

901

PART 9-MATERIALS

SECTION 901-HYDRAULIC CEMENT

901.01-Hydraulic Cement 717

SECTION 901-HYDRAULIC CEMENT

901.01-Hydraulic Cement. Hydraulic cement shall conform to the requirements of the following cited Specifications for the kind and type specified or permitted and shall be listed on the Department's QPL.

<u>Material</u>	<u>Specification</u>
Portland Cement	AASHTO M 85
Slag modified Portland Cement(Type 1-SM)	AASHTO M 240

Type I or Type I-SM cement shall be used unless otherwise specified. Different types of cement shall not be mixed.

The Contractor shall provide suitable means for storing and protecting the cement against dampness. Cement which for any reason has become partially set or which contains lumps of caked cement will be rejected.

The temperature of the cement at the time of delivery to the mixer shall not exceed 160° F(70° C).

The use of cement containing air-entraining materials will not be permitted.

SECTION 903-AGGREGATES

903.01-Fine Aggregate for Concrete	719
903.02-Fine Aggregate for Mortar	720
903.03-Coarse Aggregate for Concrete	720
903.04-Aggregate for Lean Concrete Base	721
903.05-Aggregate for Mineral Aggregate Base and Surface Courses	721
903.06-Aggregate for Plant Mix Base and Leveling Courses (Hot Mix)	724
903.07-Aggregate for Bituminous Coated Aggregate Base (Plant Mix)	727
903.08-Aggregate for Bituminous Road Mix Surface Course	728
903.09-Aggregate for Bituminous Sand-Gravel Binder and Surface Coarse (Hot Mix)	729
903.10-Aggregate for Bituminous Plant Mix Surface Course (Cold Mix)	729
903.11-Aggregate for Asphaltic Concrete Surface Courses (Hot Mix)	730
903.12-Aggregate for Slurry Seal and Micro-Surface	734
903.13-Aggregate for Hot Bituminous Seal Coat	735
903.14-Aggregate for Double Bituminous Surface Treatment	736
903.15-Aggregate for Aggregate-Cement Base Course	736
903.16-Mineral Filler	736
903.17-Aggregate for Underdrains.....	736
903.18-Aggregate for Sand-Asphalt Surface Course	736
903.19-Lightweight Aggregates for Structural Concrete	737
903.20-Stockpiling Aggregates.....	737
903.21-Test Methods	738
903.22-Sizes of Coarse Aggregate.....	739

SECTION 903-AGGREGATES

903.01-Fine Aggregate for Concrete. Fine aggregate for portland cement concrete or slag modified portland cement concrete shall conform to the requirements of AASHTO M 6, with the following exceptions and added stipulations.

- (a) The option regarding alternate freeze-thaw tests for soundness will not be exercised.
- (b) The fine aggregate shall be washed in the processing operations.
- (c) Fine aggregate manufactured from limestone or dolomite shall be processed from material which has been scalped to remove quarry fines. The material from which the fine aggregate is processed shall have a percentage of wear, AASHTO T 96, of not greater than 40.
- (d) The amount of deleterious substances shall not exceed the following limits:

	Maximum Permissible Limits Per Cent by Weight
1. Clay Lumps	0.5
2. Coal and Lignite	0.5
3. *Material Passing the No. 200 (75 μ m) Sieve	3.0
4. *Other deleterious substances (such as shale, alkali, mica, coated/grains, soft and flaky particles)	3.0

*If the fine aggregate is manufactured from limestone or dolomite and if the material finer than the No. 200(75 μ m) sieve consists of the dust of fracture, essentially free from clay or shale, this limit may be increased to 5%.

- (e) Fine aggregate shall be well graded from coarse to fine and when tested by means of laboratory sieves, shall conform to the following requirements:

Sieve Size	Total Per Cent Passing by Weight
3/8 in. (9.5 mm)	100
No. 4 (4.75 mm)	95-100
No. 16 (1.18 mm)	50-90
No. 50 (300 μ m)	5-30
No. 100 (150 μ m)	0-10
No. 200 (75 μ m)	0-3

903

- (f) Fine aggregate used in flowable mortar shall meet all the above requirements except the gradation shall be as follows:

Sieve Size	Total Per Cent Passing by Weight
12.5 mm(1/2 in.)	100
75 µm (No. 200)	0-20

903.02-Fine Aggregate for Mortar. Mortar sand shall conform to the requirements of AASHTO M 45. Sand for mortar shall be uniformly graded from coarse to fine within the following limits:

Sieve Size	Total Per Cent Passing, by Weight
No.8(2.36 mm)	100
No.50(300 µm)	15-40
No.100(150 µm)	0-10
No.200(75 µm)	0-5

903.03-Coarse Aggregate for Concrete. Coarse aggregate for any type or class of portland cement concrete shall consist of crushed stone, crushed slag, or crushed or uncrushed gravel unless otherwise specified.

Coarse aggregate for portland cement concrete base and pavement shall be furnished in 2 sizes: Size No. 4 and Size No. 67, as shown in **Subsection 903.22**. The 2 sizes shall be manufactured, within the specified limits, so as to produce Size No. 467, **Subsection 903.22**, when combined in the proper proportions at the batching plant or a size no. 467, manufactured within the specified limits of **Subsection 903.22**.

Unless otherwise specified on the Plans, coarse aggregate for structural concrete shall be Size No. 57, **Subsection 903.22**.

Coarse aggregate for prestressed and precast concrete shall be Size No. 57 or Size No. 67, **Subsection 903.22**, as may be specified or directed.

Coarse aggregate for concrete curbing placed by machine-extrusion methods shall be Size No. 7, 57, 67 or 78, **Subsection 903.22**.

Coarse aggregate for cement treated permeable base shall be Size No. 57 meeting the quality requirements above.

The coarse aggregates shall otherwise conform to the requirements of AASHTO M 80, with the following exceptions and stipulations:

(a) Deleterious Substances.

The amount of deleterious substances shall not exceed the following limits:

	Maximum Per Cent, by Weight
1. Soft or non-durable fragments (fragments which are structurally weak such as shale, soft sandstone, limonite concretions, gypsum, weathered schist or cemented gravel)	3
2. Coal and lignite	1
3. Clay lumps	0.25
4. Material passing the No. 200 (75 μ m) Sieve	1
5. Thin or elongated pieces (length greater than 5 times average thickness)	10
6. Other local deleterious substances	1

In the case of crushed aggregate, if all the material finer than the 200 mesh (75 μ m) sieve (AASHTO T 11) consists of the dust of fracture essentially free of clay or shale, Item 4, Maximum Per Cent by Weight, may be increased to 1.5. The sum of the percentages of Items No. 1, 2, 3, 4, and 6 shall not exceed 5.0.

(b) When the coarse aggregate is subjected to five alternations of the sodium sulfate soundness test (AASHTO T 104), the weighted percentage of loss shall be not more than 9. Coarse aggregate failing to meet the requirement for soundness may be accepted, provided it can be shown by evidence satisfactory to the Engineer that concrete of comparable proportions made from the same source has been exposed to weathering under conditions similar to those occurring at the site of the structure for a period of at least 10 years without appreciable disintegration.

The option regarding alternate freeze-thaw tests for soundness will not be exercised.

The percentage of wear as determined by AASHTO T 96 shall not exceed 40.

903.04-Aggregate for Lean Concrete Base. Aggregate for Lean Concrete Base shall consist of crushed limestone, crushed slag, crushed or uncrushed gravel meeting the requirements of **Subsection 903.05**, for Type B, Grading D. The aggregate may be a "crusher or pit run" or may be sized into 2 or more sizes. If the material is "crusher or pit run", care shall be taken to prevent segregation during stockpiling and handling.

903.05-Aggregate for Mineral Aggregate Base and Surface Courses. Aggregates for Mineral Aggregate Base and Surface Courses shall be crushed stone, crushed slag, crushed or uncrushed gravel, crushed or

uncrushed chert, crushed recycled concrete, or screened reclaimed asphalt pavement(RAP) together with such material as manufactured sand or other fine materials naturally contained, or added thereto as needed to conform with these Specifications.

The aggregate shall be of 2 Types: Type A and Type B.

- (a) Type A aggregate for mineral aggregate base and surface courses shall consist of hard durable particles or fragments of stone, slag, gravel, or chert, and other finely divided mineral matter. Recycled concrete aggregate or reclaimed asphalt pavement, at a maximum rate of 25%, by weight, may be used for Type A aggregate, provided the combined aggregate blend meets all the requirements specified below. The recycled concrete and asphalt shall be crushed and screened to produce a uniform stockpile before being blended with the virgin material. The recycled stockpiles shall be free of bricks, steel, wood, and all other deleterious materials. Individual, or blended materials shall meet the requirements specified below:
1. Crushed stone shall be free of silt and clay. The coarse aggregate portion (retained on the No. 4(4.75 mm) sieve) of the stone shall have a percentage of wear of not greater than 50, and when subjected to five alternations of the sodium sulfate soundness test, the weighted percentage of loss shall not exceed 15.
 2. Crushed slag shall be free of silt and clay and shall meet the quality requirements of crushed stone. It shall be reasonably uniform in density and shall have a dry-rodded weight of at least 70 lbs/c.f.(112 kgs/0.1 m³).
 3. Gravel and chert shall be screened and all oversize material may be crushed and fed uniformly back over the screen. The coarse aggregate portion shall have a percentage of wear of not greater than 50, and when subjected to 5 alternations of the sodium sulfate soundness test, the weighted percentage of loss shall not exceed 15. The portion of the material passing the No. 40(425 µm) sieve shall be non-plastic, or shall have a liquid limit of not greater than 30 and a plasticity index of not more than eight.

If fine aggregate, coarse aggregate or binder, in addition to that present in the base material, is necessary in order to meet the gradation or density requirements or for satisfactory bonding of the material, it shall be uniformly blended with the base course material at the mixing plant by a mechanical feeder to maintain a uniform flow on the belt to the mixer. Blending of materials on the stockpiles or in the pits by bulldozer, clamshell, dragline or similar equipment will not be permitted.

The composite gradation of Type A aggregate shall be the grading specified.

- (b) Type B aggregate for mineral aggregate base shall consist of crushed or uncrushed gravel, crushed or uncrushed chert, crushed stone or crushed slag, and other finely divided particles. Recycled concrete aggregate or reclaimed asphalt pavement, at a maximum rate of 30%, by weight, may be used for Type B aggregate, provided the combined aggregate blend meets all the requirements specified below. The recycled concrete and asphalt shall be crushed and screened to produce a uniform stockpile before being blended with the virgin material. The recycled stockpiles shall be free of bricks, steel, wood, and all other deleterious materials. The quality of Type B aggregate shall be the same as the quality requirements for Type A aggregate with the following exceptions:

The Sodium Sulfate Soundness shall not exceed 20. Type B aggregate shall be screened and the oversize materials may be wasted or crushed and returned over the screen and uniformly blended with the other material.

Material having a clay content greater than 12%, as determined by hydrometer analysis (AASHTO T 88), will not be permitted. Material having a clay content not exceeding 12 per cent will be acceptable provided a plasticity index-fines product does not exceed 3 when calculated by the following formula:

$$\frac{\% \text{ Passing No. 40}(425 \mu\text{m}) \times \text{P.I. of - No. 40}(425 \mu\text{m}) \text{ Material}}{100}$$

If an excess of binder occurs, crushed stone, crushed slag, gravel, chert, sand, or other approved granular materials shall be uniformly incorporated in such proportions, not to exceed twenty per cent of the total mix, as the Engineer directs.

If the quantity of binder is insufficient to bond the base or surface course properly, additional binder of approved quality, in an amount not to exceed 15% of the total mix, shall be uniformly incorporated as directed by the Engineer.

The use of material requiring the addition of coarse aggregate or binder in excess of the above limits will not be permitted, unless otherwise specified on the Plans or in the Contract.

Blending of additional material, if required, may be performed either at the screening or mixing plant or on the road. If blending is done at the plant, mechanical feeders that will maintain a uniform flow of the materials on the conveyor belt to the mixer or screening plant shall be employed. If blending is done on the road, the two or more materials shall be spread in uniform layers and blended by means of a mechanical mixer. Blending of materials on the stockpile or in the pit by means of a bulldozer, clamshell, or similar equipment will not be permitted.

When combinations of materials for Type B aggregate for mineral aggregate base and surface courses such as creek gravel and chert, bank gravel and chert, crushed stone and chert, crushed slag and chert, are permitted, they will be designated on the Plans or in the Contract, and the pertinent requirements of this

Specification for quality, blending of materials, and gradings shall apply.

The composite gradation of Type B aggregate shall be the grading specified on the Plans or in the Contract.

Grading Table for Type A and Type B Aggregate for Mineral Aggregate Base and Surface Courses

Total Per Cent by Weight, Passing Sieves

Sieve Size	Grading A	Grading B	Grading C	Grading D	Grading E
2-1/2 in. (63 mm)	100				
2 in. (50 mm)	95-100	100			
1-1/2 in. (37.5 mm)		95-100	100	100	
1 in. (25 mm)			90-100	85-100	100
3/4 in. (19 mm)		65-95		60-95	90-100
3/8 in. (9.5 mm)	35-65		45-74	50-80	65-100
No. 4 (4.75 mm)		35-55	30-55	40-65	
No. 16 (1.18 mm)		15-45		20-40	
No. 100 (150 μm)	0-10	4-15	4-15	9-18	5-15

903.06-Aggregate for Plant Mix Base and Leveling Courses (Hot Mix).

Aggregate for plant mix base and leveling courses shall consist of coarse aggregate, fine aggregate, and mineral filler when required.

If at any time the sources of materials are changed, a new mix design will be required in accordance with **Subsection 407.03**.

(a) Coarse Aggregate.

Coarse aggregate (aggregate retained on the No. 4 (4.75 mm) sieve) shall be crushed stone, crushed granite, crushed gravel, crushed slag or combination of these materials. This material shall conform to the quality requirements of ASTM D 692 except that the sodium sulfate soundness loss shall not exceed 9%, and the aggregate shall contain no more than 5% soft or nondurable particles.

Crushed gravel shall consist of siliceous particles processed from washed material. At least 70% by count of the gravel retained on the No. 4 (4.75 mm) sieve shall have a minimum of 2 fractured faces, 1 of which must be fractured for the approximate

average diameter or thickness of the particle. The addition of pea gravel or uncrushed particles shall not be permitted.

Virgin coarse aggregate for Grading A, ACRL and AS mixes shall be crushed stone, crushed slag, or a combination thereof.

The absorption of combined aggregate passing the 3/4 in.(19 mm) sieve and retained on the No. 4(4.75 mm) sieve shall not exceed 5% when tested in accordance with AASHTO T 85 when used in Grading CW mixes.

After drying in the plant, the aggregate retained on the No. 4(4.75 mm) sieve shall have a loss of not more than 1% by weight when washed over a No. 8(2.36 mm) sieve in accordance with the coating test in **Subsection 407.03**.

(b) Fine Aggregate.

Fine aggregate (aggregate passing the No. 4(4.75 mm) sieve) shall consist of limestone fines, natural sand, sand manufactured from stone, gravel, or slag, or combinations thereof. It shall consist of hard, tough grains free from injurious amounts of deleterious substances, and when subjected to 5 cycles of the sodium sulfate soundness test, it shall have a weighted loss of not more than 12%. Fine aggregate or screenings containing Calcium Sulfate (CaSO_4 /gypsum) will not be allowed if more than 5% of the material passing the No. 8(2.36 mm) sieve is chemically composed of Sulfur Trioxide (SO_3)

In natural sand and manufactured sand, the percentage of material finer than No. 200(75 μm) mesh shall not exceed 5%.

Virgin fine aggregate used in Grading A and AS mixes shall consist of crushed stone or crushed slag only and shall be stored separately from the coarse aggregate.

The amount of deleterious substances in natural sand shall not exceed the following limits:

	Maximum Permissible Limits Percent by Weight
1. Clay Lumps	0.5
2. Coal & Lignite	0.5
3. Other deleterious substances (such as shale, alkali, mica, coated grains, soft & flaky particles)	3.0

(c) The Combined Grading.

The combined gradings may be achieved by the appropriate combination of coarse aggregate with the appropriate fine aggregate. A minimum of 3 sizes of aggregate shall be required for all mix designs except for C, CS and CW mixes which shall be designed from a minimum of 2 sizes of aggregate.

The Contractor shall establish a gradation for each aggregate used in the mix. The aggregate stockpile gradation tolerance on each sieve is listed below.

3/8 in. (9.5 mm) sieve and larger	± 10%
No. 4 (4.75 mm) sieve	± 7%
No. 8 (2.36 mm) sieve	± 5%
No. 30 (600 µm) sieve	± 4%
No. 200 (75 µm) sieve (coarse aggregate)	± 2%
No. 200 (75 µm) sieve (fine aggregate)	± 4%

When the coarse aggregate portion of Grading CW mix is crushed limestone, not less than 20% nor more than 50% by weight shall be natural sand, or sand manufactured from slag or other approved non-skid aggregate. When the coarse aggregate portion is crushed gravel or crushed slag, not less than 15 nor more than 40% by weight of the mineral aggregate shall be agricultural limestone or Size No. 10 limestone screenings.

The gradations of the coarse and fine fractions of aggregate shall be such that when combined in proper proportions the resultant mixture will meet one of the following gradings, as specified:

**HOT PLANT MIX BASE COURSE
MIXTURE DESIGN RANGE OF GRADATIONS**

Sieve Size	Total Per Cent Passing, by Weight			
	Grading A	Grading AS	Grading ACRL	Grading B
2 in. (50 mm)	100	100	100	100
1-1/2 in. (37.5 mm)	81-100	75-100	80-93	95-100
¾ in. (19 mm)	50-71	55-80	60-75	70-85
3/8 in. (9.5 mm)	35-50	-	-	49-72
No. 4 (4.75 mm)	24-36	7-11	12-16	34-51
No. 8 (2.36 mm)	13-27	-	-	23-42
No. 30 (600 µm)	7-17	-	-	11-22
No. 50 (300 µm)	-	-	-	9-14
No. 100 (150 µm)	0-10	0-6	0-4	4-10
No. 200 (75 µm)	0-4.5	0-4.5	0-3.5	2.5-6.5

**HOT PLANT MIX LEVELING COURSE
MIXTURE DESIGN RANGE OF GRADATIONS**

Total Per Cent Passing, by Weight

Sieve Size	Grading BM	Grading BM2*	Grading C	Grading CW	Grading CS
1-1/4 in. (31.75mm)	-	100	-	-	-
1 in. (25 mm)	100	-	-	-	-
3/4 in. (19 mm)	85-100	81-93	100	100	-
3/8 in. (9.5 mm)	59-79	57-73	70-90	75-100	100
No. 4 (4.75 mm)	42-61	40-56	39-66	-	89-94
No. 8 (2.36 mm)	29-47	28-43	23-47	43-67	53-77
No. 30 (600 μm)	13-27	13-25	10-27	23-47	23-42
No. 50 (300 μm)	7-20	9-19	8-15	-	-
No. 100 (150 μm)	4-10	6-10	4-8	4-10	9-18
No. 200 (75 μm)	0-6.5	2.5-6.5	2.5-6.5	2.5-6.5	6-13.5

*When natural sand is used as fine aggregate, it shall be limited to a maximum amount of 20% by weight of the mineral aggregate.

Asphalt treated permeable base gradation shall be as follows:

Sieve Size	Total percent passing by weight
2 in.(50 mm)	100
1-1/2 in.(37.5 mm)	70-100
3/4 in.(19 mm)	55-80
No. 4(4.75 mm)	0-11
No. 100(150 μm)	0-4
No. 200(75 μm)	0-3

903.07-Aggregate for Bituminous Coated Aggregate Base (Plant Mix).
The mix aggregate for Bituminous Coated Aggregate Base shall be crushed stone or crushed slag meeting the quality requirements of ASTM D 692,

except that the sodium sulfate soundness loss shall not exceed 9%. Crushed slag aggregate retained on the No. 4(4.75 mm) mesh sieve shall not contain more than 20% by weight of glassy particles.

The aggregate for the bituminous mixtures shall be produced in 2 fractions.

Aggregate for Mix No. 1 shall be separated on the 1 1/4 inch(31.5 millimeter), 1 1/2 in. (37.5 mm) or 1 3/4 in.(45 mm) screen.

Aggregate for Mix No. 2 shall be separated on the 1 in.(25 mm) or 1 1/4 in. (31.5 mm) screen.

The aggregate sizes shall be such that when combined in the proper proportions the resultant mixture will meet one of the following gradings, as specified.

**AGGREGATE FOR BITUMINOUS COATED AGGREGATE
BASE (PLANT MIX)
MASTER RANGE OF GRADATIONS**

Sieve	Total Percent Passing, by Weight	
	Mix No. 1	Mix No. 2
3 in. (75 mm)	100	-
2-1/2 in.(63 mm)	95-100	-
2 in.(50 mm)	-	100
1-1/2 in.(37.5 mm)	30-70	60-95
3/4 in.(19 mm)	0-15	0-20
3/8 in.(9.5 mm)	0-3	0-5
No. 4(4.75 mm)	-	0-2

Choker aggregate for Mix No. 1 or Mix No. 2 shall be crushed stone, crushed slag or crushed gravel meeting the quality requirements of **Subsection 903.13** and the gradation requirements of Size No. 68, **Subsection 903.22**.

903.08-Aggregate for Bituminous Road Mix Surface Course. Aggregate for Bituminous Road Mix Surface Course shall consist of crushed stone, crushed slag or crushed gravel. It shall conform to the quality requirements of ASTM D 692 except that when tested for stripping, the aggregate shall have a bituminous film retention by count in excess of 95%; and at least 50% by count of the gravel retained on the No. 4(4.75 mm) sieve shall have at least 1 fractured face fractured for the approximate average diameter of the aggregate.

Aggregates which do not meet the film retention requirement may be used provided a satisfactory chemical additive is used that will result in a water resistant film.

Crushed slag aggregate retained on the No. 4(4.75 mm) sieve shall not contain more than 20%, by weight, of glassy particles.

The amount of material finer than No. 200(75 μ m) mesh shall not exceed 1%. If all material finer than the No. 200(75 μ m) mesh sieve consists of dust of fracture, essentially free from clay or shale, the percentage may be increased to 1.5.

The gradation of the aggregate shall meet the requirements for the following sizes shown in **Subsection 903.22**.

Mix Aggregate	Size No. 68
Choker Aggregate	Size No. 8

903.09-Aggregate for Bituminous Sand-Gravel Binder and Surface Coarse (Hot Mix). Aggregate for Bituminous Sand-Gravel Binder and Surface Course (Hot Mix) shall consist of local bank or pit-run sand and gravel. The portion retained on the No. 4(4.75 mm) sieve shall consist of sound, durable siliceous particles, free of shale and clay. It shall have a percentage of wear not greater than 50. The fine aggregate portion (passing the No. 4(4.75 mm) sieve) shall consist of natural or manufactured sand, and the percentage of clay, as determined by hydrometer analysis (AASHTO T 88), shall not exceed 5.

The bank or pit-run sand and gravel shall be screened and all oversize material may be crushed and fed uniformly back over the screen. After screening the bank or pit-run material shall be stockpiled before it is fed to the drier.

The combined aggregate shall meet the following gradation requirements:

**AGGREGATE FOR BITUMINOUS SAND-GRAVEL
BINDER AND SURFACE COURSE
MASTER RANGE OF GRADATIONS**

Sieve Size	Total Per Cent Passing, by Weight	
	Binder	Surface
1 in.(25 mm)	100	-
¾ in.(19 mm)	80-100	100
½ in.(12.5 mm)	-	95-100
No. 4(4.75 mm)	40-70	65-90
No. 40(75 µm)	15-40	20-45
No. 100(150 µm)	1-10	5-15

903.10-Aggregate for Bituminous Plant Mix Surface Course (Cold Mix). The mix aggregate for cold bituminous plant mix shall consist of crushed stone or crushed slag meeting the quality requirements of ASTM D 692. Crushed slag aggregate retained on the No. 4(4.75 mm) sieve shall contain not more than 20%, by weight, of glassy particles.

The amount of material finer than No. 200(75 µm) mesh (AASHTO T 11) shall not exceed 1%. If all material finer than the No. 200(75 µm) mesh sieve consists of the dust of fracture, essentially free from clay or shale, the percentage may be increased to 1.5.

The mix aggregate for leveling and surface course mixtures shall be Size No. 68, **Subsection 903.22**. Key or choker aggregate shall be crushed stone, crushed slag, or crushed gravel meeting the same quality

requirements as the mix aggregate and shall meet the gradation requirements of Size No. 8, **Subsection 903.22**.

903.11-Aggregate for Asphaltic Concrete Surface Courses (Hot Mix). Aggregate for asphaltic concrete surface courses shall consist of a combination of coarse and fine aggregate, and mineral filler when required or specified. A minimum of three sizes of aggregates shall be required for all mix designs.

The Contractor shall submit a mix design at least 14 working days prior to the scheduled start of production of any asphalt paving mixture in complete accordance with **Subsection 407.03(C)**.

If at any time the sources of materials are changed, a new mix design will be required in accordance with **Subsection 407.03(C)2**, Revision of Job Mix Formula.

(a) Coarse Aggregate.

