatives and treatment methods shall meet the requirements of AASHTO M 133. The type of treatment to be used and minimum net retention of preservative will be SHOWN ON THE DRAWINGS or in the SPECIAL PROJECT SPECIFICATIONS. All treated timber shall be completely and accurately fabricated before treatment. Except for Southern Pine, all surfaces greater than 2 inches in width, including glued laminated members, shall be incised before treatment. Glued laminated timbers shall be treated in accordance with AWPA C28.
- Retentions of preservatives in all lumber and timbers, including laminates treated before gluing, shall be determined by the assay method.
- 716.04  
Structural Glued  
Laminated Timber
- (a) The fabrication and quality control of structural glued laminated timber shall be as SHOWN ON THE DRAWINGS and in accordance with the requirements of Voluntary Product Standard ANSI for "Structural Glued Laminated Timber" (ANSI-AITC-190-1).
- (b) The members shall be manufactured as industrial appearance grade for wet use conditions, using a phenol-resorcinol resin-type adhesive throughout.
- (c) Straight or slightly cambered members, which are to be loaded perpendicular to the wide face of the laminates, shall be stamped "top" on the top at both ends of the beam.
- (d) (Reserved.)
- (e) The following shall apply to fabrication of glued laminated deck panels in lieu of dimensional tolerances given in PS 56 (ANSI-AITC-190-1).
- (1) Thickness (parallel to gluelines) . . . . .  $\pm 1/16$  inch.
  - (2) Width (perpendicular to gluelines) .  $\pm 1/8$  inch per panel.
  - (3) Length . . . . .  $\pm 1/8$  inch.
  - (4) Squareness of cross section . . . . . PS 56.

- (5) Crook . . . . . Maximum of 1/8 inch per 26-foot panel length for single crook. The sum of the maximum deviations shall not exceed this value for double crook.
- (6) Cup . . . . . Maximum of 1/32 inch per foot of width.
- (f) Calking compound used to seal deck panel joints shall meet the requirements of Fed. Spec. TT-S-00230 or Fed. Spec. TT-S-001543 (com.) and shall be brown or bronze in color.

## Section 717 - Structural Metal

Structural steel shall meet the following requirements:

717.01 Structural Steels	(a) General requirements for delivery of structural steel . . . . .	AASHTO M 160
	(b) Structural steel . . . . .	AASHTO M 183
	(c) (Reserved)	
	(d) High-strength low-alloy structural steel . . . . .	AASHTO M 161
	(e) High-strength low-alloy structural manganese vanadium steel . . . . .	AASHTO M 188
	(f) (Reserved)	
	(g) Mild steel arc-welding electrodes . . . . .	AWS A 5.1
	(h) High-strength, low-alloy columbium-vandium steels of structural quality . . . . .	AASHTO M 223
	(i) High-strength, low-alloy structural steel with 50,000 psi minimum yield point to 4 inch thick . . . . .	AASHTO M 222
	(j) High-yield-strength, quenched, and tempered alloy steel plate suitable for welding . . . . .	AASHTO M 244
	(k) General requirements for delivery of steel plates for pressure vessels . . . . .	ASTM A 20
	(l) Pressure vessel plates alloy steel, high-strength, quenched, and tempered . . . . .	ASTM A 517
	(m) Hot-formed welded and seamless high-strength low-alloy structural tubing . . . . .	ASTM A 618
	(n) Cold-formed welded and seamless carbon steel structural tubing in round and shapes . . . . .	ASTM A 500 Grade B
	(o) Hot-formed welded and seamless carbon steel structural tubing . . . . .	ASTM A 501
717.02 Bolts & Nuts	Bolts and nuts shall meet the requirements of ASTM A 307, Grade A. Plain or cut washers shall be American Standard Plain Washers.	
717.03 High-Tensile- Strength Bolts	High-strength bolts, nuts, and washers shall be in accordance with the "Specification for Structural Joints Using ASTM A 325 or A 490 Bolts," as approved by the Research Council on Riveted and Bolted Structural Joints of the Engineering Foundation. All bolts, nuts, and washers shall be ASTM A 325, Type I.	
717.04 (Reserved)		
717.05 Forgings	Forgings shall meet the following requirements:	
	(a) Alloy steel forgings; Class A forgings shall be furnished unless otherwise specified . . . . .	ASTM A 237
	(b) Carbon steel forgings; Class C 1 forgings shall be furnished unless otherwise specified . . . . .	AASHTO M 102

717.06  
Pins & Rollers

Pins and rollers more than 9 inches in diameter shall be annealed, carbon steel forgings meeting the requirements of AASHTO M 102, Class C1.

Pins and rollers 9 inches or less in diameter shall be either annealed carbon-steel forgings meeting the requirements of AASHTO M 102, Class C1, or cold-finished carbon-steel shafting meeting the requirements of AASHTO M 169, Grade 1016 to 1030, inclusive, with a minimum Rockwell Scale B hardness of 85. Material not meeting the specification for hardness may be accepted, provided it develops a tensile strength of 70,000 psi and a yield point of 36,000 psi.

