SECTION M.01

GRADATION OF AGGREGATE

M.01.01—Gradation table for sizes of crushed or broken stone, crushed and uncrushed gravel and reclaimed miscellaneous aggregate.

PERCENT PASSING BY WEIGHT (MASS) NAME							
Square Mesh Sieves	**No. 3**	**No. 4**	**No. 6**	**No. 67**	**No. 8**	**Screenings**	**Dust**
2 1/2" (63 mm)	100						
2" (50 mm)	90-100	100					
1 1/2" (37.5 mm)	35-70	90-100					
1" (25 mm)	0-15	20-55	100	100			
3/4" (19 mm)		0-15	90-100	90-100			
1/2" (12.5 mm)	0-5		20-55		100		
3/8" (9.5 mm)		0-5	0-15	20-55	85-100	100	
No. 4 (4.75 mm)			0-5	0-10	10-30		100
No. 8 (2.36 mm)				0-5	0-10	60-100	40-100
No. 16 (1.18 mm)					0-5		

Reclaimed miscellaneous aggregate shall only be used where authorized in the specifications.

SECTION M.02

GRANULAR FILL
SUBBASE
GRANULAR BASE AND SURFACES
STONE BASE
PERVIOUS STRUCTURE BACKFILL
FREE-DRAINING MATERIAL
CRUSHER-RUN STONE

M.02.01—Granular Fill: For this purpose, the material shall consist of broken or crushed stone, gravel, reclaimed miscellaneous aggregate or a mixture thereof.

1. Broken or crushed stone shall be the product resulting from the artificial crushing of rocks, boulders or large cobblestones, substantially all faces of which have resulted from the crushing operation. Broken or crushed stone shall consist of sound, tough, durable stone, reasonably free from soft, thin, elongated, laminated, friable, micaceous or disintegrated pieces, mud, dirt or other deleterious material and shall be sized to meet the requirements of grading "A," Article M.02.06.

2. Bank or crushed gravel shall consist of sound, tough, durable particles of crushed or uncrushed gravel, free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. It shall meet Grading "A" and the requirements for plasticity and resistance to abrasion indicated in Article M.02.06. Crushed gravel shall be the manufactured product resulting from the deliberate mechanical crushing of gravel with at least 50% of the gravel retained on the No. 4 (4.75-millimeter) sieve having at least one fractured face.

3. Reclaimed Miscellaneous Aggregate material shall consist of sound, tough, durable particles of crushed reclaimed waste. It shall be free of soft disintegrated pieces, mud, dirt, glass or other injurious materials and contain no more than 2% by weight (mass) of asphalt cement.

This reclaimed miscellaneous material shall meet Grading "A" and the requirements for plasticity and resistance to abrasion, which are set forth in M.02.06. It shall be tested for

soundness in accordance with M.02.06 when directed by the Director of Research and Materials.

M.02.02—Subbase: Materials for this work shall conform to the following requirements:

1. Bank or crushed gravel shall consist of sound, tough, durable particles of crushed or uncrushed gravel, free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. It shall be hard and durable enough to resist weathering, traffic abrasion and crushing. It shall be subject to testing for soundness in accordance with Article M.02.06 when directed by the Director of Research and Materials. It shall meet Grading "B" and the requirements for plasticity and resistance to abrasion indicated in Article M.02.06.

2. Crusher-Run Stone shall consist of sound, tough, durable broken stone. It shall be reasonably free from soft, thin, elongated, laminated, friable, micaceous or disintegrated pieces, mud, dirt or other deleterious material.

(a) Loss on Abrasion: The crusher-run stone shall show a loss on abrasion of not more than fifty percent using AASHTO Method T 96.

(b) Grading: The crusher-run stone shall meet Grading "A" and the requirements for plasticity indicated in Article M.02.06.

3. Reclaimed Miscellaneous Aggregate shall consist of sound, tough, durable particles of crushed reclaimed waste. It shall be free from soft, disintegrated pieces, mud, dirt, glass or other injurious material, and contain no more than 2% by weight (mass) of asphalt cement.

This reclaimed miscellaneous material shall meet Grading "B" and the requirements for plasticity and resistance to abrasion, which are set forth in M.02.06. It shall be tested for soundness in accordance with M.02.06 when directed by the Director of Research and Materials.

M.02.03—Granular Base, Rolled Bank Gravel Surface and Traffic Bound Gravel Surface: The materials for the "Rolled Granular Base" shall consist of sound, tough, durable particles of bank or crushed gravel, or reclaimed miscellaneous aggregate, or mixtures thereof with the resultant uniform blend containing no more than 2% by weight (mass) of asphalt cement. The materials for the Rolled Bank Gravel Surface and Traffic-Bound Gravel Surface shall consist of sound, tough, durable particles of bank or crushed gravel. All materials shall be free from thin or elongated pieces, lumps of clay, loam, or vegetable matter. Binder may be added and incorporated by approved methods as specified elsewhere. It shall meet Grading "A" except that the top course of the rolled bank gravel surface shall conform to Grading "C." It shall be subject to testing for soundness in accordance with Article M.02.06 when directed by the Director of Research and Materials. It shall also meet the requirements for plasticity and resistance to abrasion which, with grading, are indicated in Article M.02.06.

M.02.04—Gravel Shoulders: The materials for this work shall consist of sound, tough, durable particles of crushed or uncrushed gravel free from soft, thin, elongated or laminated pieces, vegetable or other deleterious substances. Gravel shall meet Grading "A" except that the upper 3 inches (75 millimeters) shall conform to Grading "C." It shall be subject to testing for soundness in accordance with Article M.02.06 when directed by the Director of Research and Materials. It shall also meet the requirements for plasticity and resistance to abrasion which, with grading, are indicated in Article M.02.06.

M.02.05—Pervious Structure Backfill: Pervious structure backfill shall consist of broken or crushed stone, broken or crushed gravel, or reclaimed miscellaneous aggregate containing no more than 2% by weight (mass) of asphalt cement or mixtures thereof.

Materials for this work shall conform to the following requirements:

1. Broken or crushed stone shall consist of sound, tough, durable stone, reasonably free from soft, thin, elongated, friable, laminated, micaceous or disintegrated pieces, mud, dirt or other deleterious material and shall be sized to meet the requirements of Grading "B," Article M.02.06. It shall meet the requirements of loss on abrasion indicated in Subarticle M.02.02-2(a).

2. Bank or crushed gravel shall consist of sound, tough, durable particles of crushed or uncrushed gravel free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. It shall be subject to testing for soundness in accordance with Article M.02.06 when directed by the Director of Research and Materials. It shall meet Grading "B" and the requirements for plasticity and resistance to abrasion indicated in Article M.02.06.

3. Reclaimed Miscellaneous Aggregate shall consist of sound, tough, durable particles of crushed reclaimed waste. It shall be free of soft disintegrated pieces, mud, dirt, glass or other injurious material, and contain no more than 2% by weight (mass) of asphalt cement. It shall meet Grading "B" and the requirements for plasticity, resistance to abrasion and soundness indicated in M.02.06.

M.02.06—Gradation, Plasticity, Resistance to Abrasion and Soundness Requirements:

1. Gradation:

	Grading		
	A	**B**	**C**
Square Mesh Sieves	Percent passing by weight (mass)		
Pass 5 inch (125 mm)		100	
Pass 3 1/2 inch (90 mm)	100	90-100	
Pass 1 1/2 inch (37.5 mm)	55-100	55-95	100
Pass 3/4 inch (19 mm)			45-80
Pass 1/4 inch (6.3 mm)	25-60	25-60	25-60
Pass #10 (2.0 mm)	15-45	15-45	15-45
Pass #40 (425 µm)	5-25	5-25	5-25
Pass #100 (150 µm)	0-10	0-10	0-10
Pass #200 (75 µm)	0-5	0-5	0-5

The grading percentages specified in the above table shall apply to the material after it has been delivered to the construction site as well as when tested at the pit or other source of supply.

When the fraction of the dry sample passing the No. 100 (150-µm) mesh sieve is greater than 8% by weight (mass), the sample will be washed as indicated. The amount obtained from washing shall be added to that obtained by dry sieving; and the total amount passing each sieve shall meet the above gradation.

2. Plasticity:

(a) When the fraction of the dry sample passing the No. 100 (150-µm) mesh sieve is 4% or less by weight (mass), no plastic limit test will be made.

(b) When the fraction of the dry sample passing the No. 100 (150-µm) mesh sieve is greater than 4% and not greater than 8% by weight (mass), that fraction shall not have sufficient plasticity to permit the performing of the plastic limit test using AASHTO Method T 90.

(c) When the fraction of the dry sample passing the No. 100 (150-µm) mesh sieve is greater than 8% by weight (mass), the sample will be washed; and the additional material passing the No. 100 (150-µm) mesh sieve shall be determined by AASHTO

Method T 146, except that the No. 100 (150-µm) mesh sieve will be substituted for the No. 40 (425-µm) mesh sieve where the latter is specified in AASHTO Method T 146. The combined materials that passed the No. 100 (150-µm) mesh sieve shall not have sufficient plasticity to permit the performing of the plastic limit test using AASHTO Method T 90.

3. Test for Resistance to Abrasion. Gravel materials shall show a loss on abrasion of not more than 50% using AASHTO Method T 96.

4. Soundness: When tested with magnesium sulfate solution for soundness using AASHTO Method T 104, coarse aggregate shall not have a loss of more than 15% at the end of five cycles.

M.02.07—Free-Draining Materials: Free-draining material shall consist of sand, gravel, rock fragments, quarry run stone, broken stone, reclaimed miscellaneous aggregate containing no more than 2% by weight (mass) of asphalt cement or mixtures thereof. This material, or the material from any one source of a mixture, shall not have more than 70%, by weight (mass), passing the No. 40 (425 µm) mesh sieve and not more than 10%, by weight (mass), passing the No. 200 (75 µm) mesh sieve.

SECTION M.03

PORTLAND CEMENT CONCRETE

M.03.01—General Composition of Concrete Mixes

M.03.01—General Composition of Concrete Mixes: Portland cement concrete shall consist of an intimate mixture of portland cement, other approved cementitious material (when used), fine aggregate, coarse aggregate, water, and admixtures, if ordered or permitted by the Engineer, proportioned in accordance with the following requirements:

TYPE	28-day Minimum Compressive Strength psi (megapascals)	Water / Cement; or Water / Cement plus other approved Cementitious Material (by weight (mass)) Maximum	Minimum Cementitious Material Required pounds/ cubic yard (kilograms/ cubic meter
Class "A"	3000 (21)	0.53	615 (365)
Class "C"	3000 (21)	0.53	658 (390)
Class "F"	4000 (28)	0.44	658 (390)
Pavement	3500 (25)	0.49	615 (365)
Slope Paving	2000 (14)	0.69	455 (270)

These proportions are based on the weight (mass) of the cementitious material and surface dry aggregates and on bulk specific gravity for fine and coarse aggregates.

At the option of the Contractor, other approved cementitious material may be used to replace a portion of the required portland cement in accordance with the requirements of Subarticle M.03.01-13.

When a Contractor proposes to use other approved cementitious material as a partial replacement for portland cement, he shall notify the Engineer, in writing, prior to the start of work, of the identity of the other approved cementitious material and the percentage of the required portland cement in the concrete mix which he proposes to replace with the other approved cementitious material.

The materials shall conform to the following requirements:

1. Coarse Aggregate: Coarse aggregate shall be broken stone, gravel, or reclaimed concrete aggregate defined as mortar-coated rock, consisting of clean durable fragments of uniform quality throughout. It shall be free from soft, disintegrated pieces, mud, dirt, organic or other injurious material and shall not contain more than one percent of dust by mass, as determined by the testing method used by the Laboratory. Reclaimed concrete aggregate shall not be used in prestressed concrete members.

Coarse aggregate of a size retained on a 1-inch (25 mm) square opening sieve shall not contain more than 8% of flat or elongated pieces, whose longest dimension exceeds five times their maximum thickness.

(a) Soundness: When tested with magnesium sulfate solution for soundness, using AASHTO Method T 104, coarse aggregate shall not have a loss of more than 10% at the end of five cycles.

(b) Loss on Abrasion: When tested by means of the Los Angeles Machine, using AASHTO Method T 96, coarse aggregate shall not have a loss of more than 40%.

(c) Grading: Grading of the various stone sizes shall conform to the gradation table of Article M.01.01.

Class "A": The mix shall be designed utilizing a nominal maximum size of No. 4 aggregate.

Class "C": The mix shall be designed utilizing a nominal maximum size of No. 6 aggregate.

Class "F": The mix shall be designed utilizing a nominal maximum size of No. 6 aggregate.

Pavement: The mix shall be designed utilizing a nominal maximum size of No. 4 aggregate.

Slope Pavement: The mix shall be designed utilizing a nominal maximum size of No. 3 aggregate.

(d) Samples: Samples for tests of coarse aggregate will be taken from the bins at the quarry or from approved storage piles at the site of quarry or from approved storage piles at the batch plant.

(e) Chloride content: When reclaimed concrete aggregate is used, it shall be tested for chloride content prior to being mixed with virgin aggregate. The test used to determine chloride content shall be that outlined in the FHWA Report No. FHWA-RD-77-85. No aggregate will be accepted if the chloride content as determined from this test exceeds 0.5 pound/cubic yard (0.3 kilogram/cubic meter).

2. Fine Aggregate: Fine aggregate shall be sand consisting of clean, hard, durable, uncoated particles of quartz or other rock, free from lumps of clay, soft or flaky material, loam, organic or other injurious material. In no case shall sand containing lumps of frozen material be used.

(a) Fine Material: Fine aggregate shall contain not more than 3% of material finer than a #200 (75 µm) sieve, using AASHTO T 11.

(b) Organic Impurities: Fine aggregate subjected to the colorimetric test shall not produce a color darker than Gardner Color Standard No. 11, using AASHTO T 21. If the fine aggregate fails to meet this requirement, the provisions of AASHTO M 6, Section 5.2, will govern.

(c) Gradation: Fine aggregate shall be uniformly graded from coarse to fine and shall meet the following gradation requirements.

SQUARE MESH SIEVES

TOTAL PERCENT PASSING BY WEIGHT (MASS)

3/8" (9.5 mm)	No. 4 (4.75 mm)	No. 8 (2.36 mm)	No. 16 (1.18 mm)	No. 30 (600 µm)	No. 50 (300 µm)	No. 100 (150 µm)
100	95-100	80-100	50-85	25-60	10-30	2-10

The above gradation represents the extreme limits which shall determine suitability for use from all sources of supply. The gradation from any one source shall be reasonably uniform and not subject to the extreme percentages of gradation specified above. For the purpose of determining the degree of uniformity, a fineness modulus determination will be made upon representative samples from any source. Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative sample will be rejected.

(d) Samples: Samples for tests of fine aggregate will be taken from approved storage piles at the site of the batch plant or from approved storage piles at the producing pit.

3. Cement: Cement having a temperature exceeding 160° F (71° C) at the time of delivery to the mixer shall not be used in the concrete.

Types I, II, and III portland cement shall conform to the requirements of AASHTO M 85.

Type IS, portland blast-furnace slag cement and Type IP, portland-pozzolan cement shall conform to the requirements of AASHTO M 240. The use of other approved

cementitious material as a partial replacement for Type IS or Type IP cement will not be permitted.

Type I and Type III portland cement shall be used only when required or expressly permitted by the Contract or the Engineer.

Ordering: Before starting work, the Contractor shall notify the Engineer, in writing, of the name of the manufacturer, mill, and the name of the brand of cement which he proposes to use on the work. Different brands of cement, or the same brand from different mills shall not be used on any project except with the approval of the Engineer.

All cement, except in lots of 200 bags or less, shall be shipped from bins approved by the Department.

Testing: All cement, except in lots of 200 bags or less, shall be sampled at the mill. All cements shall be tested by a laboratory, whose methods and equipment are regularly inspected by the Cement and Concrete Reference Laboratory.

When a mill applies for permission to provide cement by certification, a copy of the last two (2) inspection reports by the Cement and Concrete Reference Laboratory shall be submitted for review by the Engineer. Reports of subsequent inspections shall also be submitted as received.

The mill shall provide the Materials Testing Laboratory with 3 copies of Certified Test Reports of all cement which is being used by the ConnDOT for projects in Connecticut. The certified test report shall conform to Article 1.06.07.

4. Water: The water shall be reasonably clean, shall not be salty or brackish, and shall be free from oil, acid and injurious alkali or vegetable matter. The water shall be tested as prescribed by AASHTO Method T 26.

Water shall not be taken from shallow or muddy sources. In cases where sources of supply are relatively shallow, they shall be so enclosed as to exclude silt, mud, grass, etc.; and the water in the enclosure shall be maintained at a depth of not less than 2 feet (610 millimeters) under the intake of the suction pipe.

5. Transverse Joints for Concrete Pavement and Joint Filler for Concrete Curbing: These joints shall consist of corrosion resistant load transfer devices, poured joint seal and in addition, in the case of expansion joints, expansion joint filler conforming to the following requirements:

(a) The corrosion resistant load transfer device shall be coated steel or sleeved steel or be made of corrosion resistant material. The dimensions of any devices used shall be as shown on the plans, exclusive of any coating or sleeving. Core material of coated or sleeved metallic devices shall be steel meeting the requirements of AASHTO M 255M/M 255 Grade 520, or steel having equal or better properties and approved by the

Engineer. Nonmetallic devices shall meet the various strength requirements applicable to metallic devices as well as all other requirements stated herein.

All coated load transfer devices shall conform to the requirements of AASHTO M 254. Uncoated or sleeved load transfer devices shall meet the applicable physical requirements of AASHTO M 254. The use of field applied bond breakers will not be permitted.

The basis of acceptance for corrosion resistant load transfer devices shall be the submission by the Contractor of a minimum of two samples accompanied by certified test reports conforming to the requirements of Article 1.06.07 demonstrating that the load transfer device conforms to the requirements of AASHTO M 254 for the type of device supplied.

The Engineer reserves the right to reject any load transfer device which he deems unsatisfactory for use.

(b) The type of expansion joint filler shall be either preformed expansion joint filler or wood joint filler as indicated on the plans and shall conform to the following requirements:

(1) Preformed expansion joint filler shall be the bituminous cellular type and shall conform to the requirements of AASHTO M 213.

(2) Boards for wood joint filler shall be planed on two sides and shall be either redwood, cypress or white pine. Redwood and cypress boards shall be of sound heartwood. White pine boards shall be of sound sapwood.

Occasional small, sound knots and medium surface checks will be permitted provided the board is free of any defects that will impair its usefulness for the purpose intended. The joint filler may be composed of more than one length of board in the length of the joint, but no board of a length less than 6 feet (1.9 meters) may be used; and the separate boards shall be held securely to form a straight joint. Boards composed of pieces that are jointed and glued shall be considered as one board.

Dimensions shall be as specified or shown on the plans; and tolerances of plus 1/16-inch (1.6-millimeter) thickness, plus 1/8-inch (3.2-millimeter) depth and plus 1/4-inch (6.4-millimeter) length will be permitted.

All wood joint filler boards shall be given a preservative treatment by brushing with a creosote oil conforming to AASHTO M 133. After treatment, the boards shall be stacked in piles, each layer separated from the next by spacers at least 1/4 inch (6.4 millimeters) thick; and the boards shall not be used until 24 hours after treatment.

Prior to concreting, all exposed surfaces of the wood filler shall be given a light brush coating of form oil.

Testing of board expansion joint filler shall be in accordance with pertinent sections of AASHTO T 42.

6. Longitudinal Joint Devices: The metal used in the fabrication of longitudinal joint devices shall conform to ASTM requirements for each type of metal used. The dimensions shall be as shown on the plans.

7. Expansion Joint Fillers for Structures:

(a) Preformed expansion joint filler for bridges shall conform to the requirements of AASHTO M 153, Type I and Type II.

(b) Pre-molded expansion joint filler for bridge bearings shall conform to the requirements of AASHTO M 33.

8. Joint Sealants:

(a) Joint Sealer for Pavement: The joint sealer for pavement shall be a rubber compound of the hot-poured type and shall conform to the requirements of AASHTO M 173 unless otherwise noted on the plans or in the special provisions.

(b) Joint Sealer for Structures: The joint sealer for structures shall be as noted on the plans or as required by the special provisions.

9. Admixtures: When data is required that an admixture shall perform the desired function without injurious effects upon the concrete, this data shall be in the form of a certified statement from a recognized laboratory. The certified statement shall contain evidence based upon tests pertinent to the admixture made in the recognized laboratory by the use of concreting materials and by methods that meet the requirements of current standards of AASHTO and ASTM. Tests may be made upon samples taken from a quantity submitted by the Contractor for use on the project, or upon samples submitted and certified by the manufacturer as representative of the admixture to be supplied. A "recognized" laboratory is any cement and concrete laboratory approved by the Engineer and inspected regularly by the Cement and Concrete Reference Laboratory, sponsored by the ASTM and the NBS.

(a) Air-Entraining Admixtures: In the event an air entraining admixture is required, evidence based on tests made in a recognized laboratory shall be submitted to show that the material conforms to the requirements of AASHTO M 154 for 7 and 28-day compressive and flexural strengths and resistance to freezing and thawing. Tests for bleeding, bond strength and volume change will not be required.

An exception to the preceding requirement is the case of admixtures which are manufactured by neutralizing Vinsol resin with caustic soda (sodium hydroxide). When the Contractor proposes to use such an admixture, he shall submit to the Engineer a certification concerning the admixture in the following form:

This is to certify that the product (trade name) as manufactured and sold by the (company name) is an aqueous solution of Vinsol resin that has been neutralized with sodium hydroxide. The ratio of sodium hydroxide to Vinsol resin is one part of sodium hydroxide to (number) parts of Vinsol resin. The percentage of solids based on the residue resulting from evaporation and subsequent drying at 221° F (105° C) is (number). No other additive or chemical agent is present in this solution.

When the Contractor proposes to use an air-entraining admixture which has been previously approved, he shall submit to the Engineer a certification stating that the admixture is the same as that previously approved. If an admixture offered for use is essentially the same (with only minor differences in concentration) as another previously approved material, a certification will be required stating that the product is essentially the same as the approved admixture and that no other admixture or chemical agent is present.

Either prior to, or at any time during construction, the Engineer may require that the admixture selected by the Contractor be further tested to determine its effect upon the strength of the concrete. When so tested, 7-day compressive strength of concrete made with the cement and aggregates in the proportions to be used in the work, and containing and admixture under test in an amount sufficient to produce from 4% to 6% entrained air in the plastic concrete, shall be not less than 85% of the strength of concrete made with the same materials and with the same cement content and consistency but without the admixture.

The percentage reduction in strength shall be calculated from the average strength of at least 5 standard 6-inch x 12-inch (150-millimeter x 300-millimeter) cylinders of each class of concrete.

Specimens will be made and cured in the laboratory in accordance with the requirements of AASHTO T 126 and will be tested in accordance with the requirements of AASHTO T 22. The percentage of entrained air will be determined in accordance with the requirements of AASHTO T 152.

(b) Retarder Admixtures: The admixtures may be in liquid or powder form, and of one of the following types:

(1) A calcium, sodium, potassium or ammonium salt of lignosulfonic acid.

(2) A hydroxylated carboxylic acid or its salt.

(3) A carbohydrate.

Mix Requirements: The properties of retarded concrete prepared with the admixture under test shall be compared with those of a reference concrete prepared without the admixture. The cement, water and aggregates for both concretes shall be drawn from common sources or stockpiles and the mixes shall have the following composition:

Cement Content, bags per cubic yard (meter)	.....	6.0± 0.1 (7.9 ± 0.1)
Air Content, % (reference concrete)	.....	5.5 ± 0.5
Air Content, % (retarded concrete)	.....	6.0 ± 1.0
Slump, inches (millimeters)	.....	2 1/2 ± 1/2 (66 ± 12)
Fine aggregate, by soil volume of total aggregate, %	.....	36 to 41

An approved air-entraining admixture shall be used, if necessary, to obtain the required air content.

A sufficient amount of retarding admixture shall be used to cause an increase of 50% to 60% in setting time over the setting time of the reference mix. The setting time for both mixes shall be determined by ASTM C 403 using a pressure of 500 psi (3.45 megapascals) at a temperature of 73.4° ±3° F (23 ° ± 2° C) for the concretes and ambient air.

Required Properties of Retarder: When added to concrete in powder or liquid form, in the manner prescribed by it's manufacturer or marketer and in sufficient amount to retard the setting time 50% to 60%, the retarding admixture shall cause the concrete to have the following properties in comparison with those of the reference concrete.

When the test and reference concrete have equal cement content and equal slump, the water content shall be decreased at least 5%; the air content of the retarded concrete with or without an air-entraining admixture, shall not exceed 7%; and the compressive strength at ages of 3, 7 and 28 days shall be increased at least 10%.

Performance Requirements: When a Contractor proposes to use a previously approved retarding admixture, he shall submit a certificate stating that the admixture is identical in composition with the sample that was used for the acceptance tests. If the admixture varies in concentration from the acceptance sample, a certificate will be required stating that the product is essentially the same for chemical constituents as the approved admixture and that no other admixture or chemical has been added. Either prior to or at any time during construction, the Engineer may require the selected

admixture to be re-tested. When re-tested, the 3- and 7-day compressive strengths or 7-day flexural strength of the concrete shall meet the requirements stated above.

(c) All Other Admixtures, when specified, shall meet the requirements set forth in the special provisions or on the plans.

10. Curing Materials:

(a) Cotton Mats: Cotton mats for curing concrete shall consist of a filling material of cotton "bat" or "bats" covered with un-sized cloth and tufted or stitched to maintain the shape and stability of the unit under job conditions of handling.

The covering of the mats shall be one of the following:

(1) Cotton cloth covering shall have a mass of not less than 6.3 ounces per square yard (215 grams/square meter) and shall have an average of not less than 32 threads in warp and not less than 28 threads in filling, having a minimum average breaking strength (grab method) of 60 pounds (270 newtons) in the warp and 60 pounds (270 newtons) in the filling. The weight (mass) of the cotton cloth covering shall not fall below the specified weight (mass) by more than 5%. The raw material used in the manufacture of the cotton cloth shall be raw cotton, cotton comber waste, cotton card strip waste, or combination thereof. The other physical characteristics of the cloth shall be equal to those in such material for industrial purposes.

(2) Burlap or jute covering shall weigh (have a mass) of not less than 6.7 ounces per square yard (230 grams/square meter) and shall have not less than 8 threads per 1 inch (25 millimeters) of warp and not less than 8 threads per 1 inch (25 millimeters) of filling. It shall be the grade known commercially as "firsts" and shall be free from avoidable imperfections in manufacture and from defects or blemishes affecting the serviceability. A tolerance in weight (mass) of minus 5% will be permitted.

The filling material for the mats shall be a cotton bat, or bats, made of raw cotton, cotton waste, cotton linters, or combinations thereof, and shall weigh (have a mass) of not less than 12 ounces per square yard (410 grams/square meter). The mats shall not contain any materials such as dyes, sugar, etc., that may be injurious to the concrete. The batting used shall not be lower in quality than a batting made of U.S. Standard Grade No. 3 Linters.

The cotton thread for tufting shall be not less than 4-cord number 12's. The thread used for all sewing or stitching shall be at least equivalent in size and strength to standard 3-cord, number 30 cotton thread.

The mats shall have a filler 5 feet 9 inches (1.8 meters) in width and shall have a flap 6 inches (150 millimeters) or more in width, consisting of an extension of two

thicknesses of the covering material, extending along one longitudinal edge of the mat. The length of the mats shall be 2 feet 6 inches (765 millimeters) greater than the width of pavement slab to be cured. The length or width of the mats shall be not less than that specified by more than 2%.

The covering material for each surface of the mat shall consist of two widths of cloth joined by a lapped seam or by a seam formed by superimposing the two widths and uniting them by one row of stitches. If the seam is of the latter type, the edges shall be on the inside of the finished mat. The cotton filling material in the form of a bat or bats shall be held in place between the coverings by sewing or tufting all around the periphery of the mat within 1 inch (25 millimeters) of each of the four edges of the filler, and by sewing or quilting longitudinally at intervals not greater than 4 inches (100 millimeters), or by tufting at intervals, both longitudinally and transversely, not greater than 3 inches (75 millimeters). The sewing or tufting shall be sufficiently loose to permit substantially all of the surface of the mat to come in contact with a flat surface when in use, but not so loose as to permit the filling material to shift. The flap shall be constructed by sewing the upper and lower covering together longitudinally within 1 inch (25 millimeters) of the outer edge of the flap. Along the edge of the mat opposite the flap, the filling material shall be within 1 inch (25 millimeters) of the edges of the covering material, and the covering material shall be sewn together so as to enclose the filling material. The ends of the mats shall be finished by running an additional seam (i.e., a seam in addition to the seam holding the filling material in place) across the mats. This seam shall not be closer to the seam holding the filling material in place than 1/4 inch (6.4 millimeters) and not closer to the end of either covering than 1/2 inch (12.5 millimeters), unless the ends of the mat are finished with an overlying or whip stitch or in a manner which will not leave a raw edge. All longitudinal sewing or quilting shall average at least three stitches per 1 inch (25 millimeters) and shall have not less than five stitches in any 2 inches (50 millimeters). All other sewing shall average six stitches per 1 inch (25 millimeters) and shall have not less than nine stitches in any 2 inches (50 millimeters).

(b) Waterproof Paper: Waterproof paper shall conform to the requirements of AASHTO M 171 and in addition shall not be less than 20 feet (6.1 meters) in length and shall be of sufficient width to cover completely the surface of the pavement.

(c) Liquid Membrane-Forming Compound: Liquid membrane-forming compound shall conform to the requirements of AASHTO M 148 Type 2, Class B, or shall be a water-soluble linseed oil-based compound conforming to the requirements of AASHTO M 148, Type 2.

(d) White Polyethylene Sheeting (Film): White polyethylene sheeting (film) shall conform to the requirements of AASHTO M 171.

11. Protective Compound Material: This material shall be listed on the approved list of the ConnDOT for the specified use.

12. Non-shrink, Non-staining Grout:

(a) Bagged, pre-mixed formulations of non-shrink grout shall meet the requirements of ASTM C 1107, Grade B. The grout must be mixed with potable water for use. The grout shall be mixed to a flowable consistency as determined by ASTM C 230. All bagged material shall be clearly marked with the manufacturer's name, date of production, batch number, and written instructions for proper mixing, placement and curing of the product.

(b) The Contractor may formulate and design a grout mix for use on the project in lieu of using a pre-bagged product. The Contractor must obtain prior written approval of the Engineer for any such proposed mix design. Any such mix design shall include the proportions of hydraulic cement, potable water, fine aggregates, expansive agent, and any other necessary additive or admixture. This material shall meet all of the same chemical and physical requirements as must the pre-bagged grout, in accordance with ASTM C 1107, Grade B.

13. Other Cementitious Material:

(a) Fly Ash

1. Fly ash may be used to replace up to a maximum of 15% of the required portland cement. The fly ash shall be substituted on a weight (mass) basis, with a minimum of 1 pound (0.45 kilogram) of fly ash for 1 pound (0.45 kilograms) of portland cement.

2. Fly ash to be used as a replacement for portland cement in portland cement concrete shall meet the requirements of AASHTO M 295, either Class C or Class F, including the uniformity requirements of Table 2A. Loss on Ignition for either class of fly ash shall not exceed 4.0%.

3. Ordering: Before starting work, the Contractor shall notify the Engineer, in writing, of the class, the name and location of the producing plant and the name and location of the bulk storage facilities, if different from the producing plant, for the fly ash he proposes to use in the work. Different classes of fly ash or the same class from different producing plants, shall not be used on any project without the written express approval of the Engineer.

Fly ash shall be obtained from an approved source and shall be supplied from silos or bulk storage facilities, whose contents have been approved by the Department.

4. Testing: Fly ash shall be sampled and tested in accordance with the procedures and methods prescribed in ASTM C 311.

The producer or supplier of the fly ash shall provide the Division of Materials Testing with three copies of certified test reports from an approved laboratory for all fly ash supplied to the Department. The certified test reports shall conform to Article 1.06.07. An approved laboratory shall be defined as a laboratory whose cement and concrete

testing equipment and methods are regularly inspected by the Cement and Concrete Reference Laboratory.

Approval of the laboratory will be contingent on review by the Department of the last two inspection reports by the CCRL, which are to be submitted by the laboratory.

5. Storage: The fly ash shall be stored at the producing plant or at the supplier's terminal in approved weather-tight silos or bulk storage facilities. All silos or storage facilities shall be completely empty and clear before the fly ash is deposited therein.

Fly ash remaining in bulk storage for a period greater than one year after approval shall be re-sampled and tested prior to shipment or use. Fly ash, which has been in bulk storage for a period exceeding two years from the time of original manufacture, shall not be used on Department work.

14. Anchoring Cement: The premixed anchoring cement shall be non-metallic, concrete gray in color and packaged in bags. The mix shall consist of hydraulic cement, fine aggregate, expansive admixtures and water conforming to the following requirements:

1. The anchoring cement shall have a minimum 24 hour compressive strength of 2,600 psi (18 megapascals), when tested in accordance with ASTM C 109.

2. The water content of the anchoring cement shall be as recommended by the manufacturer. Water shall conform to the requirements of Article M.03.01-4. The potable water shall not contain chlorides or nitrates.

Portland cement shall be Type I, II, or III cement conforming to the requirements of Article M.03.01-3.

Fine aggregate shall conform to the requirements of Article M.03.01-2.

The Contractor shall provide a Certified Test Report and Materials Certificate for the premixed anchoring cement in conformance with Article 1.06.07. The Contractor shall also provide, when requested by the Engineer, samples of the premixed anchoring cement for testing and approval.

15. Chemical Anchors: The chemical anchor material shall be epoxy or polyester polymer resin. It shall contain no metals or products that promote corrosion of steel. The Contractor shall supply the Engineer with a Certified Test Report and Materials Certificate for the chemical anchor material in conformance with Article 1.06.07. The Contractor shall also provide, when requested by the Engineer, samples of the chemical anchors for testing and approval. Chemical anchor material shall be listed on the Approved Products List of the ConnDOT and approved by the Engineer for the specified use.

SECTION M.04

BITUMINOUS CONCRETE MATERIALS

M.04.01—Bituminous Concrete Materials: All facilities producing and testing bituminous concrete materials must be approved on an annual basis by the Director of Research and Materials (DRM). The basis of approval for plant machinery, materials processing & controls, and field laboratory requirements is set forth in the "Materials Testing Manual" published by the Department's Division of Materials Testing. Asphalt test modifications are also included in the Materials Testing Manual.

Materials: All sources of materials used for the production of bituminous concrete materials must be approved by the DRM prior to their use. Such materials shall include coarse aggregate, fine aggregate, mineral filler and designated bitumen combined to meet the composition limits by weight (mass) and other requirements stated in Table M.04.01. The Contractor shall submit to the Engineer a request for approval of all material sources of supply on a project-by-project basis. The Contractor shall also submit a Material Safety Data Sheet (MSDS) for each grade of binder to be used on the Project.

An adequate quantity of each size aggregate, mineral filler and bitumen shall be maintained at the bituminous concrete plant site at all times while the plant is in operation to ensure that the plant can consistently produce bituminous concrete materials that meet the job mix formula (JMF) as specified in M.04.02. The quantity of such material shall be approved by the Engineer on an individual plant basis and is dependent upon the plant's daily production capacity, but shall never be less than one day's production capacity.

1. Coarse Aggregate:

a. Requirements: The coarse aggregate shall consist of clean, hard, tough, durable fragments of crushed stone or crushed gravel of uniform quality. Aggregates from multiple sources of supply shall not be mixed or stored in the same stockpile.

b. Basis of Acceptance: The request for approval of the source of supply shall include a washed sieve analysis in accordance with AASHTO T-27. The apparent specific gravity (Gsa), bulk specific gravity (Gsb) and percent absorption (Pa_w) shall be determined in accordance with AASHTO T-85. The aggregate shall not contain more than 1% crusher dust, sand, soft disintegrated pieces, mud, dirt, organic and other injurious materials. When tested for abrasion using AASHTO T-96, the aggregate loss shall not exceed 40.0%. When tested for soundness using AASHTO T-104 with a magnesium sulfate

solution, the coarse aggregate shall not have a loss exceeding 10.0% at the end of 5 cycles.

2. Fine Aggregate:

a. Requirements: The fine aggregate shall consist of clean, hard, tough, rough-surfaced and angular grains, of natural sand; manufactured sand prepared from washed stone screenings; stone screenings, slag or gravel; or combinations thereof. Fine aggregates from multiple sources of supply shall not be mixed or stored in the same stockpile.

b. Basis of Acceptance: The request for approval of the source of supply must include the location, manufacturing and processing methods. The request for approval shall also include a washed sieve analysis in accordance with AASHTO T-27. Any fine aggregate component or final combined product shall have 100% passing the 3/8 inch (9.5 millimeter) sieve. The apparent specific gravity (Gsa), bulk specific gravity (Gsb) and percent absorption (Pa_w) shall be determined in accordance with AASHTO T-84. The fine aggregates shall be free from injurious amounts of clay, loam, and other deleterious substances.

3. **Mineral Filler:**

a. Requirements: Mineral filler shall consist of finely divided mineral matter such as rock dust, including limestone dust, slag dust, hydrated lime, hydraulic cement, or other approved mineral matter. At the time of use it shall be freely flowing and devoid of agglomerations.

b. Basis of Acceptance: The request for approval of the source of supply shall include the location, manufacturing process, handling and storage methods for the material. Mineral filler shall conform to the requirements of AASHTO M-17.

4. Liquid Bituminous Materials:

a. Performance grade (PG) binder

i. **Requirements:** Materials for this item shall have uniformly mixed and blended liquid bituminous materials that are free of contaminants such as fuel oils and other solvents. Such materials shall be properly heated and stored to prevent damage or separation. PG binders used in the production of bituminous materials shall be approved by the DRM. PG binders that are modified with fillers, extenders, reinforcing agents, adhesion promoters, additives, and thermoplastic polymers shall be approved for use only with the prior written approval from the DRM.

ii. **Basis of Acceptance:** The request for approval of the source of supply shall list the location where the materials will be produced, and manufacturing, processing, handling and storage methods along with necessary certification in accordance with AASHTO R-26. The PG binder utilized for the production of bituminous materials shall consist of the

grade specified in the Contract when tested in accordance with AASHTO M-320 and AASHTO R-29.

b. Cut-backs (medium cure type)

i. **Requirements:** The liquid petroleum materials for this item shall be produced by fluxing an asphalt base with appropriate petroleum distillates to produce the grade specified.

ii. **Basis of Acceptance:** The request for approval of the source of supply shall be submitted at least seven days prior to its use listing the location where the materials will be produced, and manufacturing, processing, handling and storage methods. The liquid asphalt shall be MC-250 conforming to AASHTO M-82.

c. Emulsions

i. **Requirements:** The emulsified asphalt shall be homogeneous and not be used if exposed to freezing temperatures.

ii. **Basis of Acceptance:** The request for approval of the source of supply must include the location where the materials will be produced, and manufacturing, processing, handling and storage methods.