The coarse aggregate (aggregate retained on the No. 4(4.75 mm) sieve) shall consist of crushed stone, crushed slag, crushed gravel, crushed granite, crushed quartzite, crushed gneiss, other approved non-skid aggregates or combinations thereof. The coarse aggregate shall meet the quality requirements of ASTM D 692 with the following exceptions and additions:

- (1) All aggregate shall have a sodium sulfate soundness loss not exceeding 9%.
- (2) Material retained on the No. 4(4.75 mm) sieve shall contain a maximum of 20% elongated pieces (length greater than 5 times the average thickness).
- (3) Combined aggregate shall consist of siliceous particles processed from washed material, of which at least seventy per cent by count, of the material retained on the No. 4(4.75 mm) sieve shall have a minimum of 2 fractured faces, 1 of which must be fractured for the approximate average diameter or thickness of the particle. The addition of pea gravel or uncrushed particles will not be permitted. The absorption of the crushed combined aggregate retained on the No. 4(4.75 mm) sieve shall not exceed 5% when tested in accordance with AASHTO T 85.
- (4) Crushed slag coarse aggregate shall contain no more than 20%, by weight, of glassy particles; except that where used in Grading G mix, the percent of glassy particles, by weight, shall not exceed 10.
- (5) After drying in the plant, the aggregate retained on the No. 4(4.75 mm) sieve shall have a loss of not more than 1% by weight when washed over a No. 8(2.36 mm) sieve in accordance with the coating test in **Subsection 407.03**.

(b) Fine Aggregate.

The fine aggregate (passing the No. 4(4.75 mm) sieve) shall consist of natural sand, fines prepared from stone, slag, gravel,

granite, quartzite, gneiss, other approved non-skid aggregates, or combinations thereof. It shall consist of hard tough grains free from injurious amounts of clay, loam or other deleterious substances. The fine aggregate when subjected to 5 cycles of Sodium Sulfate Soundness test shall have a weighted loss of not more than 12%. Manufactured sand shall have no more than five percent passing the No. 200(75 μ m) sieve when tested in accordance with AASHTO T 11. Fine aggregate or screenings containing Calcium Sulfate (CaSO_4 /gypsum) will not be allowed if more than 5% of the material passing the No.8(2.36 mm) sieve is chemically composed of Sulfur Trioxide (SO_3)

- (1) Natural sand shall be washed. The natural sand shall be so graded that not more than 5% will be retained on the No. 4(4.75 mm) sieve.
- (2) Fine aggregate consisting of natural sand will be tested in accordance with AASHTO T 11 and the amount of material finer than a No. 200(75 μ m) mesh sieve shall not exceed 4% by weight.

The amount of deleterious substances in natural sand shall not exceed the following limits:

Maximum Permissible Limits
Percent by Weight

1. Clay Lumps	0.5
2. Coal & Lignite	0.5
3. Other deleterious substances (such as shale, alkali, mica, coated grains, soft & flaky particles)	3.0

- (3) Agricultural limestone, when used as a portion of the fine aggregate, shall be manufactured from sound, durable stone and shall be crushed so that at least 85% will pass the No. 8(2.36 mm) mesh sieve and at least 50% will pass the No. 30(600 μ m) mesh sieve.

(c) The Combined Grading.

The several aggregate fractions shall be sized, graded, and combined in such proportions that the resulting composite blend will meet 1 of the following grading requirements, as specified, together with the stipulations pertaining to the constituents of the blend hereinafter specified.

The Contractor shall establish a single value for each sieve size required in the mix for each aggregate stockpile with an

allowable stockpile tolerance on each sieve as specified in **Subsection 903.06(c)**.

When Gradings D, E, or F are used for the surfacing of shoulders or for other non traffic lane construction, the design may be modified as approved by the Engineer.

**ASPHALT CONCRETE SURFACE COURSE
MIXTURE DESIGNATION
DESIGN RANGE OF GRADATIONS**

Total Percent Passing, by Weight

Sieve Size	Grading D	Grading E	Grading F
¾ in.) (19 mm)	-	-	-
5/8 in. (16 mm)	100	100	-
½ in. (12.5 mm)	95-100	95-100	-
3/8 in. (9.5 mm)	80-93	80-93	100
No. 4 (4.75 mm)	54-76	54-76	89-100
No. 8 (2.36 mm)	35-57	35-57	78-92
No. 30 (600 µm)	17-29	17-29	38-67
No. 50 (300 µm)	10-18	10-18	23-47
No. 100 (150 µm)	3-10	3-11	7-18
No. 200 (75 µm)	0-6.5	0-8	5-13

When crushed gravel is used in Grading G mix, the percent passing the No. 100(150 µm) sieve shall be 2-7.

Grading D.

The coarse aggregate shall consist of crushed gravel, crushed granite, crushed slag, crushed quartzite or crushed gneiss. Other crushed aggregate may be used provided it has the following chemical, physical, and performance characteristics for Type I, Type II, Type III or Type IV aggregate:

- (1) Type I
 - Silica Dioxide content - minimum of 40% (ASTM C-25)
 - Calcium carbonate content - maximum of 32%

The coarse aggregate shall contain a minimum of 50% by weight of acid insolubles that are coarser than the No. 100(150 µm) mesh sieve when tested in accordance with ASTM D 3042.

The British Pendulum (Tester) number BPN shall not be less than 30 when tested in accordance with AASHTO T 278 after nine hours of accelerated polishing of the aggregate using the British Wheel in accordance with AASHTO T 279.

(2) Type II

Silica Dioxide content - minimum of 30% (ASTM C-25)

The coarse aggregate shall contain a minimum of 35% by weight of acid insolubles that are coarser than the No. 100(150 µm) mesh sieve when tested in accordance with ASTM D 3042.

The British Pendulum (Tester) number BPN shall not be less than 30 when tested in accordance with AASHTO T 278 after nine hours of accelerated polishing of the aggregate using the British Wheel in accordance with AASHTO T 279.

In addition to the above requirements, the aggregate shall have met the preapproval process of the Division of Materials and Tests.

(3) Type III (for roads with current ADT of 15,000 or less excluding Interstate Highways).

Silica Dioxide content - minimum of 20% (ASTM C-25)

The coarse aggregate shall contain a minimum of 25% by weight of acid insolubles that are coarser than the No. 100(150 µm) mesh sieve when tested in accordance with ASTM D-3042.

The British Pendulum (Tester) number BPN shall not be less than 25 when tested in accordance with AASHTO T 278 after 9 hours of accelerated polishing of the aggregate using the British Wheel in accordance with AASHTO T-279.

In addition to the above requirements, the aggregate shall have met the preapproval process of the Division of Materials and Tests.

(4) Type IV (for 2 lane roads with a current ADT of 5,000 or less

Silica Dioxide content – minimum of 10% (ASTM C-25)

The British Pendulum(Tester) number shall not be less than 22 when tested in accordance with AASHTO T 278 after 9 hours of accelerated polishing of the aggregate using the British Wheel in accordance with AASHTO T 279.

The coarse aggregate must have a minimum Tennessee Terminal Texture Condition (TTTCM) value of 42.5 when tested in accordance with the method developed by the Tennessee Technological University.

In addition to the above requirements, the aggregate shall have met the pre-approval process of the Division of Materials and

Tests. The aggregate must also maintain a satisfactory level of field performance to remain an approved source.

The material shall be processed and stockpiled as an independent and separate operation. Each stockpile will be sampled and tested for approval prior to use.

The fine aggregate shall consist of natural sand or sand manufactured from gravel, slag or from crushed stone aggregate meeting the physical and chemical requirements listed above. The use of carbonate rocks such as limestone and dolomite or other aggregates tending to polish under traffic will not be permitted in the coarse aggregate and will be permitted only to the extent specified herein in the fine aggregate.

Grading E.

When Grading E is to be used as a surface for traffic lanes, the mineral aggregate shall be composed of not less than 50%, nor more than 80 percent crushed limestone, and not more than 50% or not less than 20% natural sand, slag sand, sand manufactured from gravel or other approved non-skid aggregates, or any combination of these materials, except as herein specified.

The sand percentage on the job mix formula shall be in the range of 20- to 50%. However, if needed to meet or improve the specified design criteria, the limestone and sand percentage may be altered by the numerical value of 5% from the percentage shown by the Contractor on the original job mix formula. If the aggregate percentages shown on the original job mix formula are altered, the Contractor shall submit a new job mix formula using the aggregate percentages shown on the Design.

When Grading "E" is used for surfacing of shoulders or other non-traffic lane construction, the mineral aggregate may be composed entirely of limestone including Size No. 10 (Screenings) and manufactured sand, but in no case shall the mineral aggregate for this construction consist of less than 50% limestone.

Grading F.

The mineral aggregate shall be composed of not less than 75% nor more than 85% of either natural sand, slag sand, sand manufactured from other approved non-skid aggregates, sand manufactured from siliceous materials or any combinations of these materials, and not less than 15% nor more than 25% of stone screenings meeting the gradation requirements of Size No. 10 **903.22**. Agricultural limestone meeting the requirements of **Subsection 903.11(b)** may be substituted for all or part of the stone screenings.

903.12-Aggregate for Slurry Seal and Micro-Surface.

- (a) **Aggregate for Slurry Seal.** The aggregate shall be crushed slag, crushed granite or crushed stone (crushed stone as specified for the types listed for Grading D in **Subsection 903.11(c)**) meeting the requirements of ASTM D 692, except the gradation shall be as specified below. The aggregate shall have a minimum sand

equivalent (AASHTO T 176) of 45. The aggregate shall be proportioned to produce a uniform gradation meeting the following requirements:

**GRADATION LIMITS FOR AGGREGATE
BASED ON WASH GRADATION**

Sieve	Design Master Range (Total Percent Passing)	Mixture Control Tolerances
3/8 in. (9.5 mm)	100	
No. 4(4.75 mm)	90-100	±6.0
No. 8(2.36 mm)	65-90	±5.0
No. 16(1.18 mm)	45-70	±5.0
No. 30(600 µm)	30-50	±4.0
No. 50(300 µm)	20-38	±4.0
No. 100(150 µm)	12-28	±3.0
No. 200(75 µm)	8-16	±3.0

- (b) **Aggregate for Micro-Surface.** The aggregate shall be crushed slag, crushed granite or crushed stone (crushed stone as specified for the types listed for Grading D in **Subsection 903.11(c)**) meeting the gradation limits below and the physical properties of ASTM D 692 except the percent of fractured pieces shall be 100. The aggregate shall have a minimum sand equivalent (AASHTO T 176) of 65. The aggregate shall be proportioned to produce a uniform gradation meeting the following requirements:

**GRADATION LIMITS FOR AGGREGATE
BASED ON WASH GRADATION**

Sieve	Design Master Range (Total Percent Passing)	Mixture Control Tolerances
3/8 in.(9.5 mm)	100	
No. 4(4.75 mm)	70-90	±6.0
No. 8(2.36 mm)	45-70	±5.0
No. 16(1.18 mm)	28-50	±5.0
No. 30(600 µm)	19-34	±4.0
No. 50(300 µm)	12-25	±4.0
No. 100(150 µm)	7-18	±2.0
No. 200(75 µm)	4-15	±2.0

903.13-Aggregate for Hot Bituminous Seal Coat. Aggregate for Hot Bituminous Seal Coat shall consist of crushed stone, crushed slag or crushed gravel meeting the quality requirements of ASTM D 692, except that at least 50% by count of crushed gravel aggregates shall have at least 1 fractured face. Crushed slag aggregate retained on the No. 4 sieve shall contain not more than 20%, by weight of glassy particles.

The amount of material finer than 200 mesh shall not exceed 1%. If all material finer than the 200 mesh sieve consists of the dust of fracture, essentially free from clay or shale, the percentage may be increased to 1.5.

At the option of the Engineer, the aggregate may be tested for bituminous film retention. When tested in accordance with AASHTO T 182, the aggregate shall have a bituminous film retention in excess of 95%. Aggregates that are tested and do not meet the film retention requirement may be approved provided a satisfactory chemical additive is used.

Aggregate used in the mat shall be Size No. 7, **Subsection 903.22.**

903.14-Aggregate for Double Bituminous Surface Treatment.

Aggregate for Double Bituminous Surface Treatment shall conform to the requirements of **Subsection 903.13.** Aggregate used in the mat shall be Size No. 7, **Subsection 903.22.** Aggregate used in the seal shall be Size No. 8, **Subsection 903.22.** At least 90% of the aggregate particles retained on the No. 4(4.75 mm) sieve shall have 1 or more fractured faces, fractured for the approximate average diameter or thickness of the particle.

903.15-Aggregate for Aggregate-Cement Base Course.

Aggregate for Aggregate-Cement Base Course shall consist of coarse aggregate composed of sound, tough, durable fragments of crushed stone, crushed slag, crushed or uncrushed gravel, or crushed or uncrushed chert; fine aggregate composed of natural or manufactured sand, and silt-clay or other finely divided mineral matter.

The aggregate shall be screened and of such gradation that all will pass a 1 1/2 in.(37.5 mm) sieve, not more than 75% will pass the No. 4(4.75 millimeter) sieve, and not less than 5 nor more than 15% will pass the No. 200(75 µm) sieve. The fraction passing the No. 40(425 µm) sieve shall have liquid limit not greater than 35, and a plasticity index not greater than 10. If blending of materials is required, it shall be done at the screening plant or at the stationary mixing plant.

The combined total of shale, organic material, or other unwanted substances shall not exceed 5% by weight.

903.16-Mineral Filler. Mineral Filler shall meet the requirement of AASHTO M 17, except that mineral filler shall be non-plastic.

903.17-Aggregate for Underdrains. Aggregate for Underdrains shall be crushed stone, crushed slag, or washed gravel meeting the quality requirements of ASTM D 692 and the grading requirements for Size 6, 7, 8, 57 or 78, **Subsection 903.22.**

903.18-Aggregate for Sand-Asphalt Surface Course. Aggregate for Sand-Asphalt Surface Course shall consist of natural sand and/or crushed siliceous material meeting the quality requirements of ASTM D 1073. In the natural sand the percentage of material finer than the No. 200(75 µm) mesh shall not exceed 5. The natural sand or combination of these materials shall meet the following requirements for gradation:

Sieve Size	Total percent passing by weight
No. 4(4.75 mm)	100
No. 8(2.36 mm)	95-100
No. 30(600 μm)	50-80
No. 50(300 μm)	30-60
No. 100(150 μm)	8-25
No. 200(75 μm)	2-10

903.19-Lightweight Aggregates for Structural Concrete. Lightweight aggregate for structural concrete shall conform to the requirements of AASHTO M 195 with the following additional stipulations:

1. The lightweight aggregate shall be produced by fusing raw shale, slate or clay in a rotary kiln producing particles having a wear of not more than 40% when tested according to AASHTO T 96.
2. The lightweight coarse aggregate shall conform to the grading requirements for size 3/4 in.(19 mm) to No. 4(4.75 mm) as shown in Table 1 of AASHTO M 195.
3. The absorption of the coarse aggregate shall not exceed 10% when tested in accordance with AASHTO T 85.
4. When the coarse aggregate is subjected to five alterations of the sodium sulfate soundness test in accordance with AASHTO T 104, the weighted percentage of loss shall not be more than nine.
5. That concrete with approximately 6% air content made from the aggregate has a minimum durability factor of 90% when tested in accordance with AASHTO T 161.
6. Shall be listed on the Department's QPL.

903.20-Stockpiling Aggregates. Sites for aggregate stockpiles shall be grubbed and cleaned prior to storing aggregates, and the ground shall be firm and smooth and well drained. A cover of at least 3 in.(75 mm) of aggregate shall be maintained in order to avoid the inclusion of soil or foreign material. The stockpiles shall be built in layers not exceeding 4 ft.(1.2 m) in height, and each layer shall be completely in place before the next layer is started so as to prevent segregation. The material shall be deposited in such manner as to prevent coning, except in the case of aggregate composed essentially of material finer than the No. 4(4.75 mm) sieve and base material.

Dumping, casting or pushing over sides of stockpiles will be prohibited, except in the case of aggregate for base material and fine aggregate materials.

Unless otherwise authorized, aggregates from different sources different gradings or differing in specific gravity by more than 0.03 shall not be stockpiled together. Stockpiles of different types or sizes of aggregates shall be spaced far enough apart, or separated by suitable walls or partitions, to prevent the mixing of the aggregates.

When it is necessary to operate trucks or other equipment on a stockpile in the process of building the stockpiles, it shall be done in a manner approved by the Engineer. Any method of stockpiling aggregate that allows the stockpile to become contaminated with foreign matter or causes

excessive degradation of the aggregate will not be permitted. Excessive degradation will be determined by sieve tests of samples taken from any portion of the stockpile over which equipment has operated, and failure of such samples to meet all grading requirements for the aggregate shall be considered cause for discontinuance of such stockpiling procedure.

903.21-Test Methods. In stating requirements for most materials in **Section 903**, reference has been made to AASHTO and ASTM Standard Specifications for materials. The current AASHTO or ASTM Standard Specification effective at the time of letting for a particular Contract, shall be the governing specification. Those Specifications, in turn, include reference to the respective AASHTO and ASTM methods of sampling and testing. In a few instances, however, properties of materials in **Section 903** have been specified without reference to corresponding AASHTO and ASTM Standard Specifications. In such instances, the following methods of sampling and testing will govern:

Test	Test Method
Unit Weight	AASHTO T 19
Percentage of Wear	AASHTO T 96
Soundness	AASHTO T 104
Liquid Limit	AASHTO T 89
Plastic Limit and Plasticity Index	AASHTO T 90
Sieve Analysis	AASHTO T 27
Hydrometer Analysis	AASHTO T 88
Material Passing No. 200(75 µm)	
Sieve in Aggregate	AASHTO T 11
Stripping Test of Bitumen-Aggregate Mixtures	AASHTO T 182
Resistance to Plastic Flow by:	
Marshall Method	AASHTO T 245 ¹

¹ A mechanically operated hammer with a rotating base shall be used. The compaction hammer shall have a slanted, circular tamping face. The slant on the face shall be 1.6% +0.0/-0.1."

903.22-Sizes of Coarse Aggregate. See AASHTO M 43

TABLE 1 Standard Sizes of Processed Aggregate

Amounts Finer than Each Laboratory Sieve (Square Opening) weight percent

Size	Residual Size Square opening	100 mm (4")	90 mm (3.125")	75 mm (3")	63 mm (2.512")	50 mm (2")	37.5 mm (1.512")	25.0 mm (1")	19.0 mm (3/4")	12.5 mm (1/2")	9.5 mm (3/8")	4.75 mm (#4)	2.36 mm (#60)	1.18 mm (#150)	300 mm (#10)	150 mm (#100)
1	90-37.5 mm (3.125"-1.512")	100	90-100	-	25-60	-	0-15	-	0-5	-	-	-	-	-	-	-
2	63-37.5 mm (2.512"-1.512")	-	-	100	90-100	35-70	0-15	-	0-5	-	-	-	-	-	-	-
24	63-19.0 mm (2.512"-3/4")	-	-	100	90-100	-	25-60	-	0-10	0-5	-	-	-	-	-	-
3	50-25.0 mm (2"-1")	-	-	-	100	90-100	35-70	0-15	-	0-5	-	-	-	-	-	-
357	50-4.75 mm (2"-#60)	-	-	-	100	95-100	-	35-70	-	10-30	-	0-5	-	-	-	-
4	37.5-19.0 mm (1.512"-3/4")	-	-	-	-	100	90-100	20-55	0-15	-	0-5	-	-	-	-	-
467	37.5-4.75 mm (1.512"-#60)	-	-	-	-	100	95-100	-	35-70	-	10-30	0-5	-	-	-	-
5	25.0-12.5 mm (1"-#16)	-	-	-	-	-	100	90-100	20-55	0-10	0-5	-	-	-	-	-
56	25.0-4.75 mm (1"-#60)	-	-	-	-	-	100	90-100	40-85	10-40	0-15	0-5	-	-	-	-
57	30.0-4.75 mm (1.18"-#60)	-	-	-	-	-	100	95-100	-	25-60	-	0-10	0-5	-	-	-
6	19.0-9.5 mm (3/4"-#20)	-	-	-	-	-	-	100	90-100	20-55	0-15	0-5	-	-	-	-
67	19.0-4.75 mm (3/4"-#60)	-	-	-	-	-	-	100	90-100	-	20-55	0-10	0-5	-	-	-
68	19.0-2.36 mm (3/4"-#60)	-	-	-	-	-	-	100	90-100	-	20-55	0-10	0-5	-	-	-
7	12.5-4.75 mm (1/2"-#60)	-	-	-	-	-	-	100	90-100	-	30-65	5-25	0-10	0-5	-	-
78	12.5-2.36 mm (1/2"-#60)	-	-	-	-	-	-	100	90-100	-	40-70	0-15	0-5	-	-	-
8	9.5-2.36 mm (3/8"-#60)	-	-	-	-	-	-	100	90-100	-	40-75	5-25	0-10	0-5	-	-
89	9.5-1.18 mm (3/8"-#16)	-	-	-	-	-	-	100	90-100	-	85-100	10-30	0-10	0-5	-	-
9	4.75-1.18 mm (#60-#16)	-	-	-	-	-	-	100	90-100	-	90-100	20-55	5-30	0-10	0-5	-
10	4.75 mm (#60)	-	-	-	-	-	-	100	90-100	-	100	85-100	10-40	0-10	0-5	-

*Screening

904

SECTION 904-BITUMINOUS MATERIALS

904.01-Asphalt Cements	741
904.02-Blank	742
904.03-Emulsified Asphalts	742

SECTION 904-BITUMINOUS MATERIALS

904.01-Asphalt Cements.

Asphalt cement used on TDOT projects shall only be from Certified Asphalt Suppliers that have an approved Quality Control Plan in accordance with TDOT Standard Operating Procedures.

Asphalt cement shall conform to the requirements of AASHTO M 320 and in accordance with TDOT procedures. The solubility of base asphalt cement as required in AASHTO M 320 must be reported for information every 3 months in the suppliers' quality control program. In lieu of PG 64-22 when specified, asphalt cement graded to PG 67-22 may be used. PG 67-22 shall conform to the requirements of AASHTO M 320 when all applicable tests are conducted at 67° C and -12° C, and the dynamic shear of the rolling thin film, pressure aged vessel sample shall be tested at 26.5° C.

Modification of the asphalt shall be accomplished by properly blending styrene butadiene (SB), styrene butadiene styrene(SBS) or styrene butadiene rubber(SBR) to a PG 64-22 or PG 67-22 base asphalt.

In addition to the above requirements, the PG 70-22, PG 76-22, and 82-22 shall meet the following:

	PG 70-22	PG 76-22	PG82-22
Ring & Ball Softening Point, degrees F (degrees C), min.	53(128)	57(135)	65(150)
Elastic Recovery by means of Ductilometer, % min.	45	65	70

Test Procedures

Elastic Recovery by means of a Ductilometer

The Elastic Recovery shall be tested in accordance with AASHTO T301 at 77° F(25°C).

Screen Test

The procedure shall be to pour a 1,000 gram sample heated to 275° F(135° C) through a No. 10(2.0 mm) sieve. There shall be no lumps or particles retained on the sieve.

Viscometer Test

In addition to the above, a rotational viscometer, meeting ASTM D4402 requirements with a thermostatically controlled cell will be required at all hot mix asphalt mix plants using modified liquid asphalt products. A minimum of 1 test per day shall be run on samples taken from the contractor's storage tank. Viscosity values shall be in the following ranges when tested at 275° F.(135° C):

	PG-70-22	PG 76-22	PG 82-22
Viscosity range (cP)	650-3,000	1,000-3,000	2,000-4,000*

904

* PG82-22 must be stored at proper temperatures to maintain pumpability.

Materials Certification

A certification shall be furnished to the Engineer on each project stating that the asphalt cement furnished meets the Department's specification. Quality control and compliance testing shall be completed in accordance with asphalt suppliers approved quality control plan and in accordance with TDOT procedures.

Where blending or modification occurs after the material has left the storage tanks. A complete series of tests shall be conducted on a sample taken on the first day's production and biweekly thereafter for each grade being produced. Brookfield viscosity and DSR original tests shall be performed daily at the point of blending or modification. The DSR value $G^*/\sin\delta$ shall be ≥ 1.0 kPa at the high PG grade temperature (ie. 158° F(70° C) for PG 70-22).

In addition, the producer shall provide a temperature-viscosity curve with a recommended mixing temperature range. In order to develop a temperature-viscosity curve, it may be necessary to run the viscosity test at a higher temperature. This temperature would be dependent on the softening point of the modified asphalt cement.

If an SBR modifier is used, the SBR shall be pre-blended with the asphalt cement or added by means of an "in-line" motionless mixer. The "in-line" mixer shall be a Komax Model No. 30715A, Ross LPD Motionless mixer, Koch Static Mixer or other approved equal. The "in-line" motionless mixing unit shall provide a homogeneity value of 0.15 or less. The mixing unit shall be equipped with a port(s) for obtaining representative samples of the blended material in accordance with AASHTO T 40. The mixer shall be oil jacketed. The mixer shall have a minimum diameter of 1/2 in. (13 mm) larger than the asphalt supply line onto which it is installed. The manufacturer shall document to the Engineer that the above specifications will be obtained with the mixer furnished.

904.02-Blank

904.03-Emulsified Asphalts. Two types of emulsified asphalts shall be used under these specifications, both , anionic and cationic.

The manufacturer shall furnish samples of base asphalt used in the manufacture of asphalt emulsion, as directed by the Engineer.