Threads for pins shall meet the requirements of the ANSI B1.1 Coarse Thread Series, Class 2A. Pin ends having a diameter of 1-3/8 inches or more shall be threaded six threads to the inch.

717.07  
Castings

Castings shall meet the following requirements:

- (a) Steel castings for highway bridges . . . . . AASHTO M 192  
Class 70
- (b) Chromium alloy steel castings . . . . . AASHTO M 163  
(Grade CA 15 shall be furnished unless otherwise  
specified)
- (c) Gray iron castings . . . . . AASHTO M 105  
Class 30

Iron castings shall be true to pattern in form and dimensions, free of pouring faults, sponginess, cracks, blow holes, and other defects in position affecting their strength and value for the service intended. Castings shall be boldly filleted at angles and the arrises shall be sharp and perfect. All castings shall be cleaned of scale and sand to present a smooth, clean, and uniform surface.

- (d) Malleable iron castings . . . . . AASHTO M 106  
Grade 35018

The requirements for workmanship, finishing, and cleaning shall be the same as for gray iron castings.

717.08  
Steel Grid Floors

Steel for grid floors shall meet the requirements of AASHTO M 183 or M 222. Steel grid floors shall be weathering steel, galvanized or painted as SHOWN ON THE DRAWINGS. Floors other than weathering steel or galvanized material shall have a minimum copper content of 0.2 percent.

Open-type floors shall be galvanized.

717.09  
Steel Pipe

Steel pipe shall meet the requirements of ASTM A 53, ASTM A 120, AASHTO M 222, or ASTM A 618 as SHOWN ON THE DRAWINGS.

Standard weight pipe shall be furnished.

717.10  
Galvanized Metal

Galvanized structural steel shapes, plates, bars, strips, or their products shall be galvanized in accordance with the requirements of AASHTO M 111. Galvanized nuts, bolts, and hardware shall be galvanized in accordance with AASHTO M 232.

717.11  
Sheet Lead

Sheet lead shall meet the requirements of AASHTO M 112 for common desilverized lead. The sheets shall be of uniform thickness and free from cracks, seams, slivers, scale, and other defects. Lead sheets shall be 1/8 inch in thickness with a permissible tolerance of 0.03 inch. Any holes or openings in the sheets shall be made by the sheet manufacturer.

717.12  
Welded Stud Shear  
Connectors

(a) Shear connector studs shall meet the requirements of AASHTO M 169 for cold-finished, carbon-steel bars and shafting, and cold-drawn bar, Grade 1015, 1018, or 1020, semikilled or fully killed. If flux-retaining caps are used, the steel for the caps shall be of a low-carbon grade suitable for welding and shall be in accordance with ASTM A 109 for cold-rolled carbon-steel strip.

(b) Tensile properties, as determined by tests of bar stock after drawing or tests of finished studs shall meet the following requirements:

Tensile strength (minimum) . . . . .	60,000 psi
Yield strength* (minimum) . . . . .	50,000 psi
Elongation (minimum) . . . . .	20 percent in 2 inches
Reduction in area (minimum) . . . . .	50 percent

\* As determined by the 0.2 percent offset method.

(c) Tensile properties shall be determined in accordance with applicable sections of ASTM A 370 for mechanical testing of steel products. Tensile tests of finished studs shall be made on studs welded to test plates using a test fixture with dimensions similar to those shown in Table 717-1.

If fracture occurs outside the middle half of the gauge length, the test shall be repeated.

(d) Finished studs shall be of uniform quality and condition, free of injurious laps, fins, seams, cracks, twists, bends or other injurious defects. The finish shall be produced by cold drawing, cold rolling, or machining.

(e) Studs shall meet the dimensions given in Table 717-1.

(f) The contractor shall furnish the manufacturer's certification that the studs delivered are in accordance with the requirements of this section. Certified copies of in-plant quality control test reports shall be furnished to the Engineer upon request.

Table 717-1.--Welded Stud Shear Connectors.

Standard Dimensions and Tolerances (Inches)			
Shank		Head	
Diameter	Length <sup>a</sup>	Diameter	Thickness
+0.0000	+0.062	1-1/4 ± 1/64	3/8 minimum
3/4	4		
-0.0150	-0.125	1-3/8 ± 1/64	3/8 minimum
+0.0000	+0.062		
7/8	4		
-0.015	-0.125		

<sup>a</sup>Length includes thickness of head.