1. Emulsified asphalts shall conform to the requirements of AASHTO M-140. Materials used for tack coat shall be grade RS-1. When ambient temperatures are 80˚F (27˚C) and rising, grade SS-1 or SS-lh may be substituted if approved by the Engineer.

2. Cationic emulsified asphalt shall conform to the requirements of AASHTO M-208. Materials used for tack coat shall be grade CRS-1. The settlement and demulsibility test will not be performed unless deemed necessary by the DRM. When ambient temperatures are 80˚F (27˚C) and rising, grade CSS-1 or CSS-lh may be substituted if approved by the Engineer.

5. Reclaimed Asphalt Pavement (RAP):

a. Requirements: RAP shall consist of asphalt pavement constructed with s and aggregate reclaimed by cold milling or other removal techniques approved by the DRM. For bituminous mixtures containing RAP, the Contractor shall submit a JMF in accordance with M.04.02 to the Engineer for advance approval.

b. Basis of Acceptance: The RAP material will be accepted on the basis of one of the following criteria:

i. When the source of all RAP material is from pavements previously constructed in accordance with Department specifications, the Contractor shall provide certification that the RAP is only from such pavements and that the binder is substantially free of

solvents, tars and other contaminants. Stockpiles of such materials shall be continuously labeled with a sign reading "ConnDOT RAP" and remain separate from all other materials. A request for approval for the RAP material shall include the stockpile location and estimated quantities to be used.

ii. When the RAP material source or quality is not known, the Contractor shall test the material and provide the following information along with a request for approval to the DRM at least 30 calendar days prior to the start of the paving operation. The request shall include a material certificate stating that the RAP consists of aggregates that meet the specification requirements of M.04.01-1a through c and that the binder in the RAP is substantially free of solvents, tars and other contaminants. Stockpiles of such material shall remain separate from all other RAP materials at all times. The request for approval shall include the following:

1. A 5-pound (2.5-kilogram) sample of the RAP to be incorporated into the recycled mixture.

2. A 5-pound (2.5-kilogram) sample of the extracted aggregate from the RAP.

3. After recovery of from the RAP by AASHTO T-170, the viscosity test results shall be reported when tested at 140° F (60° C) by AASHTO T-202.

4. Statement that RAP material has been crushed to 100% passing the ½ inch (12.5 millimeter) sieve and remains free from contaminants such as joint compound, wood, plastic, and metals.

6. Crushed Recycled Container Glass (CRCG):

a. Requirements: The Contractor use clean and environmentally-acceptable CRCG in an amount not greater than 5% by weight (mass) of total aggregate.

b. Basis of Acceptance: The Contractor shall submit to the Engineer a request for approval to use CRCG. The request shall state that the CRCG contains no more than 1% by weight (mass) of contaminants such as paper, plastic and metal and conform to the following gradation:

CRCG Grading Requirements

Sieve Size	Percent Passing
3/8-inch (9.5 mm)	100
No. 4 (4.75mm)	35-100
No. 200 (75m m)	0-10

7. Joint Seal Material:

a. Requirements: Joint seal material shall be a hot-poured rubber compound.

b. Basis of Acceptance: Joint seal material will be tested in accordance with the requirements of AASHTO M-301.

M.04.02—Mix design and Job Mix Formula (JMF)

1. Marshall Method - Class 1, 2, 3, 4 and 12:

a. Requirements: The Marshall method shall be employed to develop a bituminous concrete mix design that includes a JMF consisting of target values for gradation and bitumen content for each class of bituminous concrete designated for the project in accordance with the latest Asphalt Institute's MS-2 manual. Each class of bituminous concrete must meet the requirements as shown in Table M.04.01.

b. Basis of Acceptance: The Contractor shall submit to the Engineer a request for approval of the JMF in accordance with one of the methods described in c, d, and e below. Prior to the start of any paving operations the JMF and production percentage of bitumen must be approved by the Engineer, and the Contractor must demonstrate the ability to meet the approved JMF and production percentage of bitumen for each class of material. Additionally, the fraction of material retained between any two consecutive sieves shall not be less than 4%.

The Engineer will test each class of material for compliance with the submitted JMF and Table M.04.01. The maximum theoretical density (Gmm) will be determined by AASHTO T-209 (modified). If the material does not meet the requirements, the JMF shall be adjusted within the ranges shown in Table M.04.01 until an acceptable material is produced. All equipment, tests and computations shall conform to the Marshall method in accordance with AASHTO T-245 (modified).

An approved JMF from the previous operating season may be acceptable to the Engineer provided that there are no changes in the sources of supply for the coarse aggregate, fine aggregate, recycled material (if applicable) and the plant operation had been consistently producing acceptable material.

The Contractor shall not change sources of supply after a JMF has been approved. Before a new source of supply for materials is used, a new JMF shall be submitted to the Engineer for approval.

c. Marshall mixture (virgin): For Bituminous concrete materials that contain no recycled material, the limits prescribed in Table M.04.01 govern. The Contractor shall submit to the Engineer for approval, a JMF with the individual fractions of the aggregate expressed as percentages of the total weight (mass) of the mix and the source(s) of all materials. The JMF shall indicate two bitumen contents; the JMF target percentage and a production percentage (actual amount added to mix) of bitumen for each mix class by total weight (mass). For surface course Class 1, a 0.45 power gradation chart shall also be submitted on which is plotted the percentage passing each sieve. The JMF shall also indicate the target temperature of completed mixture as it is dumped from the mixer and tested in accordance with M.04.03-3.

d. Marshall mixtures with RAP: Bituminous concrete that contains RAP shall comply with requirements stated in M.04.01-1(a through e). Upon approval by the Engineer, a maximum of 10% RAP may be used with no binder grade modification. RAP material shall not be used with any other recycling option.

The Contractor may increase the RAP percentage in 5% increments up to a maximum of 30% provided a new JMF is approved by the Engineer. The following information shall be included in the JMF submittal:

i. Gradation and asphalt content of the RAP.

ii. Percentage of RAP to be used.

iii. Virgin aggregate source(s).

iv. Total JMF content based on total mixture weight (mass).

v. Production pull percentage of bitumen (added virgin) based on total mixture weight (mass).

vi. Gradation of combined bituminous concrete mixture (including RAP).

vii. Grade of virgin added, if greater than 10% of total mix weight (mass).

e. Marshall mixture with CRCG: For Bituminous concrete that contains CRCG, the Contractor shall submit a materials certificate to the Engineer stating that the mixture

and its components comply with requirements stated in M.04.0-1 (f). Additionally, 1% hydrated lime, or other approved non-stripping agent, shall be added to all mixtures containing CRCG. CRCG material shall not be used with any other recycling option.

2. Cold Patch Method - Class 5, 5A, 5B:

a. Requirements: This material must be capable of being stockpiled and workable at all times. A non-stripping agent approved by the Engineer shall be used in accordance with manufacturer's recommendations.

i. Class 5A material shall have 3/8 to ½ inch (9.5 to 12.5 millimeters) polypropylene fibers added at a minimum rate of 6 pounds per ton (3 kilograms per metric ton) of mixture.

ii. Class 5B mixture shall have ¼ inch (6.3 millimeters) polyester fibers added at the minimum rate of 2 1/2 pounds per ton (1.25 kilograms per metric ton) of mixture.

b. Basis of Acceptance: The Contractor shall submit to the Engineer a materials certificate for this material. The aggregates, fibers and binder (MC-250) shall meet the requirements as specified in M.04.01-1 (a through d) and in Table M.04.01. The use of recycled material is not permitted with this class of Bituminous concrete.

		Ranges for Bituminous Concrete Hot Mix Asphalt Mixtures								JMF Tolerance
CLASS		1	2	3	4	12	5 (f)	5A (f)	5B (f)	± Percent
Grade of PG binder content %		PG 64-28 5.0 - 6.5	PG 64-28 5.0 - 8.0	PG 64-28 6.5 - 9.0	PG 64-28 4.0 - 6.0	PG 64-28 7.5 - 10.0	MC-250 (e) 6.0 - 7.5	MC-250 (e) 6.0 - 7.5 (i)	MC-250 (e) 6.0 - 7.5 (j)	0.4
Sieve Size		Percent Passing (%)								
#200	75 m m	3 – 8 (h)	3 – 8 (h)	3 – 8 (h)	0 – 5 (h)	3 – 10 (h)	0 - 2.5	0 - 2.5	0 - 2.5	2
#50	300 m m	6 - 26	8 - 26	10 - 30	5 - 18	10 - 40				4
#30	600 m m	10 - 32	16 - 36	20 - 40		20 - 60	2 - 15	2 - 15	2 - 15	5
#8	2.36 mm	28 - 50	40 - 64	40 - 70	20 - 40	60 - 95	10 - 45	10 - 45	10 - 45	6
#4	4.75 mm	40 - 65	55 - 80	65 - 87	30 - 55	80 - 95	40 - 100	40 - 100	40 - 100	7
¼"	6.3 mm									
3/8	9.5 mm	60 - 82	90 - 100	95 - 100	42 - 66	98 - 100	100	100	100	8
	12.5 mm	70 - 100	100	100		100				8
3/4"	19.0 mm	90 - 100			60 - 80					8
1"	25.0 mm	100								
2"	50.0 mm				100					
Additionally, the fraction of material retained between any two consecutive sieves shall not be less than 4%										
Material Temperature										
° F (° C)		325 max. (163 max.)					140 – 185 (60 – 85)			
Aggregate ° F (° C)		280 – 350 (138 – 177)					100 – 175 (38 – 79)			
Mixtures ° F (° C)		265 – 325 (129 – 163)				275-325(a) (135-163)(a)	120 – 175 (49 – 79)			± 25 ° F (± 12 ° C)
Mixture Properties										
VOIDS - %		3.0 – 6.0 (b)	2.0 – 5.0 (c)	0 - 4		0 - 5.0 (b)				
Stability [g] lbs. min.		1200 (d)	1000	1000		1000				
Newtons - min.		5300 (d)	4500	4500		4500				
FLOW [g] in.		.08 - .15	.08 - .15	.08 - .18		.08 - .15				
(mm)		(2 – 4)	(2 – 4)	(2 – 5)		(2 – 4)				
VMA (m) % - min.		15(k) :16 (L)								

Notes:

(a) **300° F (149 °C) minimum after October 1.**
(b) **75 blow (Marshall Criteria)**
(c) **3-6% when used for a roadway wearing surface**
(d) **For divided highways with 4 or more lanes, a stability of 1500 lbs.(6600 N) is required.**
(e) **Contains an approved non-stripping compound**
(f) **To help prevent stripping, the mixed material will be stockpiled on a paved surface, and at a height not greater than 4 feet (1.2 m) during the first 48 hours.**
(g) **As determined by AASHTO T- 245 (modified)**
(h) **The percentage of material passing the #200 (75 m m) sieve shall not exceed the percentage of bituminous asphalt binder determined by AASHTO T-164 (modified).**
(i) **Polypropylene Fibers - 3/8 - 1/2 inch (9.5 mm - 12.5 mm), added to the mix at a minimum rate of 6 pounds per ton (3 kilograms per metric ton). Fibers shall be pre-approved by the DRM.**
(j) **Polyester Fibers - 1/4 inch (6.3 mm) added to the mix at a minimum rate of 2 1/2 lb. per ton (1.25 kg per metric ton). Fibers shall be pre-approved by the DRM.**
(k) **Mixture with 5% or more aggregate retained on ¾" (19 mm) sieve**
(L) **Mixtures finer than condition (k) above**

M.04.03—Testing and Control of Mixture: The requirements of the plant during production, the sampling & testing methods used by Engineer during production, and the cessation of supply during paving operations are as follows*:*

1. Plant production requirements

a. Storage silos**:**

i. For mixtures sampled from hauling vehicles at the plant after storage in silos (for all classes except 5, 5A, and 5B), the viscosity of the recovered asphalt shall be no greater than 5,500 poises at 140° F (550 Pa· ·s at 60° C).

ii. A storage silo's usage shall cease and that bin placed "off test" when the results from one production test from a storage silo are not within the tolerances in Table M.04.01 or the results from two production tests from a silo are not within JMF tolerances. The silo shall remain "off test" until an acceptable trial test result is obtained. The trial test will be performed by the Engineer, and if the test results are within the JMF and Table M.04.01 criteria, the silo use may resume. If the trial test fails, the remaining materials stored in the silo will be rejected.

b. Aggregates**:** The Contractor shall ensure that aggregate stockpiles are managed to provide uniform gradation and particle shape, prevent segregation and cross contamination in a manner acceptable to the Engineer.

c. Mixture**:** The Contractor shall provide to the Engineer upon request, the dry and wet mix times for each class of materials. The dry and wet mix times shall be sufficient to provide proper coating of all particles with bitumen and produce a uniform mixture. The Contractor shall make necessary adjustments to ensure bituminous concrete materials are free from moisture throughout.

d. RAP**:** The Contractor shall indicate on the ticket the percent of RAP, the moisture content, and the net weight of RAP added to the mixture. The Contractor shall make necessary adjustments to ensure bituminous concrete materials are free from moisture throughout. For each day of production, the Contractor shall not change from the JMF and RAP percentage without prior approval of the Engineer.

2. **Sampling & testing methods:** The Contractor shall furnish the Engineer a field laboratory approved by the Department to test bituminous materials during production. Material samples will be obtained from the hauling vehicles by the Engineer at the plant during each day's production, as indicated in the Department's "**Schedule of Minimum Requirements for Sampling Materials for Test"**. The following test procedures will be used:

AASHTO T-30 (modified)	Mechanical Analysis of Extracted Aggregate

AASHTO T-40 (modified)	Sampling Bituminous Materials
AASHTO T-164 (modified)	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
AASHTO T-245 (modified)	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
AASHTO T-209 (modified)	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
AASHTO T-269 (modified)	Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures

In addition, the DRM may sample any load in transit or at the Project site in accordance with Section 1.06.

The results of AASHTO T-164 (modified) and T-30 (modified) will be used to determine if the material is within the tolerances shown in Table M.04.01.

a. The Contractor will be notified that a plant is "Off Test" for a class of material when the test results indicate that any single value for bitumen content or gradation are not within the tolerances shown in Table M.04.01 for that class of material.

b. If a subsequent test indicates that the bitumen content or gradation are outside the tolerances, the Contractor may make a single JMF change on classes 1, 2, 3, 4 and 12 as approved by the DRM prior to any additional testing. Consecutive test results outside the JMF tolerances may result in rejection of the mixture.

c. Any adjustment to the JMF shall not exceed 50% of the JMF tolerances indicated in Table M.04.01 for any given component of the mixture without approval of the DRM. When such an adjustment is made to the bitumen, the corresponding production percentage of bitumen shall be revised accordingly.

3. **Cessation of Supply:** The Engineer will cease the supply of material for the Project from any plant that consistently fails to produce material that meets the JMF. The criteria for ceasing the supply of a class of material from any plant are as follows:

a**.** When the test results from three consecutive samples are not within the JMF tolerances or the test results from two consecutive samples are not within the ranges indicated in Table M.04.01.

b. When the percent of material passing the minus #200 (75m m) sieve material exceeds the percent of extracted bitumen content for three consecutive samples during any production period.

In addition, when the test results from three non-consecutive samples of a class of material not within the JMF tolerances or the test results from two non-consecutive samples not within the range indicated in Table M.04.01 during any one production period, the Engineer may cease supply of material from the plant.

Following cessation, a trial production period will be required at the plant for that class of material. Use of that class of material from that plant will be prohibited on the Project until the plant has demonstrated the ability to consistently produce acceptable material. When the DRM has approved the materials from the trial production period, the use of that material on the Project may resume.

SECTION M.05

PROCESSED AGGREGATE BASE AND PAVEMENT SURFACE TREATMENT

M.05.01—Processed Aggregate Base and Pavement
M.05.02—Surface Treatment

M.05.01—Processed Aggregate Base and Pavement: The materials for this work shall conform to the following requirements:

1. Gradation: Coarse and fine aggregates shall be combined and mixed by approved methods so that the resulting material shall conform to the following gradation requirements:

Square Mesh Sieves	Percent Passing by Mass
Pass 2 1/2 inches (63 mm)	100
Pass 2 inches (50 mm)	95-100
Pass 3/4 inch (19 mm)	50-75
Pass 1/4 inch (6.3 mm)	25-45
Pass #40 (425 µm)	5-20
Pass #100 (150 µm)	2-12

2. Coarse Aggregate: Coarse aggregate shall be either gravel, broken stone or reclaimed miscellaneous aggregate containing no more than 2% by weight (mass) of asphalt cement, at the option of the Contractor. When tested by means of the Los Angeles Machine, using AASHTO Method T 96, the coarse aggregate shall not have a loss of more than 50%.

(a) If gravel is used for the coarse aggregate, it shall consist of sound, tough, durable particles of crushed or uncrushed gravel or a mixture thereof, free from soft, thin, elongated or laminated pieces, lumps of clay, loam and vegetable or other deleterious substances.

(b) If broken stone is used for the coarse aggregate, it shall consist of sound, tough, durable fragments of rock of uniform quality throughout. It shall be free from soft disintegrated pieces, mud, dirt, organic or other injurious material.

(c) If the reclaimed miscellaneous aggregate is used for the coarse aggregate, it shall consist of sound, tough, durable fragments of uniform quality throughout. It shall be free from soft disintegrated pieces, mud, dirt, glass, organic or other injurious material.

(d) Soundness for Gravel, Broken Stone and Reclaimed Miscellaneous Aggregate: When tested by magnesium sulfate solution for soundness using AASHTO Method T 104, the coarse aggregate shall show a loss of not more than 15% at the end of 5 cycles.

3. Fine Aggregate: The fine aggregate shall be natural sand, stone sand, screenings or any combination thereof. The fine aggregate shall be limited to material 95% of which passes a No. 4 (4.75-mm) sieve having square openings and not more than 8% of which passes a No. 200 (75-µm) sieve. The material shall be free from clay, loam and deleterious materials.

(a) Plasticity: When natural sand is used, the fine aggregate shall conform to the requirements of Article M.02.06-2.

(b) Plasticity: When screenings or any combination of screenings and natural sand or any combination of stone sand and natural sand are used, the following requirements shall apply:

(1) When the fraction of the dry sample passing the No. 100 (150-µm) mesh sieve is 6% or less by weight (mass), no plastic limit test will be made.

(2) When the fraction of the dry sample passing the No. 100 (150-µm) mesh sieve is greater than 6% and not greater than 10% by mass, that fraction shall not have sufficient plasticity to permit the performing of the plastic limit test, using AASHTO Method T 90.

(3) When the fraction of the dry sample passing the No. 100 (150-µm) mesh sieve is greater than 10% by weight (mass), the sample shall be washed; and additional material passing the No. 100 (150-µm) mesh sieve shall be determined by AASHTO Method T 146, except that the No. 100 (150-µm) mesh sieve shall be substituted for the No. 40 (425-µm) mesh sieve where the latter is specified in AASHTO Method T 146. The combined materials that have passed the No. 100 (150-µm) mesh sieve shall not have sufficient plasticity to permit the performing of the plastic limit test using AASHTO Method T 90.

M.05.02—Surface Treatment: Materials for this work shall conform to the following requirements:

1. Bituminous Material: The Bituminous materials shall be selected from the following grades and shall meet the requirements shown in Section M.04.

Asphaltic Cutback	MC-70 or MC-800
Tar	RT-2, RT-4 or RT-6
Asphalt Emulsion	As directed by the Engineer

The type of bituminous material to be used, as well as its viscosity or grade, will depend upon the character and condition of the surface to be treated, the season of the year at which the work is to be done, and will be determined by the Engineer. The Contractor shall not order any material for this work until he has obtained definite instructions from the Engineer as to whether tar, asphalt or asphalt emulsion is required and as to the type of the bituminous material selected.

2. Sand Cover: Sand shall contain not more than 3% inorganic silt and clay by actual dry weight (mass), using AASHTO Method T 11 and shall conform to the following gradation requirements:

Square Mesh Sieves	**Percent Passing by Weight (Mass)**
Pass 1/2 inch (12.5 mmm)	100
Pass 3/8 inch (9.5 mm)	95-100
Pass #4 (4.75 mm)	80-100
Pass #50 (300 µm)	10-30
Pass #100 (150 µm)	0-10

SECTION M.06

METALS

M.06.01—Reinforcing Steel: The materials for this work shall conform to the following requirements:

1. Bar Reinforcement:

Bar reinforcement shall be deformed and conform to the following:

Uncoated bar reinforcement shall conform to the requirements of ASTM A 615/A 615M, Grade 60(420).

Epoxy coated bar reinforcement shall conform to the requirements of ASTM A 615M, Grade 420 and shall be epoxy coated to the requirements of ASTM D 3963/D 3963M.

Galvanized bar reinforcement shall conform to the requirements of ASTM A 615/A 615M, Grade 60 (420) and be galvanized, after fabrication, to the requirements of ASTM 767/A 767M, Class 1, including supplemental requirements. Dowels and tie bars for masonry facing and for granite curbing shall be galvanized, after fabrication, in accordance with ASTM A 767/A 767M, Class 1.

Weldable bar reinforcement shall conform to the requirements of ASTM A 706/A 706M.

Prior to incorporation into the work, samples of the uncoated, epoxy coated, galvanized and weldable bar reinforcement shall be submitted to the Engineer for destructive testing in accordance with the latest edition of the "Schedule of Minimum Requirements for Sampling Materials for Test". One sample, at least 60 inches (1550 millimeters) long, shall be submitted for each size, source of supply, and type of bar reinforcement.

2. Unit Weights (Mass): Listed below are the bar sizes with approximate diameters, areas and weights (mass).

A 615/A 615M				
		Nominal Dimensions*		
Bar	Nominal Weight			
Designation	lb./ft.	Diameter,	Cross Sectional	Perimeter
No.**	(Nominal Mass)	in. (mm)	Area	inch (mm)
	(kg/m)		sq. inch (mm^2)	
3 (10)	0.376 (0.560)	0.375 (9.5)	0.11 (71)	1.178 (29.9)
4 (13)	0.668 (0.994)	0.500 (12.7)	0.20 (129)	1.571 (39.0)
5 (16)	1.043 (1.552)	0.625 (15.9)	0.31 (199)	1.963 (49.9)
6 (19)	1.502 (2.235)	0.750 (19.1)	0.44 (284)	2.356 (59.8)
7 (22)	2.044 (3.042)	0.875 (22.2)	0.60 (387)	2.749 (69.8)
8 (25)	2.670 (3.973)	1.000 (25.4)	0.79 (510)	3.142 (79.8)
9 (29)	3.400 (5.060)	1.128 (28.7)	1.00 (645)	3.544 (90.0)
10 (32)	4.303 (6.404)	1.270 (32.3)	1.27 (819)	3.990 (101.3)
11 (36)	5.313 (7.907)	1.410 (35.8)	1.56 (1006)	4.430 (112.5)
14 (43)	7.65 (11.38)	1.693 (43.0)	2.25 (1452)	5.32 (135.1)
18 (57)	13.60 (20.24)	2.257 (57.3)	4.00 (2581)	7.09 (180.1)

* The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same weight (mass) pound per foot (kilogram per meter) as the deformed bar.

**Bar numbers are based on the number of eighths of an inch included in the nominal diameter of the bars (bar numbers approximate the number of millimeters of the nominal diameter of the bar).

3. Wire and Welded Steel Wire Fabric: Wire shall be cold-drawn steel wire conforming to the requirements of ASTM A 82 (AASHTO M 32).

Welded steel wire fabric, when used as reinforcement in concrete, shall conform to the requirements of ASTM A 185 (AASHTO M 55). The type of welded steel wire fabric shall be approved by the Engineer.

4. Bar Mat Reinforcement: Bar mat reinforcement shall conform to the requirements of ASTM A 184/A 184M (AASHTO M 54)

5. Dowel Bar Mechanical Connections: Dowel bar mechanical connections shall develop in tension and compression at least 125 percent of the specified yield strength of the bar reinforcement being spliced.

Epoxy coated mechanical connectors shall be epoxy coated in accordance with the requirements of ASTM D 3963/D 3963M.

Galvanized mechanical connectors shall be galvanized, after fabrication, in accordance with the requirements of ASTM A 767/A 767M, Class 1, including supplemental requirements.

Prior to incorporation into the work, samples of the uncoated, epoxy coated and galvanized dowel bar mechanical connections shall be submitted to the Engineer for destructive testing. One sample, complete with all the components, shall be submitted for each size, type and manufacturer of the dowel bar mechanical connections.

6. Deformed Steel Wire and Welded Deformed Steel Wire Fabric: Deformed steel wire shall be cold-worked, deformed steel wire conforming to the requirements of AASHTO M 225 (ASTM A 496). Welded deformed steel wire fabric, when used as reinforcement in concrete, shall conform to the requirements of AASHTO M 221 (ASTM A 497). The type of welded deformed steel wire fabric shall be approved by the Engineer.

7. Reinforcing Steel for Pavement: Reinforcing steel for pavement shall be in accordance with the applicable standard plans.

8. Reports and Certification: Mill test reports and materials certification shall be submitted for all types of reinforcing steel and dowel bar mechanical connections confirming they meet the requirements of the applicable specifications.

Materials Certificates shall be submitted in accordance with Article 1.06.07 for all types of reinforcing steel and dowel bar mechanical connections.

M.06.02—Structural Steel and Other Structural Materials: The materials for this work shall conform to the following requirements:

1. Structural Steel: All structural steel shall conform to ASTM A 709/A 709 M, Grade 36(250), Grade 250 unless otherwise specified.

(a) Charpy V-notch Impact Testing: Unless otherwise shown on the plans or indicated in the Special Provisions, all structural steel used for main load carrying components shall meet the Charpy V-notch impact value requirements specified herein. Main load carrying components shall include but not necessarily be limited to the following:

Flange and web plates of welded plate and box girders; rolled beams; welded cover plates; and longitudinal stiffener plates.

Flange and web splice plates.

Cross frames and their connection plates on horizontally curved girders.

Portions of trusses, arches, and rigid frames.

Charpy V-notch sampling and testing procedures shall be in accordance with ASTM A 673/A 673M (AASHTO T 243). The H (Heat) frequency of testing shall be used for structural steels conforming to ASTM Designations A 36/A 36M, A 572/A 572M, and A 588/A 588M; the P (Piece) frequency of testing shall be used for structural steel conforming to ASTM Designation A 514/A 514M/A 517/A 517M.

Charpy V-notch (CVN) impact values shall meet the following minimum values:

ASTM Designation	**Thickness—Inches (Millimeters) Foot Pounds/Joules**	**Charpy V-notch Foot Pounds @ Temp. Joules (J) @ Temp. (^{o}C)**
A 36A/36M		15 @ 40^{o} F (20 @ 4) ^{o} C
A 572*/A 572M		15 @ 40^{o} F (20 @ 4) ^{o} C

A 588*/A 588M	2 inches (50 millimeters) and under – welded	15 @ 40° F (20 @ 4) ° C
		20 @ 40° F (27 @ 4) ° C
	Over 2 inches (50 millimeters) – welded	15 @ 40° F (20 @ 4) ° C
	4 inches (100 millimeters) and under - mech. fastened	
A 514/517	2 ½ inches (64 millimeters) and under –welded	25 @ 0° F (34 @ –18) ° C
		35 @ 0° F (48 @ – 18) ° C
	Over 2 ½ inches (64 millimeters) welded	25 @ 0° F (34 @ – 18) ° C
	4 inches (100 millimeters) and under - mech. fastened	

*If the yield point of the material exceeds 65 kips per square inch (450 megapascals), the temperature for acceptability shall be reduced by 15° F (10° C) for each increment of 10 kips per square inch (70 megapascals) above 65 kips per square inch (450 megapascals).

Except as otherwise noted in the Special Provisions or on the plans, Charpy V-notch tests will be required for structural repairs but will not be required for temporary structures.

(b) Ordering Weathering Steel: When placing an order for ASTM A 588/A 588M steel which is to be used as "Weathering Steel", the fabricator shall notify the manufacturer that it is "weathering steel" (structural steel for use in bare, unpainted applications) and that the steel shall not be marked with paint or steel die stamped, but identification shall be stenciled with permanent ink.

2. Anchor Bolts: Unheaded anchor bolts shall be swaged and shall conform to the requirements of ASTM A 36/A 36M. Anchor bolts, nuts and washers shall be galvanized in conformance with ASTM A 153/A 153M

3. Eyebar Steel: Steel for eyebars shall conform to the requirements specified on the plans or in the contract documents.

4. Structural Rivets:

(a) Structural Rivet Steel: Unless otherwise specified, all rivets shall be made of structural rivet steel conforming to the requirements of ASTM A 502/A 502M, Grade 1.

(b) High Strength Structural Rivet Steel: Where high strength structural rivets are called for on the plans or in the special provisions, rivets shall be made of high-strength structural rivet steel conforming to the requirements of ASTM A 502, Grade 2.

The steel for rivets used in fastening weathering steel, conforming to ASTM A 588/A 588M, shall be modified by the addition of such alloying elements as to have, while in a fully stressed condition, weathering and corrosion characteristics equal to or exceeding the requirements for weathering steel conforming to ASTM A 588/A 588M. The final weathered appearance of the rivets shall be compatible with that of the structural steel.

5. High Strength Bolts: Bolts, nuts and circular washers shall conform to the requirements of the specification for High-Strength Bolts for Structural Steel Joints, including suitable Nuts and Plain Hardened Washers. Bolt and nut dimensions shall conform to the Manufacturer's dimensions and tolerances.

Subject to the approval of the Engineer, other fasteners which meet the chemical composition requirements of ASTM A 325 or ASTM A 490 and which meet the mechanical requirements of the same specifications in full size tests, and which have body diameter and bearing areas under the head and nut or their equivalent, not less than those provided by a bolt and nut of these same nominal dimensions shown in the table below, may be used. Such alternate fasteners may differ in other dimensions from those specified for ASTM 325 or ASTM A 490 bolts and nuts.

When high-strength, low-alloy steel conforming to the requirements of ASTM A 588/A 588M is specified, high strength bolts, if specified, shall conform to the requirements of ASTM A 325, Type 3.

Circular washers shall be flat and smooth, and their nominal dimensions shall conform to the dimensions given in the table below.

Beveled washers for American Standard beams and channels shall be square or rectangular, shall taper in thickness, and shall conform to the dimensions given in the table below.

Where necessary, washers may be clipped on one side to a point not closer than 7/8 of the bolt diameter from the center of the washers.

a Dimensions in inches
b May be exceeded by ¼ inch
c 3/16 inch nominal
d ¼ inch nominal

WASHER DIMENSIONS[a]		
	Circular Washers	**Square or Rectangle Beveled Washers for American Standard Beams and Channels**

Bolt Size D	Nominal Outside Diameter[b]	Nominal Diameter of Hole	Thickness Min.	Thickness Max.	Minimum side dimension	Mean thickness	Slope or taper in thickness
½	1-1/16	17/32	.097	.177	1-3/4	5/16	1:6
5/8	1-5/16	21/32	.122	.177	1-3/4	5/16	1:6
¾	1-15/32	13/16	.122	.177	1-3/4	5/16	1:6
7/8	1-3/4	15/16	.136	.177	1-3/4	5/16	1:6
1	2	1-1/16	.136	.177	1-3/4	5/16	1:6
1-1/8	2-1/4	1-1/4	.136	.177	2-1/4	5/16	1:6
1-1/4	2-1/2	1-3/8	.136	.177	2-1/4	5/16	1:6
1-3/8	2-3/4	1-1/2	.136	.177	2-1/4	5/16	1:6
1-1/2	3	1-5/8	.136	.177	2-1/4	5/16	1:6
1-3/4	3-3/8	1-7/8	.178[c]	.28[c]	—	—	—
2	3-3/4	2-1/8	.178	.28	—	—	—
over 2 to 4 incl.	2D-1/2	D+1/8	.24[d]	.34[d]	—	—	—

	Circular Washers						Square or Rectangle Beveled Washers for American Standard Beams and Channels		
Nominal Washer Size	Inside Diameter min	Inside Diameter max	Outside Diameter min	Outside Diameter max	Thickness max	Thickness min	Minimum side dimension	Mean thickness	Slope or taper in thickness
12	14.4	14.0	27.0	25.7	4.6	3.1	42	7	1:6
14	16.4	16.0	30.0	28.7	4.6	3.1	42	7	1:6
16	18.4	18.0	34.0	32.4	4.6	3.1	42	7	1:6
20	22.5	22.0	42.0	40.4	4.6	3.1	42	7	1:6
22	24.5	24.0	44.0	42.4	4.6	3.4	42	7	1:6
24	26.5	26.0	50.0	48.4	4.6	3.4	56	7	1:6
27	30.5	30.0	56.0	54.1	4.6	3.4	56	7	1:6
30	33.6	33.0	60.0	58.1	4.6	3.4	56	7	1:6
36	39.6	39.0	72.0	70.1	4.6	3.4	56	7	1:6
42	45.6	45.0	84.0	81.8	7.2	4.6	56	7	1:6
48	52.7	52.0	95.0	92.8	7.2	4.6	—	—	—
56	62.7	62.0	107.0	104.8	8.7	6.1	—	—	—
64	70.7	70.0	118.0	115.8	8.7	6.1	—	—	—
72	78.7	78.0	130.0	127.5	8.7	6.1	—	—	—
80	86.9	86.0	142.0	139.5	8.7	6.1	—	—	—
90	96.9	96.0	159.0	156.5	8.7	6.1	—	—	—
100	107.9	107.0	176.0	173.5	8.7	6.1	—	—	—

6. Supplementary Requirements: The specification requirements stated above for the various types of steel are modified and supplemented by the following requirements:

(a) Stock Material: Stock material of a quality substantially equal to that called for by the above specifications, and free from surface imperfections, may be

used to such an extent as the Engineer may permit. Mill test reports shall constitute a sufficient record as to the quality of material carried in stock.

(b) Full Size Tests: When full size tests of fabricated structural members of eyebars are required by the contract, the plans or specifications shall state the number and nature of the tests, the results to be attained, and the measurements of strength, deformation or other performance requirements that are to be made. The Contractor shall provide suitable facilities, material, supervision and labor necessary for making and recording the tests. The members tested in accordance with the contract will be paid for in accordance with paragraph (c) below.

(c) Payment for Full Size Tests: Any full sized member tested to destruction will be paid for by the Department at the same rate as for comparable members for the structure if the test proves satisfactory. If the test proves the member to be unsatisfactory, the members represented by it will be rejected; and all material so rejected will not be paid for by the Department. The expense of conducting the tests shall be borne by the Contractor unless otherwise specified. The scrap from the tests shall be the property of the Contractor.

(d) Anchor Bolts/High Strength Bolts—Certified Test Report: The Contractor shall submit a Certified Test Report and Materials Certificate in conformance with Article 1.06.07 and a sample of all anchor bolts and nuts and high strength bolts and nuts for testing prior to their installation. The Contractor shall not install any anchor bolts or high strength bolts prior to receipt of the approved test results and approval by the Engineer.

7. Steel Shaftings and Forgings: Pins and rollers, unless otherwise specified on the plans or elsewhere within the contract documents, shall conform to the following:

Rollers 20 inches (508 millimeters) or less in diameter shall conform to the requirements of ASTM A 668, Class C. Pins 4 inches (102 millimeters) or less in diameter shall conform to the requirements of ASTM A 108, Grade 1016 to 1030 inclusive. Pins having a diameter greater than 4 inches (102 millimeters) shall conform to the requirements of ASTM A 668, Class C.

Steel forgings for hangers shall conform to the requirements of ASTM A 668 Class G, annealed, modified by such alloying elements as will produce a steel suitable for the thickness of the hangers shown on the plans, and shall have a minimum comparative resistance to atmospheric corrosion of four times that of structural carbon steel.

Pins and rollers incorporated in structural steel components for weathering steel applications shall be corrosion-resisting (stainless) steel conforming to ASTM A 276, Types 410 or 414, which shall develop a minimum yield strength of 40,000 psi (275 megapascals).

8. Welded and Seamless Steel Pipe: Welded and Seamless Steel Pipe shall conform to the requirements of ASTM A 53, Type E or S, Grade A, Schedule 40 Black Finish.

9. Metal Castings: Castings shall be boldly filleted at angles, and the arrises shall be sharp and perfect.

Castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blowholes and other defects in positions affecting their strength and value for the service intended.

Castings shall be sandblasted or otherwise effectively cleaned of scale and sand so as to present a smooth, clean and uniform surface.

(a) Carbon steel castings shall conform to the requirements of ASTM A 27/A 27M. Grade 60-30[415-205 megapascals], 65-35 [450-240] or 70-36 [485-250] castings shall be furnished unless otherwise specified.

(b) Chromium alloy-steel castings shall conform to the requirements of ASTM A 743 or A 744, Grade 10 shall be furnished unless otherwise specified.

(c) Gray iron castings shall conform to the requirements of the specifications for gray iron castings, ASTM A 48. Unless otherwise specified, Class 30 (207) castings shall be furnished.

(d) Malleable castings shall conform to the requirements of the specifications for malleable iron castings, ASTM A 47, Grade No. 32510 (22010). Ductile iron castings shall conform to the Specifications for Ductile Iron Castings, ASTM A 536, Grade 60-40-18 (414-276-18) unless otherwise specified. In addition to the specified test coupons, test specimens from parts integral with the castings, such as risers, shall be tested for castings having a weight (mass) of more than 1000 pounds (455 kilograms) to determine that the required quality is obtained in the castings in the finished condition.

10. Bronze or Copper Alloy Bearing and Expansion Plates: Bronze bearing and expansion plates shall conform to the requirements of ASTM B 22. Alloy B shall be furnished unless otherwise specified.

Rolled copper alloy bearing expansion plates shall conform to the requirements of ASTM B 100, Alloy No. 1.

Bearing surfaces of self-lubricating bronze bearings and bearing plates shall be provided with trepanned or drilled-in recesses (not grooves) filled with a lubricating compound capable of withstanding atmospheric elements. The compound shall consist of graphite and metallic substances with a lubricating binder. The compound shall be forced into the recesses under pressure to form or retain the form of dense, non-plastic lubricating inserts. The lubricating area shall comprise not less than 25% of the total

area. The self-lubricating bearings and bearing plates shall have a finish of 125 micro-inch (3.2 microns) root mean square, and all surfaces in contact with them shall have the same degree of finish.