All emulsified asphalts shall be homogenous, and shall adhere firmly to the surface of the mineral aggregate. Failure of the emulsified asphalt to perform satisfactorily on the job shall be deemed cause for rejection, notwithstanding its ability to pass laboratory tests.

A. Anionic Emulsified Asphalts.

In general, anionic emulsified asphalts shall conform to all the requirements of AASHTO M 140, for the type and grade specified.

In addition to the classes provided for in AASHTO M 140, a special mixing material (AE-3), a special priming material (AE-P) or a special tack (TST-1P) may be specified. These special materials shall conform to the following requirements:

Type Grade Test Requirements:	Special Mixing AE-3		Special Prime AE-P		Special Tack TST-1P	
	Min.	Max.	Min.	Max.	Min.	Max.
Viscosity, Saybolt-Furol, 77° F(25° C), Sec.			10	50	10	75
Viscosity, Saybolt-Furol, 122° F(50° C), Sec.	50+ & Pumpable					
Settlement, 5 days, % 24 hours	5	5	5		0.10	0.10
Sieve Test Stone Coating % coated)	90					
Distill. to 500° F (260° C) Residue, % by weight Oil portion of distillate, % by vol.	70		45			
Distillation to 400° F(205° C) Residue, % by weight				6	12	
Tests on residue from distillation (a) Float Test, 140° F (60° C), Sec.	200	20				
(b) Ductility, 77° F (25° C), cm	40					
(c) Ductility, 111° F(4° C)					10	35
(d) Ash, by ignition, %		2				
Demulsibility (0.02 Normal/35ml)					+5	
Elastic Recovery @ 50° F(10° C)					25+	
Pen					75	150

The test requirement for settlement may be waived when the emulsified asphalt (special tack coat excepted) is used in less than 5 days' time; or the Engineer may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 days.

The AE-3 shall be of such stability that it will remain constant and uniform while being mixed with dry or approximately dry aggregate, and

shall thoroughly and uniformly coat the entire surface of each fragment while being manipulated and incorporated into the work. The emulsified asphalt after being incorporated into the work shall show no signs of re-emulsifying.

B. Cationic Emulsified Asphalts.

Cationic emulsified asphalts shall conform to the requirements of AASHTO M 208, for the type and grade specified. Solubility in trichloroethylene will be required for information only every 3 months in the supplier's quality control program.

In addition to the classes provided in AASHTO M 208, a special priming material may be specified which is designated CAE-P. This material shall meet the requirements listed for AE-P except as follows:

- (1) The Float Test shall be deleted.
- (2) Penetration Test 77° F(25° C) shall be a minimum of 300.
- (3) The particle charge shall be positive.

When approved by the Engineer, cationic emulsions may be substituted for anionic emulsions.

C. Emulsified Asphalts for Slurry Seal.

The emulsified asphalt for a Slow-Set Emulsified Asphalt Slurry Seal shall be Type CSS-1h-p meeting the requirements specified herein. The emulsified asphalt for a Quick-Set Emulsified Asphalt Slurry Seal and a Quick-Traffic Emulsified Asphalt Slurry Seal shall be Type CQS-1h-p meeting the requirements for Type CSS-1h-p with the following exceptions:

Residue, %	MIN. 60
Cement mixing test, %	(waived)

Unless otherwise specified on the Plans, a Quick-Set Emulsified Asphalt Slurry Seal shall be used.

The water shall meet the requirements of **Subsection 918.01**.

The latex modifier, when specified, shall be an unvulcanized styrene-butadiene rubber in liquid latex form. The cationic latex modifier shall conform to the following requirements:

<u>Tests</u>	<u>Cationic Latex Modifier</u>
Styrene/Butadiene Ratio, %	24/76 ± 1.5
Solids Content, %	60 Min.
ph	6.2 Max.
Lbs./gallon (kgs/liter):	
Wet Basis @ 77° F(25° C)	0.95(7.9) Min.
Dry Basis @ 77° F(25° C)	0.55(4.5) Min.

The manufacturer of the latex shall provide written certification of the results of the above noted tests.

Latex modified CSS-1h-p shall meet the requirements of AASHTO M-208 modified as follows:

Residue Requirements

Penetration @ 77° F(25° C)	30 Min.
Ductility @ 77° F(25° C)	150 +
@ 4° C	100 +
Softening Point, Ring and Ball, degrees C	54 +

The latex shall be combined with the asphalt emulsion at the emulsion mill to produce a homogeneous mixture.

The latex modified emulsion upon standing undisturbed for a period of 24 hours shall show no color striations, but shall be a uniform color throughout.

The latex modified asphalt emulsion shall meet the requirements of the Stretch Test which will be conducted as follows:

Pour onto a quart(liter) friction can lid or similar container, enough of the emulsion to cover the surface to a depth of 1/16 to 1/8 in.(1.5 to 3 mm). Immediately, while the emulsion is still brown, embed with thumb pressure several stones or chips approximately 1/2 in.(13 mm) in size , 3/8 to 5/8 in.(10 to 16 mm) into the binder. Put the lid, or similar container containing the emulsion and aggregate into a 100° F(38° C) oven and allow to cure for a minimum of 8 hours. After the curing period, remove the lid and allow it to cool for one hour. Upon lifting a stone or chip from the binder, the asphaltic material must adhere to the aggregate and must elongate for a minimum distance of 3 in.(75 mm) without loss of adhesion and without breaking.

D. Emulsified Asphalts for Micro-Surface.

The emulsified asphalt for micro-surfacing shall be Type CSS-1h-p or CQS-1h-p meeting the requirements specified in subparagraph C for slurry seals above and the following requirements:

The latex or polymer modifier and other emulsifiers shall be milled into the asphalt cement and shall show no separation after mixing. The latex or polymer modified emulsified asphalt shall have a minimum softening point (Ring and Ball) of 135° F(57° C) when tested in accordance with AASHTO T 53. The blended asphalt mixture when combined with aggregate and mineral filler shall have the following characteristics:

1. Be capable of filling up to 1/2 in.(13 mm) wheel ruts in one pass.
2. Be capable of field regulation of the setting time.
3. Be suitable for nighttime placement.

The latex or polymer modified emulsified asphalt shall be accepted by certification from the manufacturer and must also meet the requirements of Subparagraph C for Slurry Seals above.

SECTION 905-JOINT MATERIALS

905.01-Preformed Joint Fillers (Non-Extruding and Resilient Types) 748
905.02-Joint Mortar 748
905.03-Rubber Gaskets 748
905.04-Hemp or Oakum Gaskets..... 748
905.05-Joint Sealants 748

SECTION 905-JOINT MATERIALS

905.01-Preformed Joint Fillers (Non-Extruding and Resilient Types). Preformed fillers for joints shall be of the Bituminous Type unless otherwise specified on the Plans, and when designated, shall be punched to admit the dowels.

- (a) Bituminous Type.

Bituminous type preformed fillers for joints shall conform to the requirements of AASHTO M 213.

- (b) Non-Bituminous Types.

Non-bituminous types of preformed filler for joints shall conform to the requirements of AASHTO M 153, Type I, II, or III, as specified.

The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint unless otherwise specified by the Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely, and held accurately to shape, by stapling or other positive fastening satisfactory to the Engineer.

905.02-Joint Mortar. Pipe joint mortar shall consist of 1 part portland cement and 2 parts sand with water necessary to obtain the required consistency. Portland cement shall conform to the requirements of **Subsection 901.01**, Type I. The sand shall conform to the requirements of **Subsection 903.02**. The water shall be approved for quality by the Engineer. Mortar shall be used within 30 minutes after its preparation.

905.03-Rubber Gaskets. The gaskets shall conform to the requirements of ASTM C 443.

905.04-Hemp or Oakum Gaskets. Gaskets of hemp or oakum packing for joint filler shall be closely twisted, and shall be of the size and type required for the pipe under construction. Gaskets shall be in 1 piece of sufficient length to pass around the pipe and lap.

905.05-Joint Sealants.

- (a) Materials used to seal the longitudinal joint between portland cement and asphaltic concrete shall comply with the following requirements:

Hot Poured Elastic Type Sealant conforming to the requirements of ASTM D 3405 with the following exceptions. The joint sealer shall be a mixture of virgin synthetic rubber or reclaimed rubber or a combination of the 2 with asphalt and plasticizers and taciifers. Ground cured rubber scrap shall not be used. The sealer shall be free of foreign material, and when melted shall be free of lumps. The Contractor shall

furnish the Engineer a certified statement from the manufacturer showing compliance with the above composition.

The flow at 140° F(60° C) shall not exceed 0.4 in.(1 cm) in 5 hours. Ductility at 77° F(25° C) shall be not less than 16 in.(40 cm), when tested in accordance with AASHTO T 51.

The Contractor shall furnish the Engineer a certified copy of the test results, showing the batch number, indicating that the material supplied conforms to the requirements of the specifications.

- (b) Materials used to seal longitudinal and transverse joints and random cracks in portland cement concrete pavement shall be one of the following, as specified on the Plans:

1. Hot Poured Elastic Type Sealant meeting the requirements of (a) above.

2. Silicone Sealant. This sealant shall be a low modulus silicone that is specially manufactured to seal portland cement concrete pavements joints. Silicone sealant shall be furnished in a one part silicone formulation which is non-acid curing and shall meet the following requirements:

(a) Flow (MIL S 8802) in.(mm.) maximum	5 (0.2)
(b) Extrusion rate (MIL S 8802)	90-250 grams/min.
(c) Tack free time @ 77 ± 3° F(25 ± 1.5° C) and 45-55% R.H. (MIL S 8802)	35-75 minutes
(d) Specific Gravity (ASTM D 792, Method A)	1.010-1.515
(e) Durometer hardness, Shore A: cured 7 days @ 77 ± 3° F(25 ± 1.5° C) and 45-55% R.H. (ASTM D 2240)	10-25
(f) Joint movement and tensile stress @ 150% elongation (7 day cure @77 ± 3° F(25 ± 1.5° C) and 45-55% R.H.) (ASTM D 412-Die C)	± 50% joint movement 75 psi(520 kPa) maximum tensile stress

905

(g) Peel (Adhesion): Unprimed aluminum panel with aluminum screen (7 day cure @ 77 ±3° F(25 ±1.5° C) and 45-55% R.H.) (MIL S 8802)	20 lb(90 N) min. with at least 75% cohesive failure
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(h) Bond to concrete mortar concrete briquets air cured 7 days @77 ±3° F (25 ±1.5° C)	345 kPa(50 psi) minimum
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Bond to concrete mortar shall be determined by molding briquets in accordance with AASHTO T 132 sawed in half and bonded with a thin section of sealant and tested in accordance with AASHTO T 132. Briquets shall be dried to constant weight in oven at 212° F ±40°(100° C ±5°.)

A backer rod(bond breaker) shall be provided if shown on the Plans. The rod shall be compatible with the sealant and no bond or reaction shall occur between the rod and the sealant.

Materials Certification: The Contractor shall use joint fillers and sealants from the Department's QPL. The Contractor shall certify that the product meets the applicable specifications and that the material is identical to that previously tested and placed on the QPL.

The Department reserves the right to perform any testing deemed necessary to ensure compliance with these Specifications.

**SECTION 906-DAMPPROOFING AND
WATERPROOFING MATERIALS**

906.01-General 752
906.02-Class I Dampproofing and Waterproofing..... 752
906.03-Class II Dampproofing and Waterproofing..... 752
906.04-Bridge Deck Sealants..... 752

SECTION 906-DAMP-PROOFING AND WATERPROOFING MATERIALS

906.01-General. These Specifications cover the materials for use in dampproofing and waterproofing applicable to concrete surfaces. The Class of waterproofing shall be as specified on the Plans or as otherwise indicated.

906.02-Class I Damp-proofing and Waterproofing.

- A. Asphalt.
 - 1. Asphalt seal for use below ground level shall conform to ASTM D 449, Type I.
 - 2. Asphalt seal for use above ground level shall conform to ASTM D 449, Type II or Type III, as specified.
- B. Bituminous Fabric shall conform to ASTM D 173.

906.03-Class II Damp-proofing and Waterproofing.

- A. Asphalt seal for use below ground level shall conform to ASTM D 449, Type I.
- B. Asphalt seal for use above ground level shall conform to ASTM D 449, Type II or Type III, as specified.
- C. Bituminous fabric shall conform to ASTM D 173.
- D. Plain asphalt plank shall conform to ASTM D 517, Type I.

906.04-Bridge Deck Sealants.

SYSTEM A.

- 1. Membrane. The membrane shall be a laminate formed with suitably plasticized coal tar and reinforced with non-woven synthetic fibers or glass fibers. It shall be a uniformly well manufactured product, free from blemishes, discontinuities, and other defects. The membrane shall be supplied in rolls, having a width of either 30 or 48 in.(0.75 or 1.2 m) or other widths as approved by the Engineer, and shall conform to the following requirements:

Thickness	70 ± 5 mils(1.75 ± 0.125 mm)
Pliability	Pass 180° bend over a 1 in.(25 mm) mandrel at 0 to 10° F(-18 to -12° C) (ASTM D 146)
Softening Point	230° F(110° C) Minimum (R & B, ASTM D 36)

2. Mastic. The mastic shall be a cold applied type compatible with the membrane and as recommended by the manufacturer of the membrane.

SYSTEM B.

1. Membrane. The membrane shall be a laminate of rubberized asphalt and reinforced with synthetic fibers or mesh. It shall be uniformly manufactured, free from blemishes, discontinuities, or other defects. The membrane shall be supplied in rolls having a width of 36 in.(900 mm) or other widths as approved by the Engineer, and shall conform to the following requirements:

Thickness (min.)	65 mils(1.65 mm)	
Tensile Strength (min.)	300 psi (2.10 MPa)	ASTM D 882,
Elongation at Break (min.)	150%	ASTM D 882,
Pliability 180° Bend over 1/4 in.(6 mm) mandrel at -25° F(-32° C)	No cracks	ASTM D 146
Peel Adhesion, 7 days dry +7 days @ 120° F (49° C), +7 days water immersion	5.0 psi (35 kPa) min. Modified	TT-S-00230

2. Mastic. The mastic shall be a cold applied type compatible with the membrane and as recommended by the manufacturer of the membrane.

Bridge deck sealants shall be listed on the Department's QPL. Prior to approval and use of the materials for bridge deck sealant, the Contractor shall submit to the Materials and Test Engineer a notarized certification by the formulator of these materials, stating that the materials proposed for use, or materials of identical formulation, have been tested and meet all the requirements as set forth herein. This notarized certification shall be accompanied by a certified laboratory test report on the materials, or materials of identical formulation, proposed for use. This test report shall contain the numerical test data of all the requirements as set forth herein. These certifications shall be accompanied by a sample of the proposed materials for preliminary evaluation. The approval granted, based on these certifications shall remain in effect until such time that the formulation is changed, or until such time that the Materials and Tests Engineer shall, at his discretion, require that the materials be requalified for use, in which event the qualifying procedure shall be repeated.

906

The Contractor or vendor shall submit a certification from the manufacturer of the materials with each subsequent shipment of materials. The certification shall identify the shipment by lot or batch number, state the quantity of material shipped, and state that the material is identical in all respects to lot or batch number(designate) which was previously qualified for use by the Department.

The Department reserves the right to require samples of all materials to be submitted to the Laboratory for testing.

SECTION 907-CONCRETE REINFORCEMENT

907.01-Bar Reinforcement for Concrete Structures 756
907.02-Dowel and Tie Bars..... 756
907.03-Welded Steel Wire Fabric 756
907.04-Prestressing Reinforcement Steel and Anchorages 756

SECTION 907-CONCRETE REINFORCEMENT

907.01-Bar Reinforcement for Concrete Structures. Unless otherwise specified, all steel reinforcement for concrete shall be billet steel bars conforming to the requirements of ASTM A 615 Grade 60. Standard CRSI hook details shall apply unless otherwise noted on the plans. Epoxy coated reinforcing steel shall be in accordance with ASTM D-3963 and ASTM A 775 and be on the Department's QPL.

A representative 8 oz(250 milliliter) sample of the coating material from each batch shall be packaged in an air tight container, identified by batch number and furnished to the Engineer. In addition, for repair of damage incurred during shipment or installation, the fabricator initially shall furnish to the project a repair kit containing a touch-up roller and 16 ozs(500 milliliters) of touch-up coating material with each shipment of epoxy coated reinforcing steel, with additional supplies being furnished as needed.

Metal chairs and supports shall be coated with plastic, epoxy or other approved material that is chemically and electrically inert in concrete. Tie wires shall be plastic coated and approved by the Engineer prior to use with epoxy coated reinforcing steel.

907.02-Dowel and Tie Bars. Dowel bars shall be plain and shall conform to the requirements of ASTM A 36 or A 615. Paint for dowels shall meet the requirements of SSPC (Steel Structure Painting Council) Paint Specification No. 15, Type 1(red oxide paint) or SSPC Paint Specification No. 25. Plastic coated dowels shall meet the coating requirements of AASHTO M 254. Epoxy coated dowels shall meet the coating requirements of ASTM D 3963. Bond breakers, of the type as recommended by the coating manufacturer, will be required for all dowel bars except for Type A coated dowels as specified by AASHTO M 254. Tie bars shall be deformed and conform to the requirements of ASTM A 615.

907.03-Welded Steel Wire Fabric. Fabric for reinforcement shall conform to ASTM A 185. Gauges, spacing, arrangement of wires and coating shall be as designated on the Plans.

907.04-Prestressing Reinforcement Steel and Anchorages. All wire, strand, or bars shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies shall be likewise identified, and shall be certified to meet the Post-Tensioning Institute(PTI), "Acceptance Standards for Post-Tensioning Systems."

The Contractor shall furnish a minimum of 2 samples from each lot or shipment received. Additional samples shall be furnished as the Engineer may direct.

Acceptance of the steel will be based on the results of physical tests made by the Department and a manufacturer's certification showing results of the required tests, including stress strain curves representative of the lot to be used.

The wire shall be free from injurious defects and shall have a workmanlike finish with smooth surface. Material which shows injurious defects during or prior to its installation in the work shall be cause for rejection.

In addition to the above provisions, the pre-stressing steel and anchorages for post-tensioned tendons shall comply with the following requirements:

A. Seven-Wire Strand for Pre-stressed Concrete.

The strand shall conform to the requirements of ASTM A 416, for the Grade specified. In addition, the strand manufacturer shall certify that the strand has been tested and will bond to concrete of normal strength and consistency in conformance with the prediction equations for transfer and development lengths given in ACI/ AASHTO Specifications. .

B. Uncoated Stress-Relieved Wire for Pre-stressed Concrete.

Uncoated stress-relieved wire shall meet the requirements of ASTM A 421.

C. Parallel Wire Assemblies for Post-tensioning.

Assemblies shall consist of parallel wires of the number and size shown on the Plans. Wires shall be high-tensile, hard-drawn, stress-relieved, uncoated and conform to the requirements of ASTM A 421.

D. Bars for Post-tensioning.

High tensile strength alloy bars shall be stress-relieved and then cold-stretched to a minimum of 130,000 psi(900 MPa). After cold-stretching, the physical properties shall be as follows:

Minimum ultimate tensile strength	145,000 psi (1,000 MPa)
Minimum yield strength, measured by the 0.7% extension- under-load method	130,000 psi (900 MPa)
Minimum modulus of elasticity	25,000,000 psi (172,500 MPa)
Minimum elongation in 20 bar diameters after rupture	4%
Diameter tolerance	+0.03 in./-0.01 in. (+750 μ m/-250 μ m)

E. Anchorages for Post-Tensioned Tendons.

(1) For Bars.

Wedge type anchorages that will develop the minimum ultimate stress specified for the nominal bar area shall be used.

Wedge type anchorages shall bear against anchorage plates fabricated of hot rolled steel of type and quality approved by the Engineer.

(2) For Parallel Wire Assemblies.

Generally, wedge type anchorage of the sandwich plate or conical type shall be used. The anchorage device shall be capable of developing the ultimate strength of the total number of wires anchored. Conical type anchorages shall be embedded within the ends of the concrete members unless otherwise specified. Generally, anchorages shall bear against embedded grids of reinforcing steel approved by the Engineer.

(3) Alternate Types.

Alternate anchorage types conforming to the general physical requirements specified above for wedge type anchorages may be used if approved by the Engineer.

Alternate type anchorages will be required to show evidence of being capable of withstanding at least 3,000,000 cycles of twice the maximum live load stress before being approved by the Engineer.

**SECTION 908-STRUCTURAL STEEL AND
APPURTENANT MATERIALS**

908.01-Structural Steel	760
908.02-Plate for Cold Working	760
908.03-Permanent Steel Bridge Deck Forms	760
908.04-High Strength Structural Bolts	760
908.05-Cast Steel	763
908.06-Steel Forgings	763
908.07-Gray Iron Castings	764
908.08-Malleable Castings	764
908.09-Bronze Bearing Plates, Plain	764
908.10-Bronze Bearing Plates, Self Lubricating	764
908.11-Corrosion Resistant Steel	765
908.12-Elastomeric Bearing Pads	765
908.13-Copper Sheet for Flashing	765
908.14-Pig Lead	765
908.15-Structural Steel Piles	765
908.16-Steel Shells	765
908.17-Steel Pipes	765

**SECTION 908-STRUCTURAL STEEL AND
APPURTENANT MATERIALS**

908.01-Structural Steel. Unless otherwise noted, steel plate shall conform to ASTM A-709, Grade 36, while bar stock and rolled shapes shall conform to ASTM A-709 Grade 50S.

908.02-Plate for Cold Working. Plate to be bent or formed cold in the course of fabrication shall conform to ASTM A 283, Grade C.

908.03-Permanent Steel Bridge Deck Forms. Permanent steel bridge deck forms and supports shall be fabricated from steel conforming to ASTM A 446(Grades A thru E) having a coating Class G 165 according to ASTM A 525.

908.04-High Strength Structural Bolts. All bolts, nuts, and washers shall be manufactured in the United States with steel smelted and manufactured in the United States. All bolts, nuts and washers shall conform to the following:

- (A) Specifications - Unless other wise specified on the Plans all bolts, nuts and washers shall be mechanically galvanized in accordance with AASHTO M 298 (ASTM B 695) Class 50
 - 1. Bolts - AASHTO M 164(ASTM A 325) - High Strength Bolts for Structural Joints.
 - 2. Nuts AASHTO M 291 (ASTM A 563) - Carbon and Alloy, heat treated Steel Nuts, Grades DH and DH3.
 - 3. Washers:
 - a. AASHTO M 293 (ASTM F 436) - Hardened Steel Washers.
 - b. ASTM F 959 Compressible Washer Type Direct Tension Indicators for Use with High Strength Bolts.

(B) Manufacturing

- 1. Bolts - Hardness for bolt diameters 1/2 to 1 in. inclusive shall be as noted below:

<u>Bolt Size, In.</u>	<u>Min.</u>	<u>Hardness Number</u>		<u>Min.</u>	<u>Max.</u>
		<u>Brinell</u>	<u>Rockwell C</u>		
1/2 to 1 in.	248	311	24	33	

2. Nuts - Plain nuts shall be grades, DH, or DH3. Galvanized nuts shall be grade DH.
3. Marking - All bolts, nuts, and washers shall be marked in accordance with the appropriate AASHTO/ASTM Specifications.

(C) Testing:

All high strength bolts, nuts and washers shall be certified to have met the specified tests identified in their individual ASTM Specification design , both as individual components, and as assemblies (Bolts, Nuts, and Washers).

1. Bolts:
 - a. Proof load tests(ASTM F 606 Method 1) are required. Minimum frequency of tests shall be as specified in AASHTO M 164(ASTM A 325) paragraph 9.2.4.
 - b. Wedge tests on full size bolts(ASTM F 606 paragraph 3.5) are required. Minimum frequency of tests shall be as specified in AASHTO M 164(ASTM A 325) paragraph 9.2.4.
2. Nuts - Proof load tests(ASTM F 606 paragraph 4.2) are required. Minimum frequency of tests shall be as specified in AASHTO M 291(ASTM A 563) paragraph 9.
3. Assemblies - Rotational-capacity(RC) tests are required and shall be performed on all bolt, nut, and washer assemblies by the manufacturer or distributor prior to shipping. (See **Subsection 602.17(E)(1) and (2)**). This testing should be performed for complete assemblies each day at the site of bolting.

The following shall apply:

- a. Except as modified herein, the rotational-capacity test shall be performed in accordance with the requirements of AASHTO M 164 (ASTM A 325).
- b. Each combination of bolt production lot, nut lot, and washer lot shall be tested as an assembly. Where washers are not required by the installation procedures, they shall not be included in the lot identification.
- c. A rotational-capacity lot number shall be assigned to each combination of lots tested.
- d. The minimum frequency of testing shall be 2 assemblies per rotational-capacity lot.
- e. The bolt, nut, and washer assembly shall be assembled in a Skidmore-Wilhelm Calibrator or an acceptable equivalent device (note - this requirement supersedes the current AASHTO M 164(ASTM A 325) requirement that the test be performed in a steel joint). For short bolts

which are too short to be assembled in the Skidmore-Wilhelm Calibrator, see paragraph(C)(3)(i).