717.13  
Elastomeric  
Bearing Pads

Pads less than 1 inch in thickness shall be cast in a single integral layer. Pads 1 inch or more in thickness shall consist of alternate laminations of elastomer and metal or elastomer and fabric bonded together. The outside laminations shall be metal or fabric. The outside and edges of metal laminations shall be coated with elastomer not more than 1/8 inch in thickness. Laminations of elastomer shall be 1/2 inch ± 1/8 inch in thickness. Variation in thickness of an individual elastomer lamination shall not exceed 1/8 inch, and the variation in

thickness of all elastomer laminations shall not vary more than 1/8 inch from a plane parallel to the top or bottom surface of the pad. The total out-to-out thickness of the pad shall not be less than that SHOWN ON THE DRAWINGS and not more than 1/4 inch greater than that thickness. Variation in total thickness of any pad shall not exceed 1/8 inch. The length and width shall not vary more than 1/8 inch from the dimensions SHOWN ON THE DRAWINGS.

Pads containing metal laminations shall be full molded. Pads of all elastomer or with fabric laminations may be cut from large sheets. Cutting shall avoid heating of the material and produce a smooth edge with no tears or other jagged areas. If corners and edges of molded pads are rounded, the radius at the corners shall not exceed 3/8 inch and the edges shall not exceed 1/8 inch.

The bond between elastomer and metal or fabric shall fail within the elastomer when a sample is tested for separation.

Metal laminations shall be rolled mild steel sheets of not less than 0.0359 inch and not more than 0.0747 inch.

Fabric laminations shall be a long chain synthetic polymer containing at least 85 percent polyester from ethylene glycol and terephthalic acid. Each ply of the fabric shall have a breaking strength of not less than 700 pounds per inch of width in both directions.

Fabric laminations shall be single ply at top and bottom surfaces of the pad and either double ply or double strength within the pad.

The rubber constituent of the elastomer shall be 100 percent (by volume) virgin chloroprene.

The elastomer, as determined from test specimens meeting the requirements of ASTM D 15, shall meet the requirements of Section 25, Division II, AASHTO's "Standard Specifications for Highway Bridges," for the durometer as SHOWN ON THE DRAWINGS.

Bearing pads may be approved, based upon written certification from the manufacturer that all components of the pads furnished meet the applicable requirements. The certification shall be supported by a certified copy of the tests performed upon components representative of those actually used in the pads furnished.

717.14  
Structural Aluminum  
Alloy

Structural aluminum materials shall be as SHOWN ON THE DRAWINGS.

717.15  
Materials for  
Aluminum Alloy  
Bridge Rail

Aluminum alloys SHOWN ON THE DRAWINGS shall meet the requirements of the specifications listed in table 717-2.

717.16  
Aluminum Bolts  
& Nuts

Aluminum bolts and nuts shall meet the requirements of ANSI B18.2. Threads shall meet the requirements of American Standard coarse series, Class 2 fit, ANSI specification B1.1.

717.17  
Aluminum Welding  
Wire

Aluminum welding wire shall meet the following requirements:

<u>Alloys Series</u>	<u>Specification Wire</u>	
3xxx and 6xxx	AWS 5.10	ER 4043
3xxx, 5xxx, and 6x	AWS 5.10	ER 5356
5xxx and 6xxx	AWS 5.10	ER 5556 or ER 5183

Table 717-2.---Aluminum alloys for bridge railing systems.

Railing Component	ASTM Material Specifications and Alloys								Aluminum Association Designation			
	Sheet and Plate B209	Drawn Seamless Tubes B210	Bars, Rods and Wire B211	Extruded Bars, Rods, Shapes, and Tubes and Tubing B221	Seamless Pipe and Seamless Extruded Tubing B241	Welding Rods and Bars Electrodes B285	Standard Structural Shapes, Rolled or Extruded B308	Rivet Cold and Heading Wires and Rods B316	Sand Castings B26	Permanent Mold Castings B108	Former Casting Alloy Designation	
Posts and Post Bases, Structural: Wrought Cast				6061-T6 6063-T6	6061-T6 6063-T6		6061-T6 6063-T6			A444.0-T4 <sup>a</sup>	S7A-T4	
Posts, Ornamental: Wrought Cast				6061-T6 6063-T6	6061-T6 6063-T6		6061-T6 6063-T6		356.0-T6 <sup>b</sup>	A356-T6 A356-T6	SG70A-T8 SG70B-T6	
Rails & Sleeves, Structural: Wrought		6061-T6 6063-T6		6061-T6 6063-T6 6351-T5			6061-T6 6063-T6					
Bolts, Anchor: Stainless Steel Galvanized Steel Aluminized Steel												
Bolts & Screws, Misc. c, d, Aluminum, Wrought Stainless Steel Galvanized Steel Aluminized Steel Cadmium-plated Steel			2024-T4 <sup>e</sup> 6061-T6 <sup>f</sup>									
Nuts: Wrought 1/4" and Under <sup>d</sup> 5/16" and Over			2024-T4 6061-T6 6262-T9	6061-T6 <sup>h</sup>								
Washers, Flat <sup>g</sup> Wrought	Alclad 2024-T4 Alclad 2024-T3 <sup>j</sup>											



Table 717-2. (cont.)--Aluminum alloys for bridge railing systems.