The lubricant to be used for the self-lubricating plates shall provide a coefficient of friction not to exceed 0.10, as determined by the following test procedure:

A self-lubricating bronze test plate measuring not less than 5 inches (127 millimeters) long by 5 inches (127 millimeters) wide shall be prepared and shall conform to all requirements of this specification.

An assembly consisting of the fixed self-lubricating test plate and a movable steel plate shall be subjected to a vertical unit loading 1000 psi (7 megapascals). The steel plate shall then be subjected to not less than 100 cycles of horizontal movement at a speed not to exceed 30 cycles per minute. Each cycle shall consist of a forward and return movement of not more than 1/2 inch (12.5 millimeters) in each direction. The recorded horizontal force, divided by the recorded vertical force, shall be established as the coefficient of friction between the sliding surfaces.

The coefficient determined by the foregoing method shall not exceed 0.10, and tests indicating a coefficient of friction greater than 0.10 shall be cause for rejection of the lubricating compound.

Before such materials are incorporated into the work, the supplier, at his own expense, shall furnish a Certified Test Report Certificate that the lubricant, when tested as herein before described, shall not have coefficient of friction greater than 0.10.

Batches of the lubricating compound shall be clearly tagged or marked by the supplier for identification with the certification.

11. Aluminum Castings, Tubing and Fittings:

(a) The castings for ornamental posts shall be permanent mold aluminum alloy castings conforming to the requirements of ASTM B 108, Aluminum Alloy A 356.0-T6.

The castings for traffic rail posts shall be permanent mold aluminum alloy castings conforming to the requirements of ASTM B 108 Aluminum Alloy A 444.0-T4.

The finish of all castings shall be commercial with all gates, risers and seams finished flush. Casting tolerances will be plus or minus (±) 1/32 inch ((±) 0.8 millimeter).

(b) The extruded aluminum for posts, bases, post connection splice bars and rails shall conform to ASTM B 221 Aluminum Alloy 6061—T6, unless 6063—T6 is indicated on the plans or in the special provisions.

(c) Aluminum for bolts and screws shall be aluminum alloy made from rod or wire conforming to ASTM B 211 Aluminum Alloy 2024—T4.

Aluminum for nuts 1/4-inch (6.4-millimeter) tap and under shall be aluminum alloy made from rod or wire conforming to ASTM B 211 Aluminum Alloy 2024—T4.

Aluminum for nuts 5/16-inch (8-millimeter) tap and over shall be aluminum alloy made from rod or wire conforming to ASTM B 211 Aluminum Alloy 6061—T6, or 6262—T9, or extruded rods conforming to ASTM B 221 Aluminum Alloy 6061—T6.

Unless otherwise noted, all nuts shall conform to American Standard Heavy Hexagon, ASA Specification B 18.2. Threads shall conform to American Standard Coarse Series, Class 2 fit, ASA Specification B-1.1. The finished bolts and nuts shall be heat-treated to the required temper and given an anodic coating at least 0.0002 inches (5 microns) in thickness with dichromate or boiling water seal.

(d) Washers shall be made from aluminum alloy sheet or plate conforming to ASTM B 209 Aluminum Alloy Alclad 2024—T4. Shims shall be of aluminum alloy shim material made from sheet or plate conforming to ASTM B 209, Aluminum Alloy 1100-0.

(e) End caps shall be sand mold castings conforming to ASTM B 26 Alloy SG-70A Commercial Alloy 356—F or ASTM B 26 Alloy S-5A, Commercial Alloy 443-F or sheet and plate conforming to ASTM B 209 Aluminum Alloy 6061—T6.

(f) Rivets shall conform to ASTM B 316 Aluminum Alloy 6061-T6 or ASTM B 221 Aluminum Alloy 6061-T6.

12. Welded Stud Shear Connectors and Welded Studs: Stud shear connectors shall be of a design suitable for electrically end-welding to steel with automatically timed stud welding equipment. The studs shall be of the sizes and dimensions noted on the plans. Flux for welding shall be furnished with each stud, either attached to the end of the stud or combined with the arc shield for automatic application in the welding operation. Each stud shall be furnished with a disposable ferrule of sufficient strength to remain intact during the welding operation and not crumble or break; it shall not be detrimental to the weld or create excessive slag.

Stud shear connectors shall conform to the requirements of ASTM A 108, cold-drawn bar, Grades 1015, 1018 or 1020, either semi- or fully-killed. If flux-retaining caps are

used, the steel for the caps shall be of a low carbon grade suitable for welding and shall comply with ASTM A 109.

Tensile properties as determined by tests of bar stock after drawing or of finished studs shall conform to the following requirements:

Tensile strength (min.)	60,000 psi (415 megapascals)
Yield strength (min.) *	50,000 psi (345 megapascals)
Elongation (min.)	20% in 2 inches (50 millimeters)
Reduction of area (min.)	50%

* as determined by the 0.2% offset method

Tensile properties shall be determined in accordance with the applicable sections of ASTM A 370.

Finished studs shall be of uniform quality and condition, free from injurious laps, fins, seams, cracks, twists, bends or other injurious defects. Finish shall be as produced by cold-drawing, cold-rolling or machining.

Studs shall be tested for weldability in accordance with the requirements of the ANSI/AASHTO/AWS D1.5 Bridge Welding Code. Certified copies of in-plant control test reports shall be furnished to the Engineer upon request.

13. Mill and Shop Inspection of Structural Steel:

(a) Notice of Beginning of Work: The Contractor shall give ample notice to the Engineer of the beginning of work at the mill and shop so that inspection may be provided. The term "mill" means any rolling mill, foundry or fabricating plant where material for the work is to be manufactured. No material shall be manufactured or work done in the shop before the Engineer has been so notified.

(b) Facilities for Inspection: The Contractor shall furnish facilities for the inspection of material and workmanship in the mill and shop, and inspectors shall be allowed free access to the necessary parts of the premises.

(c) Inspector's Authority: The inspector shall have the authority to reject the materials or work which do not meet the requirements of these specifications. In case of dispute, the Contractor may appeal to the Engineer whose decision shall be final.

(d) Mill Orders: The Contractor shall furnish the Engineer with as many copies of mill orders as the Engineer may direct.

(e) Facilities for Testing: The contractor shall furnish without charge test specimens as specified herein, and all labor, testing machines and tools necessary to prepare the specimens and to make the full sized tests.

(f) Rejections: The acceptance of any material or finished members by the inspector shall not be a bar to their subsequent rejection if found defective. Rejected material and workmanship shall be replaced promptly or satisfactorily corrected by the Contractor.

(g) Marking and Shipping: Each member shall be painted or marked with an erection mark for identification, and an erection diagram shall be furnished with erection marks shown thereon.

The Contractor shall furnish to the Engineer as many copies of material orders, shipping statements and erection diagrams as the Engineer may direct. The mass of the individual members shall be shown on the statements. Members having a weight (mass) of more than 3 tons (2700 kilograms) shall have the weight (mass) marked thereon. Structural members shall be loaded on trucks or cars in such manner that they may be transported and unloaded at their destination without being deformed, excessively stressed or otherwise damaged.

Bolts and rivets of one length and diameter, and loose nuts or washers of each size, shall be packed separately. Pins, small parts and small packages of bolts, rivets, washers and nuts shall be shipped in boxes, crates, kegs or barrels; but the gross weight (mass) of any package shall not exceed 300 pounds (135 kilograms). A list and description of the contained material shall be plainly marked on the outside of each shipping container.

M.06.03—Galvanizing: Unless otherwise specified on the plans or in the special provisions, the zinc coating on all iron and steel materials, other than wire, shall meet the requirements of ASTM A 123/A 123M, or A 153/A 153M, whichever shall apply.

When mechanical galvanizing is used it shall meet the requirements of ASTM B 695 Class 50.

M.06.04—Filler Metal for Welding: Unless otherwise shown on the plans or as indicated in the special provisions, fill metal for welding shall conform to the requirements of AWS.

The fabricator shall note on the shop plans the electrode classification number and other identification references for the electrodes and flux he proposes to use.

SECTION M.07

PAINT

M.07.01—General for All Paints and Enamels:

1. Paints and enamels shall consist of pigments of the required fineness and composition, ground in the required vehicle by a suitable grinding machine to the required fineness. All pigments, resins, oils, thinners and driers used shall be of the best quality, free from adulterants of any kind and shall comply with the specific requirements of the specifications. Materials not definitely covered by specifications shall be of the best quality used for the purpose in good commercial practice.

2. Proportions: All proportions as specified in formulas are by mass unless otherwise specified.

3. Fineness: All pigments, except aluminum, unless otherwise specified, shall be so finely ground that 100% shall pass through a No. 200 (75-µm) sieve; and not less than 97 % shall pass through a No. 325 (45-µm) sieve.

4. Curdling, Livering, Leveling: No paint or enamel shall liver or curdle, and the pigment shall remain in suspension in a satisfactory manner. The enamel type paints shall level properly and not show brush marks.

5. Colors: All paints and enamels shall be matched to the Department's standard shades. Color chips may be obtained at the Laboratory.

6. Time of Drying: All paints or enamels, unless otherwise specified, shall dry to the full gloss in not more than 18 hours.

7. Weight (Mass) per Gallon (Liter): The weight (mass) per gallon (liter) of all paints and enamels shall be determined at 77° F (25° C).

8. Shipping: All paints and enamels shall be shipped in strong metal containers, plainly marked with the name, net weight (mass) and volume of paint or enamel content. The manufacturer's name, address, date and lot number shall be stenciled on every package.

9. Samples, Sampling, and Testing: When so requested, samples and certified analysis of all pigments, oils, resins, thinners, driers or paint furnished shall be supplied by the manufacturer within 10 days after request is made therefor.

Sampling and testing will be in accordance with ASTM, Federal Supply Service, or by methods on file in the Laboratory of the Department.

The following tests on the paints will follow the procedures outlined in Federal Test Method Standard No. 141: Paint, Varnish, Lacquer and Related Materials; Methods of Inspection, Sampling and Testing:

Tests	**Methods**
Percentage of pigment	4021
Isolation of vehicle	4032
Nonvolatile in vehicle	4041
Phthalic anhydride	7021
Weight per Gallon (Mass per liter)	4184
Uncombined water	4081
Coarse particles and skins	4092
Viscosity: Krebs-Stormer	4281
Drying time	4061
Condition in container	3011
Fineness of Grind	4411
Skinning (48 hours)	4141
Brushing properties	2141,4321
Spraying properties	2131,4331

M.07.02—Coating Systems for Structural Steel: The coating system to be used shall be selected from the Product Reference List of the latest Product Use Status Lists for ConnDOT Projects. Coating materials on this list are pre-qualified by meeting the NEPCOAT Specification Criteria for Protective Coatings.

Color: The color of the topcoat shall be as noted on the plans (FS 595 Color Number).

Packaging and Labeling of Coating Material: The container shall be designed to store the specific coating material. Each container of coating materials shall bear a label that clearly shows the name of the coating manufacturer, the name of the product, the lot and batch numbers, the date of manufacture and the shelf life expiration date. The label shall also include complete specific instructions for opening the container and for mixing, thinning, and applying the coating material contained therein. If the coating material cannot be positively identified from the label on the container, it shall not be used.

Delivery: Coating material shall be furnished in the manufacturer's original sealed and undamaged container.

Control of Materials: For each coating material, a Certified Test Report and a Materials Certificate shall be submitted in conformance with Article 1.06.07. The Certified Test Report shall contain the data required in NEPCOAT Specification Criteria for Protective Coatings, Section VII, Groups I and II.

M.07.03—Vacant
M.07.04—Vacant
M.07.05—Vacant
M.07.06—Vacant

M.07.07—Black Paint: Black paint shall be a refined tar product. It shall be homogeneous and shall dry hard in 5 hours, under normal weather conditions, with a jet black color.

It shall conform to the following requirements:

	Min.	Max.
Water Content, %	———	0.5
Engler Viscosity at 40°C.	5	8
	Min.	**Max.**
Free Carbon Insoluble in CS_2%	———	12
Distillation:		
0—170°C, %	8	20
0—235°C, %	15	35
0—270°C, %	———	41
0—300°C, %	———	46
Softening Point of Distillation Residue (R&B), °C	55	70

M.07.08—White Undercoat for Semigloss White Enamels: This white undercoat for semi-gloss white enamel shall meet the requirements of FS TT-P-659 for primer-surfacer, synthetic tints, and white for metal and wood surface.

M.07.09—Semigloss White Enamel:

1—Enamel Composition:

	Min.	Max.
Pigment, %	37	——-
Vehicle, %	——-	63
Volatile matter in vehicle, %	——-	55
Coarse particles retained on	——-	0.5
No. 325 (45 µm) screen based on pigment, %		
Viscosity, Krebs Units at 77° F (25°C).	65	75
Weight per Gallon, pound	1.2	——-
Mass per Liter, kilogram	10	
Fineness of grind (North Standard)	5	——-

2—Pigment Composition:

	Min.	Max.
Titanium Dioxide, %	60	——-
Zinc Oxide (lead free), %	——-	7
Extender Pigments, %	——-	33

The titanium-dioxide shall meet FS TT-P-442, Type 3.

The lead-free zinc oxide shall meet FS TT-P-00463 French process.

The extender pigments shall consist of any one of the following or combination thereof: magnesium silicate, barium sulfate or diatomaceous silica. A ratio of 50% magnesium silicate and 50% diatomaceous silica has been found to be satisfactory in order to produce the desired semi-gloss appearance.

3. Vehicle: The vehicle shall contain not less than 45% solids by weight (mass) and shall be composed of a long oil soya-modified alkyd resin solution or solutions, petroleum solvent thinners and driers. Rosin or rosin derivatives shall not be present. The alkyd resin solution or solutions shall conform to the FS TT-R-266, Type 1, Class A.

4. Specular Gloss: The enamel shall be flowed on a tin panel and allowed to dry for 24 hours before measuring. The specular gloss at 60 degree angle of incident, ASTM D 523 shall be between 35 and 45.

5. Setting and Drying Time: This enamel shall set to touch in less than 5 hours. It shall dry hard and tough in not more than 24 hours.

6. Flash Point: The flash point shall not be below 86° F (30° C) when determined by the Pensky-Martin closed flash tester.

7. Water Resistance: The enamel shall be flowed on a tin panel and allowed to dry for 48 hours. After being immersed for 18 hours in distilled water, it shall show no blistering or wrinkles upon removal and shall show no dulling or change in color after two hours' recovery.

8. Skinning: This enamel shall not skin over within 48 hours in a three-quarters filled closed container. Small amounts of anti-skinning agents, wetting agents, suspension agents and anti-drier absorption agents may be added at the discretion of the manufacturer.

9. Working Properties: The enamel shall be well ground, shall not settle in the container, shall be capable of being broken up with a paddle to a smooth, uniform enamel of good brushing consistency and shall have good flowing, covering and leveling properties.

M.07.10—Vacant
M.07.11—Vacant

M.07.12—Aluminum Finish Coat—Bridge Color Number 17178: This ready-mixed aluminum paint shall be applied over the second field coat and shall conform to the following requirements:

Pigment: The leafing aluminum pigment shall consist entirely of finely divided, polished aluminum flakes in paste form, and shall meet the minimum requirements for coarse particles and leafing of FS TT-P-320, Type II, Class B, latest revisions. The leafing aluminum paste shall be mixed with the vehicle on the basis of 2 pounds (0.24 kilograms) of paste to 1 gallon (1 liter) of vehicle.

Vehicle: The vehicle shall consist of a long oil alkyd resin varnish suitable for making a ready-mixed aluminum paint. The resin shall conform to the type described in FS TT-R-226, Type I, Class A. The vehicle shall be formulated as follows:

Long oil alkyd resin solution conforming to FS TT-R-266,

Type I, Class A	100 pounds (12.5 gallons)	(45 kilograms (47 Liters))
Mineral Spirits	40 pounds (6.0 gallons)	(18 kilograms (22.5 Liters))

After accurately determining the acid number of the vehicle, and before adding driers, 113 grams of Alcoa Stabilizer No. 5 per acid number per 100 pounds (45 kilograms) of vehicle solids shall be added. Example: For a vehicle with an acid number of 7 on nonvolatile basis, add 28 ounces (790 grams) of Stabilizer for every 100 pounds (45 kilograms) of vehicle solids.

The vehicle, with Stabilizer added, shall stand for at least 18 hours before mixing with the aluminum paste pigment.

Driers shall not be added until after mixing the stabilized vehicle with the aluminum paste pigment. At that time cobalt naphthenate, manganese naphthenate and zirconium octoate shall be added using 0.5% cobalt, 0.03% manganese and 0.3% zirconium, based on vehicle solids.

The finished vehicle shall meet the following requirements:

(1) It shall be clear and transparent. (4261)*

(2) The viscosity shall be between 0.85 and 1.25 poises (5 0.085 and 0.125 pascal·seconds) corresponding to tubes C to E of the Gardner Bubble Viscometer. (4271)

(3) It shall contain not less than 48% by weight (mass) of nonvolatile matter. (4041)

(4) It shall contain not less than 23% phthalic anhydride (quantitative) based on nonvolatile content. (7021)

(5) The moisture content shall not exceed 0.1% (4081)

(6) There shall be no skinning after 48 hours in a half-filled, tightly closed container. (4141)

(7) A flow-out film of the vehicle (with drier added for test purposes) on a 28-gage tin plate panel, air-dried for 48 hours, shall withstand immersion in water at 75° F ± 5° (24° C ± 3° C) for 24 hours without showing whitening, dulling, checking, or other serious defect 2 hours after removal. (Paragraph 4.47 of TT-R-266).

Mixed Paint:

(1) Composition—The paint shall show the following composition by mass:

	Min. %	**Max. %**
Paint nonvolatile (4041)	53.0	—
Pigment (aluminum pigment, non-volatile)	13.0	—
Total impurities (mica, filler, or other adulterants)	None	
Coarse pigment particles on No. 325 (45-µm) mesh screen (paint basis)	—	0.2
Vehicle		84.0
Nonvolatile matter	44.0	—
Volatile thinner	—	56.0

(2) Weight (Mass) per Gallon (Liter)—8 pounds min. (1.0 kilograms min.) (4184)

(3) Working properties—The paint, as received, shall show only slight settling, and the pigment shall be readily dispersed by moderate stirring. The resulting paint shall be smooth and uniform in appearance, free from skins or coarse particles and suitable for application by brush or spray.

(4) Leafing—The paint, when flowed on a clean glass panel, supported at an angle of 45, and then allowed to dry, protected from all drafts, for 24 hours at 75° F ± 5° F(24° C ± 3° C), shall produce a film comparable in smoothness, color, luster and opacity to that of a similar film applied at the same time and in the same manner, using a standard comparison paint. The comparison standard shall be prepared by freshly mixing 5 ounces (142 grams) of aluminum paste meeting FS TT-P-320, Type II, Class B, with 0.5 liter of long oil alkyd varnish, conforming to the vehicle described in M.07.12.

(5) Stability—Sample of the paint under test, set aside in full, tightly closed container for 30 days at 75° F ± 5° (24° C ± 3° C), shall also pass the test for leafing, given in Paragraph (4).

(6) Moisture Content—The paint shall contain not more than 0.1% water as received. (4081). The paint container described in paragraph (5) shall show no gas pressure after 30 days storage at 75° F ± 5° (24° C ± 3° C).

(7) Drying Time:

Set-to-touch 1 hour max.

Handling 12 hours max.

(8) Viscosity—The viscosity of the paint as received shall be between 40 and 55 seconds as determined by a No. 4 Ford Cup. (4282).

*Unless otherwise noted, all numbers in parenthesis refer to sections in Federal Test Method Standard No. 141.

M.07.13—Vacant
M.07.14—Vacant

M.07.15—Vinyl Wash Pretreatment: This pretreatment shall be a two-component paint mixture conforming to the requirements of DOD-P-15328 PRIMER (WASH) PRETREATMENT prepared in accordance with the manufacturer's printed instruction.

The addition of a suspending agent to the wash pretreatment may be permitted subject to the approval by the Engineer as to the type and quantity of agent requested.

M.07.16—Vacant

M.07.17—Zinc Silicate Primer: The zinc silicate primer shall be a self-cure, two-component, ethyl silicate vehicle type, zinc silicate paint, which, when properly mixed and applied, cures without use of a separate curing solution.

It shall conform to the following requirements:

1. Properties of Pigment Component: The zinc portion of the pigment component shall be a finely divided zinc powder containing, by mass, a minimum of 94% metallic zinc and a minimum of 98% total zinc using Federal Test Standard No. 141, Method 7221. All other materials contained in the pigment component shall be inert. The pigment component shall also conform to the following requirements:

	Min.	Max.
Specific gravity of zinc powder (ASTM D 153)	7.0	7.15
Average particle size in micrometers (as determined by the Fisher Sub-Sieve Sizer)	—	9.5

2. Properties of Vehicle Components: The vehicle shall consist primarily of a partially hydrolyzed ethyl silicate in an appropriate alcohol solvent and shall have the following properties:

	Min.	Max.
Matter non-volatile at 105°C, percent by weight (mass)	39	43
Silicon Dioxide, percent by weight (mass) of vehicle (without pigments)	9.0	12
Weight (Mass) per gallon, pounds at 77°F	1.0	—
(liter, kilogram at 25°C)	8.5	
Storage life of vehicle at 77°F (25°C), months	12	—

3. Properties of Mixed Paint:

	Min.	Max.
Weight per gallon at 77°F, pounds	17.0	-
(Mass per liter at (25° C, kilograms))	(2.0)	-

The total zinc portion shall be at least 79% by weight (mass) of the total solids of the dried coating.

The total solids, when heated at 105° C for one-half hour shall be not less than 72% by weight (mass).

The total solids by volume shall be not less than 65%.

The paint shall tolerate up to 1% water contamination by weight (mass) without gellation.

The usable pot life of the mixed paint shall be not less than 8 hours at 77° F (25° C) There shall be no hard settling which cannot be easily re-dispersed during this period.

Working properties shall be satisfactory at all temperatures and conditions under which the paint is applied to produce a satisfactory sprayable coating.

The mixing paint shall be so formulated as to produce a distinct contrast in color with the blast cleaned metal surfaces and any top coat.

4. Resistance Tests: Test panels of steel meeting the requirements of ASTM D 609 having dimensions of 2 x 5 inches x 1/8 inch (50 millimeter x 127 millimeters x 3.2 millimeters), shall be blast cleaned in accordance with SSPC-SP 10 "Near-White Blast Cleaning." A 3-mil (75-micron) coating (dry thickness) shall then be applied to the test panels 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 on one or more test panels. The materials will not be accepted if any individual test panel fails any of the following tests:

(a) Fresh Water Resistance. Panels shall be scribed down to base metal with an X of at least 2-inch (50-millimeter) 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.

(b) Salt Water Resistance. Panels shall be scribed down to base metal with an X of at least 2-inch (50-millimeter) legs and immersed in 5% sodium chloride at 75° F ± 5° F (24° C ± 3° C). The panels shall show no rusting, blistering, or softening upon examination after 7, 14 and 30 days. The sodium chloride solution shall be replaced with fresh solution after each examination.

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

(d) Salt Fog Resistance. The test panels will be scribed in an X pattern of at least 2-inch (50-millimeter) legs, to the steel substrate and shall be tested in accordance with ASTM B117. After 3,000 hours of continuous exposure, the coating shall exhibit no loss of bond, rust creepage or blistering at the scribe beyond 1/16 inch (1.6 mm) and no more than 2% rust at the edges.

(e) Resistance to Elevated Temperature and Thermal Shock. Panels shall be exposed to a temperature of 500° F (260° C) for one hour, then quenced

immediately in 65° F ± 5° (18° C ± 3° C) water. Panels subjected to this test shall show no blistering or flaking of the coating.

5. Application: 3-mil (75-micron) (dry thickness). The coating shall be capable of being applied in accordance with Specification requirements. All application shall be done in accordance with the manufacturer's latest printed instructions. Procedures shall also conform to the following requirements:

After initial mixing, the paint shall be strained through a metal 30 to 60 (600-µm to 300-µm) mesh screen.

Up to 1 pint (0.5 liter) of thinner per gallon (4 liters) may be added to the paint. The type of thinner shall be that approved by the manufacturer of the paint.

Stirring paddles on mechanical mixers shall reach to within 1 inch (25 millimeters) of the bottom of the stirring container during mechanical mixing.

Airless spray equipment for application of inorganic zinc silicate paint shall provide pressure of about 2200 psi (15 megapascals) at the nozzle. Fluid hose between pot and nozzle shall not be less than 3/8 inch (9.5 millimeters) inside diameter. Pressure may vary depending on tip size and pump.

Conventional spray equipment for application of inorganic zinc silicate paint shall provide pressure of not less than 10 psi (70 kilopascals) at the pot and 30 psi (210 kilopascals) at the nozzle. Fluid hose between pot and nozzle shall not be less than 1/2-inch (12.5-millimeter) inside diameter. The inorganic zinc primer coat shall not be applied when the surrounding air temperature is below 40° F (4° C).

6. Packaging and Labeling: The two components shall be packaged, in two separate containers, so that one unit of the pigment shall be mixed with one unit of the vehicle in making the paint. The lining of the vehicle container shall be of a type that will prevent attack of the container.

Each container shall bear a label clearly showing the name of manufacturer, brand name of paint, lot number, date of manufacture, net weight (mass) of contents and complete instructions and precautions for use. The instructions and precautions need only appear on the vehicle component container. The labels shall also state that containers of unused material must be kept tightly sealed, and the paint must be used within 12 hours from the time it was mixed when the temperature does not exceed 90° F (32° C). All mixed paint not used within this time shall be wasted.

7. Control of Materials: A Certified Test Report and a Materials Certificate will be required in accordance with Article 1.06.07. The Certified Test Report shall specifically include the pigment composition, the vehicle composition, the pigment properties previously stated, the vehicle properties previously stated, including the initial viscosity at 77° F (25° C) and the viscosity after 72 hours at 140° F (60° C), and the PH of the

vehicle. The test viscosities listed shall be Brookfield viscosity, Model RVT, No. 1 spindle at 50 rpm pascal·seconds

The mixed paint properties shall include: (a) the exact ratio, by mass, of the pigment component, (b) weight per gallon at 77° F , pounds (mass per liter at 25° C, kilograms,) (c) viscosity, KU @ 77° F (25° C), (d) Viscosity, KU @ 77° F (25° C), after 24 hours, (e) Non-Volatile @ 105° C, percent by mass, (f) Dry Time @ 77° F (25° C), and 50% relative humidity, 6-mil (150-micron) doctor blade clearance: (1) Set to touch, hours and (2) Dry Hard, hours, (g) Pencil Hardness when applied to plate glass panel with a 6-mil (150-micron) gap doctor blade and cured for 15 days at a relative humidity of 90-100%, (greater than H, 2H, etc.)

M.07.18—Vacant
M.07.19—Vacant

M.07.20—Waterborne Pavement Marking Paint: This is for white and yellow waterborne pavement marking paint that is to be applied to bituminous concrete and portland cement concrete pavements. This paint shall be capable of being applied with paint striping equipment that does not require heating above ambient temperatures. All requirements shall be as specified in Article M.07.21, except as follows:

1. Total nonvolatile shall not be less than 70% by weight (mass);

2. Pigment shall be 45-55% by weight (mass);

3. Weight per gallon (Mass per liter) shall not be less than 12.5 pounds/gallon (1.50 kilograms/liter) when tested in accordance with ASTM D 1475;

4. Drying time to no pick up shall be 15 minutes or less when tested in accordance with ASTM D 711.

M.07.21—Hot-Applied Waterborne Pavement Marking Paint: This is for white and yellow fast-drying waterborne pavement marking paint to be applied to bituminous concrete and portland cement concrete pavements. This paint shall be capable of being applied with paint striping equipment at an application temperature of 130° F to 145° F (54° C to 63° C).

General: Specifications and publications that apply are as follows:

FS: TT-P-1952D Paint, Traffic and Air Field Marking, Water Emulsion Base; Federal Test-Method Standard #141 Paint, Varnish, Lacquer and Related Materials, Methods of Inspection, Sampling and Testing; FS No. 595 Colors; and HH-R-590 Roofing Felt (Asbestos, Asphalt-saturated).

ASTM Standards: D 211-Specifications for Chrome Yellow and Chrome Orange; D 476-Specifications for Titanium Dioxide Pigments; D 562 Test for Consistency of Paints

Using the Stormer Viscometer; D 869-Test for 45-deg, 0-deg Directional Reflectance Factor of Opaque Specimens by Broad Band Filter Reflectometry.

Detailed Requirements, Formulation and Manufacture: The paint shall be formulated and manufactured from first-grade raw materials and shall be free from defects and imperfections that might adversely affect the serviceability of the finished product. The materials shall not exhibit settling or jellying after storage in the sealed containers as received that will affect the performance of the products. The paint shall provide the proper anchorage, refraction and reflection for the finished glass spheres when applied as specified.

Composition: The composition of the paint shall be at the discretion of the manufacturer, provided that the finished product meets the requirements of any applicable Federal, State or Local regulations for products of this type and the requirements as follows:

1. Paint shall not contain more than 0.06% lead;

2 Total nonvolatile shall not be less than 76% by weight (mass);

3. Pigment shall be 58-63% by weight (mass);

4. Resin solids shall be composed of 100% acrylic emulsion polymer;

5. Volatile organic compounds shall not exceed 150 grams/liter, excluding water;

6. Closed-cup flash point shall not be less than 100° F (38° C), and weight per gallon (mass per liter) shall not be less than 12.5 pounds/gallon(1.50 kilograms/liter) when tested in accordance with ASTM D 1475.

Viscosity: The consistency of the paint shall not be less than 80, nor more than 90 Kreb units when tested in accordance with ASTM D562. The paint shall have good spraying characteristics when the material is heated to application temperature of 130° F to 145° F (54-63° C).

Flexibility: The paint shall not show cracking or flaking when subjected to the TT-P-1952D flexibility test in which the panels used shall be tin plates that are 3 inches x 5 inches (76 millimeters x 127 millimeters) in area and 35 - 31 U.S. Gauge in thickness. The tin panels shall be lightly buffed with steel wool and thoroughly cleaned with solvent before being used for tests.

Dry Opacity: Both white and yellow paints shall have a minimum contrast ratio of 0.96. Contract ratio shall be determined by applying a wet film thickness of 0.005 inches (127 microns) to a standard hiding power chart. After drying, the black and white reflectance values shall be determined using a suitable reflectometer and the contrast ratio determined.

Bleeding: The paints shall have a minimum bleeding ratio of 0.97 when tested in accordance with FS TT-P-1952D. The asphalt-saturated felt shall conform to FS HH-R-590.

Abrasion Resistance: No less than 210 liters of sand shall be required to remove paint film when tested in accordance with TT-P-1952D.

Color: The paint shall not discolor in sunlight and shall maintain colorfastness throughout its life, approximately two years. Color determination shall be made without beads, after a minimum of 24 hours. Color for yellow paint shall be a visual match for 595-13538. If not a visual match, the diffuse day color of the paint shall conform to the CIE Chromaticity coordinate limits as follows:

	x y	x y	x y	x y	Brightness
White	0.305 0.295	0.360 0.360	0.388 0.377	0.280 0.3l0	84.0 min
Yellow	0.485 0.455	0.506 0.452	0.484 0.428	0.477 0.438	50.0 min

Glass Bead Adhesion: The paint with glass beads conforming to M.07.30, applied at the rate of 6.0 pounds/gallon (0.72 kilograms/liter) of paint, shall require not less than 150 liters of sand to remove paint film and glass beads.

Scrub Resistance: The paint shall pass 300 cycles minimum when tested in accordance with ASTM D2486.

Drying Time: The reflectorized line shall dry to no pick up in 120 seconds or less when applied at the ratio provided for specified glass spheres to paint (the paint at 15+ 1 mil (381 millimeters $\pm$ 25 millimeters) wet film thickness equivalent to 100-115 square foot/gallon (2.45-2.82 square meters/liter) and the glass spheres at the equivalent rate of 6.0 pounds/gallon (0.72 kilograms/liter). The paint shall be applied with equipment so as to have the paint at a temperature of 130° F to 145° F (54° C to 63° C) at the spray gun.

M.07.22—Epoxy Resin Pavement Markings:

General Requirements*:*

Standards: All standards herein are minimum standards.

Identification: Each container must bear a label with the following information thereon: Name and address of manufacturer, production batch number, date of manufacture, shipping point, grade name and/or identification number, type of material, number of gallons, contract number, use intended, directions for application and formula. Improperly labeled samples and deliveries shall be rejected.

Certification*:* The manufacturer shall furnish a certified test report by an independent testing laboratory prior to the start of work indicating that the material as specified has

been tested in accordance with ASTM or ACI testing procedures noted in this specification. The certified test report shall indicate the results of testing for the criteria contained herein.

Additionally, infrared spectrophotometer plots for both components of the test material shall be included by the independent laboratory in the certified test report. The unused material submitted for testing by the independent laboratory (minimum 1 gallon (4 liters) unmixed components) shall be forwarded to the ConnDOT, Materials Testing Laboratory, 280 West Street, Post Office Box 207, Rocky Hill, Connecticut 06067. This sample shall be labeled as required under Section 1.06.07.

The manufacturer shall furnish certified test reports, in accordance with Section 1.06.07 for each batch delivered for application at the project site.

Detailed Requirements:

(a) **Epoxy Resin Material:** The material shall be composed of epoxy resins and pigments only.

(b) **Composition:**

WHITE (percent by weight (mass))	YELLOW (percent by weight (mass))
20% ± 2% Titanium Dioxide (ASTM D 476 Type III)	25% ± 2% Chrome Yellow (ASTM D 211 Type III)
80% ± 2% Epoxy Resins	75%
± 2% Epoxy Resins	

(c) Color: The color of the white material shall be no darker or yellower than color chip 17778 of FS No. 595a of the latest issue, when the material is placed in a type EH weatherometer for a period of 500 hours and weathered according to ASTM G 23. Any noticeable discoloration of the epoxy markings, either during or after application to the pavement surface, as determined by the Engineer, will be considered unacceptable. Any discolored areas shall be removed and the markings shall be reapplied in accordance with this specification. The color of the yellow shall be reasonably close to color chip 13538 of the Federal Standard No. 595a of the latest issue.

(d) Adhesion Capabilities: When the adhesion of the material to portland cement concrete (the concrete shall have a minimum of 300 psi (2070 kilopascals) tensile strength) is tested according to ACI 503R testing procedure, the failure of the system must take place in the concrete. The concrete shall be 90° F (32° C) when the material is applied, after which the material shall be allowed to cure for 72 hours at 73° F ± 3.5° F (23° C ± 2° C).

(e) Abrasion Resistance: When the abrasion resistance of the material is tested according to ASTM C 501 with a CS-17 wheel under a load of 1000 grams for 1000 cycles, the wear index shall be no greater than 82. (The wear index is the weight (mass) in milligrams that is abraded from the sample under the test conditions).

(f) Hardness: The Type D durometer hardness of the material shall be not less than 75 nor more than 90 when tested according to ASTM D2240 after the material has cured for 72 hours at 73° F ± 3.5° F (23° C ± 2° C).

(g) Tensile Strength: The tensile strength of the material, when tested according to ASTM D 638, shall not be less than 6,000 psi (41 370 kilopascals) after 72 hours cure at 73° F ± 3.5° F (23° C ± 2° C).

(h) Compressive Strength: The compressive strength of the material, when tested according to ASTM D 695, shall not be less than 12,000 psi (82 740 kilopascals) after 72 hours cure at 73° F ± 3.5° F (23° C ± 2° C).

(i) Shelf Life: The individual components shall not require mixing prior to use when stored for a period of 12 months.

(j) Glass Beads: General Requirements – The beads shall be transparent, clean, colorless glass, smooth and spherically shaped, free of milkiness, pits, or excessive air bubbles and conform to the following specific requirements:

- **Quality Assurance Control** – The beads shall be segregated into maximum lots of 2,500 pounds (1125 kilograms) and lot numbers shall be stamped onto each lot. Each lot shall be tested for gradation, rounds and embedment coating.

- **Gradation** – The glass spheres shall meet the following gradation requirements:

Grading "A"		rading "B"	
Sieve Size	% Passing	Sieve Size	% Retained
#20 (850 µm)	100	#10 (2.0 mm)	0
#30 (600 µm)	80 – 95	#12 (1.7 mm)	0 – 5
#50 (300 µm)	9 – 42	#14 (1.4 mm)	5 – 20
#80 (180 µm]	0 – 10	#16 (1.18 mm)	40 – 80
		#18 (1.0 mm)	10 – 40
		#20 (850 µm)	0 – 5
		Pan	0 – 2

- **Roundness** – The glass beads shall have a minimum of 80% rounds per screen for two highest sieve quantities and no more than 3% angular particles per screen for Grading "B". The remaining sieve fractions shall typically be no less than 75% rounds.

- **Refractive Index** – The glass beads shall have a refractive index of 1.50 to 1.52.

M.07.23—Vacant

M.07.24—Preformed Black Line Mask Pavement Marking Tape:

General Requirements*:* The preformed, patterned black line mask pavement marking tape shall consist of a matte black, non-reflective tape in widths or sizes sufficiently large to mask the existing markings which are to be temporarily covered.

The patterned masking tape shall be pre-coated with a pressure sensitive adhesive and shall be capable of being adhered to existing markings, on bituminous concrete pavement or Portland cement concrete in accordance with the manufacturer's instructions without the use of heat, solvents or other additional adhesives, and shall be immediately ready for traffic use after application. The Contractor shall identify equipment necessary for proper application and removal, and make recommendations for application that will assure effective product performance.

The preformed, patterned black line masking pavement marking tape shall be suitable for use for one year after the date of receipt when stored in accordance with the manufacturer's recommendations.

Detailed Requirements*:*

(a) Composition: The non-reflective, patterned black line mask pavement marking tape shall not contain metallic foil and shall consist of a mixture of high quality polymeric materials, pigments and inorganic fillers distributed throughout its base cross-sectional area, with a matte black non-reflective top layer. The patterned surface shall have a minimum of 20% of the surface area raised and coated with non-skid particles. The channels between the raised areas shall be substantially free of particles. The film shall be pre-coated with a pressure sensitive adhesive. A non-metallic medium shall be incorporated to facilitate removal.

(b) Skid Resistance: The surface of the patterned, non-reflective black line mask pavement marking tape shall provide an initial average skid resistance value of 60 BPN when tested in accordance with ASTM E 303.