- f. The minimum rotation, from a snug tight condition (10% of the specified proof load), shall be:

- 240°(2/3 turn) for bolt lengths ≤4 diameters
- 360°(1 turn) for bolt lengths >4 diameters and ≤8 diameters
- 480°(1 1/3 turn) for bolt lengths > 8 diameters

(Note: that these values differ from the AASHTO M 164 Table 6/ASTM A 325 Table 5 Specifications).

- g. The tension reached at the above rotation shall be equal to or greater than 1.15 times the required installation tension. The installation tension and the tension for the turn test are shown below:

Bolt Dia. (in.)	1/2	5/8	3/4	7/8	1	1-1/8	1-1/4	1-3/8	1-1/2
Req. Installation Tension (kips)	12	19	28	39	51	56	71	85	103
Turn Test Tension (kips)	14	22	32	45	59	64	82	98	118

- h. After the required installation tension listed above has been exceeded, one reading of tension and torque shall be taken and recorded. The torque value shall conform to the following:

$$\text{Torque} < 0.25 \text{ PD}$$

Where:

Torque = measured torque (ft-lbs)
 P = measured bolt tension (lbs)
 D = bolt diameter (ft.)

- i. Bolts that are too short to test in a Skidmore-Wilhelm Calibrator may be tested in a steel joint. The tension requirement of Section (C) (3) (g) shall not apply. The maximum torque requirement of Section (C) (3) (h) shall be computed using a value of P equal to the turn test tension shown in the table in Section (C) (3) (g).

(D) Documentation

1. Mill Test Report(s) (MTR):
 - a. MTR shall be furnished for all mill steel used in the manufacture of the bolts, nuts, and washers.
 - b. MTR shall indicate the place where the material was melted and manufactured.
2. Manufacturer Certified Test Report(s) (MCTR):
 - a. The manufacturer of the bolts, nuts, and washers shall furnish certified test reports (MCTR) for the items furnished.
 - b. Each MCTR shall show the conformance to all applicable test requirements, the sites where tests were performed and the date of the tests.
 - c. In addition to the requirements of (D)(2)(a) and (b) above, the manufacturer performing the rotational-capacity test shall include on the MCTR:
 1. The lot number of each of the items tested.
 2. The rotational-capacity lot number as required in Section (C)(3)(c).
 3. The results of tests required in Section (C)(3).
 4. The location where the bolt assembly components were manufactured.
3. Distributor Certified Test Report(s) (DCTR):
 - a. The DCTR shall include the MCTR data required in Section (D)(2) above for the various bolt assembly components.
 - b. The rotational-capacity test performed by the distributor or manufacturer shall be reported on the DCTR.

(E) Shipping - Bolts, nuts, and washers from each rotational-capacity lot shall be shipped in the same container. If there is only one production lot number for each size of nut and washer, the nuts and washers may be shipped in separate containers. Each container shall be permanently marked with the rotational-capacity lot number such that identification will be possible at any stage prior to installation.

908.05-Cast Steel. Steel castings shall conform to the requirements of ASTM A 27, Grade 65-35.

908.06-Steel Forgings. Steel forgings shall conform to ASTM A 668, Class C1, Annealed. A record of the annealing charges shall be furnished the Engineer by the manufacturer; such record shall show the forgings in

each charge, the melt or melts from which they were secured, the chemical analyses of the respective melts, and the details of the annealing treatment.

908.07-Gray Iron Castings. All castings shall be of the type specified and shall be within reasonably close conformity with the dimensions shown on the Plans. The castings shall conform to ASTM A 48, with the additional requirements herein, and unless otherwise specified all castings shall be Class 30.

At the option of the Department, castings may be tested for strength by the transverse method in accordance with ASTM A 438. When tested by the transverse strength method, test specimens of 1.2 in.(30 mm) in diameter broken with an 18 in.(450 mm) span between supports shall meet the following breaking loads:

Class	Breaking load at center min. lbs(Newtons)
No. 20	1,800(8,000)
No. 30	2,200(9,800)

When the transverse test method is used and the test bar fails to meet the load requirements prescribed above, the broken end of the bar may be machined by the manufacturer and tested for tensile strength. If this tension specimen conforms to the requirements of the specified class, it shall be considered as having met, irrespective of the transverse breaking load.

Test bars for both transverse and tension testing shall be cast in accordance with ASTM A 48, Table II, Test Bar B.

All castings shall be cleaned of sand and scale by sand blasting or other effective methods so as to present a smooth, clean, and uniform surface.

Gray iron castings shall have the date of manufacture cast into each unit.

Manhole castings shall have the lid and lid seat of the rim machined to form a true bearing.

All castings shall weigh at least 95% of the theoretical weight shown on the Plans.

908.08-Malleable Castings. Such castings shall conform to ASTM A 47, Grade 35018.

908.09-Bronze Bearing Plates, Plain. These plates shall conform to ASTM B 22, Alloy UNS No. C 91100, or ASTM B 100, Alloy No. 510.

908.10-Bronze Bearing Plates, Self Lubricating. These plates shall be prepared from metal conforming to **Subsection 908.09** of these Specifications. They shall be provided with trepanned or drilled recesses(not grooves) to the extent of not less than 25% of their surface areas. The recesses shall be filled by pressure to produce dense non-plastic, lubricating inserts consisting of graphite and metallic substances, held together by a lubricating binder. With each lot of plates, the manufacturer shall supply additional lubricating material in stick form for an application to the surfaces of the steel plates which bear on and move over the lubricating bronze plates.

The plates shall be furnished from standard production stock by approved manufacturers.

908.11-Corrosion Resistant Steel. Corrosion resistant steel shall conform to ASTM A 588.

The Contractor shall furnish the Engineer a certification from the manufacturer covering each heat number to be used in the work. Each certification shall clearly show that all requirements of this Specification have been met.

908.12-Elastomeric Bearing Pads. Elastomeric bearing pads for use as bearings for bridge beams shall conform to the requirements of Section 18, Division II of the AASHTO Standard Specifications for Highway Bridges.

Unless otherwise specified, plain pads shall be supplied in 70(\pm 5) durometer hardness and laminated pads shall be supplied in 50(\pm 5) durometer hardness.

The manufacturer shall provide certified reports on the lot from which each shipment is made, based on tests made in his own laboratory or a commercial laboratory designated or approved by the Engineer.

908.13-Copper Sheet for Flashing. Sheet copper shall conform to the requirements specified in the current Specifications for Copper Sheet, Strip, Plate, and Rolled Bar, Type ETP, ASTM B 152. The weight per square foot(square meter) shall be as specified on the Plans.

908.14-Pig Lead. Pig lead shall conform to the requirements of ASTM B 29, and shall be common desilverized lead.

908.15-Structural Steel Piles. Structural steel piles shall be rolled steel sections of the weight and shape called for on the Plans. They shall be structural steel meeting the requirements of ASTM A 36. Steel manufactured by the acid-bessemer process shall not be used. Steel piles when placed in the leads shall not exceed the camber and sweep permitted by allowable mill tolerance. Piles bent or otherwise damaged will be rejected.

908.16-Steel Shells. Steel shells shall be of sufficient strength and rigidity to permit their being driven and to prevent harmful distortion caused by soil pressures or the driving of adjacent piles. The shells shall be sufficiently tight to exclude water during the placing of concrete. The tip and butt diameters shall be as shown on the Plans. Shells to be driven without a mandrel shall be equipped with heavy steel driving points. Neither the driving points nor the connecting welds shall project beyond the perimeter of the pile tips.

908.17-Steel Pipes. Steel pipe to be filled with concrete shall conform to the requirements of ASTM A 252, Grade 2. Closure plates for closed end pipes shall conform to the requirements of ASTM A 36.

Pipes shall be of the diameter shown on the Plans. The wall thickness shall not be less than that shown on the Plans, but in no case less than 3/16

908

in.(5 mm). The pipe, including end closures, shall be of sufficient strength to be driven by the specified methods without harmful distortion. Closure plates and connecting welds shall not project beyond the perimeter of the pile tips.

SECTION 909-FENCE, GUARD RAIL AND BARRIER

909.01-Stock Fence 767
909.02-Chain Link Fence 769
909.03-Fence Gates 772
909.04-Water Gates and Water Crossings 773
909.05-Metal Beam Rail 773
909.06-Timber Rail 773
909.07-Guard Rail Posts..... 773
909.08-Guard Rail Hardware 774

SECTION 909-FENCE, GUARD RAIL AND BARRIER

909.01-Stock Fence. Unless otherwise specified, the choice of type and kind of line post to be used, whether wood or steel, and the finish, whether painted or galvanized, will be optional with the Contractor, but he shall not change from the use of one type or kind to the other without written permission of the Engineer. The corner posts, end posts, braced line posts and all fittings and accessories shall be of the kind and have the same finish as the line post.

(a) Unless otherwise specified, the fabric shall be one of the following:

- (1) Galvanized steel woven wire meeting the requirements of ASTM A 116 for No. 11 Farm, Design No. 1047-6-11, Class III Coating.
- (2) Galvanized high tensile strength steel woven wire meeting the requirements of ASTM A 116 for No. 12 1/2 Farm Design, Class III Coating except that the top and bottom strand shall be 10 1/2 gauge and the yield strength shall be equivalent to No. 11 Farm Design 1047-6-11.

(b) Steel Posts and Braces.

Steel line posts shall be one of the following types and shall be of the lengths shown on the Plans:

1. "Studded Tee" posts, weighing 1.33 lbs/ft.(2 kgs/m).
2. "Lug-U" posts, weighing 1.33 lbs/ft.(2 kgs/m).

Each post shall be supplied with a standard anchor plate securely attached to the post.

The end, corner and braced line posts shall be one of the following types and shall be of the lengths shown on the Plans:

1. 2 1/2 x 2-1/2 x 1/4 in.(63.5 x 63.5 x 6 mm) angle steel, weighing 4.10 lbs/ft.(6.1 kgs/m). The braces shall be 2 x 2 x 1/4 inch (50 x 50 x 6 mm) angle, weighing 3.19 lbs/ft.(4.75 kgs/m).
2. 2.0 inch 2.375 O.D.(50 mm, 60O.D.) standard steel black or galvanized pipe or 2.0 in., 2.375 O.D.(50 mm, 60 mm O.D.) triple coated steel pipe, with a 0.130 in.(3.30 mm) minimum wall thickness and coated as specified under **Subsection 909.02**. The braces shall be constructed of 1.25 in.(1.660 O.D) . (32 millimeter, 42 millimeter O.D.) standard steel black or galvanized pipe or D.1.25 in.(1.660 O.D.)(32 mm, 42 mm O.D.) triple coated steel pipe with a 0.111 in.(2.80 mm)

minimum wall thickness and coated as specified under **Subsection 909.02**.

The weights specified for posts and braces are nominal weights and a plus or minus tolerance of 5% will be permitted.

The round end, corner and braced line posts shall be furnished complete with ball caps and other necessary fittings. When galvanized round posts and braces are furnished, they shall be galvanized inside and outside in accordance with ASTM F 1083.

Steel line posts and steel angle for end, corner, braced line posts and braces shall be galvanized. The galvanizing shall be in accordance with ASTM Specification A 123.

Round posts will be required at all corners that vary from 90°.

(c) Wood Posts and Braces.

Wood posts, braces and anchors shall be southern pine, oak, Douglas fir or gum, cut from sound and live trees to dimensions and shapes as shown on the Plans or as otherwise designated, and shall contain no unsound knots. Sound knots will be permitted, provided the diameter of the knot does not exceed one-third of the diameter of the piece at the point where it occurs. All knots shall be trimmed smooth with the face of the timber. The posts shall be free of decayed wood, rot and ring shake.

Post and brace sizes are shown on the Plans in inches.(mm). The size refers to the diameter for round pieces and to the edge dimension for square pieces.

An allowable tolerance of plus or minus 1/4 in.(6 mm) for sawed pieces and plus or minus 1/2 in.(13 mm) for round pieces will be permitted from the dimensions shown on the Plans. A tolerance of 2% will be allowed in the length of both round and sawed posts. The ends shall be sawed square, unless otherwise specified.

Round posts, braces and anchors shall be peeled with all bark and inner skin removed. The timbers shall have a uniform taper with a slope not greater than 1 1/2 inches in 10 ft.(37.5 mm in 3 m). The alignment shall be such that when a line is drawn from the center of the tip to the center of the butt, it shall not fall outside the center of the timber by more than 1% of the length.

Sawed posts, braces and anchors shall be sawed with parallel edges and shall not vary more than 1/4 inch(6 millimeters) from the specified dimensions, except that wane (lack of wood) not exceeding 1/8 of the dimensions of the face and 1/4 of the length of the piece on 1 corner or the equivalent on 2 or more corners will be permitted on not more than ten per cent of the pieces.

Posts, braces, and anchors shall be treated with a preservative treatment, in conformance with the requirements of **Subsection 911.02(a)**. The timbers shall be fabricated or framed before treatment.

(d) Barbed Wire.

The barbed wire shall consist of 2 No. 12 1/2 gauge twisted steel line wires with No. 14 gauge 4-point barbs spaced not more than 5 in.(125 mm) apart. It may be either galvanized or aluminum coated. The galvanized wire shall meet the requirements of ASTM A 121, chain link fence grade.

At the option of the Contractor, high tensile strength wire with barb spacings as designated above, may be used. If the Contractor elects to furnish high tensile strength wire, it shall meet the requirements of ASTM A 121, chain link fence grade for the respective wire size.

909.02-Chain Link Fence. Unless otherwise specified, the chain link fence fabric may be either of the following kinds: (a) zinc coated steel, (b) aluminum coated steel or (c) aluminum alloy, but the Contractor shall not change from the use of 1 kind to another without written permission of the Engineer.

A. Fabric.

The fabric shall be of the chain link type, meeting the requirements of AASHTO M 181. If galvanized, the fabric shall be of Type I, Class D. All chain link fabric shall be manufactured of No. 9 gauge wire pickets, forming a uniform 2 in.(50 mm) mesh, and shall be the height shown on the Plans or specified in the Contract.

B. Line Posts.

The line posts shall be 1 of the following types, and of the lengths shown on the Plans. They shall be 1.5 in.(1.900 O.D (38 mm, (48 O.D.)) galvanized steel pipe meeting the requirements of ASTM Specification F 1083, or 1.875 x 1.625 in.(47 x 41 mm) galvanized rolled form steel Standard C-Section meeting the requirements of ASTM Specification A 570 Grade E, or 1.875 x 1.625 in.(47 x 41 mm) galvanized H-Section or. 1.5 in.(1.900 O.D.)(38 mm, (48 O.D)) aluminum-alloy standard (ANSI Schedule 40) pipe meeting the requirements of ASTM Specifications B 429, Alloy 6063, Temper T6, or. 1.5 in.(1.900 O.D.)(38 mm, (48 O.D.)) triple coated steel pipe with a 0.120 in.(3 mm) minimum wall thickness and meeting the following specifications.

(1) Description.

The pipe shall be manufactured by cold rolling and electric resistance welding of steel strip conforming to ASTM A 569, ASTM A 607 or ASTM A 446 Grade D. All tubing shall be given corrosion protection by in-line application of

hot-dip galvanizing, followed by a chromate conversion coating and an electrostatically applied clear acrylic or polyester coating on the outside surface. The inside surface shall be given corrosion protection by hot-dip galvanizing or by in-line application of a zinc rich paint after fabrication.

(2) Protective Coatings.

External

- i. Hot-Dipped Zinc Coating per ASTM B 6 high grade and special high grade. The weight of the hot-dipped zinc coating shall be a minimum of 0.8 oz./s.f.(245 grams/m²). The weight of zinc coating shall be determined in accordance with ASTM A 90.
- ii. The electrostatically applied clear acrylic or polyester coating thickness shall be at least 0.1 mils(2.5 µm).

Internal

The interior surface shall be hot-dip galvanized with a minimum of 0.9 ounce(25 grams) of zinc or painted after welding with a 0.3 mil(7.5 µm) thickness of zinc rich paint. The coating shall be not less than 80% zinc powder by weight and capable of providing galvanic protection.

C. End Posts, Corner Posts, and Braces.

The end and corner posts shall be 2.0 in., (2.375 O.D.)(50 mm(60 O.D.)) galvanized standard steel pipe meeting the requirements of ASTM Specification F 1083, or 2 in.(2.375 O.D.)(50 mm(60 O.D.)), aluminum alloy standard (ANSI Schedule 40) pipe, meeting the requirements of ASTM Specification B 429, Alloy 6063, Temper T6, or 2 in., 2.375 O.D.(50 mm(60 O.D.)) triple coated steel pipe with a 0.130 in.(3.3 mm) minimum wall thickness and meeting the specified requirements as set forth under Paragraph (b).

End and corner post braces shall be 1.25 in., 1.660 O.D. (32 mm(42 O.D.)) galvanized standard steel pipe meeting the requirements of ASTM Specification F 1083, or 1.25 in.(1.660 O.D.)(32 mm(42 O.D.)) aluminum-alloy standard (ANSI Schedule 40) pipe, meeting the requirements of ASTM Specification B 429, Alloy 6063, Temper T6, or 1.25 in., 1.660 O.D.(32 mm(42 O.D.)) triple coated steel pipe with a 0.111 in.(2.8 mm) minimum wall thickness and meeting the specified requirements as set forth under Paragraph (b).

D. Top Rail.

The top rail shall be 1.25 in.(1.660 O.D.)(32 mm(42 O.D.)) galvanized standard steel pipe meeting the requirements of ASTM Specification F 1083, or 1.25 in.(1.666 O.D.)(32 mm(42 O.D.)) aluminum-alloy standard (ANSI Schedule 40) pipe, meeting the requirements of ASTM Specification B 429, Alloy 6063, Temper T6, or 1.25 in., 1.660 O.D.(32 mm(42 O.D.)), triple coated steel pipe with a 0.111 in.(2.8 mm) minimum wall thickness and meeting the specified requirements as set forth under Paragraph (b).

E. Barbed Wire.

1. Steel barbed wire shall meet the requirements of **Subsection 909.01(d)**.
2. Aluminum alloy barbed wire shall consist of two twisted strands of 0.110 in.(2.8 mm) line wire with 0.080 in.(2 mm) diameter 4-point barbs spaced not more than 5 in.(125 mm) apart. The wire and barbs shall meet the requirements of ASTM B 211 alloys of 5052-0 for the wire and 5052-H38 for the barbs.

F. Miscellaneous Fittings and Hardware.

1. Zinc-coated miscellaneous fittings and hardware shall be commercial grade steel or better quality, pressed, wrought or cast as appropriate to the article, and sufficient in strength and other properties to provide a balanced design when used in conjunction with fabric, posts and wires of the quality specified herein. All steel fittings and hardware shall be galvanized in accordance with AASHTO M 111.
2. Aluminum alloy miscellaneous fittings and hardware shall be wrought or cast aluminum conforming to the requirements of AASHTO M 181, Table I.

G. Wire Ties.

Wire ties shall be No. 9 gauge and shall be zinc-coated steel, aluminum-coated steel, or aluminum alloy, sufficient in strength and other properties to provide a balanced design when used in conjunction with fabric, posts and wire of the qualities specified herein.

H. Tension Wire.

Tension wire shall meet the requirements of AASHTO M 181.

I. Truss Rods and Turnbuckle.

Truss rods shall be 5/16 in.(7.94 mm) diameter, shall be equipped with a turnbuckle having a take-up of not less than 4

in.(100 mm) and shall be galvanized in accordance with AASHTO M 111.

J. Polyvinyl Chloride Chain Link Fence

All posts, fabric and other hardware of polyvinyl chloride chain link fence shall be steel meeting the dimensional and material requirements specified herein and shall be coated in accordance with AASHTO M 181, Type IV, Class B.

Posts shall be fitted with ornamental tops or extension arms as shown on the Plans. Ornamental tops for tubular posts shall have a base fitting into the post with a flange extending over the top of the posts to protect the post against moisture. Extension arms shall be vertical or extend in or out from the fence line at approximately 45° as specified on the Plans. The extension arms shall be suitably notched or slotted to support and space the barbed wire.

Fabrication of all materials shall be within reasonably close conformity to the sizes, shapes, dimensions and other factors set out in these Specifications or shown on the Plans, and shall show careful, finished workmanship.

The weights specified for steel posts, braces and rails are nominal weights, and a plus or minus tolerance of 5% will be permitted.

909.03-Fence Gates. Fence gates shall be of the kinds and sizes shown on the Plans. They shall be swing type, complete with latches, stops, keepers, hinges, and fabric. The latch shall have provision for fastening with a padlock. The gates shall be covered with fabric matching the fence. The hinges shall be of adequate strength to support the gate and shall not twist or turn under action of the gate. The gates, gate posts and braces shall be of the same kind and finish as the adjoining fence. All gate posts and rails shall be furnished complete with ball caps and rail ends.

A. Stock Fence Gates.

1. Posts and braces for stock fence gates shall be standard weight steel pipe complying with ASTM F 1083 or triple coated steel pipe meeting the requirements of **Subsection 909.02(b)** and furnished with all necessary fittings. The nominal diameter and length shall be as shown on the Plans for the particular gate opening.
2. The gate frames shall be the type and size specified, and shall be constructed in accordance with the details and of the materials shown on the Plans.
3. The fabric for stock fence gates shall be of the woven wire type meeting the requirements of ASTM A 116, Class II coating, and of the design shown on the Plans.
4. Barbed wire for stock fence drive gates shall meet the requirements of **Subsection 909.01(d)**, and shall be attached to the gate frame as indicated on the Plans.

5. Fittings shall be of malleable iron or pressed steel and shall be of approved design.

All gate frames, posts, braces and fittings for stock fence gates shall be galvanized. The galvanizing shall be in accordance with ASTM F 1083 or ASTM A 123, whichever is applicable.

B. Chain Link Fence Gates.

1. Posts, braces and framing members for chain-link fence gates shall be standard weight pipe meeting the requirements of **Subsection 909.02(b)**. The size and length of the posts and braces and the size and dimensions of framing members shall be as shown on the Plans.
2. Fabric for chain-link fence gates shall be of the chain-link type and shall meet the requirements of **Subsection 909.02(a)**. The height of the fabric shall be that shown on the Plans.
3. Barbed wire for chain-link fence gates shall meet the requirements of **Subsection 909.02(e)**.
4. Miscellaneous fittings and accessories for chain-link fence gates shall meet the applicable requirements of **Subsection 909.02(f), (g), and (h)**. The hinges shall be of such design to allow the gate to swing back 180°, parallel with the fence line.

909.04-Water Gates and Water Crossings. Posts, braces and accessories for water gates and water crossings shall be of the types, kinds and dimensions shown on the Plans, or directed by the Engineer, and shall meet the applicable quality requirements of **Subsection 909.01** or **909.02**.

Timber for water gates shall be of the dimensions shown on the Plans, or directed by the Engineer, and shall meet the requirements of **Subsection 911.02**.

909.05-Metal Beam Rail. The rail elements shall be corrugated sheet steel beams conforming to the requirements of AASHTO M 180, with the following exception:

The beams shall be galvanized. The Class and Type shall be as indicated on the Plans.

909.06-Timber Rail. The timber rail shall be of the dimensions shown on the Plans and shall meet the requirements of **Subsection 911.01**.

When treated timber is specified, it shall conform to the requirements of **Subsection 911.02(a)**.

909.07-Guard Rail Posts. Railing posts shall be wood or steel, and of the section, weight and length shown on the Plans. The steel shall conform to ASTM A 36 and shall be galvanized in accordance with ASTM A 123. The wood shall conform to **Subsection 911.02(a)**.

909.08-Guard Rail Hardware. Offset brackets of the resilient and non-resilient types shall be of the type specified.

Splices and end connections shall be of the type and design specified and shall be of such strength as to develop the full design strength of the rail elements.

End spring assemblies, when specified, shall be positive and of a type and design coinciding with the intent, design and strength of the railing structure, as shown on the Plans.

End anchor rods and accessories shall be as specified and shall be of such size and strength as to develop the full design strength of the rail elements.

Unless otherwise specified, all steel fittings, bolts, washers and other accessories shall be galvanized in accordance with the requirements of AASHTO M 111 or ASTM A 153, whichever may apply. All galvanizing shall be done after fabrication. Mechanically Applied Zinc Coating as specified in ASTM B 695 and meeting Class 50 coating thickness shall be acceptable as an alternate for Hot-Dipped Galvanizing specified in AASHTO M 232.

Aluminum alloy fittings, bolts, washers and other accessories shall conform to the requirements shown on the Plans.

NOTES:

910

SECTION 910-PAINT

910.01-General Requirements 777
910.02-Quick Dry Traffic Marking Paint (White and Yellow) 777
910.03-Inorganic Zinc Paint System for Steel Structures 780

SECTION 910-PAINT

910.01-General Requirements. Before any paint is manufactured under these Specifications, the Department shall be contacted for a sampling, testing and inspection procedure. All paint furnished under these Specifications shall be proportioned in accordance with the characteristics requirements set forth herein. Compounding shall be from ingredients or component materials that have been found to conform with the appropriate detailed Specifications as set forth below by reference or otherwise.

Paint shall be sufficiently ground so that it will not compact on settling to the extent of interference with ready return to a smooth, uniform paint of good brushing or spraying consistency when stirred vigorously with suitable paddles or when boxed from container to container.