Railing Component	ASTM Material Specifications and Alloys							Aluminum Association Designation			
	Sheet and Plate B209	Drawn Seamless Tubes B210	Bars, Rods and Wire B211	Extruded Bars, Rods, Shapes, and Tubes B221	Seamless Pipe and Seamless Extruded Tubing B241	Welding Rods and Electrodes B285	Standard Structural Shapes, Rolled or Extruded B308	Rivet Cold and Heading Wires and Rods B316	Sand Castings B26	Permanent Mold Castings B108	Former Casting Alloy Designation
Washers, Springlock <sup>g</sup> , Wrought			7075-T6								
Rivets: Wrought				6061-T6 <sup>f</sup>				6061-T6 <sup>k</sup>			
Shims: Wrought Cast	1100-0			6063-F <sup>b</sup>				443.0-F			S58-F
Weld Filler: Wrought						BR 3356					
End Caps: Wrought Cast	6061-T6			6061-T6					356.0-T6 356-F 443.0-F		SG70A-T6 SG70A-F S58-F

General Note: "F" temper applies to products which acquire some temper from fabricating processes.

Specific Notes:

<sup>a</sup>AASHTO Designation M 193.

<sup>b</sup>Chemical composition only.

<sup>c</sup>Compatible stainless or coated steel nuts and washers shall be used. Aluminum not permitted for anchor bolts.

<sup>d</sup>Alloy 2024-T4 shall have an anodic coating of 0.00020" minimum thickness with dichromate or boiling water seal.

<sup>e</sup>Must be used for stress-carrying bolts and may be used for minor bolts.

<sup>f</sup>Permitted as an alternate material for minor bolts.

<sup>g</sup>For use with aluminum bolts and screws. Aluminum not permitted for anchor bolt nuts and washers.

<sup>h</sup>Recommended specification is B211 but 2221 acceptable as an alternate.

<sup>i</sup>In general, T4 temper is applicable to thickness of 1/4 inch and over, and T3 is applicable to lesser thicknesses.

<sup>j</sup>Recommended specification is B316, but B221 acceptable as an alternate.

<sup>k</sup>For rivets to be cold driven.

<sup>l</sup>For rivets to be driven at temperatures of 990°F to 1050°F.

717.18  
Elastomeric  
Compression Joint  
Seals

Elastomeric compression joint seals shall meet the requirements of AASHTO M 220.

717.19  
Metal Bin-Type  
Crib Walls

The galvanized sheets shall meet the requirements of AASHTO M 218 as applicable. The metal type and thickness shall be as SHOWN ON THE DRAWINGS.

## Section 718 - Sign Materials

### 718.01 Sign Panels

Sign panels shall be panels of one-piece construction made from plywood, sheet steel, or sheet aluminum, as shown in the SCHEDULE OF ITEMS, which have the face side reflectorized.

(a) Plywood Panels. The panels shall be exterior Type B-B, high-density overlay, 60/60 with black overlay on both sides, 3/4-inch 7 ply or 1/2-inch 5 ply thick, Douglas fir plywood or better, meeting the requirements of National Bureau of Standards PS 1, current edition or AS SHOWN ON THE DRAWINGS. Other overlay colors may be used provided the back of the panel is printed with two heavy coats of black paint.

(b) Aluminum Panels. All sheets and plates shall meet the requirements of ASTM B 209, alloy 6061-T6, or 5052-H38 and shall be of the thickness shown below unless otherwise SHOWN ON THE DRAWINGS.

<u>Sign Width (Inches)</u>	<u>Sheet Aluminum Thickness (Inches)</u>
Less than 8	0.022
8-12	0.040
13-19	0.063
20-30	0.080
31-48	0.100
over 48	0.125

### 718.02 Posts

Posts shall be wood, aluminum, steel, or other material as specified.

(a) Wood Posts. Wood posts shall meet the grading, species, and dimensional requirements SHOWN ON THE DRAWINGS and meet the treatment requirements of Subsection 716.03.

(b) Steel Posts. Steel posts shall meet the requirements of ASTM A 499, galvanized in accordance with AASHTO M 111. Minimum weight per foot will be as SHOWN ON THE DRAWINGS.

The posts shall have 7/16-inch holes drilled or punched, before galvanizing, along the centerline of the web. The punching or drilling should begin 1 inch from the top of the post, at 2-inch centers for the upper 5 feet of the post.

(c) Aluminum Posts. Aluminum posts shall be standard shapes as SHOWN ON THE DRAWINGS and shall be aluminum alloy 6061-T6 or 6351-T5 meeting the requirements of ASTM B 221.

### 718.03 Fittings

Lag screws, washers, clip angles, wood screws, shear plates, U-bolts, clamps, bolts, nuts, and other fasteners shall be galvanized steel, cadmium-plated steel, aluminum alloy, or as SHOWN ON THE DRAWINGS.

Galvanizing of steel hardware shall be in accordance with AASHTO M 232. High-strength steel bolts, nuts, and washers shall meet the requirements of ASTM A 325, except as SHOWN ON THE DRAWINGS.