(c) Thickness: The patterned material, without adhesive, shall have a minimum thickness of 0.065 inch (1.65 millimeters) at the thickest portion of the patterned cross-section and a minimum thickness of 0.02 inch (0.5 millimeters) at the thinnest portion of the cross-section.

(d) Adhesion: The black line mask pavement marking tape shall adhere to the pavement and existing pavement markings under climatic and traffic conditions normally encountered in the construction work zone.

(e) Removability: The black line mask pavement marking tape shall be removable after its intended use, intact or in large pieces, manually, at temperatures above 40° F (4° C) without the use of heat, solvents, grinding or sand or water blasting. The black line mask pavement marking tape shall be totally removed from existing markings that are adequately adhered to the pavement surface, without damage to the underlying markings.

M.07.25—Black Epoxy Resin Pavement Markings:

Identification: Each container shall have a label affixed to it with the following information thereon: name and address of manufacturer, shipping point, grade production batch number, date of manufacture, grade name and/or identification number, type of material, number of liters, contract number, use intended, directions for application, and formula. Improperly labeled samples and deliveries shall be rejected.

Certification: For each batch of black epoxy resin, Certified Test Reports conforming to Article 1.06.07 shall be submitted from an independent testing laboratory and approved by the Engineer, prior to installation on the project.

Detailed Requirements:

(a) Epoxy Resin Material: The material shall be composed of epoxy resins and pigments only.

(b) Composition:

Component	Percent by Weight (Mass)
Carbon Black (ASTM D 476 Type III)	7 ± 2
Talc	14 ± 2
Epoxy Resins	79 ± 4

(c) Black Aggregate: The moisture resistant aggregate shall meet the gradation requirements as follows:

Sieve Size	Percent Retained
#20 (850 µm)	23 – 38
#50 (300 µm)	58 – 74
#270 (53 µm)	1 – 6
Pan	0 - 0.5

The moisture resistant aggregate shall have a urethane coating. The aggregate shall be angular with no dry dispensement pigment allowed.

(d) Adhesion: The black epoxy resin pavement marking material shall be formulated so as to adhere to the pavement and existing pavement markings under climatic and traffic conditions normally encountered in the construction work zone.

(e) Abrasion Resistance: When the abrasion resistance of the material is tested according to ASTM D 4060 with a CS-17 wheel under a load of 1000 grams for 1000 cycles, the wear index shall be no greater than 82.

(f) Hardness: The Type D durometer hardness of the material shall not be less than 75 nor more than 90 when tested according to ASTM D 2240 after the material has cured for 72 hours at 73.5° F ± 3.5° F (23° C ± 2° C).

(g) Compressive Strength: The compressive strength of the material, when tested according to ASTM D 695, shall not be less than 12,000 psi (82 740 kilopascals) after 72 hours cured at 73.5° F ± 3.5° F(23° C ± 2° C).

M.07.30—Glass Beads: The glass beads shall conform to the requirements of AASHTO M 247, Type 1.

SECTION M.08

DRAINAGE

M.08.01—Pipe: The pipe for this work shall conform to the following requirements:

1. Cast Iron Pipe: This pipe shall conform to the requirements of AASHTO M 64 for Extra-Heavy Cast Iron Culvert Pipe.

2. Coated Corrugated Metal Pipe and Coated Corrugated Metal Pipe Elbows: This pipe shall conform to the requirements of AASHTO M 36, Type 1, Type IR or AASHTO M245, Type 1. For either specification, the Contractor shall submit manufacturer's and/or fabricator's certified test reports and material certifications, in accordance with Section 1.06.07. AASHTO M 36, Type 1 & IR includes pipe fabricated from zinc-coated steel sheet coated with bituminous material and aluminum-coated (Type 2) steel sheet. AASHTO M 245, Type 1 is for pipe fabricated from metallic-coated and polymer-pre-coated steel sheet.

The corrugation size and sheet thickness shall conform to the following:

Nominal Inside Diameter (inches)		Specified Sheet Thickness (inches)
6	1 1/2" X 1/4"	.052
8	Corrugations	.064
10		.064, .079
12		.064, .079
15		.064, .079, .109
18		.064, .079, .109
21	2 2/3" X 1/2"	.064, .079, .109
24	Corrugations	.079, .109, .138
30		.079, .109, .138 .168
36		.079, .109, .138, .168
42		.109, .138, .168
48		109, .138, .168

54			.064, .079, .109
60			.064, .079, .109
66		3" X 1"	.079, .109, .138
72		or	.079, .109, .138
78		5" X 1"	.109, .138, .168
84		Corrugations	.109, .138, .168
90			.109, .138, .168
96			.109, .138, .168
Steel	Aluminum		
18			.064, .079 .060, .075
24			.064, .079 .060, .075
30			.064, .079 .060, .075
36			.064, .079 .075, .105
42		Helical Rib	.079, .109 .105, .135
48		3/4" X 3/4" X 7 l/2"	.079, .109 .105, .135
54			.079, .109 .105, .135
60			.109 .135
66			.109 .135
72			.109 .135
78			.109 .135
84			.109 .135

Nominal Inside Diameter (mm)		Specified Sheet Thickness (mm)
150	38 X 6.5 mm	1.32
200	Corrugations	1.63

250		1.63, 2.01
300		1.63, 2.01
375		1.63, 2.01, 2.77
450		1.63, 2.01, 2.77
525	68 X 13 mm	1.63, 2.01, 2.77
600	Corrugations	2.01, 2.77, 3.51
750		2.01, 2.77, 3.51, 4.27
900		2.01, 2.77, 3.51, 4.27
1050		2.77, 3.51, 4.27
1200		2.77, 3.51, 4.27
1350		1.63, 2.01, 2.77
1500		2.01, 2.77, 3.51
1800	75 X 25 mm	2.01, 2.77, 3.51
2100	or	2.77, 3.51, 4.27
2250	125 X 25 mm	2.77, 3.51, 4.27
2400	Corrugations	2.77, 3.51, 4.27

Steel	Aluminum	
450		1.63, 2.01 1.52, 1.91
600		1.63, 2.01 1.52, 1.91
750		1.63, 2.01 1.52, 1.91
900		1.63, 2.01 1.52, 1.91

1050	Helical Rib	2.01, 2.77 2.67, 3.43
1200	9 X 19 X 190 mm	2.01, 2.77 2.67, 3.43
1350		2.01, 2.77 2.67, 3.43
1500		2.77 3.43
1650		2.77 3.43
1800		2.77 3.43
1950		2.77 3.43
2100		2.77 3.43

Aluminum pipe sheet thickness shall be .004 inch (100 microns) less than specified above for 1 1/2-inch x 1/4-inch, 2 2/3-inch x 1/2-inch and 3-inch x 1-inch (38-millimeter x 6.5-millimeter, 68-millimeter x 13-millimeter, and 75-millimeter x 25-millimeter) corrugations. Helical Rib shall be as specified above.

Unless otherwise specified, the lightest sheet thickness listed for a specified diameter may be furnished.

The pipe and pipe elbows conforming to the requirements of AASHTO M 36 shall be coated with bituminous material as specified in AASHTO M 190 Type C. Steel Sheet, Aluminum-Coated (Type 2) does not require a coating of bituminous material or paved invert.

The pipe and pipe elbows conforming to the requirements of AASHTO M 245 shall be coated as specified in AASHTO M 246, Type B.

The thicker polymeric coating shall be on the inside of the pipe.

Coupling bands shall conform to the requirements of AASHTO M 36 or M 245, whichever is applicable. All coupling bands shall be coated with material conforming with AASHTO M190 or in conformance with M 246, Type B. Coupling bands for Steel Sheet, Aluminum-Coated (Type 2) pipe do not require a coating of bituminous material.

Only one type of coating will be allowed for any continuously connected run of pipe.

If elongation of the pipe is required, it shall be done by one of the following methods:

(a) Shop Strutting: The pipe shall be elongated by the manufacturer, after fabrication, by reducing the horizontal diameter three percent and increasing the

vertical diameter three percent, and held in the elongated shape by means of rod, all in accordance with this specification.

The rods shall be 5/8-inch (16-millimeter) diameter, threaded 7 inches (180 millimeters) at both ends with washers and nuts. The length of the rods shall be the diameter of the pipe plus 8 inches (203 millimeters). The rods shall be placed on the horizontal axis of the pipe on 2-foot (610-millimeter) spacing and located at the halfway point between the circumferential riveting.

A soft wood block 2 inches x 4 inches and 12 inches (50 millimeters X 100 millimeters and 300 millimeters) long shall be placed over the rods at each end to provide contact against the outside of the pipe. The long dimension of the blocks shall be parallel with the horizontal axis of the pipe in order to prevent distortion of the pipe when the nuts are tightened.

The 3% elongation shall be obtained by tightening on rods uniformly from end-to-end of the pipe, obtaining approximately one-quarter of the required elongation each time through the length of the pipe.

The strutting rods shall be left in the pipe until the fill is completed and well compacted, unless for some unusual condition their removal is ordered by the Engineer.

The rods shall be removed by the Contractor by cutting them from the inside of the pipe flush with the sidewalls, and a coating of bituminous material shall be applied to protect the metal of the pipe where it has been exposed.

A tolerance of 1% of the pipe diameter in the elongation will be permitted.

(b) Mechanical Elongation: The manufacturer shall elongate the pipe by increasing the diameter along the vertical axis by approximately 5% with a corresponding decrease along the horizontal axis by mechanical means in which sufficient pressure is applied to the sides of the pipe after fabrication to produce the specified distortion. The elongation shall be maintained by drilling holes in the ends of sections and placing horizontal wires. The wires shall be removed after the pipe sections have been placed, coupling bands installed and backfill placed.

3. Perforated or Plain Coated Metal Pipe for Underdrains or Outlets: This pipe shall conform to the requirements of AASHTO M 36, Type III or AASHTO M 245, Type III. The specifications are further supplemented by the following: For either specification, the Contractor shall submit manufacturer's and/or fabricator's certified test reports and Materials Certificates, in accordance with Section 1.06.07.

(a) Perforations: The minimum diameter of 1/4 inch (6.5 millimeters) for the perforations shall apply after asphalt coating. Pipe to be used for outlets shall not be perforated.

(b) Coating: The pipe conforming to the requirements of AASHTO M 36 shall be coated to the requirements of AASHTO M 190, Type A, except the thickness shall be 0.03 inches (0.75 millimeters) instead of 0.05 inches (1.25 millimeters). Steel Sheet, Aluminum-Coated (Type 2) does not require a coating of bituminous material.

The pipe conforming to the requirements of AASHTO M 245 shall be coated as specified in AASHTO M 246, Type B.

The thicker polymeric coating shall be on the inside of the pipe.

Coupling bands shall conform to the requirements of AASHTO M 36 or M 245, whichever is applicable.

All steel coupling bands shall be coated with material conforming with AASHTO M 190 or in conformance with M 246, Type B. Coupling bands for Steel Sheet, Aluminum-Coated (Type 2) do not require a coating of bituminous material.

Only one type of coating will be allowed for any continuously connected run of pipe.

Sheet thickness shall conform to Subarticle M.08.01-2

4. Coated Corrugated Metal Pipe-Arches: These pipe-arches shall conform to the requirements of AASHTO M 36, Type II, Type IIR or AASHTO M 245, Type II. The corrugation size and sheet thickness shall conform to the following: For either specification, the Contractor shall submit manufacturer's and/or fabricator's certified test reports and materials certificates, in accordance with Section 1.06.07.

Pipe-Arch Size (Inches)	Equivalent Diameter (Inches)		Specified Sheet Thickness (Inches)
17 X 13	15		.064
21 X 15	18		.064
24 X 18	21		.064
28 X 20	24		.079
35 X 24	30		.079
42 X 29	36	2 2/3" X 1/2"	.109
49 X 33	42	Corrugations	.109
57 X 38	48		.109

64 X 43	54		.138
71 X 47	60		.138
71 X 47	60		.168
66 X 51	60		.079
73 X 55	66		.079
81 X 59	72	3" X 1"	.079
87 X 63	78	or	.109
95 X 67	84	5" X 1"	.109
103 X 71	90	Corrugations	.109
112 X 75	96		.109
20 X 16	18		.064
23 X 19	21		.064
27 X 21	24		.064
33 X 26	30	3/4" X 3/4" X 7 1/2"	.079
40 X 31	36	Helical Rib	.079
46 X 36	42		.109
53 X 41	48		.109
60 X 46	54		.109
66 X 51	60		.109

Pipe-Arch Size (mm)	Equivalent Diameter (mm)	Specified Sheet Thickness (mm)
430 X 330	375	1.63

530 X 380	450		1.63
610 X 460	525		1.63
710 X 510	600		2.01
885 X 610	750		2.01
1060 X 740	900	68 X 13 mm	2.77
1240 X 840	1050	Corrugations	2.77
1440 X 970	1200		2.77
1620 X 1100	1350		3.51
1800 X 1200	1500		3.51
1800 X 1200	1500		4.27
1670 X 1300	1500	75 X 25 mm	2.01
1850 X 1400	1650	or	2.01
2050 X 1500	1800	125 X 25mm	2.77
2200 X 1620	1950	Corrugations	2.77
2400 X 1720	2100		2.77
2600 X 1820	2250		2.77
2840 X 1920	2400		2.77
500 X 410	450		1.63
580 X 490	525		1.63
680 X 540	600	19 X 19 X 190 mm	1.63
830 X 670	750	Helical Rib	2.01
1010 X 790	900		2.01
1160 X 920	1050		2.77
1340 X 1050	1200		2.77
1520 X 1170	1350		2.77
1670 X 1300	1500		2.77

Unless otherwise specified, the lightest sheet thickness listed for a specified diameter may be furnished.

Pipe-arches conforming to the requirements of AASHTO M 36 shall be coated with bituminous material as specified in AASHTO M190, Type C. Steel Sheet, Aluminum-Coated (Type 2) does not require a coating of bituminous material or paved invert.

Pipe-arches conforming to the requirements of AASHTO M 245 shall be coated as specified in AASHTO M 246, Type B.

The thicker polymeric coating shall be on the inside of the pipe.

Only one type of coating will be allowed for any continuously connected run of pipe-arch.

Coupling bands shall conform to the requirements of AASHTO M 36 or M 245, whichever is applicable. All coupling bands shall be coated with material conforming with AASHTO M190 or in conformance with M 246, Type B. Coupling bands for Steel Sheet, Aluminum-Coated (Type 2) pipe arches do not require a coating of bituminous material.

5. Corrugated Structural Plates and Bolts: These plates and bolts are for use in the construction of metal pipe of the large diameter and for metal plate arches or pipe arches to be assembled in the field, and they shall conform to the requirements of AASHTO M 167 for corrugated metal pipe. For this specification, the Contractor shall submit manufacturer's and/or fabricator's certified test reports and Materials Certificates, in accordance with Section 1.06.07. The plates shall have not less than the minimum gage shown on plans, which shall provide with the corrugations a section modulus not less than that specified.

The dimensions of plates and details of fabrication shall conform to the requirements of the manufacturer. Where the plans call for a heavier gage for the bottom of the pipe than for the remainder of the pipe circumference, the lower fourth of the circumference shall be the minimum width of the heavier gage material.

The coating shall conform to the requirements of AASHTO M 243.

6. Reinforced Concrete Pipe: Unless otherwise specified, this pipe shall conform to the requirements of AASHTO M 170, Class IV, as supplemented and modified by the following:

(a) Reinforcement: In circular pipe, only circular reinforcement will be allowed.

(b) Laps and Welds: The reinforcement shall be lapped not less than 2 inches (51 millimeters) and welded with an electric welding machine.

(**c) Quality Assurance Testing**: Circular and elliptical reinforced concrete pipe shall be tested by the three-edge bearing method prescribed in AASHTO T 280, except as follows:

1) Modified or special design pipe shall be tested to the 0.01-inch (0.3-millimeter) load and the ultimate load requirements as per AASHTO M 170 and M 207.

2) At the discretion of the Engineer, pipe of standard design, as specified in AASHTO M 170 and M 207, may be tested to the 0.01-inch (0.3-millimeter) requirement plus 10% additional load in lieu of ultimate load testing. Test pipe attaining a 0.01-inch (0.3-millimeter) crack will not be acceptable for use on ConnDOT projects.

3) Cores for absorption and determination of steel reinforcement shall be taken on a random basis as determined by the Engineer. The cores shall be at least 6 inches (150 millimeters) in diameter.

(d) Inspection: The pipe plant, materials, processes of manufacture and the finished pipe shall be subject to inspection and approval by the Department. The pipe manufacturer's records related to component materials, production and shipment of pipe for Department use shall be made available to the Department on request. The equipment and labor necessary for inspection, sampling and testing as required by the Department shall be furnished by the pipe manufacturer. Test equipment shall be calibrated at least once each 12 months, or as directed by the Engineer. The plant cement and aggregate scales shall be inspected and sealed by the approved agency at least once every twelve months.

(e) Preliminary Tests and Tests for Extended Deliveries: As directed by the Engineer, the Department shall select for test from the stock of any manufacturer proposing to supply pipe to the Department, 2 of each size pipe up through 30-inch (750-millimeter) diameter and 1 of each size greater than 30-inch (750-millimeter) diameter. These sample pipes shall be tested under Department supervision by the three-edge bearing method. Absorption tests shall be made on each size, wall thickness, and class of pipe meeting the three-edge bearing load requirements.

Frequency for extended deliveries shall be one three-edge bearing test for each 500 pipes shipped to Department projects.

For pipe that fails, its shall be necessary for the manufacturer to either physically isolate the rejected pipe at his plant or to provide some means to clearly indicate the unacceptability of the pipe. Either method shall be performed to the satisfaction of the Engineer. When production is resumed on any size, wall thickness or class previously rejected, preliminary tests shall be required.

Moreover, the frequency of tests for extended deliveries shall be one three-edge bearing test for each 200 pipes shipped to Department projects.

If 95% of all pipe tested at a particular plant from the first of the calendar year to September 30 meet specifications, including both preliminary and extended tests, it will not be necessary to perform the Fall three-edge bearing tests at this plant.

Use of compression tests on representative cylinders or cores to determine the compressive strength of the concrete incorporated into the pipe products will be at the discretion of the Engineer.

(f) Shipping: Pipe shall not be shipped until it is at least 7 days old unless earlier shipment is authorized by the Engineer on the basis of tests.

(g) Certification: Pipe will be accepted by the Department on the basis of manufacturer's certification. The manufacturer shall certify each shipment of pipe on Department Form MAT-073(PC-1), "Certification of Precast Concrete Products." Two (2) copies of this certification shall be furnished with the shipment to the Engineer at the project site.

7. Plain and Perforated Concrete Drain Pipe: The materials entering into the construction of this pipe shall be the same as described hereinbefore under Reinforced Concrete Pipe, except that the pipe shall not be reinforced.

Workmanship, variations in dimensions, marking, curing, shipping, test specimens, and inspection shall be the same as that specified for reinforced concrete pipe described above.

(a) Wall Thickness: The wall thickness of concrete drain pipe shall not be less than 3/4 inch (19 millimeters).

(b) Perforations: The perforations shall be 1/4 inch (6.5 millimeters) clear opening. The number and location of longitudinal rows of perforations shall be as shown on the plans. Unless otherwise specified, the pipe shall be 6 inches (152 millimeters) minimum inside diameter.

(c) Absorption Tests: Absorption testing shall be performed in accordance with the requirements of AASHTO T 280 and M 170.

8. Plain and Perforated Vitrified Clay Pipe: This pipe shall conform to the requirements of AASHTO M 65 for pipe of full circular cross-section as supplemented by the following requirements:

Pipe for use under pavements and shoulders shall be extra-strength pipe. Outside of these areas, standard-strength pipe may be used.

Unless otherwise specified, the pipe shall be 6 inches (152 millimeters) minimum in diameter.

9. Reinforced Concrete Elliptical Pipe: This pipe shall conform to the requirements of AASHTO M 207, Class HE IV and supplemented as follows:

(a) Manufacturing and testing shall conform to Articles M.08.01-6.

10. Slotted Reinforced Concrete Pipe for Underdrain and Outlets: This pipe shall conform to the requirements of Article M.08.01-6 and shall be slotted in accordance with AASHTO M 175, Type 2 or as shown on the plans.

The pipe for outlets shall not be slotted.

11. Slotted Drain Pipe: The pipe shall be asphalt coated and conform to Subarticle M.08.01-2. Concrete shall conform to Article M.03.01, Class "A" or pavement type. Concrete shall be cured in conformance with M.03.01. The inlet aperture shall be longitudinal on top of the pipe and may be continuous or intermittent. The opening in the pipe wall may be fabricated in the form of continuous bar risers and spacers or of intermittent cut-out segments with structural members supporting a continuous grating as indicated in the plans. End caps shall be as provided by the manufacturer.

Elastomeric polymer sealer shall meet the physical requirements of either FS SS-S-195B or ASTM D 3406 and be accepted on manufacturer's certification.

The pipe shall be helically corrugated with a continuous welded or lock seam. Pipe ends shall have 2 rolled annular corrugations on each end for jointing.

Bar Riser and Spacer Type: Riser assemblies shall be fabricated from structural steel, in accordance with the dimensions on the plans. The riser assemblies shall be hot dipped galvanized according to ASTM A123. The assemblies shall be welded to the corrugated pipe on each side of the riser at the location of the solid web spacers. The riser shall terminate 1 inch (25 millimeters) from the ends of each pipe length to allow clearance for single bolt coupling bands. The ends of the riser shall be closed with a suitable welded plate where solid web spacers do not come to the ends of the riser.

The maximum deviation from straight in both the vertical and horizontal plane of the riser assembly shall not exceed 3/4 inch (19 millimeters) in a 20-foot (6-meter) length.

Continuous Grating Type: The cut-out pipe segments shall provide a 2-inch (50-millimeter) wide slot of maximum length between the lock seams. The slot shall be left intact 1 inch (25 millimeters) on each side of the lock seam and this material shall be utilized to fasten the reinforcing bar in place.

A bent epoxy coated reinforcing bar shall cross the slotted opening on 6-inch (150-millimeter) centers. The reinforcing bar shall be an ASTM A 615, No. 13 deformed bar

epoxy coated with 7 mils of fusion bonded epoxy powder conforming to AASHTO M 284.

Grating shall be furnished unless noted in the contract documents. Grating and all bearing bars, cross bars, and bent connecting bars shall be welding quality, mild carbon steel conforming to ASTM A 569 and to the dimensions shown on the plans.

Tie down bolts shall be J-Type bolts, plated, ASTM A 307 steel supplied with self-locking nuts.

Concrete forms shall be of cellular foam plastic base, fabricated as an integral part of the pipe and reinforcing bar assembly. The form shall be capped with a thick wood or plastic cap resting on top of the foam plastic and reinforcing bar.

The maximum deviation from straight in both the vertical and horizontal plane of the completed assembly shall not exceed 3/4 inch in a 20-foot (19 millimeters in a 6-meter) length. All grating and hardware shall be galvanized in conformance with Article M.06.03. Expansion joint filler shall conform to M.03.01-5(B).

12. Vacant

13. Porous Concrete Pipe for Underdrains and Outlets: This pipe shall conform to the requirements of AASHTO M 176, except that the minimum laying length shall be 2 feet (610 millimeters).

14. Corrugated Aluminum Pipe: This pipe shall conform to the requirements of AASHTO M 196 Type I or Type IR. Sheet thickness shall conform to the requirements of M.08.01-2. For this specification, the Contractor shall submit manufacturer's and/or fabricator's certified test reports and materials certificates, in accordance with Section 1.06.07.

15. Corrugated Aluminum Pipe for Underdrains and Outlets: This pipe shall conform to the requirements of AASHTO M 196 Type III or Type IIIR. Sheet thickness shall conform to the requirements of M.08.01-2.

Pipe for outlets shall not be perforated.

16. Corrugated Aluminum Pipe Arches: These pipe arches shall conform to the requirements of AASHTO M 196 Type II or Type IIR. For this specification, the Contractor shall submit manufacturer's and/or fabricator's certified test reports and materials certificates, in accordance with Section 1.06.07.

Sheet thickness shall conform to the requirements of M.08.01-4.

17. Vacant

18. Cold-Applied Bituminous Sealer: This material, for use in sealing of joints in concrete and vitrified clay pipes, shall be free of asbestos and shall meet the following requirements:

	Min.	Max.
Penetration, 25°C, 150 grams., 5 seconds., with cone, dmn (FS SS-R-406, Method 223.12)	175	300
Loss on Heating, 325°F (163°C), 5 hours., 50 grams. (AASHTO T 47)	—	10
Total Bitumen, Benzene (AASHTO T 44), %	40	—
Inorganic Content (Ash) (AASHTO T111), %	15	50

It shall be of such consistency that it may be spread on the joints with a trowel when the temperature of the air is between -20° F and 100° F (7° C and 38° C). The bituminous material shall adhere to the concrete or clay pipe so as to make a watertight seal, and shall not flow, crack or become brittle when exposed to the atmosphere.

Unless otherwise specified, sampling shall be done in accordance with AASHTO T 40.

The bituminous sealer shall be delivered to the project in suitable containers for handling, and shall be sealed or otherwise protected from contamination. The container shall show the brand name, net mass or volume, and the requirements for application.

19. Preformed Plastic Gaskets: This material for use in sealing of joints in concrete and vitrified clay pipe shall conform to the requirements of FS SSSS00210 (G.S.A.—F.S.S.)

20. Flexible, Watertight, Rubber-Type Gaskets: This material for use in sealing concrete pipe joints shall conform to the requirements of AASHTO M 198.

21. Bedding Material: This material shall be sand or sandy soil, all of which passes a 3/8-inch (9.5-millimeter) sieve, and not more than 10% passes a No. 200 (75-micron) sieve.

When ground water is encountered, the Engineer may allow No. 6 stone conforming to Article M.01.01 to be used instead of sand or sandy soil.

22. Reinforced Concrete Culvert End: The barrel shall conform to the requirements of AASHTO M 170, Class II, except that the three-edge bearing tests will not be required. The flare shall be of the same thickness and materials as the barrel, and shall have steel reinforcement equaling or exceeding the amount shown on the table for the pertinent size.

Tongues and grooves shall be compatible with tongues and grooves of pipe meeting AASHTO M 170, Class IV.

Air entrainment shall be added to these units so as to maintain 5 to 8% entrained air.

23. Metal Culvert End: The materials used in this work shall meet the pertinent requirements of Articles M.08.01-2 and M.08.01-4.

Bolts and fittings shall conform to the requirements of ASTM A 307 and shall be galvanized to conform to the requirements of ASTM A 153.

The units shall be coated as specified in Articles M.08.012, M.08.01-4 or M.08.01-5.

Fabrication: These units shall be formed from a rectangular sheet of metal by cutting and bending to form the desired shape. Two or more sheets may be fastened together by riveting or bolting so as to form a rectangular sheet of the required width. Skirt extensions and a top plate, as needed to complete the unit, shall be separately formed. Skirt extensions shall be riveted or bolted to the skirt.

All edges which will be exposed above the surface of the ground shall be reinforced before forming the unit by either of the following means:

(1) The edge shall be bent to form a semicircular roll with an exterior diameter of 1 inch (25 millimeters), as shown in the detail drawing on the plans.

(2) A split tube of 1 inch (25 millimeters) outside diameter and not lighter than 14 gage, shall be slipped over a row of rivets spaced not more than 6 inches (152 millimeters) apart, as shown in the detail drawing on the plans.

One corrugation, matching the corrugations of the pipe or pipe-arch to which the unit is to be attached, shall be formed in the unit to insure secure and accurate alignment.

Attachment: The unit may be shop-riveted to a length of the appropriate pipe or pipe-arch, or may be field attached to the pipe or pipe arch by either of the other attachment systems shown on the plans, or by other means acceptable to the Engineer. If the unit is shop-riveted to a length of pipe or pipe-arch, this length shall be sufficient to permit proper use of standard coupling bands.

24. Vacant

25. Corrugated Polyethylene Pipe: Corrugated Polyethylene Pipe, either corrugated interior surface (Type C) or smooth interior surface (Type S) without perforations or with perforations (Type CP or SP), shall conform to AASHTO M 252 or M 294. Type D pipe shall have a smooth interior surface braced circumferentially or spirally with projections or ribs joined to a smooth outer wall. Both surfaces shall be fused to, or be continuous with, the internal supports. Type D shall conform to AASHTO M 294.

26. Geotextile: The geotextile shall be non-rotting, acid and alkali resistant and have sufficient strength and permeability for the purpose intended, including handling and backfilling operations. Fibers shall be low water absorbent. The fiber network must be dimensionally stable and resistant to delamination. The geotextile shall be free of any chemical treatment or coating that will reduce its permeability. The geotextile shall also be free of any flaws or defects which will alter its physical properties. Torn or punctured geotextiles shall not be used. For each specific use, only geotextiles which are already on the Connecticut Department of Transportation's Approved Products List for the geotextile type will be used. The Engineer reserves the right to reject any geotextile which he deems unsatisfactory for a specific use. The brand name shall be labeled on the geotextile or the geotextile container. Geotextiles which are susceptible to damage from sunlight or heat shall be so identified by suitable warning information on the packaging material.

Geotextiles susceptible to sunlight damage shall not be used in any installations where exposure to light will exceed 30 days, unless specifically authorized in writing by the Engineer.

27. Polyvinyl Chloride Plastic Pipe: The pipe shall conform to the requirements of ASTM D 1785. Couplings and elbows shall conform to the requirements of ASTM D 2466 or D 2467.

28. Polyvinyl Chloride Gravity Pipe: This pipe shall conform to one of the following specifications: ASTM F789, ASTM F 679 or ASTM F 794.

This pipe shall require a certificate of compliance and a materials certificate in conformance with Article 1.06.07.

M.08.02—Catch Basins, Manholes and Drop Inlets: The materials to be used in the construction shall be those indicated on the plans or ordered by the Engineer, and they shall conform to the requirements of these specifications.

1. Brick for Catch Basins, Manholes or Drop Inlets: Brick for catch basins, manholes or drop inlets shall conform to the requirements of AASHTO M 91, Grade SM, except that the depth shall be 2 1/4 inches (57 millimeters), the width 3 5/8 inches (92 millimeters) and the length 8 inches (203 millimeters), and except that the maximum water-absorption by 5-hour boiling shall not exceed the following limits:

Average of 5 bricks	15%
Individual brick	18%

2. Concrete Building Brick for Catch Basins, Manholes or Drop Inlets: Concrete building brick for catch basins, manholes or drop inlets shall conform to the requirements of ASTM C 55, Grade S II.

3. Masonry Concrete Units for Catch Basins, Manholes or Drop Inlets: Masonry concrete units for catch basins, manholes or drop inlets shall conform to the requirements of ASTM C 139.

4. Precast Units for Drainage Structures: Precast units for drainage structures may be used except where particular conditions require building or casting in place.

Fabrication plants shall have a quality control plan approved by the Director of Research and Materials Testing that is demonstrated to the satisfaction of the Engineer. The fabrication plant, the quality of materials, the process of fabrication and the finished precast unit shall be subject to inspection and approval by the Engineer.

Precast manholes shall conform to the requirements of AASHTO M 199 (ASTM C 478).

Circular precast catch basins and drop inlets shall conform to AASHTO M 199 (ASTM C 478) as supplemented below. Rectangular precast catch basins and drop inlets shall conform to ASTM C 913 as supplemented below:

All materials used for concrete shall conform to the requirements of Section M.03.

The provisions of Subarticle 4.01.03 (A) shall apply except that the concrete shall contain 4% - 7% entrained air. Water-absorption of individual cores taken from precast units shall be not more than 7%.

Reinforcement shall conform to the requirements of Article M.06.01.

The units shall be cast in substantial permanent steel forms so constructed that no overall dimension of a casting shall vary more than 1/4 inch (6.4 millimeters) over and under the specified dimension, and so that the frame for the inlet grate is in the desired position in the completed unit.

Suitable provision shall be made in casting the units for convenient handling of the completed casting, and additional reinforcement steel shall be provided to allow for such handling in the casting yard and during transportation and placement. Each completed unit shall be identified with the name of manufacturer and date of the concrete pour from which it was cast, either by casting this information into an exposed face of the unit or by suitable stencil. The precast units shall be cured in accordance with AASHTO M 170, except that liquid membrane-forming compounds for curing concrete shall not be used in curing the precast tops of catch basins or drop inlets.

For each day's production of precast units, the fabricator shall mold, cure and test 1 set of 4 standard cylinders, or cylinders compacted in a similar manner to the parent precast units, for the purpose of determining the compressive strength of the concrete incorporated into the precast units. Concrete used in molding the cylinders shall be representative of the concrete incorporated into the precast units during the production period. Cylinders shall be molded in accordance with AASHTO T 23, cured by the same

method as the units they represent, and tested as prescribed in AASHTO T 22. A compression test will be performed on 2 cylinders 7 days after casting. If the average compressive strength is not less than that required and no individual cylinder is less than 90% of the required compressive strength, the precast units represented by these cylinders will be acceptable for use at 7 days of age.

If the strength requirement is not met in the first test, a second test will be performed on one cylinder at 14 days; and provided the minimum strength is achieved, the units will be acceptable for use as of that date. Should the second test fail, a third compression test will be performed on the 4th cylinder at 28 days after casting; and the units will be acceptable for use at that time if the minimum strength requirement is met. If the strength requirements are not met in the 28-day test, all precast units of the production period will be rejected.

In lieu of cylinders, the fabricator may, with the permission of the Department, perform compression tests on 4-inch (100-millimeter) cores drilled from the walls of appropriate precast units to determine the compressive strength of the concrete. Cores shall be obtained and tested in accordance with AASHTO T 24.

The fabricator shall determine the air content of the concrete used in the day's production of precast units by performing tests as prescribed in AASHTO T 152.

The equipment and personnel necessary to perform the required testing shall be furnished by the fabricator and approved by the Engineer. All testing equipment shall be calibrated at least once each 12 months or as directed by the Engineer. The fabricator shall maintain records relative to the production, testing and shipment of precast units supplied to the Department. Said records shall be available to a representative of the Department upon his request.

The Department will accept precast concrete units on the basis of fabricator’s certification. The fabricator shall certify each shipment of precast concrete units on Department Form MAT PC-1, "Certification of Precast Concrete Products." Two (2) copies of this certification shall be furnished with the shipment to the Engineer at the Project site.

Precast units that are cracked, show evidence of honeycomb, or have over 10% of their surface area patched, shall be subject to rejection, even though meeting other requirements.

Upon requested, the fabricator shall furnish and deliver to the Laboratory, at no cost to the Department, a complete unit for coring and absorption test purposes. A maximum of 2 such units per year will be requested except that for each failure in the test, an additional unit shall be furnished.

5. Metal for Drainage Structures: Metal for catch basin, 13ns. Covers and gratings shall bear uniformly on their supports.

Extensions shall be designed so that the existing manhole cover or catch basin grate, when set in place, will have substantially the same bearing, fit and load carrying capacity as in the existing frame. The extension shall be designed to fit into the original frame, resting specifically on the flange and rim area. The extension shall accept the existing cover or grate so that the cover or grate is seated firmly without movement.

Ladder rungs for manholes shall conform to AASHTO M 199 (ASTM C 478). Those portions of aluminum ladder rungs embedded in concrete shall be given one coat of zinc chromate paint conforming to FS TT-P645 or equivalent.

Cast iron shall conform to the requirements of AASHTO M 105, Class 25 for the frames and Class 30 for grates.

Cast steel shall conform to the requirements of ASTM A 27, Grade optional, and shall be thoroughly annealed.

Structural Steel shall conform to the requirements of ASTM A 36, or A 283, Grade B or better, as to quality and details of fabrication, except that in the chemical composition of the steel, the 2/10 of 1% of copper may be omitted.

Malleable iron shall conform to the requirements of the specifications of ASTM A 47, Grade 22010.

The materials and method of manufacture for drop inlets shall conform to the requirements as stated on the plans or as ordered.

M.08.03—Aggregates for Underdrains: Materials for filling the trench shall consist of well-graded, clean, non-plastic sands or well-graded, clean, durable broken stone or screened gravel. The type of material to be used shall be sand, unless otherwise called for by the contract documents or ordered by the Engineer.

1. Broken Stone or Screened Gravel: This material shall conform to the gradation requirements for Size No. 8 under Article M.01.01.

1. **Sand:** This material shall be a commercial product and shall meet the requirements of Article M.03.01.2.

SECTION M.09

SHEET PILING AND PILES

M.09.01—Sheet Piling: The materials for this work shall conform to the following requirements:

1. Timber Sheet Piling: The timber, unless otherwise definitely noted on the plans or in the special provisions, may consist of any species which will satisfactorily stand driving. It shall be sawn or hewn with square corners and shall be free from worm holes, loose knots, wind shakes, decayed or unsound portions, or other defects which might impair its strength or tightness.

The piles shall be of the dimensions shown on the plans or as directed, either cut from the solid material or made by building up the piles of three planks securely fastened together. The piles shall be drift sharpened at their lower ends so as to wedge the adjacent piles tightly together.

2. Steel Sheet Piling: Steel sheet piles shall conform to the requirements of ASTM A 328/A 328M.

M.09.02—Piles: The materials for this work shall conform to the following requirements:

1. Untreated Timber Piles: Timber piles shall conform to the requirements of AASHTO M 168, as supplemented by the following requirements:

All timber piles shall be cut from sound, live trees preferably during the winter season. Piles shall contain no unsound knots or other defects which may impair their strength and durability. All knots shall be trimmed close to the body of the piles. All measurements for piles shall be taken under the bark.

Piles shall have the following minimum dimensions:

Pile Length	Tip Dia. Inches (Millimeters)	Butt Dia. Inches (Millimeters)
20 feet (6 meters) and under	8 (200)	11 (280)
21 to 40 feet (6.5 to 12 meters)	8 (200)	12 (305)
41 to 60 feet (12.5 to 18 meters)	7 (175)	13 (330)
Over 60 feet (18 meters)	6 (150)	15 (380)

2. Treated Timber Piles: The timber piles shall be pressure-treated with wood preservatives of creosote oil or creosote solution types. Piles shall comply with the requirements of Article M.09.02(1) except that piles for treatment shall be Douglas fir, larch, Southern yellow pine, Norway pine or red oak. They shall be peeled of outer bark and inner skin soon after cutting so that the piles are smooth and clean. Piles shall contain as much sapwood as possible, and care shall be taken to minimize damage to the sapwood when peeling and cleaning the piles. After preparation, the minimum thickness of the sapwood ring at the butt end shall be 1 inch (25 millimeters), except for Southern yellow pine which shall have 1 1/2 inches (38 millimeters).

Conditioning, treatment and wood preservative shall conform to the requirements of AASHTO M 133, except that creosote petroleum solution shall not be used for treatment of piles to be utilized in coastal waters.