Fifty-five gallon(208 liter) drums, equipped with efficient mechanical stirring devices, may be used for delivery of shop coat paint to fabricating shops which are equipped to handle them adequately. Fifty-five gallon(208 liter) drums equipped with stirring devices may also be used for delivery of paints to projects requiring large quantities, when authorized in writing by the Department. In all other cases, delivery of lots of 5 gallons(18.9 liter) or more shall be made in 5 gallon(18.9 liter) circular type metal pails constructed of 26 gauge or heavier metal. Each container shall be equipped with a full-top removable and replaceable lid and with a bail of sufficient strength to support the pail completely filled with the specified paint. Each container shall bear a label showing the name and address of the manufacturer, the kind and color of paint, formula, net content of container, date of manufacture and lot number.

Paint that has been manufactured for a period of time greater than 6 months shall be reinspected prior to approval for use.

910.02-Quick Dry Traffic Marking Paint (White and Yellow). These specifications cover quick dry white and yellow traffic paint, also referred to as pigmented binder, for use in marking traffic lanes or barrier lines on bituminous and concrete highways.

- (a) General Requirements. The pigmented binder shall be properly formulated so as to be suitable for application by spray equipment when heated to 130°F(55°C) maximum and applied on bituminous or portland cement concrete pavements.
- (b) Drop on Glass Beads. The glass beads drop-on type, shall meet the requirements of AASHTO M 247 Type I, Type.
- (b) Paint.

Characteristic requirements.

1. Pigment content shall be between 58% and 65% by weight. Pigment for white paint shall contain 0.99 lbs/gal.(120 grams/l) of 94% titanium dioxide. Pigment for yellow paint

- shall be lead free and contain 0.22 lbs/gal.(26 grams/l) minimum of 94% titanium dioxide.
2. Total non-volatile shall not be less than 76% by weight.
 3. Vehicle non-volatile shall not be less than 41% by weight. Vehicle shall be Rohm and Haas E-2706, DOW DT211NA or an approved equal.
 4. Minimum weight shall not be less than 13.3 lbs./gal.(1,600 grams/l).
 5. The paint viscosity shall be between 78 and 95 Kres units when tested at $77 \pm 1^\circ$ F($25 \pm 1^\circ$ C) in accordance with ASTM D 562.
 6. Drying Time:
 - FIELD -The paint shall dry to a no-tracking condition in 3 minutes when applied at 15 ± 1 mil(380 ± 25 μ m.) wet film thickness with a bead application rate of 6 lbs./gal.(0.7 kgs/l) of glass spheres per gallon(liter) of binder, when the pavement temperature is between 40 and 120° F(4 and 49° C) and the relative humidity is not exceeding 80%. The pigmented binder shall be applied with specialized equipment so as to have the binder at a temperature of 100 to 130° F(35 to 55° C) at the spray gun. The no-tracking condition shall be determined by passing over the line as applied above in a simulated passing maneuver with a passenger car travelling 35 mph(56 kph.). A line showing no visual deposition when viewed from a distance of 50 ft.(15 m) shall be considered as conforming to this drying requirement.
 - LAB - The pigmented binder without glass spheres, shall dry to no-pick-up condition in 10 minutes or less when tested in accordance with ASTM D 711.
 7. The paint shall meet the current EPA VOC requirements or 150 grams/l whichever is lower.
 8. The ph of the paint shall be a minimum of 9.6.

Qualitative Requirements.

The finished paint shall meet the following quality requirements:

1. Condition in container: The paint received shall show no livering, skinning, mold growth, corrosion of the container, or hard settling of the pigment. Any settling shall be readily dispersed when stirred by hand with no persistent foaming.
2. Color: The color for white after drying shall be flat white, free from tint, furnishing good opacity and visibility under both daylight and artificial light. For yellow, the color shall closely match chip 33538 of Federal Standard 595B.
3. Flexibility: The paint shall show no cracking or flaking when tested on a $\frac{1}{2}$ in.(13 mm) mandrel in accordance with Federal Specification TT-P-1952B.
4. Dry Opacity: The minimum contrast ratio shall be 0.95 when drawn with a 0.005 Bird Applicator.

5. Daylight Reflectance: The daylight directional reflectance of the white paint shall be not less than 85% and not less than 50% for yellow(relative to manganese oxide) when measured in accordance with Federal Test Method No. 1416.
6. Bleeding: The paint shall have a minimum bleeding ratio of 0.97 when tested in accordance with Federal Specification TT-P-1952B.
7. Scrub Resistance: The paint shall pass 300 cycles when tested in accordance with ASTM D 2484.
8. Freeze-Thaw Stability: The paint shall show no change in consistency greater than 10% when tested in accordance with Federal Specification TT-P-1952B.
9. Storage Stability: When stored at 77 ± 2 °(25 ± 2 °C) in a 3/4-filled can for a period of 30 days, the paint shall be in a homogeneous state with no skinning, curdling, hard settling or caking that cannot be readily remixed.

(e) Inspection, Testing, Packaging, and Marking.

All paint furnished under this specification shall be proportioned in accordance with the characteristic requirements set forth herein. Compounding shall be from ingredients or component materials that have been found to conform with the detail specifications as set forth herein by reference or otherwise. After manufacture, a 0.5 pt.(l) sample along with certified laboratory analysis for each batch shall be sent to the Division of Materials and Tests. A qt.(l) sample and a manufacturer's certification that the glass beads meet the requirements of ASSHTO M 247 for the type beads, shall be sent to the Division of Materials and Tests for each batch or lot of glass beads shipped for use on Tennessee projects.

Each shipment of paint and beads shall be accompanied by a detailed analysis for that particular batch and certification that all ingredients meet the requirements set forth in this specification.

The Department reserves the right to perform in-plant sampling of ingredients and finished product during manufacturing operations and to sample the packaged product when it is received by the Department. Acceptance of the product may be withheld until analysis of samples has been completed.

All paint shall be shipped in new containers that can be properly sealed.

All containers shall be plainly marked or labeled to show the following information: Description of paint, color, net gal.(liters), name of manufacturer, batch number and date of manufacture(month and year).

910.03-Inorganic Zinc Paint System for Steel Structures.

Prior to approval and use of any inorganic paint system, the manufacturer shall submit in triplicate to the Department a certified test report from an approved testing laboratory showing specific test results conforming to all requirements of these Specifications.

Inorganic Zinc

This system shall be composed of an inorganic zinc silicate primer with (1) a vinyl finish coat or (2) an intermediate tie coat followed by a high-build aliphatic urethane finish coat. The finish coat shall be as specified on the plans. The intermediate tie coat shall be one recommended by the manufacturer of the top coat. All coatings used in this system shall be supplied by the same manufacturer to insure compatibility.

1. Inorganic Zinc Silicate Primer

This paint shall be either a two-component or acid catalyzed single component, self-cure ethyl silicate zinc rich paint which, when mixed and applied in accordance with these Specifications, cures without the use of a separate curing solution, and shall have the properties described here-in.

Pigment.

The zinc portion of the pigment shall be a finely divided zinc powder containing, by weight, a minimum of 96% metallic zinc. All other materials contained in the pigment or pigment component shall be inert.

Vehicle.

The vehicle component of the 2-component type shall have a store-life at 77° F(25° C) of not less than 12 months.

Mixed Paint.

The single package paint or the 2-compound paint mixed in accordance with the manufacturer's instructions, shall meet the following requirements:

Weight per gallon(liter) at 77° F(25° C), not less than 17 lbs.(2 kgs);

Per cent total solids, by weight:

Single component, not less than 67.0

Two-component, not less than 72.0;

Per cent metallic zinc, by weight, of total solids:

Single component, not less than 81.0

Two component, not less than 75.0;

The 2-component type shall have a usable pot life of not less than 8 hours at 77° F(25°C). The single component type shall have a storage life of not less than 6 months. There shall be no hard settling which cannot be easily dispersed during either the pot life or storage life periods.

The inorganic zinc coating shall be so formulated as to produce a distinct contrast in color with the blast-cleaned metal surfaces and with the vinyl finish coat.

Properties of Mixed Paint:

Test panels of steel meeting the requirements of ASTM D 609 having dimensions of 2 x 5 x 1/8 in.(50 x 125 x 3 mm), shall be prepared by cleaning all surfaces as designated in **Subsection 603.05**. A 3 mil(75 µm) coating, (dry thickness), shall be applied to the test plates in accordance with the manufacturer's current printed instructions. The coating shall be cured as recommended by the manufacturer. Each of the following tests shall be performed. If any individual test panel fails any of the following tests, the material will not be accepted.

Fresh Water Resistance

Panels shall be scribed down to base metal with an X of at least 2 in.(50 mm) legs and shall be immersed in fresh tap water at 75° F ±5° F(24° C ±3° C). The panels shall show no rusting, blistering or softening when examined after 30 days.

Salt Fog Resistance.

Panels shall be scribed with an X of at least 2 in.(50 mm) legs down to the 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 in.(1.60 mm) from the center of the scribe mark.

Resistance to Elevated Temperatures and Thermal Shock.

Panels shall be exposed to a temperature of 500° F(260° C) for one hour, then quenched immediately in 65°±5°F(18° ±3° C) water. Panels subjected to these tests shall show no blistering or flaking of the coating.

Packaging and Labeling.

Inorganic zinc paint shall be packaged in two-component containers or in two separate containers. The components shall be

packaged in such proportions that the pigment when mixed with the vehicle, will yield 5 gal.(18.9 l) of mixed paint. Each container shall bear a label on which shall be clearly shown the name of the manufacturer, brand name of paint, the lot number, and date of manufacture. The label on the vehicle container shall also include complete instructions for use of this paint. The container shall be coated if necessary to prevent attack by the paint components.

The manufacturer's current printed instruction for application of inorganic zinc coating shall be submitted to the Materials and Tests Division, Tennessee Department of Transportation, for review and approval. The manufacturer of the inorganic zinc coating shall furnish a technical representative to assist and advise the applicator in the sandblasting and application of the zinc and vinyl finishes.

2. Intermediate Tie Coat.

The Intermediate Tie Coat shall display compatibility with and adhesion to the cured inorganic zinc when applied directly over the inorganic zinc paint in accordance with the manufacturer's printed instructions. Delete the entire section regarding **Composition.**

3. High Build Aliphatic Polyurethane Finish Coat

Composition.

The high build aliphatic polyurethane finish coat shall be a two-component, weather resistant topcoat, containing no free oils, having excellent resistance to splash and spillage of acids, alkalies, solvents, salts and water. It shall provide adequate hiding when applied in a single coat directly over intermediate tie coat. The manufacturer will establish typical density value and tolerance for each component and for the mixed paint.

The minimum weight of the mixed paint shall be no less than 13 lbs./gal.(.55 kgs/l) and shall have a solid content of no less than 58% by volume.

The mixed paint shall be of such formulation that it can be applied in a single application, without sagging, to yield a 3 mil(75 μ m) dry film thickness.

Qualified Products List Acceptance

Prior to approval and use of any paint, the manufacturer shall submit in triplicate to the Department a certified test report from an approved testing laboratory showing specific test results conforming to all requirements of these specifications. The certified test report shall 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. In addition the certified test report shall include data showing that after 250 hours exposure of 4 hour wet/dry cycles at 122° F(50° C) in a QUV cabinet using "B" bulbs the color will not vary more than 4.0 CIE Lab units from an unexposed control panel. Paint meeting the above requirements will be placed on the Department's Qualified Products List. The Department will require recertification every 2 years. Certified test results shall be submitted any time the manufacturing process or the paint formulation is changed and may be required by the Department when random sampling and testing of the material offered for use indicates nonconformance to any of the requirements herein specified.

Certifications

No paint shall be applied, either in the shop or the field, until the manufacturer of the paint has furnished the Engineer a letter of certification in triplicate stating that the material supplied conforms to the requirements specified above for prequalification and has the same formulation as the prequalified material. The Engineer reserves the right to sample and test any or all materials supplied.

SECTION 911-TIMBER AND TIMBER PILES

911.01-Timber	786
911.02-Untreated and Treated Timber	787
911.03-Timber Piles	787

SECTION 911-TIMBER AND TIMBER PILES

911.01-Timber.

(a) General.

Grading and terminology shall be as specified in AASHTO M 168. The requirements provided hereinafter are basically for bridge and miscellaneous roadway materials. Whenever lumber or timbers are to be used in buildings (houses or similar type structures) the treatments shall be with one of the type preservations noted in AASHTO M 133, applied in accordance with and at the rates specified in the current AWP procedure for such treatment.

(b) Species of Woods.

The species of wood used shall be Southern Yellow Pine unless otherwise indicated on the plans. Southern Yellow Pine shall be of at least medium grain.

(c) Grades of Timber.

Lumber ordered in multiple lengths shall be graded after having been cut to length. When so specified on the plans or in the proposal, lumber for permanent use in structures shall be grade marked or hammer stamped by a recognized acceptance agency. The grades recognized by these specifications together with the extreme allowable fiber stresses in bending for each stress grade are as follows:

1. Yard Lumber.

C Finish--A choice quality grade for finish purposes, reasonably clear, and without defects or blemishes which detract from a finish appearance, especially when painted.

No. 1----Sound and tight knotted stock. Size of defects and blemishes limited.

No. 2----Allows somewhat (approximately 50%) larger and coarser defects than No. 1. May be considered grain tight lumber.

2. Structural Timber.

Allowable Unit Stress-Visually Graded in Accordance with current Grading Rules of SPIB. Allowable stress shall be in accordance with the current SPIB.

3. Stress Grades For Structural Purposes.

Where the specifications or Plans call for standard stress grades for the various structural purposes, material of the

grades provided for the various uses shall be as noted on the Plans.

911.02-Untreated and Treated Timber.

(a) Treated Timber.

Treated timber shall be interpreted to mean timber of the species called for treated by a pressure method to retain the minimum quantity per c.f.(m³) of the provided preservative stipulated. The preservatives used shall meet the requirements for the particular type provided as specified in AASHTO M 133.

For timber that is to be pressure treated there shall be no heartwood requirement or sapwood limitation.

(b) Untreated Timber, Heart Requirements.

All timber to be used without preservative treatment shall show not less than the following amounts of heartwood:

Stringers, floorbeams and flooring, 80% of heart of any girth.

Caps, sills and posts, 75% of heart on each of the four sides measured across the side.

Bracing, struts, rails, etc., 80% of heart on both sides measured across the side.

Structural timber, treated, will not be accepted for use unless it has been inspected and found satisfactory both before and after treatment.

911.03-Timber Piles.

(a) General.

All timber piles shall be cut from live, solid, sound trees, preferably during the winter season. They shall be free from defects such as injurious ring shakes, large, loose or unsound knots, decay or other defects which might impair their strength or durability. Sound knots will be permitted provided the greatest diameter of the knot does not exceed 4 in.(100 mm) or 1/3 of the diameter of the pile at the point where it occurs. The butts shall be sawed square.

Round piles shall have a minimum diameter at the tip and at a section 3 ft.(1 m) from the butt, measured under the bark as follows:

Length of Pile	Tip Diameter	Butt End Diameter
20 ft. and under (6 m and under)	8 in. (200 mm)	11 in. (275 mm)
Over 20 feet thru 40 ft. (Over 6 m thru 12 m)	8 in. (200 mm)	12 in. (300 mm)
Over 40 ft.thru 60 ft. (Over 12 m thru 18 m)	7 in. (175 mm)	12 in. (300 mm)
Over 60 ft. (Over 18 m)	6 in. (150 mm)	13 in. (325 mm)

The diameter of the piles at the butt shall not exceed 18 in.(450 mm).

Square piles shall have the dimensions shown on the Plans.

Piles shall be cut above the ground swell. All piles shall be peeled so as to remove all the rough or outer bark and at least eighty per cent of the inner bark.

No strip of inner bark larger than 3/4 x 8 in.(19 x 200 mm) shall be left on the pile and there shall be a space at least 1 in.(25 mm) wide between strips. At least 80% of any circumference shall be free from inner bark.

The piles shall have a uniform taper from butt to tip, shall be straight grained and shall meet the following requirements for alignment: A line drawn from the center of the butt to the center of the tip shall not fall outside the center of the pile more than 0.75% of the length at any point. Piles shall be free from reverse bends. In short bends, the distance from the center of the pile to a line stretched from the center of the pile above the bend to the center of the pile below the bend shall not exceed 4% of the length of the bend or 2 1/2 in.(65 mm). All knots shall be trimmed close to the body of the piles. Piles shall be free from twist exceeding 1/2 the circumference in any 20 ft.(6 m) length.

(b) Untreated Timber Piles.

Untreated timber piles shall conform to all the general requirements for timber piles of this Subsection with the following additions:

1. Timber piles, untreated, which will be below water level at all times, may be of any species of wood which will satisfactorily withstand driving.
2. Timber piles, untreated, to be used in exposed work, shall be one of the following species: white oak, post oak, cypress, or southern yellow pine, except loblolly pine, and shall have a

diameter or heartwood of not less than 80% of the required diameter of the pile.

(c) Treated Timber Piles.

Treated timber piles may be of any species which will satisfactorily withstand driving and which will take the required preservative treatment.

Treated timber piles shall conform to all the general requirements for timber piles of this Subsection, and the timber piles shall be treated with a preservative noted in AASHTO M 133 in accordance with requirements of the current AWPA procedure.

912

SECTION 912-BRICK

912.01-Building Brick	791
912.02-Sewer Brick	791
912.03-Masonry Mortar.....	791
912.04-Concrete Masonry Units.....	791

SECTION 912-BRICK

912.01-Building Brick. Brick, when made from clay or shale, shall conform to AASHTO M 114; when made of concrete, they shall conform to ASTM C 55. The kind and grade shall be as specified.

912.02-Sewer Brick. Brick shall conform to AASHTO M 91

912.03-Masonry Mortar. Mortar shall be composed of 1 part Portland cement, and 2 parts sand. Hydrated lime in an amount not to exceed 10%, may be added to Portland cement. Water shall be added to the mixture in such quantity as to form a stiff paste.

The mortar shall be hand-mixed or machine-mixed. In the preparation of hand-mixed mortar, the sand, cement and hydrated lime shall be thoroughly mixed together in a clean, tight, mortar box until the mixture is of uniform color, after which water shall be added. Machine-mixed mortar shall be prepared in an approved mixer, and shall be mixed not less than 1-1/2 minutes.

Mortar shall be used within 30 minutes after mixing. Retempering of mortar will not be permitted.

Materials used shall conform to the following Specifications:

<u>Material</u>	<u>Subsection or spec</u>
1.Cement	901.01
2.Hydrated Lime	ASTM C 207
3.Sand	903.02
4.Water	918.01

912.04-Concrete Masonry Units. Concrete masonry units shall conform to the types, sizes and dimensions shown on the Plans, and shall meet the following requirements:

- (a) Hollow Load-Bearing masonry units shall meet the requirements of ASTM C 90, and unless otherwise specified shall be Grade 5, Type II.
- (b) Hollow Non-Load-Bearing masonry units shall meet the requirements of ASTM C 129, and unless otherwise specified, shall be Type II.

Representative samples of the masonry units shall be furnished the Department for testing.

913

**SECTION 913-CEMENT CONCRETE CURING
MATERIALS**

913.01-Water	793
913.02-Earth	793
913.03-Straw, Hay, Etc.....	793
913.04-Burlap	793
913.05-Liquid Membrane-Forming Compounds.....	793

SECTION 913-CEMENT CONCRETE CURING MATERIALS

913.01-Water. Water used in curing portland cement concrete shall be free from any substance which may be injurious to concrete when applied on the surface as a curing agent.

913.02-Earth. Earth used in curing portland cement concrete shall be free of sticks, stones or other ingredients which may be detrimental to the surface of the concrete and shall be of such nature as will retain moisture a reasonable length of time.

913.03-Straw, Hay, Etc. Straw, hay, etc., used to cure portland cement concrete shall be reasonably clean and free of sticks, or other material which will be injurious to or mar the concrete. When these materials are used for insulation in cold weather, they shall be new (not just reused), and dry.

913.04-Burlap. Burlap shall conform to AASHTO M 182, Class 3 or Class 4. If Class 1 or Class 2 burlap is permitted, at least 2 layers shall be used.

913.05-Liquid Membrane-Forming Compounds. These compounds shall conform to AASHTO M 148.

Where applied texture finish is specified, a Type 1-D, Class B, membrane which is compatible with the texture finish shall be used. Either Type 2 membrane or Type 1-D, Class B, membrane may be used on bridge decks when applied in combination with the water method of curing. Type 2 membrane shall be used in all other applications.

913.06-Sheeting Material for Curing Concrete. This material shall conform to the water vapor transmission rates specified in AASHTO M 171

914

SECTION 914-NON-METALLIC PIPE

914.01-Non-reinforced Concrete Pipe 795
914.02-Reinforced Concrete Pipe..... 795
914.03-Perforated Concrete Pipe 795
914.04-Drain Tile 795
914.05-Clay Pipe 795
914.06-Vitrified Clay Pipe..... 795
914.07-Plastic and Polyethylene Corrugated Tubing 795
914.08-Precast, Concrete Box Sections 795
914.09-Polyvinyl Chloride (PVC) Pipe 796

SECTION 914-NON-METALLIC PIPE

914.01-Non-reinforced Concrete Pipe. This pipe shall conform to ASTM C 14 for the specified diameters and strength classes. All non-reinforced concrete pipe shall be made in accordance with the TDOT procedure for the Manufacture and Acceptance of precast Drainage Structures, Noise Wall Panels, and Retaining Wall Panels.

914.02-Reinforced Concrete Pipe. This pipe shall conform to ASTM C 76 for the specified diameters and strength classes. Horizontal and vertical elliptical pipe shall conform to ASTM C 507. Arch pipe shall conform to ASTM C 506.

Precast reinforced concrete end sections shall conform to the cited Specifications to the extent to which they apply.

All reinforced concrete pipe shall be made in accordance with the TDOT procedure for the Manufacture and Acceptance of Precast Drainage Structures, Noise Wall Panels, and Retaining Wall Panels.

914.03-Perforated Concrete Pipe. This pipe shall conform to AASHTO M 175 or to ASTM C 444, for the specified diameters, and unless otherwise specified, it shall be standard strength.

914.04-Drain Tile. This pipe shall conform to AASHTO M 178 or M 179 for the specified material and diameters. Unless otherwise specified, the pipe shall be of standard quality class. When specified, the pipe spigot shall have integral spacer lugs to provide for an annular opening and self-centering feature.

914.05-Clay Pipe. This pipe shall conform to AASHTO M 65 for pipe with full circular cross section for the specified diameter and strength class. When specified, the bell shall have integral spacer lugs to provide for an annular opening and self-centering feature.

914.06-Vitrified Clay Pipe. This pipe shall conform to AASHTO M 65 for the specified diameters and strength classes for circular, unperforated pipe.

914.07-Plastic and Polyethylene Corrugated Tubing. Tubing accepted under this Specification shall conform to the requirements of AASHTO M 252 or ASTM F 405 for Heavy Duty Tubing, except as noted below:

Tubing having an elongation greater than 5% but less than 10% shall be deemed acceptable provided minimum pipe stiffness requirements in Table 1 are met when tested in accordance with ASTM F 405, Section 8.5, except that a 12 in.(300 mm) base plate shall be used.

914.08-Precast, Concrete Box Sections. Precast reinforced concrete box sections for culverts, storm drains and sewers shall meet the requirements of AASHTO M-273, M-259 or ASTM C-1433. All precast concrete box sections shall be made in accordance with the TDOT procedure on the

914

Manufacture and Acceptance of precast Drainage Structures, Noise Wall Panels, and Retaining Wall Panels.

914.09-Polyvinyl Chloride Pipe(PVC) . Pipe accepted under this Specification shall conform to the requirements of ASTM D 1785.

914.10, High Density Polyethylene Plastic Pipe Pipe accepted under this specification shall conform to the requirements of AASHTO M 294, Type S.

SECTION 915-METALLIC PIPE

915

915.01-Ductile Iron or Cast Iron Pipe..... 798
915.02-Corrugated Metal Pipe Culverts, Pipe Arches and Underdrains 798
915.03-Precoated, Galvanized Steel Culverts and Underdrains 798



SECTION 915-METALLIC PIPE

915.01-Ductile Iron or Cast Iron Pipe. Ductile iron pipe shall conform to the requirements of ASTM A 716 for the specified diameters and strength classes. Unless otherwise specified, either smooth, corrugated or ribbed pipe may be furnished. Pipe of diameter in excess of 48 in.(1,200 mm) shall conform to ANSI Standard for Cast Iron Pipe for the specified diameter and strength class. Cast iron drain pipe shall conform to ASTM A 74. Unless otherwise specified, ductile iron pressure pipe for water lines or sewer construction shall conform to the requirements of ASTM A 377 for the diameters and working pressures specified.

915.02-Corrugated Metal Pipe Culverts, Pipe Arches and Underdrains. When zinc-coated (galvanized) corrugated iron or steel pipe, pipe arches or underdrains are used, these pipes and all special sections such as elbows and flared end sections, shall be the same thickness and shall conform to AASHTO M 36. Shop-formed elliptical pipe and shop-strutted pipe shall be furnished only where shown on the Plans.

When aluminum coated steel pipe is used, it shall conform to AASHTO M 274.

When corrugated aluminum pipe, pipe arches or underdrains are used, these pipes and all special sections such as elbows and flared end sections, shall be the same gauge and shall conform to the applicable requirements of AASHTO M 196.

Galvanized corrugated structural plate for pipe, pipe arches and arches shall conform to the requirements of AASHTO M 167.