### 718.04 Reflective Materials Type II, & Type III Reflective Sheeting

All reflective materials (sheeting, legend, borders, and symbols) shall conform with the "Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects," FP, current edition and Federal Specification L-S-300C.

Colors shall be as specified in the MUTCD and enclosed drawings.

No more than 12 months shall elapse from the date of manufacture to the date of application on the substrate.

718.05  
Letters, Numerals,  
Arrows, Symbols,  
Border

Letters, numerals, arrows, symbols, border, and other features of the sign message shall be of the type, size, and series SHOWN ON THE DRAWINGS.

Colors shall be as specified in MUTCD or SHOWN ON THE DRAWINGS. Completed letters, numerals, and other units shall be formed to provide continuous stroke width with smooth edges and shall present a flat surface free of warp, blisters, wrinkles, burrs, and splinters. Units of the sign message of the type SHOWN ON THE DRAWINGS shall meet the following requirements:

(a) Type L-1: Screen Process, Applied. The letters, numerals, arrows, symbols, and border shall be applied on the reflective sheeting or opaque background of the sign by direct or reverse screen process. Messages and borders of a color darker than the background shall be applied to the paint or the reflective sheeting by direct process. Message and borders of a color darker than sign field shall be produced by the reverse screen process.

Opaque or transparent colors, inks, and paints used in the screen process shall be of the type and quality recommended by the manufacturer of the reflective sheeting.

The screening shall be done in a manner that results in a uniform color and tone, with sharply defined edges of legend and border, and without blemishes on the sign background that will affect intended use.

After screening, signs shall be air dried or baked in accordance with manufacturer's recommendations to provide a smooth, hard finish. Any signs on which blisters appear during the drying process shall be rejected.

(b) Type L-3: Direct Applied Characters. The letters, numerals, symbols, border, and other features of the sign message shall be cut from Types II or III reflective sheeting of the color specified in MUTCD or SHOWN ON THE DRAWINGS and applied to the reflective sheeting of the sign field in accordance with the instructions of the manufacturer of reflective sheeting.

The reflective sheeting shall have minimum reflective intensity as specified in tables 718-3 or 718-4.

718.06  
Delineators

The materials to be used for the delineator assembly shall be Type 1 or 2 as SHOWN ON THE DRAWINGS. The reflectors shall be amber or crystal and ready for mounting. Supporting posts shall be steel, aluminum, wood, or other material as SHOWN ON THE DRAWINGS.

## Section 719 - Flexible Downpipe

- 719.01  
General Description  
of the Fabric
- The fabric shall be nylon or dacron. It shall be coated on both sides with neoprene, hypalon, or similar elastomer. Polyvinylchloride (vinyl) coatings and laminated construction are not acceptable. Elastomer coatings shall be of uniform thickness. The coating thickness of one surface shall not vary from the coating thickness on the other surface by an amount exceeding 100 percent.
- 719.02  
Physical Properties  
of the Fabric
- (a) Tear Strength. The material shall exhibit a tear value of not less than 40 pounds across the fill and 40 pounds across the warp when tested in accordance with Federal Test Method Standard No. 191, Method 5134.
- (b) Abrasion Resistance. The elastomer coating shall not be abraded through to expose the fabric after 2,500 cycles of the wheels when tested in accordance with Federal Test Method Standard No. 191, Method 5306, using Taber Instrument Co. CS-17 wheels and a 500-gram load. Both elastomer-coated surfaces must meet this requirement.
- (c) Weight. The finished material shall weigh between 14 and 18 ounces per square yard.
- (d) Color. The color shall be black. Material color shall be compounded into the elastomer and shall not be dyed or painted. Normal outdoor exposure for 3 years shall not appreciably alter or fade the color.
- (e) Adhesion of Elastomer Coating to Fabric. The elastomer coating shall have an adhesion strength of at least 18 pounds when tested in accordance with Federal Test Method Standard No. 191, Method 5970. The elastomer coating on both surfaces must meet this requirement.
- (f) Low Temperature Properties. The material shall exhibit a brittleness temperature of -20 °F or less when tested in accordance with Federal Test Method Standard No. 191, Method 5874.
- (g) Flammability. The material shall exhibit a burning rate of less than 25 inches per minute when tested in accordance with ASTM D 568.
- (h) Weathering Resistance. The material shall exhibit a reduction in strength of not more than 10 percent as measured in accordance with Federal Test Method Standard No. 191, Method 5134, when tested for 240 hours in accordance with Federal Test Method Standard No. 191, Method 5804.
- 719.03  
Grommets
- Grommets should be made of brass, stainless steel, galvanized steel, or cadmium-plated steel with a nominal inside diameter of 1 inch.
- 719.04  
Fabrication
- (a) General Features. Down drains shall be circular in cross section. For lengths less than 50 feet, no more than one circumferential seam will be allowed. For longer lengths, not more than one circumferential seam per 50 feet will be allowed. Both ends shall be hemmed as described in Subsection 719.04(c).
- (b) Orientation of Fabric. Where a difference occurs, the surface with the greatest abrasion resistance shall form the interior of the downdrain.
- (c) Seams. Seams shall meet the requirements of Federal Standard No. 751. For longitudinal and circumferential seams, Form LSc-2 or LSc-3 shall be used. Acceptable alternate seams shall be Form SSe-2 or SSe-3. Hems shall be either Form EFA-1 or EFA-2 as SHOWN ON DRAWINGS. Seam laps may be of any nominal width providing maximum strength.