The minimum net final retention of preservative per cubic foot (cubic meter) of wood shall be as follows:

For piles to be used on land or in fresh water:		12 pounds (192 kilograms)
For piles to be used in brackish or salt water:		
Douglas fir and larch		14 pounds (224 kilograms)
Southern yellow pine		20 pounds (320 kilograms)
Red oak	(Full cell process)	refusal

Prior to furnishing the treated piles, the Contractor shall submit certification of the species, grade or class of pile material, the grade of wood preservative used, and the final net retention of the preservative in pounds (kilograms) per cubic foot (meter) of wood.

Treated piles shall be subject to inspection by the Engineer at the site. No previous certifications or approval at the treatment plant shall bar rejection in the field for injury, breakage or defects in the piles prior to their installation. The use of "S" irons for repairing or preventing checks, splits or other defects will not be permitted. All treated timber piles shall be carefully handled and properly stored. Any surface breaks which do not warrant rejection shall be given three coats of hot creosote oil.

The heads of piles shall be treated as follows: The sawed surface shall be thoroughly brush-coated with three successive applications of hot creosote, followed by a thick application of a mixture of 30% creosote and 70% pitch. The application of the pitch coat will not be required to pile heads encased in concrete. All bolt holes made in the pile subsequent to treatment shall be treated with creosoted oil by means of an

approved pressure bolt hole treater. After being so treated, all unfilled holes shall be plugged with creosoted plugs.

3. Steel Piles: Piles shall be rolled steel sections of the mass and shape called for on the plans or specified by the Engineer. Piles, splice plates and points shall be new material meeting the requirements of ASTM A 36/A 36M. Stock Steel conforming to these requirements and free from surface imperfections will be accepted upon presentation of certified mill test reports as to the quality of the stock material and receipt of affidavit that the stock material furnished is a product of the open-hearth method manufacture. Immediately prior to driving, steel piles when placed in leads shall not exceed the camber and sweep permitted by allowable mill tolerance. Piles bent or otherwise injured shall be rejected.

4. Precast Concrete Piles: Precast concrete piles shall be in strict accordance with the details shown on the plans or in the special provisions. The materials shall conform to the following requirements:

(a) Concrete: The concrete for the piles shall be air-entrained concrete composed of portland cement, fine and coarse aggregates, admixtures and water. The air-entraining feature may be obtained by the use of either air-entraining portland cement or an approved air-entraining admixture. The entrained air content shall be not less than 4% or more than 6%.

The Contractor shall design and submit for the approval of the Engineer a concrete mix which shall attain a minimum 28-day compressive strength of 5000 psi (35 megapascals), or as shown on the plans. The Contractor shall further provide a certified statement that the mix submitted shall meet the requirements.

Prior to any handling or pickup, after casting of piles the compressive strength shall be 3500 psi (25 megapascals) minimum.

(b) Coarse Aggregate shall consist of broken stone, having a maximum size of 3/4 inch (19 millimeters), conforming to the requirements of Article M.03.01.

(c) Fine Aggregate, water, air-entraining admixture and retarder admixture shall conform to the requirements of Article M.03.01.

(d) Portland Cement for the units shall conform to the requirements of Article M.03.01, except that Type III or Type IIIA portland cement may be used at no additional cost to the State.

(e) Water Reducing Admixture: The Contractor may submit, for approval of the Engineer, a water-reducing admixture for the purpose of increasing the workability and reducing the water requirement for the concrete.

(f) Calcium Chloride: The addition to the mix of calcium chloride, or admixtures containing calcium chloride, will not be permitted.

(g) Steel Reinforcement: Steel Reinforcement shall conform to the requirements of Article M.06.01.

5. Cast-in-Place Concrete Piles: Cast-in-place concrete piles shall be in strict accordance with the details shown on the plans or in the special provisions. Unless otherwise indicated, the concrete shall conform to Class "C" as shown in Article M.03.01, and no air-entraining shall be provided. The steel reinforcement shall conform to the requirements of Article M.06.01

Shells shall be manufactured specifically for use as piles. The use of other type metal products such as piping, tubing or circular forms shall not be permitted without prior written approval of the Engineer. Any such approval will be contingent upon the actual driving performance of the shell in place.

6. Prestressed Concrete Piles (Pretensioned): Materials for pretensioned piles shall conform to the requirements of Article M.14.01, except as follows:

Concrete: The concrete for the piles shall be air-entrained concrete composed of portland cement, fine and coarse aggregates, admixtures and water. The air-entraining feature may be obtained by the use of either air-entraining portland cement or, if permitted by the Engineer, an approved air-entraining admixture. The entrained air content shall be not less than 4 percent or more than 6%.

The Contractor shall design and submit for the approval of the Engineer a concrete mix, which shall attain a minimum strength of 5000 psi (35 megapascals). The mix shall have a minimum cement content of 6.0 bags per cubic yard (8.0 bags per cubic meter). The compressive cylinder strength at the time of transfer of prestressing load shall be a minimum of 3500 psi (25 megapascals). No piles shall be removed from the casting plant, nor be transported to the work site, nor be driven until the compressive strength is 5000 psi (35 megapascals) minimum.

The Contractor shall further provide a certified statement that the mix submitted shall meet the requirements. Its ultimate strength at 28 days shall have a minimum value of 5000 psi (35 megapascals).

Fine Aggregate: The fine aggregate shall conform to the requirements of Article M.03.01-2 except as amended by the addition of the following:

Fine aggregate for use in prestressed piles shall not contain any materials that are deleteriously reactive with the alkalies in the cement in an amount sufficient to cause excessive expansion of mortar, grout or concrete; except that if such materials are present in injurious amounts, the portland cement shall be modified in accordance with the provisions listed under the requirements for portland cement.

Portland Cement: Portland cement for the piles shall conform to the requirements of Article M.03.01, except as supplemented and amended hereinafter.

Type III or Type IIIA portland cement may be used at the Contractor's option. The tricalcium aluminate ($3Ca\ Al_2O_3$) content of the portland cement shall be limited to a maximum of 8%. Where high sulfate resistance is required, as specified on the plans or as directed, the tricalcium aluminate content shall be limited to a maximum of 5%. This criteria is attained when the water-soluble sulfate (as SO_4) in soil exceeds 0.20% or the sulfate (as SO_4) in ground or surface water exceeds 1,000 parts per million.

Where the fine aggregate contains materials that are deleteriously reactive with the alkalies in the cement, as noted in the requirements of fine aggregate, the portland cement shall contain less than 0.6% alkalies calculated as sodium oxide or shall have a material added that has been shown to prevent harmful expansion due to the alkali-aggregate reaction.

Splicing cement shall conform to the requirements of the special provisions.

Pile Tip: Steel for the pile tip shall conform to the requirements of Article M.06.02. Anchorages for the pile tip shall conform to the requirements of Article M.06.01 or M.06.02, whichever shall apply.

Jet Pipe: The jet pipe and fittings shall be a 2-inch (50-millimeter) galvanized steel pipe provided with a top connection and bottom jetting outlets as shown on the plans or as directed. With the approval of the Engineer, other material may be substituted for the galvanized pipe, connections, fittings and outlets.

Pile Extension: Materials for pile extensions shall conform to the requirements listed above or as noted on the plans.

SECTION M.10

RAILING AND FENCE

M.10.01—Cable Guide Railing and Anchorages: The materials for this work shall meet the following requirements:

1. Wire Rope: Wire rope shall be Class A, 3/4-inch (19 millimeter) in diameter, conforming to the requirements of AASHTO M 30.

2. Fittings: All fittings shall meet the details as shown on the plans. Fittings subject to the direct action of the wire rope shall be sufficiently strong to develop the full-specified tensile strength of the rope. Fittings used in the attachment of two ropes shall be sufficiently strong to develop the full-specified tensile strength of both ropes. Other fittings shall be in accordance with standard commercial specifications, and shall be free from flaws or defects that would tend to impair their use or durability.

All metal fittings shall be galvanized, after fabrication, to meet the requirements of ASTM A 153.

3. Steel Posts: All steel posts shall meet the requirements of ASTM A 36.

Steel posts shall meet the details shown on the plans as to size, shape and weight; and they shall be punched or drilled as indicated on the plans. After fabrication, all posts shall be galvanized to meet the requirements of ASTM A 123.

4. Anchorages: Anchorages shall be as shown on the plans.

5. Wood Posts: Wood posts shall meet the requirements of Subarticle M.10.04-2 except that the diameter shall be as shown on the plans

6. Steel Eyebolt and Standard Turnbuckle: The steel eyebolt and standard turnbuckle shall meet the requirements of ASTM A 237 and shall be galvanized to meet the requirements of ASTM A 153.

7. Connector Plate Bolts: The connector plate bolts shall meet the requirements of ASTM A 325 and shall be galvanized to meet the requirements of ASTM A 153.

8. Cast Steel Connector Plate: The cast steel connector plate shall meet the requirements of ASTM A 27, Grade 65-35 and shall be galvanized to meet the requirements of ASTM A 123.

9. Malleable Iron Connector Plate: The malleable iron connector plate shall meet the requirements of ASTM A 47, Grade No. 32510 and shall be galvanized to meet the requirements of ASTM A 123.

M.10.02—Metal Beam-Type Rail and Anchorages: The materials for this work shall comply with the plans as to size, shape and weight.

1. Steel Posts, Welded-Soil Plates, Brackets, Back-Up Rails and Channel Rubrails:

(a) Steel posts, welded-soil plates, brackets, back-up rails and channel rubrails shall meet the requirements of ASTM A 36. After fabrication, all steel posts, welded-soil plates, brackets, back-up rails and channel rubrails shall be galvanized to meet the requirements of ASTM A 123.

(b) All welding shall meet ANSI/AASHTO/AWS D1.5.

(c) Weathering steel for posts shall meet Subarticle M.06.02-1 (b). The dimensions of each post shall meet the plans and ASTM A 6. All weathering steel posts shall be galvanized after fabrication to meet the requirements of ASTM A 123 and the plans. A single ¾ inch (19 millimeters) diameter hole may be punched or drilled 2 inches (50 millimeters) from the top of each post, in the center of the web, to facilitate the galvanizing process.

2. Wood Posts: Wood posts shall be commercial lumber Grade No. 1 or better and meet AASHTO M 168. It shall have a minimum stress rating of 1,350 psi (9.3 megapascals) and be either rough sawn (non-planed) or S4S (surface four sides) Southern Yellow Pine or Douglas Fir-Larch with nominal dimensions as indicated on the plans. Variation in the size of any dimension shown on the plans shall not be more than ± ¼ inch (6 millimeters).

After all end cuts are made and all holes are drilled the wood shall be pressure treated with Ammoniacal Copper Zinc Arsenate (ACZA) conforming to AWPA Standard P5 to a minimum net retention of 0.60 lb./cubic foot (9.61 kilograms/cubic meter) in the assay zone in accordance with AWPA Standard C14. All wood shall be free of excess preservatives and solvent at the conclusion of the treatment process. Post treatment cleaning shall be by expansion bath or steaming in accordance with AWPA Standard C2. Wood shall be Kiln or air-dried to a maximum moisture content of 25% after treatment (KDAT – 25) and grade marked after treatment by an agency certified by the ALSC.

3. Rail Elements (W-Beam, Thrie-Beam) and Terminal Sections: Rail elements and terminal sections shall meet the requirements of AASHTO M 180 and the following:

(a) Class A (12 gauge): Base metal nominal thickness, 0.105 inches (2.7 millimeters).

(b) Class B (10 gauge): Base metal nominal thickness, 0.135 inches (3.5 millimeters).

(c) Galvanizing shall be Type II.

(d) Acceptance shall be based on Article 5.3 "Acceptance by Brand Registration and Guarantee" of AASHTO M 180.

(e) Weathering steel for rail elements and terminal sections shall meet the requirements of AASHTO M 180 Class A Type IV.

(f) Rail elements with radii less than or equal to 150 feet (45.72 meters), as shown on the plans, shall be shop fabricated and then permanently stamped or embossed with the designated radius (R = _____) on the element near the brand registration stamp.

4. Box Beam Rail Elements: Elements shall be either structural tubing 8 x 6 x ¼ (203 x 152 x 6.4) or structural tubing 6 x 6 x 3/16 (152 x 152 x 4.8) manufactured from either ASTM A 500 Grade B cold-rolled tubing, ASTM A 501 hot–rolled tubing or Automatic Rollover Protective Steel. When ASTM A 500 Grade B steel is used, the DROP-Weight-Tear Test in conformance with ASTM E 436 shall be performed. All plates shall meet ASTM A 36. All material for box beam rail elements and splices shall be galvanized after fabrication in accordance with ASTM A 123.

5. Steel Plates, Steel Washer Plates and Square Steel Washers: These shall meet the requirements of ASTM A 36 and shall be galvanized to meet the requirements of ASTM A 153 unless otherwise noted on the plans.

6. Bolts, Rods, Washers, and Nuts: Anchor bolts and rods for attachment to barriers and parapets shall meet ASTM A449. The nuts for anchor bolts and rods shall meet ASTM A 563, Grade B. The washers for anchor bolts or rods shall meet the requirements of ASTM F 436. All other bolts and nuts, unless otherwise noted on the plans, shall meet the requirements of ASTM A 307.

Bolts, nuts and washers, unless otherwise noted on the plans, shall be galvanized after fabrication to meet the requirements of ASTM A153.

7. End Anchorages: The bar reinforcement shall meet the requirements of Subarticle M.06.01-1. The Class "A" concrete shall meet the requirements of Article M.03.01. Anchor bolts and rods for end anchorages shall meet the requirements of AASHTO M 314.

8. Galvanized Coating Touch-up: The zinc dust-zinc oxide paint for galvanized coating touchup shall meet the requirements of AASHTO M 180.9.6.1.

9. Plastic Blockouts: Plastic blockouts shall be made with a minimum of 50% recyclable polyethylene plastic comprised of low-density and high-density polyethylene with a specific gravity less than or equal to 1.0 in accordance with ASTM D 792 and be recyclable. They shall also have a minimum compressive stress of 450 psi (3.1 megapascals) in accordance with ASTM D 695, meet the dimensions indicated on the plans, and be a shade of gray or black. Blockouts must have been crash-tested and have approval in writing by the FHWA in compliance with NCHRP Report 350, Test

Level 3 requirements. Each blockout shall be stamped at the factory with the manufacture's identification and lot number. The Contractor shall furnish to the Engineer prior to construction a Certified Test Report and a Material Certificate for the blockouts in conformance with Article 1.06.07.

M.10.03—Barways:

1. Wood Posts: Wood posts shall meet the requirements of Subarticle M.10.04-2, except the minimum diameter shall be as shown on the plans.

2. Wood Rails: Wood rails shall be made of Number 1 Common Fir or other lumbers of equal quality, approved by the Engineer, and S4S.

3. Fittings: Fittings shall be of the type and dimensions shown on the plans and must be approved by the Engineer.

M.10.04—Wire Fence:

1. Wire Fencing: The wire fencing shall be composed of woven wire fencing of an approved type.

It shall be 45 inches (1.14 meters) in height, plus or minus 1/2 inch (12.5 millimeters), and shall be constructed of not smaller than No. 9 gage (American Steel & Wire) wire. There shall be not less than 8 horizontal wires spaced at various distances apart with the smaller spaces at the bottom to the fence.

Vertical stays, securely welded or fastened to the horizontal wires, shall be provided at intervals of 12 inches (305 millimeters), plus or minus 1/8 inch (3 millimeters), and shall run from top to bottom of the fence.

Each wire shall be galvanized by the hot-dip method conforming to the requirements of ASTM A 116, Class 2 or protected with other protective coating approved by the Engineer.

2. Wood Posts: Wood posts for wire fence shall meet any one of the following specifications, provided that all posts on any one project shall meet the same specification:

(a) Untreated Posts: These posts shall be cut from either of the species locust or red cedar.

All posts shall be round, straight and of the length shown on the plans. Red cedar posts shall have a minimum diameter of 5 inches (125 millimeters) at the small end; for locust posts the same minimum diameter shall apply after removal of the bark. The bottom shall be sawed off square and all knots hewn flush with the surface. On locust posts, the inner and outer bark shall be removed and the surface shaved smooth.

(b) Treated Posts: These posts shall be cut from one of the following species: Norway (red) pine, southern yellow pine, scotch pine, pitch pine, oak, red maple, black birch or yellow birch.

All posts shall be round, straight, of the length shown on the plans, and after removal of the bark, shall have the minimum diameter at the small end as shown hereinbelow. Top and bottom of the posts shall be cut off square, with a maximum permissible deviation of 10 degrees at the butt end. Reduction of the total diameter of the butt end by felling undercuts of up to 25% is permissible, but not more than one such undercut will be permitted on a post. The posts shall be peeled as soon after cutting as possible and shall be conditioned for treatment by air seasoning to moisture content of 20 to 35% (dry basis). The outer bark must be removed completely. No single patch of inner bark on any post may be neither more than 3/4 inch (19 millimeters) wide nor more than 12 inches (305 millimeters) long, and adjacent patches must be separated from each other by a strip of bark-free wood at least 1 inch (25 millimeters) wide. Branch stubs and overgrown knots shall be trimmed close to the face of the post. All posts shall be treated for their full length.

Timber preservatives used and method of treatment shall be the following:

Pentachlorophenol Cold-Soaking Treatment: Posts to be treated with pentachlorophenol shall have at the small end a minimum diameter of 5 inches (125 millimeters), as determined by a circumference tape. The pentachlorophenol shall meet the requirements of AASHTO M 133. Pentachlorophenol may be obtained as liquid concentrates containing up to 40% pentachlorophenol. The concentrate shall be reduced to 5% strength by the addition of Stoddard solvent, kerosene or No. 2 fuel oil. Treatment shall be by immersing the posts in cold preservative for a sufficient length of time to provide for the retention specified below. Retention of 5% pentachlorophenol solution immediately after treatment shall be not less than 5 pounds/cubic foot (80-kilograms/cubic meter) of wood. Radial penetration at a point midway between the ends of the post shall be 1 inch (25 millimeters) or more.

3. Metal Post: Metal posts shall be of the length shown on the plans, straight and true to section, and shall be of a standard commercial type.

All posts, braces, anchors, plates and other devices shall be galvanized on all inner and outer surfaces by an approved method.

The zinc coating shall weigh not less than 2.0 ounces/square foot (610-grams/square meter) when tested in accordance with AASHTO T 65.

All end posts shall have one brace; all corner and intermediate braces or pull posts shall have two braces.

(a) Intermediate or Line Posts: Intermediate or line posts shall meet one of the following types and to the minimum requirements stated for each:

Quadruple Ribbed Tee Post: Quadruple ribbed tee post minimum weight = 1.32 pounds/linear foot (2 kilograms/meter).
Channel or U Post: Channel or U Post, minimum weight = 1.12 pounds/linear foot (1.7 kilograms/meter).
Standard Tee Post: Standard tee post, minimum weight = 1.22 pounds/linear foot (1.8 kilograms/meter).
Tubular Post: Tubular post, minimum outside diameter 1 3/4 inches (45 millimeters) minimum gage No. 15. (U.S. Standard).
Angle Post: Angle posts minimum section 2 inch x 2-inch x 1/4 inch (50 x 50 x 6.4 millimeters).

(b) End posts, corner posts, pull posts and braces shall meet one of the following types and do the minimum requirements stated for each:
Tubular Section Post and Brace: Tubular section post and brace, minimum outside diameter 2 1/2 inches (64 millimeters), minimum gage No. 8 (U.S. Standard).
Standard Pipe Section Post and Brace: Standard pipe section post and brace, minimum weight per linear foot, 3.65 pounds (1.66 kilograms).
Angle Post and Brace: Angle post and brace, minimum section of post 2 1/2 inch x 2 1/2 inch x 1/4 inch (64 millimeters x 64 millimeters x 6.4 millimeters), minimum section of brace 2 inches x 2 inch x 1/4 inch (50 millimeters x 50 millimeters x 6.4 millimeters).
The minimum weights stated for the several types of posts do not include anchors, plates or other devices. Intermediate or line posts shall be provided with a plate or anchor or other satisfactory means to hold the posts in proper alignment and plumb. Plates or anchors shall be securely fastened to the post by welding or by a minimum of 2 rivets per plate.
All posts having a tubular or pipe section shall be provided with a suitable cap at the top.

M.10.05—Chain Link Fence: All gage measurements of finished wire shall be United States Steel Wire Gage or equivalent. Tolerance for wire sizes shall be as specified in AASHTO M-181. Materials for this work shall meet the following requirements:

1. Fabric: Wire Fencing shall be composed of woven wire of the chain link type. It shall be not less than the height specified on the plans or in the special provisions and shall be constructed of not smaller than No. 9 gage wire. The wire shall be woven to form a continuous fabric having 2-inch (50-millimeters) mesh. The chain link fabric shall have a knuckled finish on both edges.

(a) Aluminum-Coated Steel Fabric: The base metal of the fabric shall be of steel wire having a minimum tensile strength of 80,000 psi (550 megapascals), coated with aluminum alloy applied at the rate of not less than 0.40 ounces/square foot (122 grams/square meter) of uncoated wire surface.

(b) Polyvinyl chloride-coated steel fabric shall meet the requirements of FS RR-F-00191, Type IV, and shall be the color green.

(c) Aluminum Alloy Fabric shall meet the requirements of ASTM B211, Alloy 6061 wire having a minimum tensile strength of 50,000 psi (345 megapascals).

2. Metal Posts and Rails: Metal posts shall be straight, true to section and of sufficient length to enable the post to be encased for a depth of 2 feet 8 inches (815 millimeters) in a concrete footing which shall have a depth 3 feet (1 meters) below ground.

All posts, rails, braces, anchors, plates and other devices shall meet one on the following specification.

Galvanized material shall be made of steel of a standard commercial type, hot-dip galvanized with a zinc coating weighing not less than 2.0 ounces/square foot (610 grams/square meter) when tested in accordance with AASHTO T65 or shall be in accordance with AASHTO M181, Class 2.

The Contractor shall provide a Materials Certificate in accordance with Article 1.06.07 for materials conforming to AASHTO M181, Class 2.

All aluminum coated steel posts and rails shall meet ASTM F669, minimum yield strength 50,000 psi (345 megapascals), for industrial chain link fence. The posts and rails shall be manufactured by roll forming aluminum coated steel strip and electric resistance welding into tubular form. The outside of the weld area shall be metabolized with commercially pure aluminum to a thickness sufficient to provide resistance to corrosion equal to that of the remainder of the outside of the tube. The aluminum coating weight on the outer and inner surfaces shall be a minimum of 0.75 ounces/square foot (230grams/square meter), Triple spot test 0.70 ounces/square foot (215 grams/square meter), single spot test, as measured in accordance with ASTM A428.

Polyvinyl chloride-coated material shall be made of steel of a standard commercial type coated inside and outside with the same polyvinyl chloride coating as the chain link mesh or shall have all surfaces galvanized with the outside galvanized surface coated with the same polyvinyl chloride coating as the chain link mesh.

Aluminum Alloy shall meet the requirements of FS RR-F-00191.

3. Fittings: These shall be malleable irons, pressed steel, or aluminum alloy. The fittings shall be either hot-dip galvanized, polyvinyl chloride-coated, or aluminum alloy.

(a) Hot-dip galvanizing shall meet the requirements of ASTM A 153.

(b) Polyvinyl chloride-coated material shall have the same polyvinyl chloride coating as the chain link mesh.

(c) Aluminum alloy shall meet the requirements of FS RR-F-00191.

4. Tension and Tie Wire:

(a) Tension wire for steel fence shall be coil spring steel not less than 7 gage. The base material shall have a minimum tensile strength of 80,000 psi (550 megapascals) with an aluminum coating applied at a rate of 0.40 ounces/square foot (122grams/square meter) of surface area.

Aluminum tension wire shall not be less than 6 gage 6061-T6 or 5052-H38 Aluminum Alloy.

(**b)** Wire clamps for fastening fabric to line posts shall not be less than 6 gage. Tie wires or hog rings used to fasten the fabric to the top rail or tension wire shall be not less than 9 gage aluminum for aluminized or aluminum fabric fence and not less than 9 gage polyvinyl chloride coated steel wire for polyvinyl chloride fence.

Aluminized steel hog rings for aluminized fabric shall not be less than 11 gage.

5. Gates: Gates shall be of the same type of materials used for the chain link fence.

M.10.06—Vacant
M.10.07—Vacant

M.10.08—Three-Cable Guide Railing (I-Beam Posts) and Anchorages:

1. Wire Rope: Wire rope shall be Class A coating, 3/4-inch (19 millimeters) in diameter, Type 1 construction conforming to AASHTO M 30.

2. Fittings:

(a) Material indicated on the plan as "Cast Steel" shall meet the requirements of ASTM A 27 Grade 70-40 Class 1.

(b) Material indicated on the plan as "Malleable Iron" shall meet the requirements of ASTM A 47, Grade 32510.

(c) The cable wedge for splices and cable fittings shall be malleable iron casting conforming to ASTM A 47 Grade 32510. The cable wedge shall be uncoated (black).

(d) The cable splice shall meet the requirements of ASTM A 536 Ductile Iron Grade 65-45-12. All cable ends and splices shall meet the details on the plans and have the properties necessary to develop the full tensile strength (25,000 lbs.)(112 kilonewtons) of ¾" (19 millimeters) wire rope.

(e) The spring cable end assembly (compensating device) casting shall meet the requirements of ASTM A 47 Grade 32510 and must have a spring rate of 450-500

pounds/inch (80 – 88 N/millimeters) and a total available throw of 6 inches (150 millimeters) minimum.

(f) Hook bolts, as installed, shall develop an ultimate pull-open strength from 500 pounds to 1,000 pounds (2.2 kilonewtons to 4.5 kilonewtons) applied in a direction normal to the longitudinal axis of the post.

(g) Steel turnbuckle cable end assembly shall be pearlitic malleable iron casting conforming to ASTM A 220 Grade 50005.

(h) Standard hex nuts and lock nuts shall meet the requirements of ASTM A 563 Grade B.

(i) After fabrication, all metal fittings and forged cast fittings required by the plans to be galvanized shall be galvanized to meet the requirements of ASTM A 153.

3. Steel Posts and Welded-Soil Plates: All steel posts and welded-soil plates shall meet the requirements of ASTM A 36. All required holes shall be punched or drilled. After fabrication, all posts and welded soil-plates shall be galvanized to meet the requirements of ASTM A 123.

(**a)** All welding shall meet ANSI/AASHTO/AWS D1.5.

(b) Weathering steel for posts shall meet Subarticle M.06.02-1 (b). The dimensions of each post shall meet the plans and ASTM A6. All weathering steel posts shall be galvanized after fabrication to meet the requirements of ASTM A 123 and the plans. A single ¾ inch (19 millimeters) diameter hole may be punched or drilled 2 inches (50 millimeters) from the top of each post, in the center of the web, to facilitate the galvanizing process.

4. Anchorages: Class "A" concrete shall meet the requirements of Article M.03.01. Bar reinforcement shall meet the requirements of Subarticle M.06.01-1.

Breakaway anchor angles, washers and anchorage plates shall meet the requirements of ASTM A 36. Anchor bolts and rods for end anchorages shall meet the requirements of AASHTO M 314. Hex nuts shall meet the requirements of ASTM A 563 Grade B. Breakaway anchor-angle tiepin shall be 3/16 inch (5 millimeters) diameter meeting the requirements of ANSI CR1018 and galvanized after fabrication to meet the requirements of ASTM A 123. The angles, rods, top nuts and washers shall be galvanized in accordance with the requirements of ASTM A 153.

SECTION M.11

MASONRY FACING
CEMENT AND DRY RUBBLE MASONRY
BRICK
MORTAR

M.11.01—Masonry Facing: The materials for this work shall conform to the following requirements:

1. Masonry Facing Stone: This stone shall be of the kind specified in the proposal or on the plans and shall be of a size, quality and color acceptable to the Engineer. The stone shall be hard and durable, resistant to weathering action, reasonably fine grained, and free from structural defects that would impair its strength or durability. Preferably, the stone shall be from a quarry the product of which is known to be of satisfactory quality. Stone shall be of such character that it may be truly cut to such lines and surfaces, either plain or curved, as may be required. Any stone having defects which have been repaired with cement or other materials will be rejected. Samples of stone shall be submitted when required. Masonry facing stone shall be of two grades: dimensioned masonry stone and ashlar masonry stone.

> **(a) Dimensioned Masonry Stone:** Dimensioned masonry stone shall be dressed to true size and shape, in conformity with the requirements of the plans or as ordered. General details and controlling dimensions will be shown on the plans. The Contractor shall prepare such additional detail drawings as he may require for his guidance, and all such drawings shall be approved by the Engineer before construction is started.
>
> **(b) Ashlar Masonry Stone:** Ashlar masonry stone shall be of such sizes and shapes as to produce the general effect shown on the plans.

Surface Finish: For the purpose of these specifications, the finishes of exposed surfaces of masonry facing stone are defined as follows:

Sawed Face: Exposed surfaces shall be true planes with a tolerance of 3/16 inch (5 millimeters) from a straightedge placed on the surface in any direction. All saw-faced stone shall be sandblasted to remove rust stains. Where impractical to saw, the surface shall be six-cut. Face arises of all exposed surfaces shall be true and out of wind.

Six-Cut: Exposed surfaces shall be true planes with a tolerance of 3/16 inch (5 millimeters) from a straightedge placed on the exposed surface in any direction. The

exposed surface shall be finished with a tool having six blades to the inch (25 millimeters).

Four-Cut: Same surface tolerance as for 6-cut; exposed surfaces to be finished with a tool having four blades to the inch (25 millimeters).

Fine-Pointed: Projections on fine-pointed finished surfaces shall not exceed 1/2 inch (12.5 millimeters). Exposed edges shall be pitched to true lines.

Rough-Pointed: Projections on rough-pointed finished surface may vary from 1/2 to 1 inch (12.5 millimeters to 25 millimeters). Exposed edges shall be pitched to true lines.

Split-Face: Exposed surfaces shall have face edges pitched to line and shall have no projection of more than 1 1/2 inches (38 millimeters) above the plane of the edges.

Rock-Face or Quarry Face: Exposed surfaces shall be freshly split granite; they shall have no projection of more than 3 inches (75 millimeters). Hollow faces will not be permitted. They shall be pitched to straight and true lines and shall have a chiseled draft on all edges if so indicated on the plans.

Exposed surfaces of face stone shall be given the surface finish indicated on the plans.

2. Vacant:

M.11.02—Cement Rubble Masonry and Dry Rubble Masonry: The materials for this work shall conform to the following requirements:

1. Masonry Stone: This stone shall be of approved quality, sound, durable and free from structural defects or imperfections tending to destroy its resistance to the weather. The individual pieces shall be roughly rectangular in shape, with at least 1 fairly even face, and shall have a volume of not less than 4 cubic feet (0.12 cubic meters), except where smaller pieces are required for closure or where the character of the construction makes the use of smaller pieces necessary.

M.11.03—Brick Masonry: The materials for this work shall conform to the following requirements:

Brick: The brick for use other than the construction of catch basins, manholes and drop inlets shall conform to the requirements of AASHTO M 114, Grading SW.

The brick shall have a fine-grained, uniform, and dense structure, free from lumps of lime, laminations, cracks, checks, soluble salts, or other defects which may in any way impair their strength, durability, appearance, or usefulness for the purpose intended. Bricks shall emit a clear, metallic ring when struck with a hammer.

M.11.04—Mortar: Mortar shall be composed of one part portland cement and two parts, by volume, of surface dry fine aggregate. Hydrated lime, in an amount not to exceed 4 pounds (1.8 kilograms) of lime to each bag of cement, may be added at the option of the Engineer. Cement and hydrated lime shall conform to the following requirements:

(a) Portland cement, Types I, II or IS, and water shall conform to the requirements of Article M.03.01.

(b) Hydrated lime shall conform to the requirements of ASTM C 6.

(c) For laying stone, precast units, or for shotcrete, fine aggregate shall conform to Grading A, table below. In all other respects, it shall conform to the requirements of Article M.03.01-2.

(d) For pointing stone or the precast units and for laying brick or sealing pipe joints, the fine aggregate shall conform to Grading B, table below. In all other respects it shall conform to the requirements of Article M.03.01-2.

Table of Gradation, Fine Aggregate for Mortar

Square Mesh Sieves	**Grading**	
	A	B
	Percentage Passing by weight (mass)	
Pass 3/8 inch (9.5 millimeters)	100	
Pass #4 (4.75 millimeters)	95-100	
Pass #8 (2.36 millimeters)	80-100	100
Pass #16 (1.18 millimeters)	50-85	
Pass #30 (600 microns)	25-60	
Pass #50 (300 microns)	10-30	10-40
Pass #100 (150 microns)	2-10	0-10

SECTION M.12

BEARING AREAS
RIPRAP
SLOPE PAVING & SLOPE PROTECTION
WATERPROOFING AND DAMPPROOFING
STONE AND GRANITE SLOPE CURBING
CALCIUM CHLORIDE FOR DUST CONTROL
WOOD

M.12.01—Bearing Areas: Materials for this work shall conform to the following requirements:

1. Vacant

2. Prefabricated Pads: Prefabricated pads shall consist of cotton duck impregnated with rubber and shall be a single sheet of 1/8 inch (3.2 millimeters) minimum thickness with a tolerance of plus 15% or minus 5%, composed of 8 ounce (227 grams) duck and high quality natural rubber constructed in five or more plies. The breakdown stress for compression perpendicular to the plane of lamination shall be not less than 11,000 pounds psi (76 megapascals).

M.12.02—Riprap: Materials for this item shall consist of sound, tough, durable and angular rock, free from decomposed stones or other defects impairing its durability. The size of a stone as hereinafter specified shall be its least dimension. Broken concrete or rounded stones are not acceptable. The type of material to be used shall be as noted on the plans, in the special provisions or as may be ordered by the Engineer.

1. Standard Riprap: This material shall conform to the following requirements:

(a) Not more than 15% of the riprap shall be scattered spalls and stones less than 6 inches (150 millimeters) in size.

(b) No stone shall be larger than 30 inches (760 millimeters) in size, and at least 75% of the weight (mass) shall be stones at least 15 inches (380 millimeters) in size.

2. Intermediate Riprap: This material shall conform to the following gradation:

Stone Size	**% of the weight (mass)**
18 inches (460 millimeters or over)	0
10 inches to 18 inches (255 millimeters to 460 millimeters)	30-50
6 inches to 10 inches (150 millimeters to 255 millimeters)	30-50
4 inches to 6 inches (100 millimeters to 150 millimeters)	20-30
2 inches to 4 inches (50 millimeters to 100 millimeters)	10-20
less than 2 inches (less than 50 millimeters)	0-10

3. Modified Riprap: This material shall conform to the following gradation:

Stone Size	**% of the weight (mass)**
10 inches (255 millimeters or over)	0
6 inches to 10 inches (150 millimeters to 255 millimeters)	20-50
4 inches to 6 inches (100 millimeters to 150 millimeters)	30-60
2 inches to 4 inches (50 millimeters to 100 millimeters)	30-40
1 inch to 2 inches (25 millimeters to 50 millimeters)	10-20
less than 1 inch (less than 25 millimeters)	0-10

4. Special Riprap: This material shall conform to the gradation of Article M.01.01 for No. 3 stone.

M.12.03—Slope Paving: The stone for this work shall consist of sound, tough, durable rock, free from decomposed stone or other defects impairing its durability. Each piece

shall have an area on its exposed surface of not less than 2 square feet (0.2 square meter) and a thickness not less than 9 inches (230 millimeters), except that stone for the two bottom rows shall be of such size that they can be embedded at least 2 feet (610 millimeters) into the ground; and they shall have a thickness of not less than 12 inches (305 millimeters).

Concrete slabs shall conform to the dimensions given above for stone, except that the maximum surface dimensions shall not exceed 10 linear feet (3 meters) in any direction.

The concrete shall conform as regards materials and proportions, to the requirements of Article M.03.01 for Slope Paving Concrete.

M.12.04—Waterproofing: The materials for this work shall conform to the following requirements:

1. Waterproofing Asphalt: For woven glass fabric, the seal coat material shall be an asphalt conforming to ASTM D 449, Type III.

Asphalt flashing cement shall be a compound of asbestos and asphalt conforming to the requirements of ASTM D 2822.

Primer for use with asphalt in waterproofing shall conform to the requirements of ASTM D 41.

2. Fabric: Woven glass fabric saturated with asphalt shall conform to the requirements of ASTM D 1668.

Resin-treated woven glass fabric shall conform to the requirements of ASTM D 1668 and shall be compatible for use with asphalt.

3. Mortar: Mortar shall conform to the requirements of Article M.11.04.

4. Reinforcement: Reinforcement shall conform to the requirements of Article M.06.01.

5. Metal Flashing: Metal flashing shall be of the type and dimensions called for on the plans, and the quality shall be acceptable to the Engineer.

6. Joint Filler: Filler for use in horizontal joints shall be a straight refined petroleum asphalt conforming to the following requirements:

	Min.	Max.
Penetration at 77°F (25°C)., 100 grams., 5 seconds	50	60
Flashpoint, open cup method, in °F (°C)	450 (232)	
Softening point, in °F (°C)	120 (49)	130 (55)
Loss on heating, at 325°F (163°C), 50 grams, 5 hours, %		0.5
Ductility, at 77°F (25°C), 5 centimeters per minute	85	
Total bitumen (Sol. in carbon disulphide) %	99.5	

Filler for use in vertical joints shall be an asphalt conforming to above specified requirements, to which has been added 20%, by weight (mass) of asbestos fiber. The incorporation of the asbestos fiber with the asphalt shall be done at the factory of the manufacturer to insure a uniform distribution of the fiber throughout the mix.

M.12.05—Dampproofing: The materials for this work shall conform to the following requirements:

Asphalt for Primer: Asphalt for primer shall conform to ASTM D 41.

Asphalt for Seal Coat: The asphalt for seal coat shall meet one of the following:

1. Hot-applied asphalt seal coat—ASTM D 449, Type 1

2. Cold-applied asphalt seal coat—ASTM D 4479, Type 1 (Asbestos Free)

3. Cold-applied emulsified asphalt seal coat—ASTM D 1227, Type III or IV

M.12.06—Stone Curbing: The materials for this work shall conform to the following requirements:

1. Granite Curbing: Stone for this work shall be hard and durable granite, fundamentally of light color, of general uniform texture, of smooth splitting appearance, free from seams or imperfections that would impair its structural reliability and containing only such color variations as in the opinion of the Engineer would reasonably be characteristic of the material source. The Contractor shall submit for approval, the name of the quarry and the type of curb which the Contractor proposes to use. Samples of curbing shall be submitted for approval only when requested by the Engineer. Such

submission shall be made sufficiently in advance of ordering so that the Engineer may have an opportunity to judge the stone, both as to quality and appearance. No stone from any other quarry shall be used unless it has been properly approved.