Mechanically Galvanized Zinc Coating meeting ASTM B 695 Class 50 shall be acceptable as an alternate for Hot-Dipped Galvanizing (AASHTO M 232) as applicable to hardware for fabrication of Structural Plate pipe, pipe arches and arches.

Corrugated aluminum alloy structural plate for pipe, pipe arches and arches shall conform to the requirements of AASHTO M 219.

When material supplied for any of the items mentioned above are to be bituminous-coated, the metal to be coated shall be free of grease, dirt, and other contaminants. Bituminous coating and paving shall conform to the requirements of AASHTO M 190. The coating shall be applied in accordance with recommended procedures and as directed by the Department.

915.03-Precoated, Galvanized Steel Culverts and Underdrains. Precoated galvanized steel pipe shall conform to AASHTO M 245, Grade 10/10 unless otherwise specified.

SECTION 916-HIGHWAY SIGNING MATERIALS

916.01-General Requirements 800
916.02-Aluminum..... 800
916.03-Steel 800
916.04-Stainless Steel..... 801
916.05-Fabrication..... 801
916.06-Reflective Sheeting..... 805
916.07-Legends, Borders and Accessories 807
916.08-Flexible Delineator Posts 810
916.09-Paints 811



SECTION 916-HIGHWAY SIGNING MATERIALS

916.01-General Requirements. All parts used in constructing highway signs shall be new and shall conform to the requirements of these Specifications, the Plans and the AASHTO Specifications for Sign Supports for highway signs, luminaires and traffic signals, latest edition. If any departures of materials and fabrication from the Plans or Specifications are deemed necessary by the Contractor, details of such departures, and the reasons, therefore, shall be submitted to the Engineer for approval. No such departure shall be made without the prior written approval of the Engineer.

The Contractor shall furnish the Department notarized certified copies of the chemical and physical properties of all materials incorporated in the structures and accessories that are required for this work.

916.02-Aluminum and Composite material signs. Aluminum and composite material mounted signs shall conform to the requirements of the following Specifications, unless otherwise specified:

- (a) Aluminum flat sheet (sign blanks) and plates, ASTM B 209, Alloy 6061 T6 or 5052-H38. Composite material sign blanks shall be selected from the Department's QPL. The sign blanks shall be flat and shall contain no visible lateral bow.
- (b) Extruded shapes (sign panels), bars, rods, ASTM B 221, Alloy 6063, T6.
- (c) Posts and truss chords, ASTM B 221, Alloy 6061-T6.
- (d) Structural shapes, ASTM B 308, Alloy 6061-T6.
- (e) Delineator sheets, ASTM B 209, Alloy 6061-T6.
- (f) Post and truss bracing members, ASTM B 221, Alloy 6063-T6.
- (g) Bolts other than anchor bolts, ASTM B 211, Alloy 2024-T4. Chromated sealed anodic coating at least 5 μm (0.0002 in.) thick shall be applied to all finished bolts.
- (h) Nuts, ASTM B 211, Alloy 6262-T9 for 5/16 in.(8 mm) and larger, and Alloy 2024-T4 for 1/4 in.(6 mm) and under, tamper-proof type.
- (i) Washers, ASTM B 209, Alloy Alclad 2024-T4.
- (j) Weld filler wire, ASTM B 285, Alloy ER5356 or ER5556.
- (k) Flange splicing material, ASTM B 209, Alloy 6061-T6.
- (l) Post caps and chord caps, ASTM B 26, Alloy SG-70A-F.
- (m) Rivets, ASTM B 316, Alloy 6053-T6.
- (n) Shims, ASTM B 209, Alloy 1100-0.
- (o) Posts clips, ASTM B 308, Alloy 6061-T6.
- (p) Letters, numerals, and symbols, ASTM B 209, Alloy 3003-H14.

916.03-Steel. Steel shall conform to the requirements of the following Specifications, unless otherwise specified:

- (a) Steel structural shapes, ASTM A 709 Grade 50 S and plates, ASTM A 709 Grade 36, galvanized in accordance with ASTM A 123.

- (b) Posts, chord and bracing members, ASTM A 53, Grade B pipe, galvanized.
- (c) Post caps and chord caps, ASTM A 27, galvanized in accordance with ASTM A 123.
- (d) Galvanized bolts, nuts and washers, ASTM A 307.

916.04-Stainless Steel. Stainless steel shall conform to the requirements of the following specifications:

- (a) Stainless steel bolts, washers and screws, ASTM A 193, Austenitic steel.
- (b) Stainless steel nuts, ASTM A 194, Grade 8F, except that the nuts shall be lock nuts with semi-finished hex nuts equivalent to American Standard Heavy Series.

916.05-Fabrication.

- (a) General.

Fabrication of all signs and supports shall be in accordance with the details shown on the Plans. Any departure from the Plans shall be submitted in the form of shop drawings. Work shall be done in a uniform, workmanlike manner.

All fabrication of steel components specified to be galvanized, including the forming of holes or perforations, shall be completed prior to galvanization.

All signs and supports shall be fabricated in a plant operated by a fabricator who has the necessary experience to manufacture quality signs and supports meeting these Specifications. The Contractor shall furnish the Department the name of the fabricators of the signs and supports before fabrication is started and, if requested by the Department, information shall be furnished as to the fabricator's qualifications and experience.

- (b) Shop Drawings.

For any departure from the Plans, the Contractor shall submit, for approval of the Engineer, eight copies of drawings showing complete detail design of said departure and any other information necessary to complete the sign assembly.

- (c) Flat Sheet Signs.

Flat sheet signs shall be fabricated of a single piece of sheet aluminum or composite material(when allowed) without joints and without supporting frame, unless otherwise specified.

- (d) Multiple Panel Signs.

Multiple panel signs shall be made of extruded sections. All extruded sections shall be 12 in.(30 cm)wide, mounted horizontally and shall have no vertical joints. All panels shall be

flat and straight within commercial tolerances established by the aluminum industry.

(e) Overhead Sign Supports.

Overhead sign supports shall be fabricated in accordance with the Plans and approved shop drawings.

All welding shall be performed in the shop in accordance with Plans and the Special Provisions of the Contract.

Brackets shall be provided for mounting signs (including future signs) of the type to be supported by the structures. They shall be adjustable to permit mounting the sign faces at any angle between a truly vertical position and 3° from vertical. This angle shall be obtained by rotating the front lower edge of the sign forward of the top edge. All brackets shall be of lengths equal to the heights of the signs being supported.

All steel fabricated components other than stainless steel parts, including clamps and brackets, shall be thoroughly cleaned and galvanized by the Hot-Dip process, meeting applicable ASTM Specifications designated in **Subsection 916.03**.

(f) Cutting (Metals).

Materials 1/2 in.(13 mm) thick or less may be sheared, blanked, sawed or milled. Materials over 1/2 in.(13 mm) thick shall be sawed or milled. Cut edges shall be true and smooth and free from excessive burrs or ragged breaks.

Re-entrant cuts shall be filleted by drilling prior to cutting.

Flame cutting will not be permitted for aluminum.

(g) Bolt Holes (In Metals).

Bolt Holes shall either be drilled to finished size, or they may be blanked to finished size provided the diameter of the blanked hole is at least twice the thickness of the metal being blanked.

(h) Preparation of Signs Surfaces.

All fabrication including cutting, welding and punching of holes, excluding mounting holes for demountable letters, numerals, symbols, and borders, shall be complete prior to surface preparation.

Prior to painting or application of reflective sheeting to the aluminum, sign panels shall be treated in strict accordance with the following procedure and composite material sign

panels shall be treated per the manufacturer's recommendations:

1. Preliminary Cleaning.

A complete submersion in a six per cent solution of an inhibited alkaline cleaner at 160 to 180° F(71 to 82° C) for 3 minutes followed by a cold water rinse.

2. Etching.

Preliminary cleaning shall be followed by a surface etch by immersion for three minutes in a 6 to 8% dilute phosphoric acid solution followed by spraying with a cold water rinse and immersion for 1 minute in circulating hot water at 180° F(82° C).

3. Handling.

No metal shall be handled, except by device or clean canvas gloves, between all cleaning and etching operations and the application of paint and/or reflective sheeting. There shall be no opportunity for metal to come in contact with grease, oils, or other contaminating substances after cleaning and etching and prior to the application of paint and/or reflective sheeting.

- (i) Shop Painting and Reflectorization.

All legends, borders and background shall be of the color and placed on the sign as shown on the Plans.

1. Application.

Reflective sheeting shall be applied to properly treated base panels with mechanical equipment in a manner specified for the manufacture of traffic signs by the sheeting manufacturer. Type II adhesive coated sheeting shall be pre-perforated.

Sign faces comprising two or more pieces or panels of reflective sheeting shall be carefully matched for color at the time of sign fabrication to provide uniform appearance and brilliance, both day and night. Alternate, successive width sections of either sheeting or panels shall be reverse and consecutive to insure that corresponding edges of reflective sheeting lie adjacent on finished sign. Nonconformance may result in non-uniform shading and an undesirable contrast between adjacent widths of applied sheeting which will not be acceptable. Splices shall be held to a minimum. When spliced, Type I adhesive coated sheeting shall be overlapped not less than 3/16 in.(5 mm). Type II

adhesive coated sheeting may be spliced with overlap not less than 3/16 in.(5 mm) or butted; when butted, the gaps shall not exceed 1/32 in.(800 µm). Only butt splices will be permitted on signs screen processed with transparent color. Sheeting applied to extruded sections shall extend over top edges and down side legs a minimum of 1/16 in.(2 mm). After aging 48 hours at 75° F(24° C), adhesion of reflective sheeting to sign surface shall be strong enough to resist stripping from the panel when tested with a stiff putty knife, and meet other applicable requirements as previously specified for Reflective Sheeting.

2. Silk Screening.

All legends and borders on signs, except demountable or cut-out legends and borders, shall be applied by silk screening after the sheeting is attached to the panels, unless otherwise approved by the Engineer. All screening shall be done in a workmanlike manner and as recommended by the manufacturer of the reflective sheeting.

The Contractor may apply black legends and borders to signs having silver reflectorized backgrounds by equally effective methods when approved by the Engineer. Proper size screen mesh shall be used in reverse screening to ascertain that the finished colors match the prescribed Standard Interstate Colors (AASHTO Manual). Any noticeable deviation from the shades shall be cause for rejection of any sign.

After silk screening, or reverse silk screening, the sign shall be baked in an approved oven for a period of one hour at a temperature of C 200° F(93° C).

(j) Packaging.

All signs shall be packaged in such manner that they will be protected during shipment and storage. The packaging shall be adequate to prevent damage to any part of the sign, including any demountable legends or borders. Before packaging, all signs shall be free of moisture and all paints shall be thoroughly dry. Adhesive tapes shall not be applied to any sign surfaces. All packaged signs shall be kept entirely dry.

All assembled or partially assembled signs, other than flat sheet signs, shall have sufficient braces securely attached to prevent buckling or warping from the time of assembling to attaching on permanent supports.

916.06-Reflective Sheeting. Reflective sheeting shall meet the requirements of AASHTO M 268 and the supplementary requirements for fungus resistance of AASHTO M 268. The sheeting material shall have a precoated adhesive backing or a heat and pressure activated adhesive backing protected by a removable liner.

Reflective Sheeting for all signs with a SILVER-WHITE and ORANGE when used on temporary barricades and channelizing drums shall be Type III or better as specified by AASHTO M 268.

Reflective Sheeting for all signs with a SILVER-WHITE, YELLOW, RED, GREEN, BROWN or BLUE background shall be Encapsulated Lens or Micro-prismatic Lens material meeting or exceeding the minimum requirements for Type III or higher as specified by AASHTO M 268. FLOURESCENT ORANGE background material shall meet or exceed the requirements for Type IV, as specified by AASHTO M 268, with the following changes:

Minimum Retroreflection Values for
Fluorescent Orange Sheeting

Divergence Angle (Deg.)	Incidence Angle (Deg.)	Fluorescent Orange
0.2	-4	200
0.2	+30	85
0.5	-4	80
0.5	+30	40

Daytime Color:

Color shall conform to the requirements in the table below. Daytime color and maximum spectral radiance factor (peak reflectance) of sheeting, mounted on test panels *of the same material to be used on the project* shall be determined instrumentally in accordance with ASTM E 991. The values shall be determined on an instrument meeting the requirements of ASTM E 991 that has circumferential viewing (illumination). Computations shall be done in accordance with ASTM E 308 for the 2° observer.

Color Specification Limits ** (Daytime)
Luminance

Color	Luminance								Factor Y(%)	
	1		2		3		4		min.	max.
	x	y	x	y	x	y	x	y		
Orange (new)	.583	.416	.523	.397	.560	.360	.631	.369	30	
Orange (weathered)	.583	.416	.523	.397	.560	.360	.631	.369	20	45

916

**The 4 pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant D_{65} .

806

Specular Gloss:

The retroreflective sheeting shall have a specular gloss of not less than 50 when tested in accordance with ASTM D 523 using an 85° glossmeter.

In addition to the above requirements, the sign sheeting material shall have met the Department's pre-approval process and be listed on the Department's QPL.

916.07-Legends, Borders and Accessories. Letters, numerals, symbols, borders and route markers shall conform to the MUTCD:

Type "A" Class I (Demountable)

The silver-white letters, numerals, symbols, borders and route markers shall be of a pre-coated pressure sensitive or a tack free heat activated adhesive reflective sheeting permanently adhered to the sign panel. The reflective sheeting shall meet the requirements of **Subsection 916.06** (Type III or higher as specified by AASHTO M 268).

The reflective sheeting shall be mechanically applied to the properly prepared sign panel with the equipment and in a manner prescribed by the sheeting manufacturer. Letters, numerals, symbols, borders and route markers shall be 0.032 in.(0.8 mm) thick aluminum sheet of 3003 H14 Alloy or approved composite material. Aluminum shall be properly degreased and etched or treated with a light, tight, amorphous chromate type coating.

Each letter, numeral, symbol and route marker shall be supplied with mounting holes and shall be secured to the sign surface with corrosion resistant screws, bolts, or rivets.

Type "A" Class 2 Cut-Out (Direct Applied Reflective Sheeting Copy)

The silver-white cut-out letters, numerals, symbols, borders and route markers shall be of a pre-coated pressure sensitive or a tack free heat activated adhesive reflective sheeting and shall meet the requirements of **Subsection 916.06** (Type III or higher as specified by AASHTO M 268).

Type "B"

(a) General.

The demountable sign letters, digits, arrows, borders and alphabet accessories shall be reflectorized using acrylic plastic prismatic reflectors supported by embossed aluminum frames. They shall conform to the Standard Alphabet for Highway Signs of the FHWA.

The reflectors shall be acrylic plastic meeting the requirements of Federal Specification L-M 500, Type 1, Class 3. In order that the Department may readily check the suitability of the raw material used in the reflectors, the Contractor shall stipulate the

manufacturer of such material and the identification of the particular molding compound.

The reflectors shall consist of a clear and transparent plastic face, herein referred to as the lens, and the opaque plastic back of identical material fused to the lens under heat and pressure around the entire perimeter to form a homogeneous unit permanently sealed against dust, water, and water vapor. The reflector shall be colorless.

The lens shall consist of a smooth front surface free from projections or indentations other than for identification and a rear surface bearing a prismatic configuration such that it will effect total internal reflection of light. The manufacturer's trade mark shall be molded legibly into the face of the lens.

(b) Optical Requirements.

1. Specific Brightness.

The specific brightness of each reflector intended for use in cut-out letters, symbols and accessories shall be equal to or exceed the following minimum values with measurements made with reflectors spinning. Failure to meet the specific brightness minimum shall constitute failure of the reflector being tested. Failure of more than 2 reflectors out of 50 subjected to test shall constitute failure of the lot.

Observation Angle Degrees	Entrance Angle Degrees	Specific Brightness Cd/m ² /lux
1/10	0	14.0
1/10	20	5.6
1/6	0	10.0
1/6	20	4.0
1/3	0	7.0
1/3	20	2.8

For amber reflectors, the specific brightness minimum shall be 60% of the value shown for crystal.

2. Optical Testing Procedure.

The reflector to be tested shall be located at a distance of 100 ft.(30.5 m) from a single uniformly bright light source having an effective diameter of 2 inches. The light source shall be operated at approximately normal efficiency. The return light from the reflector shall be measured by means of a photoelectric photometer having a minimum sensitivity of 1×10^{-7} footcandles(1.08×10^{-6} lux) per scale division.

The photometer shall have a receiver aperture of 1/2 in.(13 mm) diameter, shielded to eliminate stray light. The

distance from light source center to aperture center shall be 2.1 in.(53 mm) for 1/10° observation angle 3.5 in. (89 mm) for 1/6° observation angle, and 6.9 in.(175 mm) for 1/3° observation angle. During testing the reflectors shall be spun so as to average orientation effect.

If a test distance other than 100 ft.(30.5 m) is used, the source and aperture dimensions and the distance between source and aperture shall be modified in the same proportion as the test distance.

(c) Durability.

1. Seal Test.

The following test shall be used to determine if a reflector is adequately sealed against dust and water.

Submerge 50 samples in water bath at room temperature. Subject the submerged samples to a vacuum of 5 in.(125 mm) gauge for 5 minutes. Restore atmospheric pressure and leave samples for water intake. The intake of water in any form constitutes failure. Failure of more than 2% of the number tested shall be cause for rejection of the entire lot.

2. Heat Resistance Test.

Three reflectors shall be tested for four hours in a circulating air oven at 175° F (79 ±3° C, ±5). The test specimens shall be placed in a horizontal position on a grid or perforated shelf permitting free air circulation. At the conclusion of the test, the samples shall be removed from the oven and permitted to cool in air to room temperature. The samples after exposure to heat shall show no significant change in shape and general appearance when compared with unexposed control standards.

3. Corrosion Test.

The assembled cut-out letter, symbol or accessory shall withstand the combined corrosion test set forth in ASTM B 117.

(d) Fabrication.

All items except border strips shall be fabricated from 0.040 in.(1 mm) sheet aluminum or approved composite material. Border strips shall be fabricated from 0.032 in.(810 μm) aluminum, or composite material.

Mounting holes shall be provided within the frames, in accordance with the manufacturer's directions, to

permit the use of screws, rivets or other acceptable fasteners.

The size and spacing of the reflector holes shall be such as will provide maximum night legibility and visibility of the finished cut-out figure.

(e) Finishing.

After the metal fabrication has been completed, the finishing process shall be as follows:

Preparation.

Aluminum frame surfaces shall be prepared in accordance with the provisions of **Subsection 916.05(h)** and treated with Alodine 1200, Iridite 14-2, Bonderite 721, or equal product, in strict accordance with the recommendations of the manufacturer of the chemical used.

Enameling.

After treating the frames shall be finished in the color specified with baking enamel in strict accordance with the recommendations of the manufacturer of the enamel.

916.08-Flexible Delineator Posts. The height of the delineator post shall be as shown on the plans. The width of the post shall present a minimum 3 in.(75 mm) wide profile in the direction of approaching traffic. The top 14 in.(350 mm) of the front of the delineator post shall have a smooth surface capable of readily bonding the pressure sensitive reflective sheeting. The color of the delineator post shall be white unless otherwise noted on the plans. ReflectORIZATION shall be by the use of reflective sheeting.

The reflective sheeting shall meet the requirements of AASHTO M 268, Type III or higher retroreflection performance level.

The reflective sheeting strip on the delineators shall be 9 in.(200 mm) in length and sufficient width to provide a 3 in.(75 mm) wide profile facing approaching traffic. The top of the reflective sheeting shall be 1/2 in.(13 mm) from the top of the delineator post.

The reflective sheeting for Flexible Type II Object Markers shall consist of 3 yellow squares spaced 4 1/2 in.(115 mm) center to center, each square being 3 in. (75 mm) long with sufficient width to present a 3 in. (75 mm) wide profile when mounted on a post. The top square shall be 1/2- in. (13 mm) from the top of the object marker post.

The contractor shall select material from the Department's QPL. The manufacturer shall certify that the materials to be supplied are formulated the same as when tested by the National Transportation Products Evaluation Program and will conform to the requirements of this specification. The Department reserves the right to periodically sample and test delineator posts.

916.09-Paints. All paints shall be as specified below, or approved equal, and produced by a properly equipped manufacturer who has had prior experience in manufacturing paints of the general character specified and who can cite applications, other than sample panels, of paints of this general character of which satisfactory service has been rendered by his paints for a period of not less than five years.

Black paint for nonreflectorized message application shall be high quality opaque process paste made with synthetic resin as manufactured or recommended by the manufacturer of the reflective sheeting.

Transparent blue, red and green paint and thinner for the application on the silver reflective sheeting for signs and reflectorized backgrounds shall be as recommended by the manufacturer of the reflective sheeting. The colors, when thoroughly dry, shall match the Standard Interstate Colors (AASHTO Manual) when compared in natural daylight.

917

**SECTION 917-ROADWAY AND STRUCTURE
LIGHTING MATERIALS**

917.01-General Requirements	813
917.02-Roadway Lighting Standards	813
917.03-Lighting Assembly Strength Test	819
917.04-Wiring.....	819
917.05-Metallic Conduit.....	819
917.06-Metallic Conduit Fittings.....	820
917.07-Non-metallic Rigid Conduit	820
917.08-Luminaires	820
917.09-Fittings, Pull-Boxes, and Bends	820
917.10-Relays, Switches, Control Cabinets, Etc.	820
917.11-Service Poles and Wood Standards	820
917.12-Guying Components.....	821
917.13-Grounding Materials.....	821
917.14-Splicing Materials.....	821
917.15-Drag Wire	821
917.16-Photoelectric Relay.....	821

SECTION 917-ROADWAY AND STRUCTURE LIGHTING MATERIALS

917.01-General Requirements. Prior to purchasing any materials, the Contractor shall submit for approval a complete list of all materials which he proposes to furnish. The list shall show the manufacturer's name, catalog number, and such other definitive or descriptive data as is necessary to adequately define the item. When requested by the Engineer, the Contractor shall furnish samples of the material and notarized certificates by the manufacturer that the material meets the requirements of these Specifications and all industry standards referred to herein.

All guarantees on mechanical and electrical equipment, which are normally furnished by the manufacturer, shall be obtained by the Contractor and given to the Engineer. The Engineer will then transmit these guarantees to the agency which will be responsible for maintenance of the equipment in the future.

All material and equipment shall be designed, manufactured and tested in accordance with the requirements of at least one of the societies listed below. All appropriate material shall be Underwriter's Laboratories approved and shall be so labeled. The following list of societies provide specifications that may be applicable to the manufacture of materials: ASTM, IPCEA, NEMA, IEEE, ANSI, and AASHTO.

All materials and equipment furnished under these Specifications shall be new.

917.02-Roadway Lighting Standards. These Specifications are for prestressed concrete, aluminum, and steel lighting standards. The standards to be furnished under these Specifications shall be of the design and dimensions that are shown on the Plans, and shall conform with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. Calculations for the design of each type of pole and bracket arm length shall accompany the shop drawings when submitted for approval.

1. Prestressed Concrete.

Scope.

These Specifications apply only to the manufacture of concrete lighting standards to be used for the support of lighting units.

Method of Manufacture.

All standards furnished shall be manufactured by an approved method that will insure dense and uniform concrete. The concrete shall be placed in one continuous operation. The method of manufacture shall provide a means to produce a smooth cable raceway of 2 in.(50 mm) up to the hand hole. Above the hand hole a 1 in.(25 mm) raceway shall be provided.

Curing.

Following the casting operation, the concrete shall be cured with low temperature saturated steam. Following the steam curing and during the reduction of the curing temperature, the standards shall not be subjected to severe temperature changes.

Anchor Base.

The standards shall be furnished with the type of base that is shown on the plans. The base shall be cast as an integral part of the standard.

Foundations.

Where a precast butt base is specified on the Plans, the standards shall be furnished with a precast butt foundation which shall be cast as an integral part of the standard. A conduit entrance slot not less than 2 x 9 in.(50 x 225 mm) shall be provided in precast butts at the location shown on the Plans.

Anchor Bolts.

The anchor bolts shall be high-strength steel meeting the requirements of AASHTO M 314, Grade 55 having a minimum yield strength of 55,000 psi(379 MPa) and a minimum ultimate strength of 90,000 psi(620 MPa), each fitted with a hex nut and lock-washer.

Aluminum Bracket Arm.

Where aluminum bracket arms are specified, they shall be fabricated from aluminum alloy pipe or tapered tubes. Pipe shall conform to the requirements for nominal 2 in.(50 mm) diameter or larger Schedule 40 pipe of Aluminum Alloy 6063-T6, ASTM B 241. Tapered tubes shall conform to the requirements for Aluminum Alloy 6063-T6, ASTM B 221. Cast aluminum clamps shall be cast of Aluminum Alloy No. B-443.

Steel Bracket Arms.

Where steel bracket arms are specified, they shall be fabricated from nominal 2 in. (50 mm) diameter or larger Schedule 40 pipe conforming to ASTM A 53. The steel bracket arm shall be galvanized after fabrication in accordance with the requirements of ASTM A 123. Precautions to be taken to obtain high quality galvanized coatings shall be as prescribed in ASTM A 385.

The design and dimensions of the bracket arm assembly shall be as specified on the Plans. The installed bracket shall provide a weather resistant connection with smooth wiring raceway. All bolts and nuts shall be of stainless steel. All other steel parts and associated hardware shall be hot-dip galvanized in accordance with ASTM A 123 or ASTM A 153.