(d) Stitches and Thread. Stitches shall be in accordance with Federal Standard No. 751, Form 301. Thread shall be dacron of at least 1,320 denier. Minimum number of stitches shall be six per inch. All stitches shall be tensioned for maximum strength.

(e) Grommet Installation. Grommets placed in pieces of material identical to that of the main body of the downdrain, but separate from it in the form of attachment flaps, shall be sewn to each side of the downdrain. The flaps shall be located in longitudinal lines (generators) that have an included central angle of 120 degrees. Flaps shall be spaced at 20-foot intervals. In addition, one pair of flaps shall be placed within 1 foot of the outlet end of the downdrain. No flaps shall be placed at the inlet end of the downdrain. The spacing between the inlet end of the downdrain and the closest set of flaps shall be 20 feet. Seams and stitches shall be in accordance with Subsections 719.04(c) and (d). Each grommet attachment must be able to withstand a pull of at least 200 pounds in a direction perpendicular to the longitudinal axis of the downdrain.

(f) Size. Size shall be determined by the inside diameter to a tolerance of -0 or +1 inch and length to a tolerance of 1 foot.

719.05  
Documents & Tests

(a) Certification. The contractor shall provide the Forest Service with a current document from the fabric manufacturer certifying that the fabric meets the requirements in Subsections 719.01 and 719.02.

(b) Submission of Samples. The contractor shall supply the Forest Service the following samples for testing 30 days prior to the proposed installation:

(1) Two pieces of fabric each with minimum dimensions of 3 feet by 6 feet.

(2) The samples shall be sewed together with a longitudinal seam representative of that used in compliance with Subsection 719.04(c).

(3) A 10-foot sample of thread to be used in compliance with Subsection 719.04(d).

(c) Rejected Products. Rejected products may be reworked by the manufacturer and resubmitted by the contractor.

## Section 720 - Geotextiles

720.01  
General

Geotextiles shall be woven or nonwoven fabric consisting of long-chain polymeric filaments such as polypropylene, polyethylene, polyester, polyamide, or polyvinylidene chloride formed into a stable network such that the filaments retain their relative position to each other. When SHOWN ON THE DRAWINGS or listed in table 720-1, the fabric shall contain stabilizers and/or inhibitors added to the base material to make the filaments resistant to deterioration due to ultraviolet or heat exposure. Fabric edges shall be selvaged or otherwise finished to prevent the outer material from pulling away from the fabric. The fabric shall conform to the physical strength requirements in table 720-1 for the appropriate function.

The contractor shall furnish the Engineer, in duplicate, a certificate signed by a legally authorized official from the contractor. The certificate shall attest that the geotextile meets the chemical, physical, and manufacturing requirements stated in this specification. When requested by the Engineer, or listed in table 720-1, a sample of 5 square yards of the geotextile shall be furnished from each shipment for verification testing. The sample shall be labeled with the lot and batch number, date of sampling, project number, specifications, manufacturer, and project name.

720.02  
Delivery, Storage,  
& Handling

During shipment and storage, geotextiles shall be wrapped in a heavy duty protective covering. The geotextile shall be protected from mud, soil, dust, debris, and sunlight during transport and at the storage area.

720.03  
Acceptance Test &  
Requirements

The properties will be determined in accordance with the test procedures in Subsection 720.07. Geotextiles for geotextile-reinforced retaining walls shall be pretested for Grab Tensile, 1 inch Cut Strip, and 8 inch Strip. The pretest results shall be provided to the Engineer prior to incorporating the geotextile reinforcement in the retaining wall. The geotextile function shall be as SHOWN ON THE DRAWINGS.

720.04  
Securing Pins

Pins for securing the geotextiles shall be of steel, a minimum of 3/16 inch in diameter, and at least 15 inches in length. Each pin shall have one end capable of retaining a 1-1/2 inch diameter fender washer and the other end pointed. When necessary to secure the geotextile in place or when SHOWN ON THE DRAWINGS, the securing pin/washer assembly shall be driven through the geotextile until the fender washer is firmly against the geotextile and holding it securely in place.

720.05  
Seams and Overlaps

The minimum overlaps at ends of rolls or between parallel rolls of fabric shall be SHOWN ON THE DRAWINGS but not less than the following:

Soil CBR	Minimum Overlaps
Greater than 2	1.5 feet
1 to 2	2 to 3 feet
0.5 to 1	3 feet or sewn
Less than 0.5	Sewn
All roll ends	3 feet or sewn

Fabric shall be stapled or pinned at the overlaps to maintain them during construction activities. Spacing of pins shall be a minimum of 5 feet on centers for roll ends and as SHOWN ON THE DRAWINGS for parallel rolls.