The finish and surface dimensions for the curb shall conform to the following requirements:

The curbstone shall have a top surface free from wind; it shall be pointed, peen-hammered or sawed to an approximately true plane, and shall have no projections or depressions greater than 1/8 inch (3.2 millimeters). The front and back arris lines shall be pitched straight and true.

On the back surface of the curbstone there shall be no projection for 3 inches (75 millimeters) down from the top which would fall outside of a plane having a batter of 4 inches in 12 inches (100 millimeters in 305 millimeters) from the back arris line.

The front face shall be at right angles to the plane of the top and shall be smooth quarry-split, free from drill holes in the exposed face. There shall be no projections greater than 3/4 inch (19 millimeters), or depressions greater than 1/2 inch (12.5 millimeters), measured from the vertical plane of the face through the top arris line for a distance of 8 inches (200 millimeters) down from the top. For the remaining distance, there shall be no projections or depressions greater than 1 inch (25 millimeters) measured in the same manner. The arris lines at the ends shall be pitched with no variation from the plane of the face greater than 1/8 inch (3.2 millimeters).

The ends of all stones shall be square with the planes of the top and face and so finished that, when the stones are placed end to end as closely as possible, no space more than 1/2 inch (12.5 millimeters) shall show in the joint for the full width of the top or down on the face for 8 inches (200 millimeters). On curbstones having a length of 6 feet (1.8 meters) or more, the remainder of the end may break back not over 9 inches (230 millimeters); whereas, on shorter curbstones, they shall not break back more than 6 inches (150 millimeters).

If sawed, the curbstones shall be thoroughly cleaned of any iron rust or iron particles.

For straight curbing, 80% of the stones shall be furnished in lengths of not less than 6 feet (1.8 meters), and the remaining 20% in lengths of not less than 4 feet (1.2 meters), interspersed at random, to allow for closures.

Curbstones to be set on a radius of 100 feet (30 meters) or less shall be cut to the curve required, and their ends shall be cut on radial lines. Requirements for length of individual stones in curved curbing vary with radii of curves.

2. Bluestone Curbing: Stone for this work shall be of a good grade, free from structural defects, and shall be approved by the Engineer.

It shall conform to the requirements contained hereinbefore for granite curbing, except that the top surface and the top 8 inches (200 millimeters) of the front face shall be "fine-pointed" in conformity with the requirements of Article M.11.01 for masonry facing stone.

M.12.07—Granite Slope Curbing: The materials for this work shall conform to the following requirements.

1. Granite Slope Curbing: Stone for this work shall be hard and durable granite, fundamentally of light color, of general uniform texture, of smooth-splitting appearance, free from seams or imperfections that would impair its structural reliability and containing only such color variations as, in the opinion of the Engineer, would reasonably be characteristic of the material source. The exposed face of all curbing shall be smooth, quarry-split to an approximate true plane, and shall have no projections or depressions which will cause over 1 inch (25 millimeters) to show between a 2-foot (610-millimeter) straightedge and the face when the straightedge is placed as closely as possible on any part of the face. If projections on the face are more than that specified, they shall be dressed off. The top arris line at the face shall be pitched to a line which shall not show over 1 inch (25 millimeters) in any direction between the stone and a straightedge the full length of the stone. The bottom arris line at the face shall be pitched so that not over 1 inch (25 millimeters) shall show between the stone and a straightedge, the full length of the stone, when viewed at right angles to the plane of the face. The ends shall be square to the plane of the face and so finished that when the stones are placed end to end as closely as possible, no space more than 1 1/2 inches (38 millimeters) shall show in the joint for the full width of the face. The arris lines at the ends shall be pitched with no variation from the plane of the face more than 1/4 inch (6.4 millimeters). Drill holes not more than 3 1/2 inches (90 millimeters) in length of 1/2 inch (12.5 millimeters) in depth will be permitted. The sides shall not be under the square more than 4 inches (100 millimeters) or over the square at the back more than 1 inch (25 millimeters).

The straight slope curbing shall be in lengths of not less than 2 feet (610 millimeters). The curved slope curbing shall be in lengths of at least 6 inches (150 millimeters). The curbing shall have a minimum thickness of 3 inches (75 millimeters) and a maximum thickness of 6 inches (150 millimeters).

When the slope curbing is set adjacent to concrete pavement or gutters, the width of the face of the curbing shall be 12 inches (300 millimeters), with a tolerance of plus or minus 1/2 inch (12.5 millimeters). When set adjacent to surfaces other than concrete, the curbing finished shall have a face width of not more than 13 inches (330 millimeters) and not less than 11 inches (280 millimeters).

2. Mortar: The mortar for this work shall conform to Article M.11.04.

3. Gravel Base: The gravel base under the slope curbing shall be gravel fill conforming to Article M.02.03.

M.12.08—Granite Stone Curbing for Bridges: The materials for this work shall conform to the following requirements:

1. Granite Curbing: Stone for this work shall be hard and durable granite, fundamentally of light color, of general uniform texture, of smooth-splitting appearance, free from seams of imperfections that would impair its structural reliability, and containing only such color variations as in the opinion of the Engineer would be reasonably characteristic of the material source. When so directed by the Engineer, the Contractor shall submit samples of the type of curb he proposes to use.

The finish and surface dimensions for the curb shall conform to the requirements shown on the plans.

The ends of all stone shall be jointed square with the planes of the top and face and finished smooth except that, if so noted on plans, the extreme end face of the curbing shall be finished to a radius as shown on the plans.

The minimum length of a stone shall be 4 feet (1.2 meters), except that stones of lengths less than 4 feet (1.2 meters) will be so noted on the plans.

The maximum length of stone to be used on horizontal and vertical curves shall be such as to produce the effect of a smooth, continuous curve. Curbs to be set on a radius of 160 feet (50 meters) or less shall be cut to the curve required, and their ends shall be cut on radial lines.

Detailed cutting plans or schedule shall be submitted for approval of the Engineer prior to cutting stones.

2. Mortar: The mortar for this work shall conform to Article M.11.04.

3. Metal Anchors: Metal anchors shall be steel conforming to the requirements of Article M.06.01-1 bar reinforcement and shall be thoroughly galvanized by the hot-dip process after fabrication.

M.12.09—Vacant

M.12.10—Calcium Chloride for Dust Control: Calcium chloride shall conform to AASHTO M 144, except that the pellet form and the flake form shall be equally acceptable.

M.12.11—Vacant

M.12.12—Concrete Block for Slope Protection: Concrete blocks shall be solid, precast, rectangular blocks 16 inches (406 millimeters) in length, 8 inches (203 millimeters) in width, and 4 inches (100 millimeters) in thickness. No dimensions shall differ from the theoretical block size specified by more than 1/2 inch (12.5 millimeters).

The blocks shall achieve 3,000 psi (21 megapascals) at 28 days. The concrete mix shall use 3/8 inch (No. 8) or larger coarse aggregate.

M.12.13—Wood: The materials for this work shall conform to the following requirements and shall have a Material Certificate, Certificate of Compliance and Certified Test Report in conformance with 1.06.07.

1. Wood in contact with or immersed in water, such as piers, docks, ferry slips, boardwalks, warfs, bridges, etc. shall be one of the following: Bongossi, Ekki, or Azobe (Lophira Alata, Lophira Procera), Bonalim (Dinizia Excelsa) or Greenheart (Ocotea Podiaei).

Piles, dolphins, bulkheads or lead-in jetties shall be one of the following: Basralocus (Dicorynia guianensis, Dicorynia paraensis), Greenheart (Ocotea Podiaei) or Bongossi, Ekki or Azobe (Lophira Alata, Lophira Prozera) in order of preference.

2. Wood in contact with the ground such as piles, noise-wall or safety wall poles or posts, bulkheads, etc. shall be one of the following: Bongossi, Ekki or Azobe (Lophira Alata, Lophira procera), Bonalim (Dinizia Excelsa), Greenheart (Ocotea Rodiaei), Pressure Treated Southern Yellow Pine or Pressure Treated Douglas Fir-Larch. Pressure treatment shall be CCA in accordance with AWPA P-5, 0.60 pounds per cubic foot (9.6 kilograms/cubic meter) or Pentachlorophenol in accordance with AWPA P-9, Type B (L.P.G.), 0.50 pounds per cubic foot (8.0 kilograms/cubic meter).

3. Wood in above ground use such as decking, railings, bridges, noise or safety walls and platforms shall be one of the following: Bongossi, Ekki or Azobe (Lophira Alata, Lophira Procera), Bonalim (Pinizia Excelsa) or Greenheart (Ocotea Rodiaei).

Pressure treated wood, where specified shall be No. lKD or better Southern Yellow Pine or Douglas Fir-Larch. Pressure treatment shall be CCA in accordance with AWPA P-5, 0.40 pounds per cubic foot (6.4 kilograms/cubic meter) or Pentachlorophenol in accordance with AWPA P-9, Type B (L.P.G.), 0.50 pounds per cubic foot (8.0 kilograms/cubic meter). Pressure treated wood shall be stained or painted in conformance with the plans or special provisions.

SECTION M.13

ROADSIDE DEVELOPMENT

M.13.01—Topsoil: The term topsoil used herein shall mean a soil meeting the soil textural classes established by the USDA Classification System based upon the proportion of sand, silt, and clay size particles after passing a No. 10 (2 millimeter) sieve and subjected to a particle size analysis. The topsoil shall not contain less than 6% nor more than 20% organic matter as determined by loss on ignition of oven-dried samples dried at 221° F (105° C).

The following textural classes shall be acceptable:

Loamy sand, including coarse, loamy fine, and loamy very fine sand

Sandy loam, including coarse, fine and very fine sandy loam

Loam

Silt loam, with not more than 60% silt

The topsoil to be furnished by the Contractor shall be loose and friable and free from refuse, stumps, roots, brush, weeds, rocks and stones over 1 1/4 inches (30 millimeters) in diameter. The topsoil shall also be free from any material that will prevent the formation of a suitable seedbed or prevent seed germination and plant growth.

The Contractor shall notify the Engineer of the location from which he proposes to furnish topsoil to the project at least 15 calendar days prior to delivery.

The topsoil and its source shall be inspected and approved by the Engineer before the material is delivered to the project. Any material delivered to the project, which does not meet specifications or which has become mixed with undue amounts of subsoil during any operation at the source or during placing and spreading, will be rejected and shall be replaced by the Contractor with acceptable material.

When topsoil is not furnished by the Contractor, it shall be material that is stripped in accordance with Section 2.02 or is furnished by the State from areas adjacent to the project, and shall meet the above specifications.

1. Planting Soil: Soil Material to be used for plant backfill shall be one of the following textural classes:

Loamy sand, with not more than 80% sand

Sandy loam

Loam

Silt loam, with not more than 60% silt

Clay loam, with not more than 30% clay

Sandy clay loam, with not more than 30% clay

Planting soil shall be made loose and friable, shall be free from refuse, stumps, roots, brush, weeds, rocks and stones 2 inches (50 millimeters) in diameter. The material shall also be free from any material that will prevent the proper planting of the plant material, or prevent the growth of plants.

(a) For ericaceous plants and broad-leaved evergreens requiring an acid soil, planting soil shall have a true pH of 4.5 to 5.5. If it has not, it shall be amended by the Contractor at his own expense to the proper pH range by mixing with sulphur.

(b) Planting soil for general planting of nonacid-loving plants shall have a true pH value of 5.6 to 6.5. If it has not, it shall be amended by the Contractor at his own expense to the proper pH range by mixing with dolomitic limestone.

The amount of either sulphur or limestone required to adjust the planting soil to the proper pH range (above) shall be determined by the Engineer on the basis of agronomic tests. The limestone shall conform to the requirements of Article M.13.02. The sulphur shall be commercial or flour sulphur, unadulterated, and shall be delivered in containers with the name of the manufacturer material, analysis and net weight (mass) appearing on each container.

The Engineer reserves the right to draw such samples and to perform such tests as he deems necessary to assure that these specifications are met.

M.13.02—Agricultural Ground Dolomitic Limestone: Agricultural ground dolomitic limestone shall conform to the standards of the Association of Official Agricultural Chemists, and must comply with all existing State and Federal regulations.

The material must comply with the following gradation:

Square Mesh Sieves	Percent Passing By Weight (Mass)
Pass #10 (2.0 millimeters)	100
Pass #20 (850 microns)	90
Pass #100 (150 microns)	40
The minimum calcium carbonate equivalent shall be	90

The Engineer reserves the right to draw such samples and perform such tests as he deems necessary to assure that these specifications are met.

M.13.03—Fertilizer: Fertilizer shall be commercial grade granular 10-10-10 fertilizer. The fertilizer shall be delivered to the project in new, clean, sealed containers which bear a label fully describing the contents, the chemical analysis of each nutrient, the fertilizer grade, the net bulk, the brand, and the name and address of the manufacturer. The fertilizer and labels shall conform to all existing State and Federal regulations, and shall meet the standards of the AOAC International.

The delivery of each shipment of fertilizer to the project shall be accompanied by a properly executed and acceptable affidavit of the form shown herein. The affidavit shall be submitted to the Engineer. The Engineer reserves the right to draw such samples and perform such tests as may be deemed necessary to insure compliance with these specifications.

Form for Affidavit—Fertilizers (Official Stationery of Supplier)

Date ……...

To Whom It May Concern:

I hereby certify that I have sold and delivered ……..…tons

of commercial fertilizer of ……..…grade. This material is designated as our batch number(s)……

and was delivered to…….

for…….

(Contractor's Name)

Connecticut Department of Transportation Project Number(s):

……

at ……., Connecticut. The material was delivered

on …….. The labels and contents meet all State and

Federal regulations.

(List analyses of each major plant nutrient as percent by weight (mass).)

Signature ……

Company Official

Signature and Seal…….

Notary Public

Should the material fail to conform with these specifications, the Contractor shall supply additional acceptable material and perform such work necessary to rectify the deficiencies without cost to the State.

M.13.04—Seed Mixtures: (a) The grass seed mixture shall conform to the following:

Species	**Proportion By Weight (Mass) Pounds (kilograms)**	**Minimum Purity (Percent)**	**Minimum Germination (Percent)**
CHEWINGS FESCUE, (FESTUCA RUBRA VAR. COMMUTATA) CERTIFIED VARIETY: JAMESTOWN, ATLANTA, VICTORY, SHADOW OR EQUAL CERTIFIED VARIETY; NAME THE VARIETY	35 (15.9)	97	80
HARD FESCUE, (FESTUCA LONGIFOLIA)	30 (13.6)	96	85

CERTIFIED VARIETY: RELIANT, SPARTON, SCALDIS OR EQUAL CERTIFIED VARIETY; NAME THE VARIETY			
COLONIAL BENTGRASS, (AGRASTIS TENUIS) CERTIFIED VARIETY: HIGHLAND OR EQUAL CERTIFIED VARIETY; NAME THE VARIETY	5 (2.3)	95	90
BIRDSFOOT TREFOIL, (LOTUS CORNICULATUS) VARIETY ARVENIS, CERTIFIED VARIETY: EMPIRE OR EQUAL LOW GROWING VARIETY; NAME THE VARIETY	10 (4.5)	96	90
PERENNIAL RYEGRASS, (LOLIUM PERENNE) TRUF TYPE, CERTIFIED VARIETY: NAME THE VARIETY	20 (9.1)	98	90

The Birdsfoot Trefoil will be inoculated before planting. Under no circumstances should annual Ryegrass, Italian Rye, or any other seed be added to the seed mixture.

(b) The "temporary" grass seed shall be perennial ryegrass (Lolium perenne) or an improved variety thereof, such as Manhattan, having a minimum purity of 98% and a minimum germination of 90%.

The seed mixture shall be delivered in new, clean, sealed containers. Labels and contents shall conform to all State and Federal regulations. Seed shall be subject to the testing provisions of the AOSA.

The seed shall be delivered to the project accompanied by a properly executed affidavit for each type and shipment of seed. The affidavit shall be of the form shown herein. The Engineer reserves the right to take such samples and to make such tests as he may deem necessary to insure compliance with these specifications. The Contractor shall supply such additional acceptable material and perform such work as required to rectify any deficiencies without cost to the State.

Form for Affidavit—Seed (Official Stationery of Supplier)

Date ……

To Whom It May Concern:

I hereby certify that …….pounds. (kilograms) of seed

mixture, lot number …….., (Label attached) has been

sold and delivered to …….

for……..

(Contractor's Name)

Connecticut Department of Transportation Project number(s)

…….

at ……, Connecticut. The material was delivered

on …… . The labels and contents meet all

State and Federal regulations. The mixture consists of:

(State component parts, proportions, minimum purity, minimum germination.)

Signature …….

Company Official

Signature and Seal……..

Notary Public

M.13.05—Mulch Materials:

1. Wood Chips: Wood chips shall be obtained from sound, green wood, and shall be 1/8 inch (3 millimeters) nominal thickness with not less than 50% of the chips having an area of not less than one square inch (650 square millimeters), nor more than 6 square inches (3900 square millimeters). The material shall be free from rot, leaves, twigs, shavings, debris, and any material injurious to plant growth.

2. Hay: Hay shall be from acceptable grass or legume mowings, free from weeds, reeds, twigs, debris or other objectionable material. It shall be free from rot or mold, and

shall have a moisture content of not more than 15% when delivered to the project. No salt hay shall be used.

3. Wood Fiber Mulch: Wood fiber mulch or wood cellulose fiber mulch shall be material manufactured for mulching seeded areas. The material may be made from coniferous or hardwood trees. It shall be free from shavings, rot, mold, foreign material or debris. It shall be of uniform texture. It may contain a nontoxic marking dye. The moisture content of the material when delivered to the project shall not be more than 12% by weight (mass). It must be capable of forming a homogeneous slurry when mixed in water. It shall be delivered to the project in clean, new, sealed containers bearing the brand, net weight (mass), and name and address of the manufacturer.

The Engineer reserves the right to draw such samples and perform such tests on any mulch material as deemed necessary to assure that the material meets all requirements.

M.13.06—Compost: Compost shall be a stable, humus-like organic material produced by the biological and biochemical decomposition of source-separated compostable materials, separated at the point of waste generation, that may include, but are not limited to, leaves and yard trimmings, food scraps, food processing residuals, manure and/or other agricultural residuals, forest residues and bark, and soiled or non-recyclable paper. Compost shall not be altered by the addition of materials such as sand, soil and glass. Compost shall contain no substances toxic to plants and shall not contain more than 0.1% by dry weight (mass) of man-made foreign matter. Compost shall pose no objectionable odor and shall not closely resemble the raw material from which it was derived. Compost shall have a minimum organic matter content of 30% dry unit weight (mass) basis as determined by loss on ignition in accordance with ASTM D 2974. Compost shall be loose and friable, not dusty, have no visible free water and have a moisture content of 35 – 60% in accordance with ASTM D 2974. The particle size of compost shall be 100% less than 1 inch (25 millimeters) in accordance with AASHTO T 27 and shall be free of sticks, stones, roots or other objectionable elongated material larger than 2 inches (50 millimeters) in greatest dimension. The pH of compost shall be in the range of 5.5 - 8.0. The maturity of the compost shall be tested and reported using the Solvita Compost Maturity Test and must score 6 or higher to be acceptable. The soluble salt content of compost shall not exceed 4.0 mmhos/centimeter as determined by using a dilution of 1 part compost to 1 part distilled water. Compost may be either commercially packaged or used in bulk form. All compost shall be from DEP regulated, permitted or approved facilities. All compost material must be environmentally acceptable and must be accompanied by a Materials Certificate and Certified Test Report in accordance with Section 1.06.07. The Engineer reserves the right to draw samples and perform tests as may be deemed necessary to assure that the material conforms to these specifications.

M.13.07—Plant Materials: The materials for this work shall conform to the following requirements:

1. General: For the most part, "Standardized Plant Names," 1942 edition prepared by the Editorial Committee of the American Joint Committee on Horticultural Nomenclature, shall be the authority for all botanical plant names.

All plants shall be first-class representatives of their normal species or varieties. They shall have well-furnished branch systems together with vigorous fibrous root systems.

Plants shall be free from all insect pests, plant diseases, disfiguring knots, stubs, sun-scalds, abrasions of the bark or any other form of injury or objectionable disfigurements. All plant material shall comply with the State and Federal laws with respect to inspection for plant diseases and insect infestations.

Plants shall not be pruned before delivery and no plants shall be cut back from larger sizes to meet the sizes specified.

Plants shall be nursery grown unless otherwise specified and bear evidence of proper nursery care, including adequate transplanting and root pruning.

No plant will be considered to be nursery grown unless it has been growing in a nursery for at least two years and unless it has been root pruned or transplanted no more than five years prior to digging.

2. Nursery-Grown Plants: Nursery-grown plants shall conform with the requirements as specified in the current edition of "U.S. American Standards for Nursery Stock," or as further specified in the plans. Nursery-grown trees shall have no cuts which are not healing, no cuts over 3/4 inch (19 millimeters) in diameter which have not completely calloused over and no abrasions of the bark. They must have good fibrous root systems characteristic of the kind.

Trees shall have straight trunks, well-balanced tops and a single leader or as may be characteristic of the species.

Trees in which the leader or branches have been cut back or otherwise topped or de-horned will not be accepted. The caliper of shade trees up to and including 4 inches (100 millimeters) in diameter shall be measured above the root collar (or swelling at the ground) 6 inches (150 millimeters) above ground level. Caliper shall be the determining measurement in grading. Height measurements shall be given in single feet (half meters) in sizes up to and including 6 feet (2 meters) (e.g. 1.5-2 meters) and single meters in larger sizes (e.g. 2-3 meters).

Small deciduous trees shall be completely natural. Tree "clumps" shall have three or more main stems starting from the ground. Bush from trees shall be those with branches which start from the main trunk close to the ground in the manner of a shrub.

Vines and groundcover plants shall be well-furnished with vigorous root systems. They shall be field-grown unless otherwise specified. Plants grown in pots or bands shall

have sufficient roots to retain the soil in which they are growing when such plants are removed from their containers. However, such plants shall not be root-bound.

3. Collected Plants: Collected plants specified to be collected from a natural environment, or from a site where they were planted as seedlings or transplants and where they may not have received subsequent care, shall be clean, sound stock free from any form of injury. The quality of balled and burlapped (B & B) trees and shrubs shall be identical with that specified for nursery-grown B & B and balled, burlapped and platformed material.

Preference will be given to plants which have been previously transplanted or root pruned at sufficiently frequent intervals to have developed a fibrous root system as follows:

(a) No tap root shall be present.

(b) The majority of lateral roots extending beyond the dimensions of the ball shall be fibrous or pliable enough to allow combing out and saving. (This means that said roots must be pliable enough to bend around the ball of the plant without breakage or rupture).

A lateral root over 3/4 inches (19 millimeters) in diameter at its protrusion beyond the dimension of the ball shall not be considered pliable enough to save.

The length of the majority of lateral roots protruding beyond the ball shall not be greater than will allow the smallest fibrous rootlets at their tips to be saved. Lateral roots, which extend beyond the ball more than approximately one-half the given diameter of the ball, shall not be considered practical to save.

Root-pruning shall consist of the complete severance of the bottom tap roots and side roots. No plant will be accepted if it has not completely recovered from the shock of its last root pruning. (Recovery may take one or more growing seasons).

Plants not meeting these transplanting and root pruning requirements, but acceptable to the State in all other particulars as to size and quality, may be accepted, provided the diameter of the ball furnished is at least one-third greater than that specified above for nursery-grown plants of the same kind and size, or as the Engineer may specifically direct in writing. The specified dimensions for the size of ball shall not be decreased except in specific cases and only by special permission of the Engineer.

Plants specified as clumps shall be collected from good soil which has produced a fibrous root system typical of the nature of the plant. The clumps shall be dug with earth and incidental vegetation adhering to the roots.

4. Inspections: All plants shall be subject to inspection by the Engineer. The Contractor shall designate his wholesale plant material source(s) of supply to the Engineer in

writing at least one month in advance of each planting season to facilitate an orderly and timely inspection of the items to be installed. The Contractor shall be represented during such inspection. Inspection may be made at the nursery, plantation, or collecting field by the Engineer. The Department reserves the right to make inspections outside the State of Connecticut, at all contractor designated plant material sources of supply.

Further inspections will be made when the materials are delivered to the project site or storage area. All tagged samples shall be delivered to the project for which they were sampled. All deliveries to the planting site shall be accompanied by both the vendor's invoice, designating kind, size, quantity and sources of supply and certificates of inspection in accordance with M.13.07-8 (Certificates of Inspection). The State reserves the right to inspect all plant materials at the growing sites.

5. Substitutions: No change in size, kind or quality of plants from those specified will be permitted without written approval of the Engineer. The Contractor shall submit a written request for permission to make a substitution. Upon receipt of this letter, the Engineer will suggest plants meeting the requirements of the contract as to function, size and type and indicate the reduced cost to the State as the result of said substitution. In no case shall the price for substitutions exceed the bid price of those replaced.

The Engineer may approve, on the basis of unavailability, the substitution of plantation-grown or collected plant materials for specified nursery-grown materials at price reductions of 10% and 20% respectively below the contract unit bid price to the State.

Plantation-grown stock are plants which have been systematically set out in clean, open, tillable, agricultural soil, but where a minimum of aftercare has been carried out.

Collected stocks are plants of natural origin (not planted by man) with little or no subsequent care.

6. Digging Plants: Plans shall be dug immediately before shipment. Special precaution shall be taken to avoid any unnecessary injury to or removal of fibrous roots. Damaged roots shall be cut off clean. No cold storage plants will be accepted unless authorized by the Engineer.

(a) After deciduous bare-root plants are dug, their roots shall be protected from exposure to sun, wind and freezing temperatures. All bare roots of trees, shrubs and vines, unless otherwise directed, shall be puddled in a wet clay mixture which will cover and adhere to the entire root system. Bare roots shall be further protected by wrapping them in wet straw, moss, burlap or other suitable material, or by heeling them in and watering them in order to keep them fresh and viable.

(b) Balled and burlapped plants shall be lifted so as to retain as many fibrous roots as possible. All B & B plants must come from soil which will hold a firm ball. The latter shall be wrapped with burlap, or similar approved material, and tightly

laced in such a manner as to hold the balls firm and intact. All B & B material arriving with broken or loose balls, or with manufactured balls, will be rejected.

7. Transportation and Labeling: Plants transported by open vehicles shall be covered by tarpaulins or other suitable covers securely tied to the body of the vehicle. Closed vehicles shall be adequately ventilated to prevent overheating of the plants. The heads of trees shall be tied in carefully to prevent breakage of the leaders and the branches. Trunks and branches shall be adequately supported on padding to prevent their being scraped or bruised.

Legible labels shall be attached to all separate plants, boxes, bundles, bales or other plant containers, indicating the name, size, and quantity of units in each container and other information necessary for inspection.

8. Certificates of Inspections: Certificates of inspections, issued by Federal or State authorities (or both) attesting to the freedom of the plant material from diseases and insect infestations, shall accompany each shipment, invoice or order of stock. On arrival of shipment, such certificates shall be filed with the Engineer.

9. Delivery: Notice of delivery of plants shall be given to the Engineer by the Contractor at least 48 hours in advance of the anticipated delivery date, unless otherwise authorized. The Engineer shall be furnished a legible copy of the invoice for each shipment showing kind, sizes and quantities of materials.

All plant materials which are delivered in such a stage as to reasonably endanger their survival will not be accepted.

All plant materials shall be produced in a latitude north of Washington, D.C. and in a longitude east of the Mississippi River.

10. Spring Planting: All deciduous plants shall be received with buds unopened and intact; evergreen plants with the new growth retarded.

11. Fall Planting: Deciduous plants shall not be dug before the plants have hardened off.

12. Water: Water shall be free from oil, acid, alkalis, salts and any other substances harmful to plants. Water from streams shall not be used unless authorized by the Engineer.

13. Peat:

(a) Peat shall be commercially packaged peat from sedge, sphagnum or reed sources. Material shall be in such physical condition that it may be rudded through a 1/2-inch (12.5-millimeter) mesh screen, and may be readily mixed with soil material. It shall be free from sticks, roots, stones and other objectionable

material. It shall be delivered to the project in clean, new, sealed containers bearing the brand, net bulk, and name and address of the packer. The material shall have an acidity that falls in the pH range of 3.0 to 7.0. It shall have a minimum organic content of 90% and a minimum water-absorbing capacity of 1000%. The Engineer reserves the right to draw such samples and perform such tests as may be deemed necessary to assure that the material conforms to these specifications.

(b) Compost conforming to Article M.13.06 may be substituted for peat.

14. Miscellaneous:

(a) Anchor stakes for guying trees shall be of sound hardwood with a minimum length of 2 feet (610 millimeters) and minimum diameter of 2 inches (50 millimeters) at the smaller end. Stakes made from lumber shall measure no less than 2 inches x 2 inches (50 millimeters x 50 millimeters) in section throughout their lengths. Trees over 3 1/2 inches (90 millimeters) in caliper shall require either stakes or dead-men for support as approved by the Engineer. The type of stake used shall be uniform throughout the job.

(b) Tree support posts shall be sawed posts cut to a uniform square cross-section of 2 inches x 2 inches (50 millimeters x 50 millimeters) throughout their lengths. They shall be cut from sound, hard, clean, straight wood free from crooks, 8 feet (2.5 meters) long for major trees and 4 - 5 feet (1.2 meters - 1.5 meters) long for minor trees or as approved by the Engineer.

(c) Hose for protecting the bark of major and minor trees from guy wires shall be of good quality rubber or plastic hose acceptable to the Engineer, with a minimum inside diameter of 3/8 inch (9.5 millimeters) and a maximum inside diameter of 3/4 inch (19 millimeters).

(d) Guy wire shall be pliable, new, annealed, galvanized, 12-gage, for staking trees and 10-gage for guying.

(e) Flags shall be white cotton cloth or white plastic ribbon, 2 inches (50 millimeters) wide and 18 inches (460 millimeters) long. Gauze is not acceptable.

(f) Tree wound paint shall be waterproof tree paint approved by the Engineer.

(g) Anti-desiccant shall be an emulsion such as will provide a film over plant surfaces, permeable enough to permit transpiration. Anti-desiccant shall be delivered in containers of the manufacturer and shall be mixed according to the manufacturer's instructions.

(h) Wrapping material for tree trunks shall be treated, laminated tree wrapping paper in rolls, four inches (100 millimeters) wide, or as approved by the Engineer.

(i) Twine for tying wrapping material to trees shall be jute twine not less than 2-ply for trees under 3 inches (75 millimeters) in caliper, and not less than 3-ply for trees of larger caliper.

M.13.08—Sod: Sod shall be living sod procured from areas where the soil is reasonably fertile and from areas similar in the degree of moisture to the area to be planted. It shall be cut or stripped, by approved methods, from turf areas relatively free of large stones, roots or other materials which might be detrimental to the sodding operation or to future maintenance. The sod shall contain a sufficient proportion of pasture grasses to insure a good mat of roots and a reasonably dense turf unless Type No. 1, which is a superior quality, is specified on the plans.

Any growth more than 3 inches (75 millimeters) in height shall be mowed to a height of 3 inches (75 millimeters) not more than 5 days before the sod is lifted.

Sources of sod shall be made known to the Engineer at least 5 days before cutting and shall be approved before mowing. The sod shall be cut into squares or rectangular portions which shall be 12 inches (300 millimeters) wide and may vary in length, but must be of a size which will permit them to be lifted without breaking. The sod shall be sufficiently moist so the soil will adhere firmly to the roots when it is handled and may require watering before lifting. Field grown sod shall be cut to a minimum depth of 1 1/2 to 2 inches (38-50 millimeters). Where Type No. 1 Sod is specified, it shall be cut to a minimum depth of 1 to 1 1/2 inches (25-38 millimeters).

Type No. 1 Sod shall be obtained from inspected and approved commercial sod farm sources of supply and shall be free from noxious weeds, insect infestations, and fungus and bacterial diseases.

M.13.09—Erosion Control Matting: Erosion control matting shall be from the Department's Qualified Products List. Staples shall conform to the Manufacturer's requirements. Material which shows signs of degradation shall not be used and shall be removed from the project.

SECTION M.14

PRESTRESSED CONCRETE MEMBERS

M.14.01—Materials: Materials for pretensioned members shall conform to the following requirements:

1. Concrete: The concrete for the members shall be air-entrained concrete composed of portland cement, fine and coarse aggregates, admixtures and water. The air-entraining feature may be obtained by the use of either air-entraining portland cement or an approved air-entraining admixture. The entrained air content shall be not less than 4% or more than 6%.

The Contractor shall design and submit to the Engineer a concrete mix which shall attain a minimum 28-day strength (f'c) as shown on the plans. The compressive strength (f'ci) at the time of transfer of prestressing load shall be as shown on the plans. The Contractor shall further provide a certificate stating that the mix submitted shall meet the requirements. Its ultimate strength at 28 days (f'c) shall have the minimum value shown on the plans.

a) Coarse Aggregate shall consist of broken stone, having a maximum size of 3/4 inch (19 millimeters), conforming to the requirements of Article M.03.01.

b) Fine Aggregate, Water, Air-Entraining Admixture and Retarder Admixture shall conform to the requirements of Article M.03.01.

c) Portland Cement for the members shall conform to the requirements of M.03.01, except that Type III or Type IIIA portland cement may be used at no additional cost to the State.

d) Water-Reducing Admixture: The Contractor may submit, for the approval of the Engineer, water-reducing admixture for the purpose of increasing workability and reducing the water requirement for the concrete.

When the Engineer has previously approved the use of a high range water reducer in the concrete mix, the entrained air content shall be not less than 5% nor more than 8%.

(e) Calcium Chloride: The addition to the mix of calcium chloride or admixture containing calcium chloride will not be permitted.

2. Prestressing Steel: Prestressing elements shall be uncoated, high tensile strength, seven-wire strand conforming to the requirements of AASHTO M 203.

Before incorporating the elements into the work, a minimum of one sample, 7 feet (2.2 meters) in length and one sample, 1 foot (25 millimeters) in length from each reel shall

be furnished to the Engineer for testing. When reel packs are identified with the same heat number, only one reel pack need be tested for every 5 reel packs.

3. Reinforcing Steel and Tie Wire: All deformed bars, stirrups, dowels, threaded dowels and tie wire shall conform to the requirements of Article M.06.01-1.

4. Paint for the main prestressing strand ends shall conform to the requirements of Article M.08.01-5 for coating material.

5. Strapping for the beams shall be 3/4 inch x 0.035 inch (19 millimeter x 0.9 millimeter), uncoated or galvanized, heavy-duty steel strapping having a minimum ultimate tensile strength of 110,000 psi (760 megapascals). Strapping shall be obtained from a manufacturer approved by the Engineer.

Before incorporating the strapping in the work, samples of the strapping at least 3 feet (1 meter) long shall be furnished from each coil for testing. Approval of the material shall be obtained before the material is incorporated in the work.

6. Lifting Hooks, Pipe Sleeves, Base Protective Plates, Threaded Inserts, devices and attachments shall be of the size indicated on the plans or of a design satisfactory for the purpose intended.

7. Transverse Tie Strands shall be galvanized 7-wire strand, of the size noted on the plans, specially manufactured for prestressing, and shall conform to the pertinent requirements of Article M.14.01-2. The tie strands shall be coated with an approved high quality corrosion-resistant mastic and inserted into a black polyethylene tube having a minimum wall thickness of 0.032 inch (0.9 millimeter). The strands shall be clamped at each end by an aluminum strandvise coated with clean vinyl paint or an approved equal.

8. Nonshrink Grout for Longitudinal Shear Keys between Deck Units and for Recesses at Ends of Transverse Tie Strands and Deck Units. The grout shall conform to the requirements of Article M.03.01-12. At exposed locations, the grout used for patching shall match the color of the adjacent surface.

9. Void Forms: Internal voids may be formed by the use of heavy paper or fiber forms, specially made for this purpose, or with an alternate acceptable to the Engineer. These forms must be of substantial construction and adequately waterproofed in order to maintain their shape during the entire construction cycle. The end caps shall also be of similar construction. Before incorporation of the forms in the work, a sample 4 feet (1.2 meters) in length with end caps shall be furnished the Engineer for testing. Approval of the material shall be obtained before the material is incorporated in the work.

SECTION M.15

HIGHWAY ILLUMINATION

M.15.01—General Requirements: The contractor may use material and products of any manufacturer provided they meet the design standards and are approved by the department. Materials requiring approval are as follows:

1. Light standards
2. Luminaires
3. Service Items
4. Junction Box
5. Single Conductor
6. Cable in Duct
7. Navigation Lights

M.15.02—Anchor Bolts:

1. Light Standard Base: Anchor bolts shall be high strength steel having a minimum yield point of 50,000 psi (345 megapascals). Each anchor bolt shall have a thread 6 inches (150 millimeters) long. The dimensions shall be as shown on the plans. A hexagon nut, hold down washer, and lock washer, shall be furnished with each bolt. The threads and hexagon nuts shall be hot-dip galvanized as per ASTM A 153/A 153M

2. Pedestal and Controller Foundation: The anchor bolts shall be ASTM A 36 steel rods having a minimum yield of 36,000 psi (250 megapascals). The dimensions shall be as shown on the plans. Each anchor bolt shall have a 90-degree bend at one end and

shall be threaded at the other end for a sufficient length to properly mount the pedestal or controller. Threads, nuts, flat washers and lock washers shall be galvanized as per ASTM A 153/A 153M.

3. Span Pole and Mast Arm Foundations: Anchor bolts shall meet the requirements of AASHTO Specification M 314. In addition, only Grade 55 or Grade 105 material may be used. The threaded end of Grade 55 material must be painted yellow. The threaded end of Grade 105 material must be painted red. Steel conforming to ASTM Specifications A 675 Grade 90, A 449 or A 687 is also acceptable and, if used, shall be clearly designated as such on the submitted shop drawings, and properly annotated on all certifications.

The chemical requirements for all categories are a maximum Phosphorous content of 0.04% and a maximum Sulfur content of 0.05%.

Anchor bolts shall have a diameter of at least 1 1/2 inches (38 millimeters). The dimensions shall be as shown on the plans or as recommended by the manufacturer. Each anchor bolt shall be furnished with two nuts, two flat washers, and one lock washer. The threads, nuts and washers shall be hot-dip galvanized in accordance with the requirements for Class C of AASHTO M 232 (equivalent to ASTM A 153/A 153M). The nuts shall conform to the requirements for nuts within AASHTO M 314.