2. Aluminum

Scope.

These specifications apply only to the manufacture of aluminum lighting standards to be used for the support of lighting units.

General.

The poles shall consist of an aluminum shaft having a base attached to the lower end and complete with anchor bolts where required. All material shall conform to the requirements of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. All welding shall be in accordance with AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

Shaft.

The shaft shall be either spun seamless tubing or formed of sheet aluminum. The shaft may have one continuous longitudinal weld. The pole shaft shall have a uniform taper of approximately 0.14 in./ft.(12 mm/m) or shall be tapered in increments as approved by the Engineer.

Shafts may be furnished either in 1 or 2 pieces in accordance with current practices of the manufacturer; except when the required shaft length exceeds standard shipping limits, the shaft shall be furnished in 2 pieces.

The 2 piece shafts shall assemble by telescoping the upper section over the lower section with a firm tapered fit. The telescoping length of the shaft shall be not less than 14 in.(350 mm). Assembly of the shaft shall be performed in the presence of the Engineer or a qualified representative authorized by him. The sections shall be correctly plumbed and force fitted. Welding of the joint will not be permitted.

An opening shall be furnished near the top of the shaft to provide a cable entrance from the shaft into the bracket arm. The opening shall be designed to provide a smooth cable guide for wiring. The top of the shaft shall be equipped with a removable pole top of aluminum alloy held securely in place by means of set screws. The shaft (excluding transformer base standards) shall have a reinforced handhole, size as specified on the Plans, with a bolt on cover. A grounding nut or lug for accommodating a 1/2 in.(13 mm) UNC threaded bolt or stud shall be provided in the shaft or base.

Anchor Base.

The shaft shall have an anchor base which is strong enough to develop the full strength of the shaft it supports. The base shall be provided with 4 holes to receive the anchor bolts, and a suitable means for attaching bolt covers. Four removable bolt covers shall be provided with each base.

Breakaway Device

The breakaway device shall conform to the breakaway characteristics as established by Section 7 of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals. In determining if an item meets the breakaway requirements of the AASHTO Standard Specifications, testing and reporting procedures comparable to those given in NCHRP Report 153 should be followed. Acceptance may be based on a single test if the test change in momentum and the analytically inferred changes in momentum over the speed range are less than 750 pound-seconds(3,335 N-seconds). If the first dynamic test change in momentum is between 750 and 1,100 pound-seconds(3,335 to 4,895 N-seconds), a second dynamic test will be needed unless assurance that the test results are representative of what would result from further dynamic tests can be demonstrated analytically and statically. The results of the second test must also meet the specification requirements. The Contractor shall furnish documentation of the breakaway characteristics to the Engineer prior to fabrication.

Bracket Arm-Aluminum.

Bracket arms for aluminum standards shall meet the same requirements as specified for aluminum bracket arms for concrete standards.

Anchor Bolts.

The anchor bolts shall be high-strength steel, each fitted with a hex nut and lock-washer. Each anchor bolt shall have a suitable provision for anchoring the bottom end in the concrete foundation and shall be threaded at the top end. The exposed portion of the threaded end of the anchor bolt, all nuts, washers, couplings, studs, etc., shall be zinc coated, unless otherwise specified, in conformance with the requirements of ASTM A 153. The anchor bolts shall be capable of resisting, at yield strength stress, the bending moment of the shaft at its yield strength stress.

Finish.

All hardware not otherwise specified shall be aluminum or stainless steel. All materials shall be furnished in natural aluminum color. Pole shafts shall be furnished with either polished or brush finished surface. Shaft and bracket arm assembly shall be tire-wrapped with a heavy water resistant paper for protection during shipment and installation.

3. Steel.

Scope.

These Specifications apply to the manufacture of steel lighting standards to be used for the support of lighting units.

General.

The poles shall consist of a steel shaft having a base welded to the lower end and complete with anchor bolts. All castings shall be clean, smooth, with details well defined and true to pattern. Gray iron castings shall conform to ASTM A 126, Class A, or ASTM A 48, Class 20. Steel castings shall conform to ASTM A 27, Grade 65-35.

Anchor Base.

A 1 piece cast steel base of adequate strength, shape, size, and chamfered, shall be secured to the lower end of the shaft by two continuous electric arc welds. The base shall telescope the shaft and 1 weld shall be on the inside of the base at the end of the shaft, while the other weld shall be on the outside at the top of the base so that the welded connection shall develop the full strength of the adjacent shaft section to resist bending action.

Four removable anchor bolt covers shall be provided with each base, and each cover shall attach to the body of the base by a suitable means. Where a transformer base is specified, it shall be of the design, dimensions and material shown on the Plans.

Breakaway Device

The breakaway device shall conform to the same requirements as specified for aluminum poles above.

Shaft.

The steel shaft may have only 1 longitudinal electrically welded joint and shall not have any intermediate horizontal joints or welds. Only 1 length of steel sheet shall be used, which shall be formed into a continuous shaft.

The shaft shall be fabricated from not less than No. 11 gauge steel conforming to the requirements of ASTM A 242, ASTM A 595, ASTM A 606 or ASTM A 607.

After forming and welding, the shaft shall be longitudinally cold rolled under sufficient pressure to flatten the weld and increase the physical characteristics of the shaft so that the metal will have a minimum guaranteed yield strength of 48,000 psi (331 MPa). The shaft (excluding transformer base standards) shall have a reinforced handhole, size as specified on the Plans, with a bolt on cover. A ground nut or lug for accommodating a 1/2 in. (13 mm) UNC threaded bolt or stud shall be provided in the shaft or base. The top of the shaft shall be equipped with a pole cap held securely in place by set screws.

Bracket Arm-Steel.

Bracket arms for steel standards shall meet the same requirements as specified for steel bracket arms for concrete standards.

Anchor Bolts.

Anchor Bolts for steel standards shall meet the same requirements as specified for anchor bolts for aluminum standards.

Finish.

Steel lighting standards shall be either painted or galvanized, as indicated on the Plans, in accordance with the following:

- a. When painting is permitted or specified, all materials not to be galvanized shall be thoroughly cleaned and shop painted with 1 coat of zinc chromate primer meeting the requirements of **Subsection 910.04(f)** before the parts are handled or packaged for shipment.
- b. Galvanizing of steel standards and bracket arms, and fittings, except hardware and anchor bolts, shall meet the requirements of ASTM A 123.

Galvanizing of hardware and anchor bolts shall meet the requirements of ASTM A 153.

4. High Mast.**Scope.**

These Specifications apply only to the manufacture of steel lighting standards over 90 ft.(27.5 m) in length to be used for the support of head frame, ring assembly, suspension and power cables and luminaires.

General.

The poles shall consist of a steel shaft, handhole, anchor base, head frame, suspension cables, power cables, anchor bolts and foundation and all equipment to complete the installation. Standards shall conform to the requirements of AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.

Shaft.

The shaft shall be tapered from top to bottom, either cylindrical or multi-sided in cross section and either single piece or slip-fit multi-section construction. Slip-fit design shall consist of tapered sections which telescope each other, and shall be fabricated so that the minimum length of the overlap joint shall be 1 1/2 times the maximum inside diameter of the overlapping section. Each section shall be numbered and show minimum and maximum overlap.

- (a) Weathering steel shafts shall conform to ASTM A 595 Gr. C; miscellaneous plates, bars and structural shapes to ASTM A 709 Grade 50 S. Fabrication and welding of these poles shall be in accordance with the requirements of AWS 01.1
- (b) Galvanized steel shafts shall be high strength steel cold formed fabricated with one longitudinal weld and have a minimum yield strength of 50,000 psi(345 MPa) and a maximum specified yield strength of 65,000 psi(448 MPa) after fabrication. Design shall be based on the yield strength of the material used but not to exceed 60,000 psi(414 MPa). The shaft shall be hot dipped galvanized in accordance with ASTM Specifications A 123.

917.03-Lighting Assembly Strength Test. The complete assembly of all standards, except high mast, when placed upright on a suitable foundation shall meet the following strength requirements:

- a. A vertical load of 100 lbs(45 kgs) applied at the point of luminaire attachment shall not produce a deflection in excess of 5% of the horizontal length of the bracket.
- b. A vertical load of 250 lbs(115 kgs) applied at the same point as in (a) above shall not produce collapse, rupture or permanent deformation of any portion of the assembly.
- c. A horizontal load of 60 lbs(27 kgs) applied at the point of luminaire attachment and normal to plans of bracket assembly shall not produce a horizontal deflection in excess of 5% of the horizontal length of the bracket.
- d. A horizontal load of 500 lbs(225 kgs) applied at the top of the shaft, in any direction, shall not produce a deflection in excess of 8% of the length of the shaft nor shall said load cause failure of any component part of the assembly.

The Contractor shall furnish a signed warranty from the manufacturer stating that the materials used in standard and bracket fabrication fully meet the requirements of these Specifications and will satisfactorily withstand the specified horizontal and vertical loads in the above tests.

917.04-Wiring. The size and type of conductor cable shall be as shown on the Plans and shall be in strict compliance with the National Electrical Code, the National Electrical Safety Code and local codes.

All conductor cable placed in conduits and light standards unless otherwise stated on the Plans shall be single-conductor AWG copper with UL rated 600 volt type insulation suitable for wet or dry installation with the conductor temperature not exceeding 167° F(75° C).

Direct-burial cable and cable in-duct shall be in accordance with the Plans.

917.05-Metallic Conduit. Rigid steel conduit shall conform to Federal Specifications WW-C-581 or ANSI C 80.1. It shall be galvanized inside

917

and outside by one of the following processes: Hot-dip galvanized, metallized galvanized, electro-galvanized.

Flexible metal conduit shall conform to the requirements of Federal Specification WW-C-566.

Aluminum conduit shall meet the requirements of Federal Specification WW-C-540.

Where welded steel pipe for ordinary use is specified on the Plans, it shall be hot-dipped galvanized inside and out and shall meet the requirements of ASTM A 53 for Welded Steel Pipe for ordinary uses.

917.06-Metallic Conduit Fittings. Galvanized steel conduit fittings shall meet all the requirements of Federal Specifications WW-C-581 or ANSI C-80.4.

917.07-Non-metallic Rigid Conduit. Non-metallic rigid conduits and fittings shall be polyvinyl chloride (PVC) conforming to Schedule 40 or 80, as specified, ASTM D 1785 for conduit and ASTM D 2466 for fittings or polyethylene conduit meeting the requirements of ASTM D 1248 and D 2447.

917.08-Luminaires. Luminaires shall be complete, including power regulated ballast, lamps, insulating transformer (where required), and associated hardware and wiring. Luminaires shall utilize and include a high intensity discharge lamp of the type specified on the Plans.

The luminaires shall be capable of providing the illumination level and uniformity of illumination that is specified when installed as shown on the Plans. Photometric and electrical requirements shall equal or exceed the requirements shown on the Plans.

917.09-Fittings, Pull Boxes, and Bends. Fittings, pull-boxes, bends and miscellaneous hardware shall be in accordance with the details shown on the Plans, with the National Electrical Code, and shall be compatible with the adjacent conduit and materials.

917.10-Relays, Switches, Control Cabinets, Etc. Relays, switches, control cabinets and miscellaneous electrical equipment shall be in accordance with the applicable codes and shall be as specified on the Plans.

917.11-Service Poles and Wood Standards. Wood service poles and standards shall be of the class and length shown on the Plans and, unless otherwise specified, they shall meet the requirements of the following Specifications: Wood service poles and standards shall be of treated southern pine, shall be classified according to the latest American Standard Dimensions of Southern Pine Poles and shall meet the requirements of ANSI 05.1. The poles shall be treated with pentachlorophenol or other approved treatment at the rate recommended by the local power authority. The treatment shall conform to the requirements of **Subsection 911.03(c)**.

Metal service poles shall be of the kind, design, type and dimensions shown on the Plans.

917.12-Guying Components. Guying components for wood poles shall consist of zinc-coated wire strand, zinc-coated anchor rod, four-way expanding anchor and necessary accessories. The wire strand shall conform to the requirements of ASTM A 475 for the particular grade, size and type specified. The anchor rod, anchor and accessories shall be hot-dipped galvanized.

All guying components shall be in accordance with the details shown on the Plans.

917.13-Grounding Materials. Grounding materials shall be in accordance with the details shown on the Plans. Clamps that are designed for use with the designated rods shall be used.

917.14-Splicing Materials. Splicing materials shall be as specified on the Plans and shall be of a design and material consistent with the location and type of splice indicated.

917.15-Drag Wire. Drag wire to be installed in the conduit shall be nine-gauge galvanized iron wire, unless otherwise specified.

917.16-Photoelectric Relay. The photoelectric relay for operating the multiple relays in the control center shall be a unit type assembly with a locking type plug so that the unit may be easily removed for maintenance purposes.

The photoelectric relay shall operate from 105 to 285 volts, shall have a minimum control range of 0.5 to 5.0 ft. cdl.(5.4 to 54 lux), and shall have a sensitivity adjustment for both on and off for the total range. The relay contacts shall be able to handle a minimum of 1,000 watts at 250 volts.

SECTION 918-MISCELLANEOUS MATERIALS

918.01-Water	823
918.02-Calcium Chloride.....	823
918.03-Sodium Chloride.....	823
918.04-Lime.....	823
918.05-Plastic Center Strip	823
918.06-Asphalt Plank	823
918.07-Precast Manholes and Catchbasins.....	823
918.08-Preformed Plastic Pavement Marking Materials	823
918.09-Chemical Additives	826
918.10-Masonry Stone.....	828
918.11-Waterstops	828
918.12-Epoxy Resin Systems	830
918.13-Select Material for Soil-Cement Base	830
918.14-Grass Seed	830
918.15-Commercial Fertilizer.....	832
918.16-Ammonium Nitrate.....	832
918.17-Agricultural Limestone.....	832
918.18-Mulch Material	832
918.19-Staples	832
918.20-Snowplowable Reflective Pavement Markers	832
918.21-Grout.....	833
918.22-Manhole Steps	834
918.23-Thermoplastic Pavement Marking Material	834
918.24-Inoculants for Legumes	837
918.25-Crown Vetch Sprigs	837
918.26-Raised Reflective Pavement Markers with Adhesive.....	837
918.27-Filter Cloth	837
918.28-Erosion Control Blankets	838
918.29-Precast Prestressed Bridge Deck Panels	838
918.30-Applied Textured Finish Material	839
918.31-Fly Ash	840
918.32-Ground Granulated Blast Furnace Slag	841

SECTION 918-MISCELLANEOUS MATERIALS

918.01-Water. Water used in mixing concrete shall be reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable matter, or other substances injurious to the finished product. Water will be tested in accordance with AASHTO T 26. Water known to be of potable quality may be used without test. Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

918.02-Calcium Chloride. Solid forms of calcium chloride shall conform to the requirements of AASHTO M 144, for the type specified, except that the requirements for total alkali chlorides and impurities will be waived when calcium chloride is to be used in Mineral Aggregate Base or Surface Courses.

Calcium Chloride Liquor shall be a clear liquid free from suspended matter and shall meet the following requirements:

Concentration of Calcium Chloride Liquor.....	32%	38%
Total Calcium Chloride by Wt., Min.	32	38
Total Magnesium Chloride by Wt., Max.	0.5	0.5

A solution of Calcium Chloride solution less than 32% shall not be used.

Each shipment of Calcium Chloride Liquor shall be accompanied by a certification from the manufacturer denoting concentration, new weight, and guarantee of the percentage of calcium chloride.

918.03-Sodium Chloride. Sodium Chloride shall conform to the requirements of ASTM D 632, for the type specified.

918.04-Lime. Lime shall conform to the requirements of ASTM C 977, for the type specified.

918.05-Plastic Center Strip. Plastic center strip for longitudinal joints in concrete pavement shall be of an approved type not less than 10 mils(250 μ m) in thickness.

918.06-Asphalt Plank. Asphalt Plank shall meet the requirements of ASTM D 517, for the type specified.

918.07-Precast Manholes and Catchbasins. These items shall conform to ASTM C 478. All Precast Manholes and Catch Basins shall be made in accordance with the TDOT procedure for the Manufacture and Acceptance of precast Drainage Structures, Noise Wall Panels, and Retaining Wall Panels.

918.08-Preformed Plastic Pavement Marking Materials. The marking material shall be prefabricated plastic consisting of white or yellow pigmented plastic with reflective glass spheres uniformly distributed throughout the entire cross sectional area and shall be capable of being

affixed to bituminous or portland cement concrete pavement by either a pressure sensitive precoated adhesive or a liquid contact cement. The material shall be provided complete in a form that will facilitate rapid application and protection during shipment and storage. Solvents, adhesives and necessary equipment for proper application for life shall be in accordance with manufacturer's instructions. The material shall be manufactured and packaged in such a manner to permit storage at normal shelf temperatures for periods of up to one year after purchase. Contact cements, where used, shall have a shelf life of 6 months. The material shall mold itself to pavement contours, breaks, faults, and the like by action of traffic at normal pavement temperatures. The material shall have resealing characteristics so that it will fuse with itself and with previously applied marking materials of the same composition under normal conditions of use.

Prefabricated legends and symbols must conform to the applicable shapes and sizes as outlined in the Manual on Uniform Traffic Control Devices for Streets and Highways. These pavement markings shall be on the Department's QPL.

Materials.

The marking material shall be a 60 mil(1.50 mm) retroreflective pliant polymer conforming to the following requirements:

1. Composition. The retroreflective pliant polymer pavement marking film shall consist of a mixture of high quality polymeric materials and pigments with 1.50 minimum refractive index glass spheres uniformly distributed throughout its cross sectional area, and with a reflective layer of beads bonded to the top surface. Composition shall be as follows:

Material	Min.% By Weight
Resins & Plasticizers	20
Pigments	30
Graded Glass Beads	33

This material shall be capable of adhering to asphaltic or portland cement concrete, by means of a pressure sensitive, precoated adhesive, or by a liquid contact cement applied at the time of installation.

2. Resealing. The retroreflective pliant polymer shall be patchable as shown in the following test:
 - a. Cut two 1 x 3 in.(25 x 75 mm) pieces of the pliant polymer; mark the reflective side of 1 of the pieces with a pencil to delineate a 1 x 1 in.(25 x 25 mm) area at the end of the piece.
 - b. Wet the surface of the area delineated with a cloth soaked in contact cement or a mixture of MEK and toluene, for one minute, keeping the surface wet. At the end of 1

- minute, scrape the beads and binder off the sample and wipe the residual binder from the area. Let the sample dry for at least one minute.
- c. Remove the liner from back of the second piece of retroreflective pliant polymer and place the backside on top of the cleaned area on the first piece. The sample (while held together) should now form 1 piece 4 in.(100 mm)long by 1 in.(100 x 25 mm) piece with the 1 x 1 in.(25 x 25 mm) overlap patch in the center.
 - d. Place the patched sample on a hard surface under 1,000 grams per square in.(155 grams per cm²) (the area of the overlap splice) maintained at 140° F(60° C) for 2 hours.
 - e. Remove the sample from the heat and allow to cool to 70° F(21° C) (room temperature).
 - f. Pull the sample in opposite directions to place a shear strain on the patched area. The 2 pieces shall not separate without tearing.
3. Tensile Strength. The film shall have a minimum tensile strength of 40 psi(275 kPa) of cross section when tested according to ASTM D 638. A sample 6 x 1 x 0.06 in.(150 x 25 x 1.5 mm) shall be tested at a temperature between 70° and 80° F(21 to 27° C) using a jaw speed of ¼ in.(6 mm) per minute.
 4. Elongation. The film shall have a minimum elongation of 75% when tested according to ASTM D 638.
 5. Plastic Pull Test. A test specimen made the same size as in paragraph 3 shall support a dead weight of 4 lbs.(1.8 kgs.) for not less than 5 minutes at a temperature between 70 and 80° F(21 to 27° C).
 6. Pigmentation. The pigments shall be selected and blended to provide a marking film that is white or yellow conforming to standard highway colors through the expected life of the film.
 - a) Pigments. Sufficient titanium dioxide pigment meeting Federal Specification TT-P-442 shall be used in white markings to insure a dense opaque marking. Pigments shall include titanium dioxide for white plastic and C. P. medium chrome yellow for yellow plastic.
 - b) Sufficient medium chrome yellow pigment meeting Federal Specification TT-P-346b, Type 111, shall be used to insure a durable finished color that complies with Highway Yellow Color Tolerance Chart and matches Chip 33538 of Federal Standard 595. The yellow plastic shall have a minimum of 18% pigment as chrome yellow.
 7. Glass Beads. The glass beads shall be colorless and have a minimum index of refraction of 1.50 when tested using the liquid oil immersion method. The size and quality of the

beads will be such that performance requirements for the retroreflective pliant polymer film shall be met.

The film shall have a glass bead retention quality such that when a 2 x 6 in. (50 x 150 mm) sample is bent over a 1/2 in. (13 mm) diameter mandrel, with the 2 in. (50 mm) dimension perpendicular to the mandrel axis, microscopic examination of the area on the mandrel shall show no more than 10% of the beads with entrapment by the binder of less than 40%.

8. Skid Resistance. The surface of the retroreflective pliant polymer shall provide a minimum skid resistance value of 35 BPN when tested according to ASTM E 303.
9. Reflective Intensity. The white and yellow film shall have the following initial reflective values at 0.2° and 0.5° observation angles measured in accordance with the photometric testing procedures of Federal Specification L-S 300A, Paragraph 4.4.7.

Reflective values shall be expressed as candlepower per foot candle/5 s.f.(candela per lux/m²) of material at an 86° entrance angle.

	White (degrees)		Yellow (degrees)	
Observation Angle	0.2	0.5	0.2	0.5
Entrance Angle	0.20	0.15	0.15	0.10

10. Thickness. The retroreflective pliant polymer film without adhesive, shall be supplied in a standard thickness of 60 mils(1.5 mm).
11. Performance. The retroreflective pliant polymer, when applied according to the recommendations of the manufacturer, shall provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. The pliant polymer shall provide a cushioned resilient substrate that reduces bead crushing and loss. The film shall be weather resistant, and through normal traffic wear shall show no appreciable fading, lifting or shrinkage throughout the useful life of the marking. It shall also show no significant tearing, roll back or other signs of poor adhesion.

918.09-Chemical Additives.

(A) Admixtures

- (1) For portland cement concrete mixtures: These additives shall conform to the requirements of AASHTO M 194, covering the following seven types:

Type A- Water reducing admixtures

Type B- Retarding admixtures
 Type C- Accelerating admixtures
 Type D- Water-reducing and retarding admixtures
 Type E- Water-reducing and accelerating admixtures
 Type F- Water-reducing, high range admixtures
 Type G- Water-reducing, high range admixtures
 and retarding admixtures

Before any admixture is approved for use in portland cement concrete mixtures under these Specifications, the manufacturer of the admixture or the Contractor shall furnish the Department documentary evidence that the material proposed for use has been tested in accordance with the methods of test specified in AASHTO M 194 and meets the requirements of that Specification and shall be listed on the Department's QPL. Documentary evidence shall be the results of tests conducted by a testing laboratory inspected at regular intervals by the National Bureau of Standards and approved by the Department. The Department may from time to time require a notarized certification from the manufacturer stating that the material is identical with that originally approved and has in no way been changed or altered.

(2) Air-Entraining Admixtures:

Air-Entraining Admixtures shall conform to the requirements of AASHTO M 154, except that the tests for bleeding, bond strength and volume change will not be required.

The Contractor will be required to furnish a material that appears on the Department's QPL.

A product may become approved by furnishing test data from a recognized laboratory showing that the air-entraining admixture proposed for use conforms to the requirements of these Specifications. A recognized laboratory is defined as one of the following: A State Transportation Department Laboratory; a Federal Highway Administration Laboratory; or other laboratories which are regularly inspected by the Cement and Concrete Reference Laboratory and approved by the Department.

(B) Bituminous Additives

- (1) The anti-stripping additive shall be hydrated lime conforming to ASTM C 977 or other Heat Stable Asphalt Anti-stripping Additive containing no ingredient harmful to the bituminous material or the workmen, and shall not appreciably alter the specified characteristics of the bituminous material when added in the recommended proportions.

When hydrated lime is the anti-stripping additive, an amount equal to 1% by weight of the aggregate shall be used. A uniform lime coating of the aggregate shall be obtained in a manner

acceptable to the Engineer prior to adding the bituminous material to the mixture.

When an anti-stripping additive is used other than hydrated lime, the percentage of anti-stripping additive used is not to exceed 0.5%, but in no case shall the percentage of additive used be less than 0.3% by weight of the asphalt cement.

The Department will maintain a list of qualified antistripping products. No product shall be used unless it appears on this list.

- (2) Silicone additives. shall be mixed at the rate of 1 pt.(31 l) of silicone per 4 gal.(m³) of diesel fuel. One half pt.(60 ml) of this mixture may be used per 1,000 gal.(3,800 l) of asphalt.

918.10-Masonry Stone. Masonry stone shall be sound, dense and durable, free from excessive cracks, pyrite intrusions and other structural defects. Stones which will be used with mortar shall be free from dirt, oil, or other material that might prevent good adhesion with the mortar.

When the crushed aggregate is subjected to 5 alternations of the sodium sulfate soundness test, the weighted percentage of loss shall be not more than 12.

918.11-Waterstops. Waterstops shall be of the type, shape and dimensions shown on the Plans.