Seams of sewn fabric shall be interlocking or sewn twice to provide a minimum of 70 percent of unseamed material.

720.06  
(Reserved)

<u>Test</u>	<u>Description</u>
Grab Tensile ASTM D 1682	ASTM D 1682 Grab Test Method, using 1 square inch jaws and 12 inch per minute travel rate (five samples each in warp and in fill directions).
1-inch Cut Strip Test ASTM D 1682	ASTM D 1682 1-inch cut strip test using a specimen 1 inch wide by 6 inches long.
8-inch Strip Test	Use the ASTM D 1682 1-inch cut strip procedure with the following modifications: <ol style="list-style-type: none"><li>1. Maintain minimum specimen width to gauge length ratio of 2 to 1 and minimum spacing between test grips of 4 inches (100 millimeter).</li><li>2. Test at constant strain rate of 10 percent per minute.</li><li>3. Test at standard laboratory conditions of 65 plus or minus 2 percent relative humidity and temperature of 70 °F plus or minus two degrees (21 °C plus or minus one degree).</li><li>4. Condition specimens by soaking for a minimum of 12 hours and test surface damp.</li><li>5. Use grips that do not weaken the specimen (disallow tests that fail at the grips) and which hold the geotextile without slippage. If slippage cannot be sufficiently limited, elongation must be measured between points on the specimen rather than between the grips.</li><li>6. Results should present the total unit load (applied force per unit width of specimen) versus strain curve as well as failure unit load and strain.</li></ol>
Bursting Strength (unaged fabric)(a)	ASTM D 751 Diaphragm Bursting Tester (five samples)
Puncture Strength (unaged fabric)(a)	ASTM D 751 Tension Testing Machine with ring clamp steel ball replaced with 5/16-inch diameter solid steel cylinder centered within ring clamp (five samples).
Abrasion Resistance	ASTM D 1682 Grab Tensile after abraded as required by ASTM D 1175 Rotary Platform, Double Head Method; rubber-base abrasive wheels equal to CS-17 "Calibrase" by Taber Instrument Co.; One kilogram load per wheel; 1,000 revolutions (five samples).
Percent Open Area	Each of five samples, unaged(a), shall be placed separately in a 2-inch by 2-inch glass slide holder and the image projected with a slide projector on a screen. A block of 25 openings near the center of the image shall be selected and the length and width of each of the 25 openings and widths of the fibers adjacent to the openings shall be measured to the nearest 0.001 inch. The percent open area is determined by dividing the sum of the open areas of the 25 openings by the sum of the total area



of the 25 openings and their adjacent fibers.

#### Permeability Test

Either constant head or falling head permeameters similar to those conventionally used with soils may be used if the following factors are provided for:

1. Geotextiles characteristically have high permeability and small thickness. Therefore, resistance to flow through the fabric specimen is lowered to reduce errors. The permeameter and outlets must be designed, also, to offer very little resistance to flow, or head must be measured adjacent to both sides of the fabric.

2. The system must be deaired and deaired distilled water shall be used. Special care must be used to ensure removing all bubbles from the fabric. This may require presoaking some geotextiles.

(a) Unaged fabric is defined as fabric in the condition received from the manufacturer or distributor.

3. The fabric shall be supported across the orifice to prevent stretching.

4. Tests shall be run with head losses across a single geotextile specimen less than 12 inches (30 centimeters).

5. Results may be presented as either or both permeability or permittivity. To determine permeability requires the fabric thickness. The test shall be run at 70 °F plus or minus two degrees (20 °C plus or minus one degree) or temperature shall be measured and test results corrected to this temperature.

#### Thickness Test

Test Conditions. This test determines the perpendicular distance between a movable plane pressure plate and a reference plane separated by the geotextile in question. Any system capable of maintaining the plates parallel, maintaining the required pressure, determining the spacing, and satisfying the following considerations is satisfactory:

1. Minimum pressure foot area should be 3 square inches (20 square centimeters).

2. Test temperature to be 70 °F plus or minus two degrees (21 °C plus or minus one degree).

3. Specimens shall be conditioned by soaking for 12 hours minimum and tested surface damp.

4. The nominal thickness shall be measured with a pressure of 3.3 N/m<sup>2</sup> (0.07 psi). If thicknesses are desired at other pressures, the device shall allow for adding weights to provide these pressures.

DETERMINATION OF EQUIVALENT OPENING SIZE (EOS). Five unaged samples shall be tested according to Method A or B.

Method A. Sand Method. About 150 grams of each of the following fractions of a sand composed of sound rounded particles shall be obtained.