Field welding and field bending of anchor bolts is prohibited. If anchor bolts do not fit with the base plate, the Contractor shall replace the foundation or use a remedy recommended by the pole manufacturer and approved in writing by the Engineer.

The Contractor shall ensure plumbness of the hooked anchor bolts in the foundation. A minimum anchor bolt embedment of at least 4 feet (1.2 meters) is required. The amount of threading shall be as shown on the typical drawings.

Bolt Sampling Requirements:

1. Submit samples marked by manufacturer or fabricator.

2. Submit one sample of each size and heat number.

3. Submit a proper Materials Certificate for each sample.

4. Submit a proper Certified Test Report for each sample.

M.15.03—Rock Anchors: Rock anchors shall be malleable iron dipped in corrosion-resistant asphalt paint.

M.15.04—Light Standards: (anchor base and transformer base), (aluminum).

(a) General: Each light standard with appurtenances attached thereto shall be fabricated of aluminum alloy, designed and constructed in accordance with the plans and current requirements of AASHTO "Standard Specification for Structural Support for Highway Signs, Luminaires and Traffic Signals." Light standards with brackets and luminaires shall be designed to withstand a wind speed of 90 mph (145 kilometers per hour).

(b) Base: Light standard with transformer base shall conform to the breakaway requirements of the current AASHTO "Standard Specifications for Structural Support for Highway Signs, Luminaires and Traffic Signals" and shall be identified with visible markings. The transformer base shall be approximately 17 inches (430 millimeters) high with a door having an approximate opening of 9 inches x 12 inches (250 millimeters x 300 millimeters).

A bonding lug shall be provided in each transformer base and each anchor base shaft shall have the handhole frame or anchor base tapped for bonding. All castings shall be clean and smooth with all details well-defined and true to pattern. It shall be the Contractor's responsibility to verify existing bolt circle diameters by field checking that the bolt circle of the light standard base will match the anchor base on the foundation or structure.

(c) Shaft: Shaft shall be fabricated of aluminum alloy 6063-T6 or 6005-T5 as specified under AASHTO, current edition. Each shaft shall be seamless, tapered, circular in cross section. The shaft shall be one piece, however shafts over 40 feet (12 meters) may be fabricated from two pieces and factory joined, welded, grounded to appear as one piece and have a smooth continuous finish.

Each shaft shall be designed and fabricated in such a manner that each shaft-bracket connection will accommodate single member type brackets 2 to 8 feet (1 meter to 2 meters) in length, or truss type brackets 10 feet to 15 feet (3 meters to 5 meters) in length. Each shaft designed to 2 feet to 8 feet (1 meter to 2 meters) single member bracket shall have the wall thickness of that required for the 8-foot (2-meter) bracket, and each shaft for the 10-foot to 15-foot (3-meter to 5-meter) truss type bracket shall have the wall thickness of that required for the 15-foot (5-meter) bracket.

Each shaft shall be provided with an aluminum pole cap with self-tapping screws and an internal vibration damper. The internal vibration damper shall be factory installed, location and size as determined by the pole manufacturer.

The shaft shall be finished with a uniform surface having the natural color of aluminum. The shaft shall have a smooth, uniform finish, free from disfiguring scratches, dents and similar markings.

(d) Bracket Arms: The bracket arms shall have an upsweep design and shall accommodate a 2-inch (50-millimeter) slipfitter type luminaire, fabricated of

tubular elliptical aluminum which after fabrication shall have a mechanical strength not less than that of T-6 temper for 6063 alloy and T-5 temper for 6005 alloy. Truss type brackets shall have an aluminum end cap on the bottom member and a 1/8-inch (4-millimeter) weep hole located in the vicinity of the lowest point of the bottom member. The bracket arms shall be a truss-type for lengths 10 feet (3 meters) and longer and shall consist of a single member for shorter lengths. The bracket arm shall be furnished with a finish similar to that of the shaft to insure uniformity of appearance. The maximum upsweep for brackets up to 15 feet (5 meters) in length shall not exceed 3 feet 6 inches (1 meter). Bracket arm lengths shall be as indicated on the plans.

(e) Handhole: Each anchor base light standard shall have a handhole with a reinforced frame and cover approximately 4 inches x 6 inches (100 millimeters x 150 millimeters) located approximately 12 inches (300 millimeters) up from the base of the pole and placed 90 degrees from the bracket arm on the far side of the traffic flow.

(f) Isolation Pad: Each light standard mounted on any bridge structure shall have 1/2-inch (12-millimeter) thick elastometric pad of the same surface area as pole base, installed between the pole base and the structure, with four 11/32-inch (10-millimeter) thick by 2-inch (50-millimeter) O.D. minimum elastomeric washers installed on the top side of the base, between two standard galvanized flat washers. Elastomeric pads and washers shall conform to Article M.17.01.

(g) Hardware: All screws, nuts, bolts, washers and miscellaneous hardware used to assemble the light standard, base and brackets shall be stainless steel with the exception of washers and nuts for anchor bolts. Stainless steel bolts and washers shall conform to the requirements of ASTM A193, Grade B8. Stainless steel nuts shall conform to the requirements of ASTM A 194, Grade 8.

(h) Design Requirements: The pole manufacturer shall certify on the catalog cuts or shop drawings that the light standard, with appurtenances, conform to all pertinent requirements of AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals" including the latest AASHTO breakaway requirements and in accordance with definition given to the latest edition of AWS, as specified under AASHTO, Section 5, Article 1.5.5., Fabrication of Welded Aluminum Structure.

M.15.05—Roadway Luminaire: The luminaire shall be of the "cobra-head" type for roadway lighting with gray finish. The housing shall be die-cast aluminum with refractor door hinged on one end and latched on the other. It shall have a 2-inch (50-millimeter) slip fitter for end mounting and factory-installed bird guard. Reflector is to be aluminum, refractor to be glass. The optical assembly shall have a captive, non-wicking gasket to filter air. There shall be no photoelectric control receptacle unless specifically required for the application, and there shall be no open holes in the housing. The socket shall be

porcelain enclosed for mogul base lamp and adjustable to provide IESNA Light distribution type as shown on the plans.

The integral ballast shall be the regulator type with high power factor (above 90%) and in full compliance with current ANSI lamp/ballast specifications. Starting current shall be less than operating current. The ballast shall be capable of starting and operating a specified lamp at -20°F (-28° C). The unit shall be designed to operate under ±10% line voltage variation. The ballast shall operate at the specified circuit voltage. The entire ballast and starter unit shall be pre-wired and quick-disconnect type for ease of maintenance.

Conductors shall be #10 AWG in accordance with Article M.15.11. Insulation shall be THHN.

The breakaway-type fuse holders shall be of rubber or molded plastic housing which is watertight, as detailed on the plans. They shall be rated at 600 volts. Fuses shall be UL listed, fast-acting, current-limiting and rated at 10 amp, 600 volt and 100,000 AIC.

The luminaire shall have an identification sticker indicating the lamp type and wattage located on the underside of the luminaire, in accordance with current ANSI Standards.

The lamp shall be all position of the source and wattage called for on the plans, and in accordance with the current ANSI specification. The lamp shall be new and unused at the time of installation.

M.15.06—Vacant

M.15.07—Underbridge Luminaire: The luminaire shall be wall or pendent mounted with distribution type, wattage and voltage as specified on the plans.

The wall-mounted luminaire shall be complete with an optical assembly consisting of an anodized aluminum reflector and a single piece prismatic refractor made of thermal shock-resistant borosilicate glass protected by a clear polycarbonate shield. If specified, a steel wire guard shall be placed over the polycarbonate shield or used in lieu of the polycarbonate shield. The door shall be die-cast aluminum, self-hinged and secured by two captive stainless steel threaded fasteners. The housing shall be die-cast aluminum with a 3/4-inch (19-millimeter) threaded top entry and a captive non-wicking filtering gasket against which the door shall seat when closed. The luminaire shall provide a maximum vertical candle-power under 75 degrees and shall be UL listed as suitable for wet locations.

The pendant mounted luminaire shall be complete with a prismatic polycarbonate refractor and UL listed as suitable for wet locations. The housing shall be die-cast aluminum with a 1 1/4-inch (32-millimeter) threaded top entry and a die-cast aluminum refractor holder hinged to the luminaire housing in a manner that allows easy removal of the assembly. The refractor shall be securely held by means of a stainless steel hinge

and a positive acting spring loaded latch which will permit single action release and closing with a snap action.

The lamp socket shall have a porcelain enclosed mogul base. The socket for a pendent mounted luminaire shall be adjustable to provide the IESNA light distribution type called for on the plans.

The integral ballast shall be the regulator type with high power factor (above 90%) and in full compliance with current ANSI lamp/ballast specifications. The ballast shall be capable of starting and operating a specified lamp at
-20°F (-28° C). Starting current shall be less than operating current. The unit shall be designed to operate under ± 10% line voltage variation. The ballast shall operate at the circuit voltage specified on the plans. The entire ballast and starter unit shall be pre-wired.

Conductors shall be #10 AWG, 600V, in accordance with Article M.15.11. Insulation shall be THHN.

Fuse holders shall be of rubber or plastic molded housing which is watertight and shall be used in each branch circuit supplying a luminaire or luminaires. They shall be rated at 600 volts. Fuses shall be UL listed, fast-acting, current-limiting and rated at 10 amp, 600 volt and 100,000 AIC.

Mounting materials and hardware shall be as indicated on the plans or as directed by the Engineer.

Conduit shall be in accordance with Article M.15.09.

The luminaire shall have an identification sticker indicating the lamp type and wattage in accordance with current ANSI Standards.

The lamp shall be all position of the source and wattage called for on the plans, and in accordance with the current ANSI Standard. The lamp shall be new and unused at the time of installation.

M.15.08—Vacant

M.15.09—Electrical Conduit:

1. Rigid Metal Conduit: Rigid Metal Conduit (RMC) and fittings shall be galvanized steel. Each section of conduit shall be labeled as UL listed, and shall conform to the requirements of the latest UL and ANSI standards for Rigid Metal Conduit. Set-screw or compression fittings shall not be used.

2. Intermediate Metal Conduit: Intermediate Metal Conduit (IMC) and fittings shall be galvanized steel. Each section of conduit shall be labeled as UL listed, and shall

conform to the requirements of the latest UL and ANSI standards for Intermediate Metal Conduit. Set-screws or compression fittings shall not be used.

3. Polyvinyl Chloride Conduit: Polyvinyl Chloride Conduit (PVC) and fittings shall be UL listed, and shall conform to the requirements of the latest UL and ANSI standards for Polyvinyl Chloride Conduit. Schedule 40 grade shall be used where underground, Schedule 80 grade shall be used on surface.

4. Liquid Tight Flexible Metal Conduit: Liquid tight flexible metal conduit shall consist of a continuous strip of flexible galvanized metal, coated with an extruded jacket of polyvinyl chloride. Liquid tight flexible metal conduit shall be suitable for use in wet locations and shall meet the requirements of the latest UL and ANSI standards for liquid tight flexible metal conduit.

M.15.10—Cast Iron Junction Box: Junction Boxes shall be cast iron constructed to NEMA Type 4 requirements. The junction box cover shall be attached with approved stainless steel bolts and sealing washers, and shall be equipped with a neoprene cover gasket. For an 18-inch x 12-inch x 8-inch (450-millimeter x 300-millimeter x 200-millimeter) cast iron junction box, cover bolts shall be 1/4 inch x 5/8 inch (6 millimeters x 16 millimeters); threads shall be 20 N.C.; and the head shall be hex type and shall accept a 7/16-inch (11-millimeter) socket.

The covers for cast iron junction boxes shall be 1/4 inch (6 millimeter) thick steel conforming to the requirements of ASTM A 36 and shall be galvanized in accordance with ASTM A 123. Holes for the cover bolts shall be recessed in the cover plate to accept a 7/16-inch (11-millimeter) socket wrench.

All junction boxes recessed in concrete shall have an outside flush flange with a recessed cover and the conduit entrance holes shall be slip fit.

Junction boxes which are for surface mounting shall have threaded hubs or threaded bosses with a minimum of 5 full threads. All boxes and covers shall be hot-dip galvanized conforming to the requirements of ASTM A 153.

Rigid metal conduit for drain pipe shall conform to the requirements of Article M.15.09-1.

M.15.11—Single Conductor:

1. Insulation: Insulation type, size, and voltage rating shall be as shown on the plans. Insulation shall be permanently color identified throughout its entire length. Color shall be as called for on the plans. A green, white or natural gray color shall not be used unless it is a grounded conductor. The rating, type, size, and manufacturer shall be durably marked in accordance with the NEC.

2. Conductor: Conductors shall be single conductor, stranded, copper, meeting the latest ICEA, UL, NEMA, and FS for the type specified.

M.15.12—Cable in Duct: The materials for this item shall consist of single conductors in a flexible non-metallic conduit, the whole unit shall be pre-assembled for direct burial. The size, number and type of single conductors shall be as called for on the plans and shall conform to Article M.15.11. The conductors shall be laid parallel, not twisted, so they may be individually removed.

The duct size shall be governed by the number and size of the single conductors contained as listed below. Nominal duct size shall be as follows unless otherwise noted on the plans:

1 1/4 inches (32 millimeters) with minimum bending radius of 18 inches (460 millimeters) for up to four No. 2 conductors.

2 inches (50 millimeters) with minimum bending radius of 24 inches (600 millimeters) for more than four No. 2 conductors and through four No. 2/0.

The duct material shall be polyethylene and meet the requirements of Schedule 40. The duct shall meet all applicable standards of the latest NEMA Standard Publications no. TC-2 and TC-7.

M.15.13—Bare Copper Grounding Conductor: The conductor shall be 7-strand, soft-drawn, bare copper wire of the size specified on the plans.

M.15.14—Vacant

M.15.15—Service Entrance Cabinets:

1. Cabinets: The service entrance cabinet and the lighting control cabinet shall be sheet aluminum and conform to NEMA type 3R enclosure requirements. Type and dimensions are as called for on the plans. The doors shall be hinged, weatherproof gasketed, with handle and Conn-1 lock for the lighting control cabinet, and a stainless steel door handle with hasp for utility company padlock for the service entrance cabinet. The cabinet shall have a full-size backboard of 3/4-inch (19-millimeter) smooth marine grade plywood, painted black.

2. Instrument Transformer Cabinet: The instrument transformer cabinet shall conform to the requirements for the service cabinet.

3. Meter Socket and Enclosure: The meter socket and enclosure shall conform to utility company specifications.

4. Pedestal: For pedestal mounted cabinets, the pedestal shall conform to Article M16.03.2.

5. Foundations: Concrete shall conform to Article M.03.01—Class "A." Anchor bolts shall conform to Article M.15.02.2. Pedestal foundation may be precast.

6. Transformer Pad: Concrete shall conform to Article M.03.01—Class "A." The pad may be pre-cast. This item shall conform to Utility Company requirements.

7. Ground Rod: The ground rod shall be dimensioned as shown on the plans, copper clad steel. The clamp shall be a square head bolt type.

8. Conduit: Conduit shall be of the type called for in the plans and conform to Article M.15.09.

9. Conductors: Conductors shall conform to Article M.15.11.

10. Photoelectric Control: The photoelectric control shall have an adjustable turn on setting set at approximately 2 foot-candles (20 lux) with a time delay of at least 3 to 5 seconds. The control relay shall have single pole double throw contacts rated for 1000 watts. The coil shall operate at 120 Volts AC. It shall be applicable to the electrically operated, mechanically held contactor. Conductors shall be #12 AWG conforming to Article M.15.11. The manual switch shall be a three-way toggle switch mounted in a single gang utility box.

11. Contactor: The control contactor shall be of the size, rating and number of poles, as shown on the plans. It shall be electrically operated (120 volt), and mechanically held.

12. Control Transformer: The transformer shall be dry type, single-phase, two winding for wall mounting, of the size rating and voltages as called for on the plans.

13. Circuit Breakers: Circuit breakers shall be thermal magnetic type, non-enclosed, front-connecting, for mounting to the backboard. The number of poles, voltage rating and current rating shall be as shown in the plans.

14. A utility light shall be mounted in the cabinet with porcelain or plastic base, pull chain and incandescent lamp.

15. Ground Fault-Circuit Interrupter Receptacle: The ground fault-circuit interrupter receptacle shall be 20 amp, 125 volt, 60 HZ Class A, and shall be UL listed.

16. Main Disconnect Safety Switch: The main disconnect safety switch shall be a heavy-duty, non-fusible, three pole, single throw switch, with a manual lever, appropriate service grounding kit, rated for 480 volts, with a current rating as shown on the plans, NEMA Type 1 housing, UL-listed, and suitable for use as service equipment.

M.15.16—Navigation Light: The navigation light shall be of a type approved by the United States Coast Guard and shall be in accordance with their regulations for lighting bridges.

The navigation light shall be made with a bronze casting and shall be entirely weatherproof. It shall be ventilated to prevent sweating of the lens, and the vent shall be screened to prevent entry of bugs and insects. All parts of the lamp shall be interchangeable so that each lamp can be assembled with a 180-degree or 360-degree 8-inch (200-millimeter) fresnel lens.

Each navigation light shall be equipped with 2 100-watt, 120-volt lamps and a lamp failure relay. The green navigation lights shall have a 360-degree green fresnel lens. The red navigation lights on the structure or pier shall have 180-degree red fresnel lens.

Flexible cords shall be type S.O. three conductor #10 AWG rated at 600 volts.

SECTION M.16

TRAFFIC CONTROL SIGNALS

M.16.01—General Requirements: Where reference is made to certain manufacturers' material or products, it is not the intent to preclude the use of others, but rather to establish minimum acceptable design standards. The Contractor may substitute material and products of other manufacturers, provided they meet the minimum design standards and are approved by the Engineer.

M.16.02—Vacant

M.16.03—Pedestals: The materials for this work shall conform to the following requirements:

1. Vacant

2. Aluminum Pedestals:

(a) Shaft: The shaft shall be made of ASTM B 210 Grade 6063-T6 or ASTM B 221 Grade 6005-T5 aluminum alloy and shall be either a seamless tapered tube with a 6-inch (150-millimeter) outside diameter at the base and a 4 1/2-inch (115-millimeter) outside diameter at the top, or a seamless straight tube with a 4 1/2-inch (115-millimeter) outside diameter. The height of the pedestal shall be as required by the item. The shaft shall have a minimum wall thickness of 125 inches (3.2 millimeters) and shall be devoid of welding except at the base. The shaft shall be satin brush finished and each shaft shall be individually protected from scratches, dents and abrasions during handling and shipping.

(b) Base: The base shall be a permanent mold casting of 356 aluminum alloy conforming to ASTM B 108 and shall be of the dimensions shown on the plans. The tapered shaft shall be secured to the base by means of a circumferential fillet weld on the inside of the base top, and the straight shaft shall be secured by means of threads and machine screws, which when set, shall be flush with the base top. The base shall be provided with a cast aluminum door with dimensions shown on the plans, which shall be held in place by an approved locking device. Each base shall be provided with a grounding stud. All hardware used on the pedestal shall be 304 stainless steel conforming to ASTM A 276.

M.16.04—Poles: The materials for this work shall conform to the following requirements:

1. Steel Poles:

(a) Round Continuously Tapered Shaft: The continuously tapered shaft must have a maximum of 2 longitudinal continuous arc welds. No intermediate horizontal joints or welds will be allowed. Poles shall have a uniform wall thickness that tapers uniformly. All cross sectional shapes will be allowed, but multisided poles are required to be equilateral with a minimum of 8 sides. The shaft diameter must decrease from the butt end at the rate of not less than 0.07 inches (6 millimeters) and not more than 0.14 inches per foot (12 millimeters/meter) of length. Laminated pole designs (e.g. 2-ply pole shafts) will not be permitted.

The shaft shall be placed under sufficient pressure to flatten the weld and increase the physical characteristics to a minimum guaranteed yield strength of 48,000 psi (331 megapascals).

(b) Round Step Tapered Shaft: Round step tapered shafts shall be fabricated from round pipe sections with a maximum of one longitudinal seam. Horizontal seams must be joined by a hot-swaged shrink fit and continuously seal welded to prevent the entrance of water.

The shaft diameter must decrease from the butt end at the rate of not less than 0.07 inches (6 millimeters) and not more than 0.14 inches per foot (12 millimeters/meter) of length. This is accomplished through the use of decreasing diameter round pipe sections.

(c) Base: The base shall telescope the shaft and shall have two continuous transverse arc welds, one being on the inside of the base at the end of the shaft and the other weld on the outside at the top of the base. The welded construction shall develop the full strength of the adjacent section resistant to bending action.

The anchor base shall have four holes to receive the anchor bolts and four holes directly behind each anchor bolt hole for ventilation. The anchor bolt holes shall be .375 inches (9.5 millimeters) larger than the diameter of the anchor bolt.

(d) Pole Size: The traffic signal span pole shall have the yield strength, bolt circle, and length indicated on the plans.

(e) Span Clamp: The span clamp shall be made of steel capable of supporting a minimum load of 12,000 pounds (53.5 kilonewtons) without sustaining permanent distortion. There shall be one span clamp per span wire attachment. Additional span clamps shall be provided as required.

(f) "J" Hook: The "J" Hook shall be affixed inside the top of the pole for handling and cable support.

(g) Luminaire Bracket: The type and spread of the luminaire bracket shall be as indicated in the details on the plans. The bracket shall be the single-arm type for brackets 8 feet (2.5 meters) and under in length and the truss type for brackets 10 feet (3 meters) and longer in length unless otherwise specified.

The truss type shall consist of an upper and lower galvanized steel member securely joined by means of a vertical strut steel pipe without ornamental steel scroll.

The brackets shall be attached to the pole by means of a bolted clamp so that the angle for the arm may be adjusted in the field.

(h) Handhole: A steel handhole reinforcing frame a minimum size 4 x 6.5 inches (100 x 165 millimeters), complete with removable cover, shall be welded to the shaft approximately 15 inches (380 millimeters) above the base. The cover shall be fabricated from galvanized steel.

(i) Wire Entrance Fitting: All steel span poles shall include wire entrance fittings. The number and size of the wire entrance fittings shall be as required to accept the cables shown on the plans. A neutral bracket and 1-inch (25-millimeter) entrance fitting shall be provided for service cables. A separate fitting will also be required for any communications cable. These couplings will be continuously welded to the pole at a 45-degree angle to the pole shaft.

(j) Anchor Bolt Covers: Four removable galvanized ferrous or aluminum anchor bolt covers that attach to the pole base shall be provided. The anchor bolt covers shall be attached by a tapped hole and screw to either the pole base or pole shaft. The covers shall fit snugly and have a neat appearance.

(k) Electrical Ground: Each span pole shall be electrically grounded to a ground rod. The span pole will be connected to the ground rod by a #8 AWG copper wire. The wire shall be connected to the pole by a stainless steel bolt and to the ground rod by a square head bolt clamp, conforming with the NEC.

(l) Identification: Span pole information (as described below) shall be included on the poles in the form of a stamp on the top of the base plate, or an aluminum tag riveted to the base of the pole or to the pole shaft below the handhole.

(a) Minimum load at yield

(b) Name of manufacturer

(c) Year of manufacture

(d) Height of the pole

(m) Fabrication: The steel pole shall be fabricated in conformance with the current AASHTO "Standard Specification for Structural Support for Highway Signs, Luminaires and Traffic Signals." The pole manufacturer shall include a statement on his materials certificates stating that the welding design and fabrication is in accordance with the AWS Structural Welding Code D1.1-Steel.

(n) Finish: The steel span pole (shaft and base and luminaire bracket) shall be hot-dip galvanized, conforming to the requirements of ASTM A123/A 123M. Pole cap, bolt covers, handhole covers, span clamps, bolts, screws, washers, nuts, and wire entrance fittings shall be galvanized as per ASTM A153/A 153M.

2. Wood Poles:

(a) Pole: Wood poles shall conform to the requirements of ANSI 05.1 and AWPA C-1 and AWPA C-4. The pole shall be class 3 and of sufficient length to obtain the necessary height of the signals above the pavement or the mounting height of luminaires above the pavement.

The poles shall be trimmed by machine without materially changing their size or taper. Poles shall be branded on the face, have a flat roof, and shall be aluminum tagged on the butt in accordance with ANSI 05.1. The arrangement and order of the code letters and figures shall be as the following example indicates.

PTC	Supplier's code or trademark
F-78	Plant location and year of treatment
SPC	Species and preservative code
3-35	Class and size

The dimensions for the poles required shall not be more than 3 inches (75 millimeters) shorter or 6 inches (150 millimeters) longer than the nominal length. The length shall be measured between the extreme ends of the pole. The minimum bottom circumference shall be measured at a point 6 feet (2 meters) from the butt and the minimum dimensions for the poles shall be as follows:

	Bottom	Top
Length	**Circumference**	**Circumference**
30' (9.1 m)	**32" (813 mm)**	**23" (584 mm)**
35' (10.7 m)	**34" (864 mm)**	**23" (584 mm)**
40' (12.2 m)	**36" (914 mm)**	**23" (584 mm)**
45' (13.7 m)	**37.5" (953 mm)**	**23" (584 mm)**
50' (15.3 m)	**39" (990 mm)**	**23" (584 mm)**

The preservative treatment of the pole shall be done in accordance with the Standard Specification for Preservatives and Pressure Treatment Process for Timber, AASHTO M 133. The following named preservatives are acceptable. The properties shall be those set forth in the referenced AWPA standards:

1. Creosote	AWPA	P-1
2. Pentachlorophenol	AWPA	P-8
3. Chromated Copper Arsenate - Type C	AWPA	P-5

(b) Anchor: The anchor to be used for guying the pole shall be a four-way sliding plate as indicated on the plans.

(c) Anchor Rod: The anchor rod to be used for guying the pole shall be of drop steel and shall be hot-dip galvanized. It shall be as indicated on the plans. It shall conform to one of types as listed in the special provisions.

(d) Anchor Guy Strand Wire: The anchor guy strand wire shall be 3/8-inch (10-millimeter) 7-wire strand, supplied with a zinc coating by the hot-dip galvanized process in accordance with ASTM A 475 for zinc-coated steel wire strand, and shall have a minimum breaking strength of strand of 11,200 pounds (50 kilonewtons) for utilities grade.

(e) Guy Wire Protector: The guy wire protector to be used shall be the half-round type either fabricated from a minimum of 16-gauge hot-dip galvanized steel or from high impact 13454A Polyvinyl Chloride ASTM D 1784 compound standard. It shall have hot-dip galvanized steel clamps. The steel clamps shall conform to ASTM requirements A36 for steel and A123 for galvanization. There will be 3 clamps which will accept any strand size 1/4-inch (6.4-millimeter) diameter and larger, and any anchor rod up to a 1-inch (25-millimeter) diameter.

M.16.05—Mast Arm Assembly: The materials for this work shall conform to the following requirements:

1. Aluminum:

(a) Shaft: The shaft shall be 6005-T5 Aluminum Alloy as specified by ASTM B 221 or approved equal, and shall be a seamless tube tapered by cold working. The shaft wall thickness, length and tube diameters shall be as indicated on the Plans. The shaft shall have a satin brush finish and shall be suitably protected during handling and shipping.

(b) Arm: The arm shall be of tapered elliptical truss-type design. The arm shall consist of an upper and lower member joined by vertical braces and clamps of 356 Cast Aluminum Alloy conforming to ASTM B 108 for attachment to the Shaft. All necessary fittings and adjustable signal mounting assemblies required for attachment of the signal heads shall be included with the arm. The arms and struts shall be fabricated of 6005-T5 wrought aluminum alloy as specified by ASTM B-221 or approved equal. The arm shall be formed to dimensions as shown on the plans. The wall thickness shall be as shown on the plans. All vertical braces shall be 2 3/8 inches (60 millimeters) O.D. having a .140-inch (3.6-millimeter) wall thickness and elliptically shaped to a cross-section of 3 inches x 1 3/4 inches (76 millimeters X 44.5 millimeters). The clamp castings shall withstand the design load of the arm assembly as shown on the shop drawings.

(c) Shoe Base: The shoe base shall be 356 cast aluminum, conforming to ASTM B 108 of adequate shape and size to develop the full strength of the adjacent shaft section. The base shall be secured to the lower end of the shaft by two continuous welds. The base shall telescope the shaft, and one weld shall be on the inside of the base at the end of the shaft and the other weld shall be on the outside at the top of the base. The base shall be provided with four holes for mounting on the 16-inch (406-millimeter) bolt circle and four cast aluminum bolt covers which shall be attached to the base by means of stainless steel screws.

(d) Transformer Base: The transformer base shall be a permanent mold casting of 356-T5 aluminum alloy conforming to ASTM B 108 and shall be of sufficient size to withstand the full design load of the shaft. The transformer base shall have a door of dimensions shown on plans attached to the base by means of cast lugs at the bottom and a stainless steel socket head cap screw with a wrought aluminum latch at the top. The bottom of the base shall have provision for anchorage at the corners to accept four anchor bolts.

(e) Welding: Welding of aluminum shall conform to the AASHTO "Specifications for the Design and Construction of Structural Supports for Highway Luminaires," Section 10—Fabrication of Welded Aluminum Structures.

2. Steel:

(a) Shaft: The shaft shall be made from one length of sheet steel not less than the gauge specified. There shall be a maximum of two longitudinal continuous arc welds. There shall be no intermediate horizontal joint or weld. The length of sheet steel shall be

formed into a continuously tapered shaft, having a taper of approximately 0.14 inches per foot (12 millimeters/meter). The arm sizes are as shown on the Plans.

After the welding and cold-rolling, the shaft shall be placed under sufficient pressure to flatten the weld and increase the physical characteristics of the shaft so the metal will have a minimum yield of 48,000 psi (331 megapascals). Cross-sectional shapes other than round will be allowed. A steel handhole reinforcing frame a minimum size 4 inches x 6.5 inches (100 millimeters x 165 millimeters), complete with removable cover, shall be welded to the shaft approximately 15 inches (380 millimeters) above the base. The cover shall be galvanized steel. There shall be a 0.5-inch (12.5-millimeter) tapped hole near the base of the shaft for the grounding bolt.

A round step tapered shaft will also be acceptable. The shaft shall be fabricated from round pipe sections with not more than one longitudinal seam, joined by a hot-swaged shrink fit, continuously seal-welded to prevent the entrance of water. Stepped round shafts must decrease in diameter from the butt end at the rate of not less than 0.07 inches (6 millimeters) and not more than 0.14 inches per foot (12 millimeters/meter) of length by use of decreasing diameter round pipe sections. The minimum yield strength of the material shall be 48,000 psi (331 megapascals).

A flange plate, a minimum of 1.250 inch (32 millimeters) thick, shall be welded to the pole near the top supported by side plates tangent to the pole and gusset plates, both top and bottom. The flange plate shall have a 2.50-inch (64-millimeter) diameter wiring hole and four tapped holes for 1 1/4-inch (32-millimeter) high tensile bolts.

A device shall be provided near the top, inside of the pole, to relieve the strain on the cable feeding the signals. The pole cap shall be secured by means of set screws.

Where shown on the plan, there shall be provided a steel tapered luminaire bracket. The bracket shall be the single arm type for brackets 8 feet (2.4 meters) and under in length and truss type for brackets 10 feet (3 meters) and longer. The truss type shall consist of an upper and lower member securely joined by means of a vertical strut. The upper and lower members shall be 2-inch (50-millimeter) I.P.S. steel pipe without ornamental steel scroll. The length of the bracket shall be as shown on the plans.

(b) Anchor Base: A one-piece steel anchor base of the adequate strength, shape and size shall be secured to the lower end of the shaft by two continuous electric arc welds. The base shall telescope the shaft, and one 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. The 2 welds shall be approximately 2 inches (50 millimeters) apart, and the design shall be such that the welded connection shall develop the full strength of the adjacent shaft section to resist bending action.

The base shall be provided with four holes to receive the anchor bolts, and four tapped holes for attaching the anchor bolt covers.

(c) Mast Arm: The mast arm may be made of one length or two lengths of steel. There shall be a maximum of 2 longitudinal continuous arc welds. The length of sheet steel shall be formed into a continuous taper shaft having a taper of approximately 0.14 inch per foot (12 millimeters/meter). After the welding and cold-rolling, the mast arm shall be placed under sufficient pressure to flatten the weld and increase its physical characteristics so that the metal will have a guaranteed minimum yield strength of 48,000 psi (331 megapascals).

A flange plate, 1.25 inches (32 millimeters) thick, shall telescope the large end of the mast and be welded by two continuous electric arc welds. One weld shall on the outside of the plate, adjacent to the shaft, and the other weld on the inside at the end of the tubular cross-section. The flange plate shall have four holes for the 1.25-inch (32-millimeter) high tensile bolts, which shall match the four tapped holes in the mounting plate on the pole.

Mast arms for step tapered shafts may be two-piece construction with a telescoping joint secured by a thru-bolt and lock nut. Arms less than 35 feet (10.7 meters) in length need not be tapered. The arm shall be not less than the gauge specified. The minimum yield strength of the material shall be 48,000 psi (331 megapascals).

Each mast arm shall be drilled in the field on the bottom surface for wire outlet holes and signals positioned at the location indicated on the signal plans. Rubber grommets shall be provided and installed by the Contractor at each field drilled hole to protect the signal cables from chafing.

A steel removable cap shall be attached to the end of the arm by a set screw. For each required signal, a clamp and clevis with 3/4-inch (19-millimeter) diameter hole shall be furnished.

(d) Finish: The steel mast arm assembly and luminaire bracket shall be hot-dip galvanized, conforming to the requirements of ASTM A 123/A 123M unless otherwise specified. Pole Cap, bolt covers, handhole covers, bolts, washers, nuts and screws shall be galvanized, conforming to the requirements of ASTM A 153/A 153M.

(e) Fabrication: The steel Mast Arm Assembly shall be fabricated in conformance with the current AASHTO "Standard Specification for Structural Support for Highway Signs, Luminaires and Traffic Signals." The manufacturer shall include a statement on his materials certificates stating that the welding design and fabrication is in accordance with the AWS Structural Welding Code D1. 1 Steel.

3. Identification: Mast Arm identification (as described below) shall be included in the form of a stamp on the top of the base plate, or an aluminum tag riveted to the base of the shaft below the handhole.

(a) Maximum equivalent end load (mass and area)
(b) Name of manufacturer

(c) Year of manufacture
(d) Arm length

M.16.06—Traffic Signals: The materials for this work shall conform to the following requirements:

1. General: The components of a traffic control signal head assembly or unit shall conform to the I.T.E. requirements for Adjustable Face Traffic Control Signal Head Standards Technical Report of the latest issue.

2. Traffic Control Signals: Each signal head shall be of the adjustable, vertical type with the number and type of sections and lamps as shown on the plans, shall provide a light indication in one direction only; and shall be adjustable through 360 degrees without the removal from the mounting bracket; and shall be mounted at the locations, and in the manner as shown on the plans. Unless otherwise indicated on the plans, all signal heads shall be standard and shall contain three lights arranged as follows: Red-top; Amber-center; Green-bottom. All signal heads in this contract shall be of the same make and type.

3. Housing: The signal head housing shall be made of a die-cast aluminum alloy per ASTM B 85. The signal head housing shall consist of an assembly of three or more separate sections, expansible type, for vertical mounting, substantially secured together in a watertight and rigid manner to form a unit of pleasing appearance.

Each section shall house an individual optical unit. The signal head shall be so designed that sections may be added or removed from the head assembly by the use of simple tools.

The housing shall be a die casting, rigidly constructed with a smooth outer surface. There shall be a round opening in the top and bottom of each head to receive a 1 1/2-inch (38-millimeter) supporting pipe frame. The portion of the housing section around the opening shall be reinforced and serrated so that serrated fittings may be used to secure the housing. The top and bottom of the housing shall include such other openings as are necessary to accommodate fastening devices to hold sections together, and such openings shall not permit entrance of foreign particles. Each section shall be positively indexed with respect to an adjacent section to prevent misalignment. Each housing section shall be equipped with a door with an opening and fittings for the optical unit and visor. The door shall be arranged for easy access to the optical unit components and wiring. It shall be hinged on its left side so that the door cannot be removed without the use of tools at 2 points and shall be provided with a simple, positive-acting door locking device made from stainless steel to assure tight closure. The door or housing shall be grooved to receive a neoprene gasket to provide a resilient seal between the door and housing. The body and door of each housing section shall be of die-cast aluminum alloy and shall be clean, smooth, and free from flaw, crack, blow holes, or other imperfections. The door locking device and visor fastening screws shall be made of stainless steel. All other screws, nuts, washers, hinge pins, latch parts,

clips and parts used in the assembly of the signal housing shall be made of either naval brass, everdur, phosphor bronze, stainless steel or approved equal.

4. Brackets: The signal heads, except for post-top mounting, shall be supported by mounting brackets consisting of assemblies of 1 1/2-inch (38-millimeter) standard, iron pipe and malleable iron fittings. All members shall be plumb and level, symmetrically arranged, and securely made up. Construction shall be such that all conductors are concealed within poles and assembly.

Each section of the housing shall be provided with a removable cap visor of not less than #16 B & S Gage Aluminum. The cap visor shall be painted a flat black on the inside to prevent reflection, and must also eliminate sun-phantom. The visor shall fit snugly against the door and shall not permit any perceptible filtration of light between the door and the visor.

A terminal block shall be mounted inside of the back of the housing in the top section. The terminal blocks shall have sufficient studs with separate screws to terminate all field wires and lamp wires independently to the block.

When indicated on the plans, a backplate of dimensions, as shown on the plans, constructed of 3003H 14 aluminum alloy sheet .051-inch (1.3-millimeter) minimum thickness conforming to ASTM B209 (B209M) shall be attached to the signal head housing. The backplate shall be painted a flat black on both sides.

5. Optical Unit: The optical unit shall consist of a lens, reflector, reflector frame, and socket and traffic signal lamp of the size shown on the plans. Other necessary equipment shall be designed to give clearly visible signal indications within an angle of at least 45 degrees to the traffic to be controlled and from 10 feet to 300 feet (3 meters to 91.5 meters), under all light and atmospheric conditions except dense fog; and shall be of such design as to eliminate sun-phantom effects. The optical unit shall be readily accessible for maintenance.

Lenses shall be of the color indicated, circular in shape, with a visible diameter of 8 inches (203 millimeters), unless otherwise noted on the plans, except that all arrow lenses shall have a visible diameter of 12 inches (305 millimeters). Except where indicated on the plans, the use of adapters to achieve 12-inch (305-millimeter) indications will not be allowed. Lenses shall be of such design to give an outward and downward distribution of light with a minimum above the horizontal. Arrow lenses shall conform in design to ITE standards and shall be of a green light diffusing nature, giving uniform distribution of illumination on all areas of the lens. The field for arrow lenses shall consist of a black ceramic compound, baked or fired into the glass.