A. Metallic.

Metallic waterstops shall be sheet copper conforming to the requirements of **Subsection 908.13**.

B. Nonmetallic.

Nonmetallic waterstops shall be manufactured from either natural rubber, synthetic rubber, or polyvinyl chloride (PVC) at the option of the Contractor. Waterstops shall be produced by such a process that, as supplied for use, they will be dense, homogeneous, and free from holes and other imperfections. The cross section of the waterstop shall be uniform along its length and transversely symmetrical so that the thickness at any given distance from either edge of the waterstop will be uniform.

Rubber waterstops shall be fabricated from a high grade thread-type compound. The basic polymer shall be natural rubber or a co-polymer of butadiene and styrene, or a blend of both. The compound shall contain not less than seventy percent by volume of the basic polymer, and the remainder shall consist of reinforcing carbon black, zinc oxide, accelerators, anti-oxidants, vulcanizing agents, and plasticizers, but shall contain no factice.

Samples taken from the finished waterstop shall meet the following requirements when tested in accordance with the current specified ASTM method of test.

ASTM

Title	Requirement	Method of Test
Tensile Strength (Die "C")	2500 psi , min. (17.25 MPa, min.)	D 412
Ultimate Elongation (Die "C")	450 % , min.	D 412
Shore Durometer Hardness	60-70	D 2240
Specific Gravity	1.15 ± 0.03	D 297 (Sec. 17)
Water Absorption (% by wt.)	5 % , max.	D 570
Tensile Strength after accelerated aging, oxygen-pressure method.	80 % , min.	D 572

Polyvinyl chloride Waterstop.

This waterstop shall be extruded from an elastomeric plastic material. The material shall be a plastic compound, the basic resin of which shall be polyvinyl chloride. The compound shall contain any additional resins, plasticizers, stabilizers, or other materials needed to insure that when the material is compounded it will meet the performance requirements of this Specification. No reclaimed polyvinyl chloride shall be used.

<u>Title</u>	<u>Requirement</u>	<u>Method of Test</u>
Tensile Strength (Die "C")		
Sheet Material	2,000 psi (13.8 MPa)	ASTM D 412
Finished waterstop	1700 psi (11.7 MPa)	ASTM D 412
Ultimate Elongation (Die "C")		
Sheet Material	350% Min.	ASTM D 412
Finished waterstop	300% Min.	ASTM D 412
Stiffness in Flexure	750 psi min. (5.2 MPa Min.)	ASTM D 747
Accelerated Extraction		CRD C 572
Tensile Strength (Die "C")	1750 psi (12.1 MPa)	ASTM D 412
Elongation (Die "C")	300%	ASTM D 412
Effect of Alkali (After 7 Days)		CRD C 572
Change in Weight	-0.1 to + 0.25%	
Change in Hardness, shore Durometer	± 5%	
Low Temperature		
Brittleness	-35° F(-37° C)	ASTM D 746
Specific Gravity	1.3	ASTM D 792

For polyvinylchloride waterstops, the supplier shall submit a certificate stating that all of the performance requirements specified for the sheet material under Polyvinylchloride Waterstops have been complied with. In

addition, the supplier shall submit an affidavit to the effect that the sheet sample is of the same material in all respects as that to be used in the manufacture of the finished waterstop. The supplier shall also specify the value of the specific gravity of the finished waterstop material to within plus or minus 0.02.

Waterstops shall be manufactured with an integral cross section which shall be uniform within plus or minus 1/8 in.(3 mm) in width, and the web thickness or bulb diameter within plus 1/16 in.(1.5 mm) and minus 1/32 in.(0.8 mm).

The Contractor shall furnish the Department a certified test report from an approved laboratory covering each lot or unit of finished waterstops. These test reports shall contain the numerical laboratory test data of the required tests.

918.12-Epoxy Resin Systems. The epoxy resin systems shall be on the Qualified Product List maintained by the Division of Materials and Tests.

918.13-Select Material for Soil-Cement Base. Select material for soil-cement base shall be of such general character as to be classified as Group A-1 or A-2, AASHTO M 145. The material shall be of such size that all will pass the standard 1-1/2 in. (37.5 mm) sieve.

918.14-Grass Seed. The seed shall meet the requirements of the Tennessee Department of Agriculture and no "Below Standard" seed will be accepted.

Grass seed furnished under these Specifications shall be packed in new bags or bags that are sound and not mended.

The vendor shall notify the Department before shipments are made so that arrangements can be made for inspection and testing of stock.

The vendor shall furnish the Department a certified laboratory report from an accredited commercial seed laboratory or from a State seed laboratory showing the analysis of the seed to be furnished. The report from an accredited commercial seed laboratory shall be signed by a Registered Member of the Society of Commercial Seed Technologists. At the discretion of the Department, samples of the seed may be taken for check against the certified laboratory report. Sampling and testing will be in accordance with the requirements of the Tennessee Department of Agriculture.

When a seed group is used, the percentages forming the group shall be as set out below, unless otherwise specified.

Seed	GROUP "A" Quantity Per Cent by Weight	Seeding Dates
Kentucky 31 Fescue	80	February 1-July 1
English Rye	5	
Korean Lespedeza	15	

GROUP "B"

Kentucky 31 Fescue	55	June 1-August 15
English Rye	20	
Korean Lespedeza	15	
German Millet	10	

GROUP "B1"

Bermudagrass (hulled)	70%	April 15 - August 15
Annual Lespedeza	30%	

GROUP "C"

Kentucky 31 Fescue	70%	August 1-December 1
English Rye	20%	
White Clover	10%	

GROUP "C1"

Crown Vetch	25%	February 1-December 1
Kentucky 31 Fescue	70%	
English Rye	5%	

Groups "A", "B", and "C" when sown on slopes 3:1 and steeper shall be over seeded with Sericea Lespedeza at the rate of 15 lbs per acre(0.2 kgs per 100 m²). When over-seeding is performed between February 1 and July 1, Scarified Sericea Lespedeza shall be used with an additional 2 lbs per acre(22 grams per 100 m²) of Weeping Lovegrass. Between July 1 and December unhulled Sericea Lespedeza shall be used. Group "C1" seed shall be used only when specified in the Plans.

Seed groups and approved varieties to be used for temporary seeding according to dates.

GROUP "D"
Jan. 1-May 1

Italian Rye	33-1/3%
Korean Lespedeza	33-1/3%
Summer Oats	33-1/3%

GROUP "E"
May 1-July 15

100%
*Sudan-Sorghum Crosses
or
**Starr Millet
100%

GROUP "F"
July 15-Jan. 1

Balboa Rye	66-2/3%
Italian Rye	33-1/3%

Fertilizer is to be commercial grade 10-10-10 or equivalent.

*Dekalb Sudan SX11, Lindsey 77F, TN Farmer's Co-op GHS-1 or GHS-2A.
**Star Millet, GaHi-1

In mixing or forming Groups, seed shall be uniformly mixed. Group seed shall not be mixed until after each type seed that is used to form the "Group" has been tested and inspected separately and approved for purity and germination by the Department. Seed mixed before tests and inspection are made will not be accepted.

918.15-Commercial Fertilizer. Manufactured fertilizer shall be a standard commercial fertilizer containing the specified percentages by weight of nitrogen, phosphoric acid and potash.

The fertilizer shall be furnished in standard containers with the name, weight and guaranteed analysis of the contents clearly marked. The containers shall insure proper protection in handling and transporting the fertilizer.

All commercial fertilizer shall comply with local, state and federal fertilizer laws.

918.16-Ammonium Nitrate. Ammonium Nitrate shall be a standard commercial product, shall conform to the requirements for other commercial fertilizers as specified in **Subsection 918.15** and shall have a minimum of 33-1/2% nitrogen.

918.17-Agricultural Limestone. Agricultural Limestone shall contain not less than 85% of calcium carbonate and magnesium carbonate combined, and shall be crushed so that at least 85% will pass the No. 10 mesh(2 mm) sieve and 50% through a 40 Mesh(425 µm) Sieve.

918.18-Mulch Material. All hay and straw mulch materials shall be air dried and reasonably free of noxious weeds and weed seeds or other materials detrimental to plant growth on the highway or on adjacent agricultural lands.

Hay shall be stalks of approved grasses, sedges or legumes seasoned before baling or loading.

Straw shall be stalks of rye, oats, wheat or other approved grain crops.

Both hay and straw shall be suitable for spreading with standard mulch blower equipment.

918.19-Staples. Wire not smaller than 11 gage, formed into a "U" shape with legs at least 6 in.(150 mm) in length and a crown one inch in width shall be used. Staples will be of sufficient thickness for soil penetration without undue distortion.

918.20-Snowplowable Reflective Pavement Markers.. The reflector shall consist of an acrylic shell filled with tightly adherent potting compound. The filler shall be a potting compound selected for strength, resilience and adhesion adequate to pass the necessary physical requirements. The shell shall contain 1 or 2 reflective faces. The reflector shall be adhesively attached to an iron casting with an elastomeric pad.

The reflector shall meet the following requirements:

- (a) Dimensions. Each reflector shall be 4 ± 0.5 in. (100 ± 13 mm) by 2.0 ± 0.25 in. (50 ± 13 mm) at the base. Height of the reflector shall be 0.40 in. (10 mm) or no higher than 0.50 in. (13 mm). The slope of the reflector shall be 30° and the minimum area of the reflective surface shall be 1.87 in² ($1,200$ mm²).
- (b) Outer Surface. The outer surface of the shell shall be smooth except for purposes of identification.
- (c) Base Surface. The base of the marker shall be substantially free from gloss or substances that may reduce its bond to adhesive.

The markers, either mono- or bi-directional as specified, shall be attached to an iron casting. Both ends of the casting shall be shaped to deflect a snowplow blade. The casting shall be designed so that the markers may be removed and replaced when needed to restore reflectivity in the future.

The castings shall meet the following requirements:

- (a) General. The casting shall be 10 ± 0.5 in. (250 ± 13 mm) long by 5.5 ± 0.5 in. (140 ± 13 mm) wide. The maximum projection of the casting above the roadway shall not exceed 0.5 in. (13 mm). The casting shall be designed so that snowplow blades will ride over it without contacting the reflective marker.
- (b) Casting Material. The casting shall be nodular iron conforming to ASTM A 536, Grade 72-45-05, hardened to 52-54 RC.
- (c) Identification. Each casting shall be marked with manufacturer's name and model number of marker.

All reflectors and castings supplied shall be from the Department's QPL.

918.21-Grout. Grout shall be mixed in small quantities as needed, and shall not be retempered or used after it has begun to set. Unless otherwise specified or directed, the grout shall consist of one part portland cement and two parts sand by volume mixed with sufficient water to form a grout of proper consistency. When non-shrinking or non-shrinking fast-setting grout is specified, it shall be formulated by the incorporation of an admixture, or a pre-mixed grout may be used. The formulation and the admixture or the premixed grout used will be subject to the approval of the Engineer, and shall be mixed and used in accordance with the recommendations of the manufacturer. These special grouts will be classified as follows:

- Type I - Non-shrinking Grout
- Type II - Non-shrinking, Fast-setting Grout

Portland cement for grout shall conform to the requirements of **Subsection 901.01**. Sand for grout shall conform to the requirements of **Subsection 903.02**. Water for grout shall be approved by the Engineer.

918.22-Manhole Steps. Steps used in manholes or catch basins shall meet the requirements of ASTM C 478, Article 11.2.1 or be the design shown on the Plans.

1. Cast iron steps shall conform to the requirements of **Subsection 908.07**.
2. Aluminum steps shall be fabricated from aluminum alloy 6061, T6, with a minimum tensile strength of 38,000 psi(262 MPa), a minimum yield strength of 35,000 psi(241 MPa), and an elongation in 2 in.(50 mm) of not less than 10%.
3. An approved list of commercially designed steps is maintained by the Department.

918.23-Thermoplastic Pavement Marking Material. This material shall conform to AASHTO M-249 with the following changes. The material requirements are as follows.

COMPOSITION: The retroreflective pavement marking material shall be an Alkyd/Maleic based thermoplastic material consisting of homogeneously mixed pigments, filler, resins and glass beads. The pigment, beads, and filler shall be uniformly dispersed in the resin. The material shall be manufactured from virgin material using no reprocessed components.

The material shall be free from all skins, dirt, and foreign objects and shall comply with requirements from the following table.

Table 1		
Component	White	Yellow
% Binder Content	19.0 min	19.0 min
% TiO ₂ Pigment,	10.0 min	N/A
% Yellow Pigment (Lead Chromate)	N/A	4.0 min
	35 min	35 min
% Intermix Glass Beads	36 max*	43 max*
% Calcium Carbonate \ Fillers		

*The amount of Calcium Carbonate and inert fillers shall be as opted by the manufacturer, providing all other specifications are met.

The Titanium Dioxide shall be Rutile Type II in accordance with ASTM D 476 with a minimum purity of 93%.

White thermoplastic shall not contain anatase titanium dioxide pigment.

Provide yellow thermoplastic that contains only heat resistant silica encapsulated lead chromate pigment. The lead chromate pigment must contain a minimum of 60% lead chromate.

The total silica content used in the formulation of the thermoplastic shall be the premixed beads. Uniformly disperse the pigment, beads and filler in the binder.

The Alkyd / Maleic binder shall consist of a mixture of synthetic resins and high boiling point plasticizers one of, which shall be solid at room temperature. At least one-half of the binder composition shall be 100% Maleic modified glycerol ester of resin and shall be no less than 15% of the entire material formulation. The binder shall contain no petroleum, hydrocarbon resins, tall oil resins or rosins.

The thermoplastic material shall be free of contaminates and shall be dry blended or hot mixed from 100% virgin stock using no reprocessed materials.

The Thermoplastic material shall be formulated such that when it is on the roadway surface at any natural temperature it exists in a hard, solid state with cold ductility that permits normal movement with the road surface without chipping, or cracking.

The thermoplastic shall not deteriorate or discolor when held at the application temperature for periods of time up to 4 hours or upon repeated reheating (a minimum of 4 times).

The color, viscosity, and chemical properties versus temperature characteristics of the thermoplastic material shall remain constant for up to 4 hours at the application temperature and shall be the same from batch to batch.

The thermoplastic material shall be readily applicable at temperatures between 400°F and 440°F(204 to 227° C) from the approved equipment to produce lines and symbols of the specified thickness above the pavement surface.

Physical Requirements: After 4 hours @ 425°F: The thermoplastic material after heating for 4 hours \pm 5 minutes at $425 \pm 3^\circ\text{F}$ ($218 \pm 2^\circ\text{C}$) and cooled to $77 \pm 3^\circ\text{F}$ ($25 \pm 2^\circ\text{C}$) shall meet the physical requirements set forth in AASHTO M-249 with the following changes.

The material shall be tested in accordance with AASHTO T-250 and or with the appropriate method in Federal Test Method Standard #141 or ASTM Designation.

Safety – No toxic fumes.

Bond Strength – (ASTM-D4796), 180 p.s.i.(1,241 kPa) min.

Specific Gravity – Not to exceed 2.30.

Yellowness Index – The white thermoplastic shall not exceed a yellowness index of 0.15.

Flash Point – The Thermoplastic shall have a flashpoint of no less than 500°F (162°C).

Glass Beads**General:**

All beads used for Thermoplastic Pavement Markings shall be clear, transparent, colorless glass, smooth and spherically shaped, free of milkiness, pits, or excessive air bubbles and conform to the following specific requirements.

Silica content of the glass beads shall be no less than 60%.

Color and Clarity: Beads shall be colorless, clear and free from carbon residues.

Roundness: Minimum true spheres overall shall be 70% when tested in accordance with ASTM-D-1155,

Index of Refraction: Minimum of 1.50, when tested by the liquid emersion method @ 77°F(25° C)

Air Inclusions: Maximum of 3% overall

Intermix Glass Beads

Glass Beads used for intermix shall be premixed into the thermoplastic mixture and shall consist of 35% of the overall thermoplastic formulation. The intermix beads shall conform to AASHTO M-247, Type I with the exception of minimum true spheres overall shall be 70% as stated above, when tested in accordance with ASTM D-1155. The intermix beads shall be manufactured using 100% North American recycled glass cullet.

Drop on Glass Beads

Glass Beads used for Drop on shall conform to AASHTO M 247, Type I with the exception of minimum true spheres overall shall be 70% overall as stated above. Drop on glass beads shall be capable of being applied at the specified application rates. The Type I glass beads shall be manufactured using 100% North American recycled glass cullet.

Type I beads shall be applied at a minimum application rate of 10 lbs/100ft²(480 Pa). Beads shall be applied across the entire line width assuring uniform application and embedment of the beads to 50 to 60% of the bead diameter.

Glass beads shall be capable of flowing freely through dispensing equipment in any weather suitable for pavement marking application.

The producers of the thermoplastic compound and glass spheres shall furnish to the Department 3 copies of certified tests reports showing results of all tests specified therein and shall further certify that the materials meet all requirements. In addition, the department shall randomly sample molten thermoplastic material for verification testing in accordance with AASHTO T-250.

918.24-Inoculants for Legumes. Inoculants for treating legume seed shall be standard cultures of nitrogen-fixing bacteria that are adapted to the particular kind of seed to be treated. The inoculant shall be supplied in convenient containers of a size sufficient to treat the amount of seed to be planted. The label on the container shall indicate the specified legume seed to be inoculated and the date period to be used.

918.25-Crown Vetch Sprigs. The crowns shall meet the requirements of the Tennessee Department of Agriculture and no "Below Standard" crowns will be acceptable. All crowns as delivered shall have a minimum rhizome (underground stems) length of 3 in.(75 mm). Crowns furnished under these specifications shall be packed in clean polyethylene bags that are sound and not mended.

The supplier will be required to submit to the Department a certified report, signed by a Senior Member of the Tennessee Department of Agriculture, Division of Plant Industries, indicating the purity of planting stock to be furnished. At the discretion of the Engineer samples of the crowns may be taken for check against the certified report. Sampling and testing will be in accordance with the requirements of the Tennessee Department of Agriculture.

918.26-Raised Reflective Pavement Markers with Adhesive. Raised reflective pavement markers shall be listed on the Department's QPL.

Reflective Pavement Markers:

Classification

1. Type 1 One-Color, Reflective Markers (Two-way Traffic).
2. Type 2 One-Color, Reflective Markers (One-Way Traffic).
3. Type 3 Two-Color, Reflective Markers (One-way Traffic).

918.27-Geotextile Material. Geotextile material shall meet the requirements of AASHTO M 288 as called for on the plans. When the soil permeability and percent of soil passing the No. 200(75 μ m) sieve are not provided, AASHTO M 288, Table 1 is supplemented as follows:

- (1) Geotextile permeability, ≥ 0.80 mm/s
(ASTM D 4491)
- (2) Apparent opening size, Sieve No. 50 - No. 100
(ASTM D 4751) (300 μ m -150 μ m)

Material

Specification

Geotextile (Type I)	AASHTO M 288 Subsurface Drainage, Tables 1 and 2 Class 2 with 15% to 50% of in situ soil passing 0.075 mm.
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918

Geotextile (Type II)	As specified by the Plans or Standard Drawings.
Geotextile (Type III)	AASHTO M 288 Erosion Control, Tables 1 and 5 with 15% to 50% of in situ soil passing 0.075 mm.
Geotextile (Type IV)	AASHTO M 288 Stabilization, Tables 1 and 4, Class 1 with an elongation less than 50%.
Geotextile (Type V)	As specified by the Plans or Special Provisions

The contractor shall furnish a certified laboratory test report from an approved testing laboratory with each shipment of materials. Laboratory test reports shall include the actual numerical test data obtained. All rolls shall be clearly labeled as being part of the same production run from which the test date was derived. Fabric shall be protected to prevent damage during transportation, storage, and installation. Geotextile rolls shall be covered during storage to protect against UV degradation and shall be stored with rolls elevated up off of the ground. Fabric that is torn, punctured, or otherwise damaged shall not be installed.

918.28-Erosion Control Blankets. All Erosion Control Blankets shall be listed on the Department's QPL.

918.29-Precast Prestressed Bridge Deck Panels. Precast prestressed deck panels shall be constructed and inspected in accordance with the plans, approved shop drawings, and the Standard Specifications. The panels shall be fabricated in a plant certified by the Precast/Prestressed Concrete Institute(PCI) category B-3.

Panels are to be cast on beds that are clean, straight, level and in good repair. Bulkheads and headers are to be of size and configuration to adequately hold cables in place during casting operations. Forms, headers, cables, reinforcing bars or other steel that comes in contact with freshly placed concrete shall be kept below 90° F(32° C) during casting operations. Freshly cast panels are to be covered and cured in accordance with **Subsection 615.11.**

The location and details of projecting bars or other hardware used for lifting and handling panels shall be as shown on the approved shop drawings. Projecting bars shall be protected against impact and shall not be bent in the shop, during handling and transporting or in the field. It shall be the responsibility of the Fabricator and/or Contractor to protect panels from damage during lifting, storing, and transporting.

Any small damaged or isolated honeycombed areas which are purely surface in nature (not over 1 in.(25 mm) in depth) shall be repaired at the

fabrication plant with an approved epoxy grout. Panels with more extensive damage or honeycomb shall be replaced.

The Contractor shall inspect the panels at the point of delivery to the job site for identification, dimensional tolerances, cracks and structural damage. Panels exhibiting excessive cracking or other structural damage shall be replaced.

Panels having any of the following defects shall be replaced:

1. Any crack that comes within 1 in.(25 mm) of a strand.
2. Corner cracks or breaks that involve 1 strand.
3. Isolated damage or honeycomb larger than approximately 6 in. (150 mm) in diameter or length and 1 in.(25 mm) in depth that involves 1 strand.

In evaluations for the above defects, a crack is defined as a fissure of any length that extends from the surface of the panel to the mid-depth of the panel or to a strand, in accordance with any of the following conditions.

1. The crack is visible at the ends or edges of the panel.
2. The strand is visible within the crack.
3. The crack can be probed to mid-depth or to the strand.
4. The crack is visible on the top and bottom surface of the panel at approximately the same relative location.

Any new crack that appears in a panel after the deck is poured will be considered to extend to the mid-depth of the panel or to a strand. Panels exhibiting new cracks after the slab is poured will be replaced or repaired to the satisfaction of the Engineer.

Defects not covered by the above shall be subject to review by the Engineer.

918.30-Applied Textured Finish Material. The material for applied textured finish shall meet the requirements of Federal Specifications TT-C-00555, Type II except as modified below:

A. Freeze-Thaw Test.

1. Cast and cure 3 concrete specimens, not less than 4 x 6 x 6 in. (100 x 150 x 150 mm), of a mix designed for structures. Fourteen days moist curing with a drying period in room air at 60 to 80° F(15 to 27° C) for 24 hours before coating with spray finish is required. Caution shall be taken that there be no excessive oil on specimen forms. Coat sides of specimens (brush permitted) as hereinbefore set out and cure at room temperature for 48 hours; after which:
 2. Immerse in water at room temperature 60 to 80° F(15 to 27° C) for 3 hours; remove and,
 3. Place in cold storage at -15° F(-26° C) for 1 hour; remove and,
 4. Thaw at room temperature (60 to 80° F(15 to 27° C)) for 1 hour.

5. Repeat Steps 3 and 4 to complete a total of 50 cycles.
- B. Material shall be subjected to a 5,000 hour exposure test conforming to ASTM G 155, operating Xeon Arc light apparatus for non-metallic materials. At the end of said exposure test, the exposed sample must not show any chipping, flaking or peeling.
 - C. Fungus Growth Resistance. Material to be used must pass a fungus resistance test as described by Federal Specification TT-P-29b with a minimum incubation period of 21 days where no growth shall have been indicated after the test.

Sampling and Testing.

The Contractor shall submit to the Materials and Tests Engineer a 1 qt.(1 l) sample of the material he proposed to have qualified for use. This material will be tested and placed on the Department's QPL if it meets specifications.

After the material has been initially qualified and placed on the QPL, the Contractor shall submit for each project the material as used, a certified statement from the formulator stating that the material furnished is identical in all respects to that which was initially qualified.

This shall not constitute a waiver on the part of the Department of any requirements with respect to samples and sampling, and the right is retained to perform any or all of the tests specified.

918.31-Fly Ash. The fly ash shall meet the requirements of AASHTO M-295, Class F or Class C, for the class specified. Fly ash of different classes or sources used as a partial cement replacement in Type I, Portland cement concrete will not be permitted on the same project.

A. Chemical Requirements Fly Ash Class

F C

1. Uniformity requirements:

The loss on ignition of individual samples shall not vary from the average established by the 10 preceding tests, or by all preceding tests if the number is less than 10, by more than: Loss on ignition, max variation, percentage points from average	1.0	1.0
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B. Physical Requirements F C

1. Pozzolanic activity index:

With Portland cement, at 7 days, min, % of control	60	60
With Portland cement, at 28 days, min, % of control	75	75

Source Approval. Fly ash used in the work shall be obtained from an approved source as shown on the Department's QPL.

918.32-Ground Granulated Blast Furnace Slag. Ground granulated Blast Furnace Slag shall meet the requirements of AASHTO M 302, Grade 100 or Grade 120. Ground granulated blast furnace slag of different grades or sources used as a partial cement replacement in Type I Portland cement concrete will not be permitted on the same project.

Source Approval. Ground granulated Blast Furnace Slag used in the work shall be obtained from an approved source as shown on the Department's QPL.