Designated EOS	U.S. Standard Sieve Number		Designated EOS	Passing	Retained On
	Passing	Retained On			
20	10	20	70	50	70
30	20	30	100	70	100
40	30	40	120	100	120
50	40	50			

The fabric shall be affixed to 8-inch diameter standard sieve having openings larger than the coarsest sand used. The cloth shall be attached so that no sand can pass between the cloth and the sieve wall. The sand shall be oven dried. Shaking shall be accomplished as described in ASTM D 422; and shall be continued for 20 minutes. Determine by sieving (using successively coarser fractions) that fraction of sand of which 5 percent or less by weight passes the cloth; the equivalent opening size of the cloth sample is the "retained on" U.S. Standard Sieve number of this fraction.

Method B. Glass Bead Method. About 50 grams of each of the following fraction of standard glass beads shall be obtained.

Designated EOS	U.S. Standard Sieve Number		Designated EOS	Passing	Retained On
	Passing	Retained On			
20	18	20	70	60	70
30	25	30	100	80	100
40	35	40			
50	45	50			

Within each size range, 98 percent of the beads should be within the specified range. The fabric shall be affixed to an 8-inch diameter standard sieve having openings larger than the largest beads to be used in the test. The fabric shall be attached to the sieve so that no beads can pass between the fabric and the sieve wall. Shaking shall be accomplished as described in ASTM D 422 and shall be continued for 20 minutes. Determine by sieving (using successively coarser fractions) that size of beads of which 5 percent or less by weight passes through the fabric; the equivalent opening size of the fabric sample is the "retained on" U.S. Standard Sieve number of this fraction.

Table 720-1.--Physical requirements.

Geotextile type a,b Function (Type)	1, 2, 3, 4 (A) Separation	1, 2, 3, 4 (B) Normal Stabilization	1, 2, 3, 4 (C) Heavy Duty Stabilization	1, 2, 3, 4 (D) Silt Fence	3 (E) Light Riprap Drainage (Low Abrasion)	3 (F) Heavy Riprap, Buttresses, and Gabions	1 (G) Reinforce- ment Retaining Walls	1, 2 (H) Pavement Rein- forcement	(I) Erosion Control
Sample Required							yes		
Ultraviolet Sta- bilization				yes	yes	yes	yes		
Grab Tensile, Lbs., ASTM D 1682	110 min	200 min	275 min	100 min	100 min	200 min	125 min <sup>b</sup>	90 min	
Grab Tensile elong. (%, ASTM D 1682)	15 min	15 min	15 min	15-40 <sup>f</sup>	15 min	15 min	min	55 min	
Eqiv. Opening size (E05) US std sieve	20-100 <sup>g</sup>	20-100	20-100		70-100 <sup>b</sup>	70-100 <sup>b</sup>			
1 in. Cut Strip Test, (Lbs.) ASTM D 1682							75 min <sup>b</sup>		
8 in. Strip Test, (Lbs.)							75 min <sup>b</sup>		
Bursting Strength, Unaged Fabric ASTM D 751	200 min	375 min	500 min	200 min	250 min	490 min			
Puncture Strength, Unaged Fabric ASTM D 751	42 min	80 min	100 min		60 min	120 min			
Abrasion Resistance (Lb.) ASTM D 1682					30 min	55 min			
X Open Area	9				4-10 <sup>b</sup>	4-10 <sup>b</sup>			
Permeability, cm/sec	0.001 min	0.001 min	0.001 min		0.01 min	0.01 min			
Weight, oz/yd <sup>2</sup>	4 min	4 min	6 min	4 min	6.0 min	6.5 min	6 min		
Thickness, mils	15 min	15 min		10 min	10 min	10 min			
Shrinkage from Asphalt Texas DOT 3099								10% Max	
Absorbance gal/yd <sup>2</sup> Texas DOT 3099								0.2-0.3	
Retention Efficiency X VTM 51e				75 min					
Slurry Flow Rate g/m/ft <sup>2</sup> VTM 51e				0.3 min					

Table 720-1. (cont.)--Physical requirements.

geotextile type:

- 1 - Nonwoven needle punched.
  - 2 - Nonwoven heat bonded.
  - 3 - Woven monofilament.
  - 4 - Woven slit film.
- Unless otherwise SHOWN ON THE DRAWINGS.  
To be used for riprap without wave action and cushioned from rock placement by a layer of sand or by zero drop height placement, in drainage trenches, and beneath concrete slabs (low abrasive uses).  
To be used where subgrade soils have properties as follows:  
Separation - CBR greater than 3 or vane shear greater than 10 psi and/or particle size less than 2 inches.  
Normal Stabilization - CBR between 1.5 and 3 or vane shear between 6 and 10 psi and/or particle size less than 4 inches.  
Heavy Duty Stabilization - CBR between 0.5 and 1.5 or vane shear between 2 psi and 6 psi and/or particle size less than 6 inches.
- eVirginia DOT Test.  
fFabric and support system.  
gWoven fabric with EOS between 20 and 70 shall have percent open area less than 4.0.  
hAs shown in the SPECIAL PROJECT SPECIFICATIONS or SHOWN ON THE DRAWINGS.