Each lens shall be polycarbonate capable of withstanding continuous illumination of a standard traffic signal lamp without thermal distortion [100-Watt - 8-inch (203-millimeter) lens] [150-Watt – 12-inch (305-millimeter) lens]. The lens shall be 3/16 to 5/16 inch (4.8 millimeters to 8 millimeters) in thickness, smooth on the outside surface, annealed to

relieve internal stresses and of high illumination transmission. An air-cured neoprene lens gasket shall be provided between the lens and the signal door and between the lens and the reflector ring. The two ends of the lens gasket shall be joined together by vulcanizing or other approved method. Each lens shall have the word "Top" marked on its flange to indicate proper positioning of the lens in the door, together with the trademark of the lens manufacturer and label indicating conformance with the specifications set forth in the ITE standards. The lens and its gasket shall provide water-tight and dust-tight construction. The gasket shall be molded, heat-resistant neoprene.

The reflector shall be made of specular Alzak aluminum, the thickness of the anodic coating to a minimum of 0.0001 inch (2.5 microns), or its equivalent, spun or punched from metal not less than .025 inch (0.6 millimeter) thick, equipped with a bead or flange on the outer edge to stiffen the reflector and insure its being held true to shape. The reflecting surface shall be totally free of flaws, scratches, defacements or mechanical distortion.

An opening in the back of the reflector for the lamp holder shall be so constructed that there will be no dark spots cast on the lens. The reflector shall be of the pressure type, free floating and must insure full seal against the lens gasket. The reflector frame shall be of die-cast aluminum constructed completely around the reflector, and arranged to assure maintaining proper positioning of the reflector with respect to the lens under normal operating conditions. Proper position shall be maintained after opening and closing the unit for lamp replacement and other maintenance functions. A dust-tight gasket shall be provided between the reflector and the reflector-holding ring. If this gasket is of neoprene, it shall be made continuous by vulcanizing ends together or by another process approved by the Engineer. Additional dust-tight gasketing shall be provided between the lamp holder and the reflector.

6. Lamp Socket: The lamp socket shall be so designed that the tip or center contact shall retain its spring action and shall not twist or turn when lamps are installed. The ring or outer contact shall be securely fastened to the receptacle base so that it will not become loose, break out, or turn when replacing lamps. The lamp socket shall be mounted so that when a lamp is properly inserted and adjusted it shall retain that position. The lamp socket shall be made of heat-resistant material designed to hold a traffic signal lamp of the wattage indicated on the plans, and shall be of the vibration-proof type, weatherproof molded construction, immune to the operating temperatures of the unit and substantially supported, independent of the reflector. Each lamp socket shall be the adjustable type and shall be wired with two leads using a minimum size of #18 AWG, 600 volt, 115 degree C stranded wire not less than 3 feet (1 meter) long. This wire shall be marked in accordance with Article 310-11 of the latest edition of the NEC. The sockets shall be so wired that a white lead will be connected to the shell of the socket and a black lead to the bottom or end terminal of the socket.

All lamps shall have indelibly etched thereon the name of the manufacturer, the ratings in watts for which the lamp was designed and the operating voltage of the lamp. Each lamp shall have the beam candela specifications of the ITE.

The lamps shall operate at 67 or 69 watts as the case may be at plus or minus 4% at rated voltage. The lamps shall have a voltage rating of 125 volts and the initial lumen rating of the 67-Watt lamp shall not be less than 618 and the 69-Watt lamp not less than 630.

The bulb designations shall be AT-21 or A-21 for the 67-Watt and A-21 for the 69-Watt. The 67-Watt lamps shall have a maximum over all length of 4.625 inches (117 millimeters) and a light center of 2.44 inches (62 millimeters). The 69-Watt lamps shall have a maximum over all length of 4.44 inches (113 millimeters) and a light center of 3 inches (76 millimeters). All lamps shall have a fuse wire within their structure to prevent damage to lamp circuitry or receptacle and they shall also have an aluminum reflector disc incorporated within the bulbs to assist light control.

The base of the lamps shall be medium, made of brass, and shall have the base stamped or printed with "Scratch Out" letters and numerals which indicate 12 months of the year and at least 4 indications for years. This is for the purpose of maintaining control for re-lamping.

The burning position shall be base down or horizontal and the lamps shall have a rated life of 8,000 hours of use guaranteed by the manufacturer.

The 67-Watt lamps shall be installed in traffic signals with 8-inch (203-millimeter) lenses. The 69-Watt lamps shall be installed in the traffic signals with 12-inch (305-millimeter) lenses.

7. Mountings: All signal heads shall be equipped with positive locking devices and fittings designed to prevent the heads from turning due to external forces. Number 2 Permatex or approved equal shall be used at all points where lock nuts and washers are used in assembling heads.

8. Dual Color Fiber Optic Section: When called for on the plans, signals shall be provided which display alternate legends, consisting of either a green or amber directional arrow. The arrows shall be illuminated by the use of fiber-optics and shall be clearly legible and visible, at full intensity, anywhere within a 50-degree cone, centered about the optical axis.

Any combination of colors shall be available by changing color filters installed in the unit, i.e., a signal supplied to display both a green and amber arrow could be field modified to display red and green arrows without the necessity of removing the signal from the case.

One lamp, type ENL, shall be used for each message. These lamps shall be operated between 10.5 and 10.8 volts. Average lamp life shall be not less than 8,000 hours. Field data, laboratory data and manufacturing specifications shall be supplied to substantiate lamp life.

Non-lensed, fully randomized bundles shall be used to provide a 50-degree, total-viewing angle. 19 individual enlarged-diameter bundles shall be used to form the arrow legend. The same bundles shall be used to display either message.

In order to help balance the intensity between colors, provisions shall be made in the construction of the signal to supply approximately 50% more light to the green arrow indication than supplied to the amber arrow indication.

Transformers shall be used to reduce the incoming 120 volts AC to 10.8 volts AC. The transformer shall have Class A insulation and shall be rated at 48.5-volt amps.

Power consumption of the dual color arrow shall be less than 50 Watts.

A separate transformer and bulb shall be used for each color to allow connection with the controller wiring and conflict monitors. Identical lamp types shall be used for each message.

Fiber optics shall be glass fiber bundles assembled on flat black matrix panels with mechanical protection for the assembly. The glass fibers at the input and output ends shall be ground smooth and optically polished for maximum light transmission. Matrix panel to have flat black non-reflective finish.

To eliminate long term condensation effects of thermal cycling, individual fiber-optic bundles shall not be jacketed or encased. Lamps shall be mounted horizontally to prevent their collecting water from condensation or possible gasket leaks.

The front panel shall be rotatable to indicate the desired direction when installed. No moving parts shall be permitted. Fiber-optics shall be protected by a black ABS plastic vacuum formed sculptured cover to eliminate the possibility of damage when installing or re-lamping.

The front panel of the signal section shall be colored black to minimize legibility of the arrow when not illuminated. No color at all shall appear when not illuminated regardless of sunlight intensity.

All fiber-optic, transformers and lamps shall be mounted on the door of the signal section. All screws, washers, nuts and bolts shall be corrosion-resistant stainless steel. All components shall be readily accessible when the door is opened. The only tool required for maintenance shall be a standard screwdriver.

9. Painting: All surfaces of the signal housing, door, visors, inside and out, shall be cleaned and coated with a Primer conforming to FS MIL-P-8585. The surfaces shall then be finished with three coats of infrared oven baked paint, before assembly.

First Coat: The primer shall be iron oxide backing primer and shall meet or exceed the requirements of FS TT-P-636, paragraph 4.2.3.

Second Coat: Shall be light gray exterior baking enamel and shall comply with FS TT-E-489, either #16251, #16314, or #16376 Gray.

Third Coat: Highway Yellow Enamel shall be traffic signal highway yellow exterior baking enamel and shall comply with FS TT-E-489. The color shall be No. 13538 according to Federal Standard No. 595. The inside of the visors shall be phthalic anhydride black synthetic baking enamel, with zero (0) gloss reflectance and shall meet the performance requirements of Mil-E-5557 Enamel Heating Resisting Glyceryl Phathalate Type 4, Instrument black. The housing door and the outside of the visor shall be painted Flat Black unless otherwise specified.

M.16.07—Pedestrian Signal: The materials for this work shall conform to the following requirements:

A. General: The pedestrian signal shall be one section, rectangular in shape, and shall conform with the MUTCD. The over-all size of the pedestrian signal, including visor, shall be as shown on the Typical Installation details. The pedestrian signal shall be the LED type unless indicated otherwise. The display shall be the international symbols for "walk" and "don’t walk". The symbols shall be clearly legible when illuminated. The symbols shall have the dimensions as shown on the plans. The "Walk" symbol shall be Lunar White. The "Don’t Walk" symbol shall be Portland orange.

B. Housing: The housing shall be one-piece, corrosion-resistant, aluminum alloy casting. The top and bottom of the housing shall have an opening to accommodate standard 1 1/2-inch (38-millimeter) pipe brackets. Each housing shall have a terminal block with a sufficient number of terminals to accept field wires. Two integrally-cast hinge-lugs shall be cast on one side of each housing, and two integrally-cast latch-screw pads shall be cast on the other side of the housing.

The housing door shall be a one-piece, corrosion-resistant, aluminum alloy casting. Two hinge-lugs shall be cast on the other side of each door. The door shall be attached to the housing by means of two stainless steel hinge pins. Two stainless steel hex-head, captive-latch screws shall be permanently attached to the door bosses by means of keeper washers. The door shall have a neoprene gasket which, when the door is closed, shall cause a seal against the housing, making a weatherproof and dust-tight seal.

Each signal shall be provided with an aluminum visor approximately 7 inches (178 millimeters) long, which shall encompass the top and sides of the signal face. The top of the visor shall have a downward tilt of approximately 3-1/2 degrees. The visor shall be blanked and formed, shall be not less than .05 inches (1.3 millimeters) thick, and shall meet the minimum requirements of ASTM B209 (B209M).

C. Optical Unit:

1. Incandescent: The incandescent optical unit shall consist of a lens, reflector frame, lamp socket, and traffic signal lamp.

The lens shall be of rigid type polyester resin having an especially high heat distortion point and excellent resistance to degradation at high temperatures. Lens thickness shall be a minimum of 3/16-inch (4.8 millimeters). The lens gasket shall be molded neoprene rubber channeled to cover the entire perimeter of the edge. The gasket shall press against the frame when the door is closed to form separate dust-tight optical compartments.

Reflectors shall be of one-piece parabolic construction, designed to direct light from the lamp outward with maximum efficiency. The reflector shall have a flange that will form a flush fit with the gasket when the door is closed.

Sockets shall be one-piece molded construction and shall be fastened to the reflector. The socket shall have a "lamp grip" to prevent the lamp from loosening. Color-coded leads of 18-gauge wire shall be attached to the terminal block in the signal. Lamps shall be 67-watt standard traffic signal lamps.

2. LED: The optical unit shall consist of multiple LED light sources and a regulated power supply assembled as a sealed unit. The diodes shall be arranged to display a full-hand symbol side by side with a full pedestrian symbol. The optical unit shall fit into a standard pedestrian signal housing so that it may be installed into an existing incandescent pedestrian signal. The LED optical unit shall be capable of maintaining message symbol integrity despite any partial loss of LEDs. The beam color shall match that of the incandescent message: walking symbol - lunar white, hand - Portland orange. The beam pattern and intensity shall meet ITE specifications. The intensity may not degrade by more than 10% per annum. The optical unit shall be warranteed by the manufacturer for a period of five years.

Electrical Requirements:

- Input Voltage: 89 VAC to 135 VAC
- Wattage: 15 Watts
- Input Impedance at 60 Hz must satisfy all conflict monitor requirements.
- A regulated power supply shall be engineered to protect the LEDs from electrical surges and transient voltages.

D. Pedestrian Signal (Audible):

Voltage: 120VAC 50/60 Hz, ± 15 % of nominal line voltage.
Operating current: .33 amps.
Standby current: .027 amps.
Decibel at 10’ (3 meters): 88dB.
Operating temperature: -31º F to 161º F (-35º C to 71.6º C).
Net weight: 1.7 pounds. (.77 kilograms).

Rated life: 400 hours at 50% duty cycle.

Housing:

Cast Aluminum.
Weatherproof with neoprene gasket.
4 7/8" (12.2 centimeters) square box.
Depth 2" (5 centimeters).
Tapped for 1/2" (3.2 centimeters) conduit.
UL listed.

Properties:

Single audible device with varying
tone modules.
Internal gain control - output adjustable from 64 dB to a maximum of 88 dB at 10 ft. (3 meters).
Active to coincide with "walk" indication and pulse to coincide with "Don't Walk" indication.

Tone Module:

470 Hz continuous.
Sturdy plastic housing.
Edge connector termination's to allow rapid installation or removal of module.
Varying tones

E. Hardware: All exposed screws and fasteners shall be stainless steel. All internal screws, fasteners and metal parts shall be stainless steel, non-corrosible materials; or cadmium-plated ferrous materials.

F. Painting: All surfaces of the signal housing, door, and visors, inside and out, shall be finished with three coats of infrared-oven- baked paint before assembly. All brackets and hardware shall be painted dark green by the manufacturer. The color shall be No. 14056, Federal Standard No. 595.

First Coat—Primer: Shall be iron oxide baking primer and shall meet or exceed the requirements of FS TT-P-645.

Second Coat—Gray Enamel: Shall be light gray exterior baking enamel and shall comply with FS TT-E-489, #16251 or #16314 or #16376 gray.

Third Coat—Dark Green Enamel: Shall be DARK GREEN exterior-baking enamel and shall comply with A-A2962. The color shall be No. 14056, Federal Standard No. 595. The inside of the visors shall be according to FS TT-P-527. The color shall be lusterless black Color No. 37038 to comply with Federal Standard No. 595.

M.16.08—Pedestrian Push Button: Pedestrian push buttons shall be of substantial tamper-proof construction and shall consist of a direct push type button with a single momentary contact switch in die-cast aluminum alloy housing to meet the minimum requirements of ASTM B 85, on which shall be attached the push button advisory sign as shown on the plans.

The switch shall have snap action contacts, connected by a three-bladed beryllium copper spring, and shall be rated at 10 amperes, 125 volts. Pedestrian push buttons shall not have any levers, handles, or toggle switches externally or internally, and shall operate on 12 volts AC. The pedestrian push button shall conform in size and the required force to activate the pedestrian signals as specified in the Americans With Disabilities Act (ADA), Section 14.2.6 Crossing Controls.

The assembly shall be weatherproof and so constructed that it will be impossible to receive any electrical shock under any weather conditions. Installations within the housing shall be so designed that they can be removed as units from the housing for the purpose of inspection and maintenance. Push-button contacts shall be entirely insulated from the housing and operating buttons. The contacts shall be normally open, and shall be closed only when the push buttons are operated by pressure, restoring immediately to the normal open position when the pressure is released. The back of the housing shall be flat type to provide a rigid installation. Cable entry shall be through the back so that all wiring may be concealed with no external conduit required, except when indicated on the plans.

Painting: All surfaces of the unit shall be finished with three coats of infrared oven baked paint, before assembly.

First Coat: Primer, shall be epon oxide baking primer and shall **meet and exceed one performance specification of FS TT-P-636.**

Second Coat: Gray Enamel, shall be lusterless and shall comply with FS TT-E-527.

Third Coat: Yellow Enamel, shall be Federal Yellow Baking Enamel and shall comply with FS TT-E-489. The Color shall be 13538 according to Federal Standard No. 595.

M.16.09—Controllers: The materials for this work shall conform to the following requirements:

1. Pretimed Controller: It is the purpose of this section to set forth minimum design and operating requirements for the 3-dial pre-timed expansible type controller.

Constancy of Intervals: The length of any interval portion shall not change by more than 5% when the voltage of the power supply varies from 95 volts to 130 volts and the ambient temperature within the cabinet housing the controller varies from -30° F to 160° F (-34° C to 71° C). This performance shall be obtained without the use of any heater elements.

Power: The controller and all associated equipment shall be designed for use with 120-volt 60-cycle single-phase, alternating current.

Components: All components of the controller shall be designed for heavy duty. All motors, operating coils, bearings, contacts, relays, flashers, etc. shall be sufficiently large, rugged, and accessible to insure reliability and minimum maintenance. The dial contacts shall be of the leaf-spring type mounted on a molded bakelite block and equipped with terminal screws. The contact size shall be at least 1/4-inch (6.4-millimeter) diameter, 1/16-inch (1.6-millimeter) thick, and contain at least 90% pure silver. The contacts that handle any signal light load shall not require fine adjustment and readjustment for satisfactory and continuous operation. All such mechanisms shall be neatly and systematically arranged to make possible thorough inspection while **the controller is operating in accordance with its normal functions.**

Cabinet: Each controller assembly shall be completely wired and housed in a rigid metal cabinet with a suitable finish. The cabinet shall be of clean-cut design and appearance and shall be substantially constructed of aluminum. The pedestal mounted and pole mounted cabinets shall be approximately 15 inches x 19 1/4 inches x 35 inches (380 millimeters x 490 millimeters x 890 millimeters) in size or the equivalent in volume, and the base mounted cabinet shall be approximately 17 inches x 34 inches x 48 inches (430 millimeters x 865 millimeters x 1220 millimeters) in size or the equivalent volume. The cabinet shall have a main door which shall be equipped with a special CONN-1 lock and key and an auxiliary door which shall be equipped with a lock and a police key. Door hinge pins shall be of stainless steel material. Two keys shall be furnished for each lock. When closed, both doors shall fit tightly to neoprene gasketing material. The cabinet shall contain a suitably designed vent for the purpose of releasing any explosive gases which may enter the cabinet. The "T" vent (1 1/2-inch (38-millimeter) diameter) shall be mounted on the top of the cabinet, with a screen vent at the bottom of the cabinet.

A panel behind the auxiliary door shall contain the following:

1. A switch to control the change from automatic control to flashing operation and vice-versa. In the flashing position, the control unit shall not be de-energized.

2. A switch to control the change from automatic control to manual operation and vice-versa. A manual cord not less than 6 feet (2 meters) long equipped with a rubber-covered hand switch, and permanently installed.

3. A "Main Switch" which will be used for signal shutdown. During signal shutdown, power to the controller shall be unaffected. The function of this switch can be incorporated into the flash switch by providing a three-position switch (NORMAL-OFF-FLASH).

The cabinet shall contain a means of mounting the controller, which will permit easy access to controller while in operation and accessibility to the components and

terminals for maintenance and repair purposes. The cabinet shall be provided with necessary openings for mounting and connections and be wired to include a cable for time-clock installations with an octal 5-pin plug.

All panel wiring shall be neat and firm and the panel, which shall be mounted in the rear of the cabinet, shall mount the following:

1. Neutral Bus Bar, for neutral side of power supply line. This Bus Bar shall be rated for 30 amperes.

2. Terminals for conductors of signal light cable - one for each signal circuit and one or more terminals for the common conductors. This terminal bus shall be rated for 30 amperes. No pressure type terminal blocks will be accepted.

3. A 1-piece 120-volt convenience outlet and lamp receptacle. A heavy-duty 30-ampere screw-type fuse and socket shall be mounted on the left side of the controller cabinet. The controller equipment and terminals shall be so arranged within the cabinet that they will not prevent the entrance, training and connection of the incoming conductors. All field terminals shall be suitably identified.

The cabinet shall have a hole for cable entrance into the bottom of the cabinet of at least 3 inches (76 millimeters) in diameter. There shall be an adapter for mounting the cabinet on a 4-inch (100-millimeter) pipe, provided with each cabinet.

The outgoing traffic control signal circuits shall be of the same polarity as the line side of the power supply. The grounded side of the power supply shall be grounded to the controller cabinet.

All conductors shall be provided with lugs for attachment to binding posts. Combining of conductors to one lug will not be allowed. Non-hygroscopic materials, having good insulating qualities, shall be used for all insulating purposes. All internal wiring to lamp circuits shall be #14 AWG stranded drawn copper. Wiring shall be cabled. The cable connection from the panel board to the controller shall be made by an "MS" type positive plug. A minimum of 19 signal circuits shall be provided each rated at a minimum of 15 amperes.

Leakage resistance between electrical connections or to ground shall not be less than 1 megohm. A minimum spacing of 1/2 inch (13 millimeters) shall be maintained between any terminal connection and any other similar connection or ground. The electrical connection from the controller to the outgoing and incoming circuits shall be made in such a manner that the controller may be replaced with a similar unit without the necessity of disconnecting and reconnecting the individual wires leading therefrom. Connector plugs shall be used that will contain sufficient contacts for proper functional operation of the controller. The controller to be supplied shall be wired complete for three 3-dial operation. All relay jack panels shall be of the female type.

Timer: The timer of the controller shall consist of a signal switching unit with a combination interval and offset timing dial unit securely mounted and of such construction that the entire timer assembly can be swung out from the cabinet for inspection or maintenance without breaking any electrical connections or interrupting the normal operation of the controller. The timer shall be connected electrically to the panel of the controller by means of an electrical jack or plug disconnect that will permit quick removal of the complete timer assembly as a single unit when necessary.

Timer Housing: The timer shall be enclosed in a rigid metal housing with a transparent window so that all timing settings, interval, offset and total cycle length control shall be visible but not accessible when the control box door is open.

Color Sequence: It shall be possible by effecting a change in the shape of the cams operating the signal circuit contacts to obtain any signal color sequence desired. A minimum of 19 signal circuits and 16 signal color intervals shall be provided on a single cam bar.

Period Timing: All signal color interval adjustments shall be quickly made, without tools, from the front of the timer on a dial clearly marked and calibrated in percent from 0% to 99%. Any signal color interval shall be adjustable to a minimum of 2% in steps of 1%. The timing dial shall give a visual indication of the relative length of each color period at all times. The duration of each signal color interval in percent of the total time cycle shall be as indicated on the percentage dial calibration. Each timing key shall be self-locking in the timing dial.

Timing Dial Units: The controller shall be furnished with three dial units each consisting of a synchronous motor-driven timing dial together with its dial contacts and other necessary parts and shall be provided with adequate mechanical mounting and electrical jacks so that it can be removed and/or replaced quickly without the use of tools in a single operation wherein both mounting and electrical connections are made simultaneously.

Motor: A drive coil shall drive the synchronous motor at the cycle length called for by the timing gear. There shall be provided a means of positively stopping the dial motor while the local controller is re-synchronizing with the master controller.

Each motor shall be of the self-starting synchronous type, such as Telechron heavy duty or disk type and shall have sufficient torque to permit its dial to operate synchronous at all outside temperatures between -30° F and 160° F (-34° C and 71° C). The transfer to an unused dial shall be possible within this same temperature range. The motor torque shall be sufficient to operate the timer at synchronous speed when used with a 30-second cycle and shall be sufficient to overcome any tendency to slow up due to shocks or vibration, thereby providing synchronous operation between the limits of 95-130 volts.

Timing Dial: The timing dial shall support the timing keys over their entire length and shall contain 100 precision die-cast slots for this purpose. All timing keys for a given function shall be identical and each key having specialized function shall be appropriately colored to provide a visual indication of such function. All contacts operated by the various timing keys shall have helical springs controlling both movement and contact pressure so that flexible arm adjustments are eliminated.

It shall be possible to keep the timing dials, not controlling the sequence at any given time, running continuously. This will allow an offset relationship to be maintained between on interconnected (hard-wire) intersections.

Cycle Change: Each controller shall be furnished with a cycle gear as specified on the plans, installed in the timing dial unit and gears for 60-70-80-90-100 seconds shall be furnished and stored in the controller cabinet. The range of possible gear change shall be from 30 to 120 seconds in 5-second steps with gears other than those normally supplied with the controller. Gears within the 30- to 120-second range shall be available from the controller manufacturer. It shall be possible to change the total cycle on the street easily and quickly without the use of tools. The action of changing gears shall automatically indicate the total cycle value in use on a scale visible from the front of the timer. The mesh between the motor pinion and any time cycle gear shall be indexed automatically so as to result in proper mesh for free-running gearing and to avoid any possibility of binding which might affect synchronous operation of the driving motor.

Manual Offset: Due to the synchronous motor drive of the timing dial, it shall be possible to obtain coordination between respective dials at adjacent but non-interconnected intersections by means of a simple motor synchronizing switch mounted on the front of the dial unit where it will be tamper-proof by virtue of the timer housing herein before specified.

Automatic Offset: The timing dial unit shall be equipped with means by which it may be automatically resynchronized by remote control when connected to a master controller. The dial unit shall be furnished complete for triple offset. The controller shall be so wired that a choice of 3 different offsets on the dial may be remotely selected over a total of not more then 3 interconnecting offset conductors.

All offset adjustments shall be made without tools on the same timing dial as the signal color period adjustment but calibrated separately in steps of 1% from 0% to 99% in the reverse direction from the color period timing. Each offset key shall be clearly identifiable. It shall only be necessary to move one offset key to change an offset setting and each key shall be self-locking in the timing dial.

Signal Switching Unit: The signal switching unit shall provide wiring for a minimum of 19 signal light circuits. Each of the signal contacts shall open and close independently of each other so that the flexibility of their operation shall not be limited. The movable signal circuit contact arms shall be of hardened steel or other suitable rigid material so

that they shall be wear-resistant and shall not flex, bend or take a permanent set in operation.

All make and break contact tips, whether movable or fixed, shall give contact faces not less than 5/16 inch (8 millimeters) in diameter, 1/8 inch (3.2 millimeter) thick and shall be made of at least 90% pure silver and 10% cadmium oxide, by weight (mass), or superior alternate material. The contacts shall be capable of breaking a current of 15 amperes, 120-volt, 60-cycle alternating current, one million (1,000,000) times without excessive pitting or burning when operated 120 times an hour. All signal contacts shall be readily accessible and easily inspected. The operation of moving or replacing movable contacts shall not change the contact pressure adjustment and shall be accomplished easily and quickly with the use of simple tools. The stationary contacts shall be replaced by the use of simple tools.

The ratchet motor shall be capable of effectively changing the position of the cams with equal efficiency up to and including the capacity of the camshaft.

Panel Board: A molded or pressed panel shall be provided on which all signal terminals (plus and common), relays, flashing mechanism and switches, flash combination terminals, terminals for field addition of manual switch accessory and terminals to allow all dial motors to run under non-interconnected operation shall be mounted.

Flasher: A Jack-mounted, unit type motor-driven or solid state flasher complete with radio interference suppressor shall be furnished to permit flashing operation of the signals when the timer is disconnected and removed from the controller. This shall be a two-circuit flasher rated at approximately 20 amperes.

Manual and Remote Switches in the Auxiliary Door: Manual switching flexibility shall be provided to permit the following operations:

Flashing Operation: The manual and remote flash switch or relays shall provide flashing indications for 4 independent circuits so that the controller may be used to control 2-phase vehicle movements and 4-phase vehicle movements (in doing so, power to dial motors shall be unaffected). In addition flash combination terminals shall allow the selection of flashing either yellow or red on the cross streets.

Manual Operation: The Auto-Hand switch shall provide means whereby manual timing of the signals may be obtained with a separate momentary contact hand switch. Operation of the timer by manual control shall provide the same color sequence as on automatic operation and no momentary undesirable indications shall show. Manual control shall be possible with the main door of the cabinet door closed.

Dial Selector Switch: The manual dial selector switch in the main cabinet shall provide for the selection of dials by:

1. Remote Control

2. Dial 1
3. Dial 2
4. Dial 3
5. Clock Position

Relay Wiring Provisions:

Jack-mounted relays shall be provided for:
1. Flashing 4-signal circuits
2. 2-dial transfer relays

Wires and Insulation: Except where soldered, all wires shall be provided with lugs or other approved terminal fittings for attachment to binding posts.

All wiring between various parts of the control box shall be a minimum of #18 AWG type TFF with 2/64—105 C. thermoplastic insulation or approved equivalent. Where cable wire must be clamped to the walls of the control box to prevent undue wear or flexing of the wires, such clamps shall be of suitable non-conducting material, such as rubber insulated metal straps.

The wiring from the timer jack connection to the terminal board shall be covered with a braided stocking or other method approved by the Engineer. The individual signal circuit wiring shall have a current carrying capacity of not less than 15 amperes.

Actuated Pedestrian Phase: The actuated pedestrian phase shall be obtained by effecting changes on the signal circuit cams and the dial drum in conjunction with auxiliary equipment which shall be external to the controller. Other than these changes, the controller shall be standard in all respects.

When an actuated pedestrian phase is called for, the pedestrian timing shall be taken out of 2 phases with no change in the cycle length.

The pedestrian clearance interval shall be flashing "DON'T WALK."

Painting: All outside surfaces of the cabinet and door shall be finished with 3 coats of infrared oven-baked paint before assembly.

First Coat—Primer: Shall be epon oxide baking primer and shall meet or exceed FS TT-P-636.

Second and Third Coats—Aluminum: The second and third coats will be aluminum paint in conformance with the requirements of Article M.07.12.

Manuals: The contractor shall secure from the manufacturer a comprehensive service controller.

Six (6) paper prints of the cabinet wiring diagram the entire field connection chart shall be left blank.

A comprehensive parts list, detailing all replaceable components as to manufacturer part number, and commercially available part number, and manufacturer's net price each, shall be provided. This list may be referenced from the drawings supplied with the equipment.

Guarantee: The contractor shall secure from the manufacturer a guarantee for the equipment for a period of 12 months, which time shall commence from the date of delivery. If a unit is found to be defective during this 12-month period, it will be the responsibility of the contractor to assume the cost of shipping the controller to and from the factory, supplying parts and making repairs at no cost to the State of Connecticut.

M.16.10—Flasher Cabinet:

1. Cabinet: All equipment shall be housed within an aluminum or aluminum alloy weatherproof cabinet. If not cast aluminum, the seams shall be at least 0.125 inches (3.2 millimeters) in thickness and the seams shall be continuously welded. The cabinet shall be clean cut in design with a door, which shall encompass substantially the full area of the front of the cabinet. When closed, the door shall fit tightly to neoprene gasket material. The door shall be equipped with a CONN-1 lock and shall have stainless steel hinge pins. Two keys shall be provided with each cabinet. The cabinet shall have a screened "T" vent on top and a screened cut out of the bottom for ventilation. The size of the cabinet shall conform to the following dimensions:

Depth	Width	Height
12-14 inches	12-16 inches	14-25 inches
(305-355 millimeters)	(305-405 millimeters)	(355-635 millimeters)

A panel shall be mounted in the back of the cabinet on which shall be mounted the following items:

(a) Circuit Breaker - 15 Amp
(b) Duplex Convenience Outlet
(c) Lamp Receptacle
(d) Terminal Block – Heavy-duty, screw type, to accommodate lugs for wire size #16 to #14 AWG.
(e) Neutral Buss Bar - Rated for 30 Amps.
(f) Radio interference filter - Rated for 30 Amps, 120 VAC, 60 HZ, and shall meet the standards of the Underwriter's Laboratory and the Radio and Television Manufacturer's, Association.
(g) Solid-State flasher mounting rack and socket.

2. Flasher: The flasher shall conform to the latest NEMA Publication, part 8, with the following additions:

The flasher output shall be from optically isolated solid-state relays.

The solid-state relay shall switch off with an input between 3 and 32 volts D.C.

The flasher shall have an L.E.D. indicator connected to each output for visual reference.

M.16.11—Vacant

M.16.12—Loop Vehicle Detector and Sawcut: The materials for this work shall conform to the following requirements:

1. Loop Vehicle Detector:

A. Functional Requirements: The loop detector shall be an electronic device, capable of detecting the presence of a moving or parked vehicle; and the detection shall be accomplished by the presence of a parked or moving vehicle over a wire loop embedded in the pavement. The detector unit shall be of the "self-tuning type." The detector shall be capable of tuning to an inductance range of 50-1000 micro Henries. It shall be possible to select a minimum of the following modes of operation, which shall function as follows.

(1) Mode 1 (Short Detection): The detector sensing unit shall detect a vehicle as slow as 1/10 mile per hour (0.2 kilometer/hour) entering the loop. If a vehicle stops over a portion of the loop such as waiting for a left turn, the remaining portion of the loop shall detect additional vehicles passing over the unoccupied portion of the loop. The time for the remaining portion of the loop to become capable of detecting additional vehicles shall be no longer than the minimum time it takes for the next vehicle to pass over the loop.

(2) Mode 2 (Long Detection): The detector sensing unit shall detect a vehicle as slow as 1/10 miles per hour (0.2 kilometer/hour) entering the loop. When a vehicle remains over the loop or a portion thereof, the detector sensing unit shall cause detection to persist up to at least 10 minutes. After this period any vehicle passing over the unoccupied portion of the loop shall be detected.

(3) Delayed Output Detection: The detector sensing unit shall provide digital type timing, with capabilities of 0-30 seconds delay. The sensing unit shall provide the delay except when the controller is in the green interval of the associated phase. During this green, the delay set into the detector will be omitted.

The sensing unit may also be used as a standard vehicle detector by leaving the selector switch in "off" position. A standard detector wire harness with a type "MS" plug is to be used.

B. Electrical Requirements: The detector sensing unit shall operate on 115 volts, 60 cycles A.C. and shall draw not more than 15 watts.

The unit shall contain an integral regulated power supply which will operate independent of line voltage variations between 100 and 135. The power supply shall be regulated by Zener reference and series regulation and shall be fused.

The detector shall operate properly at all temperatures between -30° F and +150° F (-34° C and 66° C). An automatic frequency control feature and automatic equalization feature shall be included in the detector to compensate for long-term drift due to environmental changes.

All transistors and integrated circuits shall be plug-in type for serviceability. The detector relay driver shall employ a silicon transistor.

C. Mechanical Requirements: The detector shall be housed in a durable finished fabricated sheet aluminum case. No special tools shall be required for removal of the cover. Removal of the cover shall provide access to the entire circuit and all components while the unit is connected and operating. The electrical connections of both the incoming and outgoing circuits shall be made by means of suitable multi-pin plug. The entire unit shall be replaced with a similar unit without the necessity of disconnecting the reconnecting individual wires leading therefrom. The plug receptacle shall be attached to one end of a connecting cable at least 48 inches (1.2 meters) long. The cable shall be color coded and each wire shall be fitted with a spade type lug for easy attachment to the controller terminal block.

A switch mounted on the front of the detector unit shall be provided for selecting the mode of operation to be in effect. Also mounted on the front of the detector will be an indicator light, which will register vehicle actuations.

When 2-channel loop amplifiers are used, each channel shall have a connecting plug with all wires in each of the harnesses connected so that it may be replaced with two single channel amplifiers.

The loop identification tag shall be 3 inches x 5 inches (80 millimeters x 130 **millimeters), 10 mill (0.25 millimeters) thick plastic.**

2. Sawcut:

A. #14 AWG type THWN, or THHN stranded wire rated at 600 volts shall conform to the appropriate articles of the NEC. The wire shall be encased in flexible vinyl plastic or polyethylene tubing having a 3/16-inch (4.8-millimeter) ID, a minimum of 1/32-inch (0.8-millimeter) wall and a 1/4 inch (6.4-millimeter) OD. The tubing shall be capable of resisting deterioration from oils and solvents, have a smooth bore and be highly abrasion resistant. The loop detector wire shall conform in all respects to I.M.S.A. Specification.

B. The plastic compound shall be liquid with a synthetic resin base with a specific gravity of approximately 1.7. It shall have a minimum viscosity of 3500 centipoise second (3.5 pascal·seconds) at 77° F (25° C) and a maximum viscosity of 65,000 centipoise second (65 pascal·seconds) at 25° F (-4° C). The plastic compound shall be polymerized (cured) by the addition of a specific reaction initiator (hardener). Sufficient hardener (usually a liquid organic peroxide) shall be used to cure the plastic compound in approximately 30 minutes at 70° F (21° C). It shall be possible to cure the compound at temperatures below freezing. The plastic compound, after curing shall have sufficient strength and resiliency to withstand stresses set up by vibration and expansion and contraction due to temperature changes. The compound shall also be resistant to most chemicals and solvents, including most salts, acids and hydrocarbons.

The plastic compound shall conform to the following testing requirements: ASTM D 149, ASTM D 495, ASTM D 638, ASTM D 1167, and ASTM D 192.

A one-part urethane elastomeric compound may be substituted for the plastic compound.

The elastomeric compound shall not require curing by the addition of a reaction initiator. The uncured elastomeric compound shall have a viscosity of 5,000 centipoise second to 35,000 centipoise second (5 pascal·seconds to 35 pascal·seconds). The elastomeric compound shall be viscous enough not to flow out of a sawcut in a sloped road, but still fully encapsulate all wires in the sawcut. The elastomeric compound shall form a surface skin within 60 minutes at 75° F (24° C). The elastomeric compound shall be packaged in a standard liter caulking cartridge with the nozzle designed for insertion in a sawcut 0.25 to 0.125 inch (3 millimeters to 6.4 millimeters) in width and 1.5 to 2.5 inches (38 to 64 millimeters) in depth. The compound shall also be available in 5-gallon (19-liters) pails to be used with a pneumatic pump application system. After hardening, the elastomeric compound shall remain flexible and exhibit no visible shrinkage. The elastomeric compound shall have sufficient strength and resiliency to withstand normal stresses such as: vibration, expansion and contraction; and to resist most chemicals and vehicular fluids such as: motor oil, gasoline, brake fluids, and antifreeze solution.

The elastomeric compound shall conform to the following testing requirements: ASTM D 1875, ASTM D 2834, ASTM D 1640, ASTM D 2340, and ASTM D 412.

C. The flexible plastic conduit shall conform to the requirements of ASTM D 2737.

M.16.13—Magnetic Vehicle Detector: The materials for this work shall conform to the following requirements:

1. The magnetic elements shall be housed in a nonferrous case, and they shall be waterproofed by the vacuum impregnation process. The detector shall have an internal resistance not to exceed 3500 ohms and shall be designed for operation with a magnetic detector solid state amplifier. One end of the housing shall be threaded to accommodate a conduit. The assembled detector shall not be rendered inoperative or

continuously operated by parked cars or other fixed iron objects such as road reinforcement and water or gas pipes which may be within its zone of influence.

The single lane magnetic detector shall consist of two main assemblies, the detector coil unit and the pavement box. The coil unit shall be assembled with two iron-covered coils connected in series and molded in a solid block of insulating material. The pavement box shall be a heavy duty aluminum casting with dimensions of approximately 9 inches x 8 inches x 6 inches (230 millimeters X 200 millimeters X 150 millimeters). Flanges threaded for 1 1/4-inch (32-millimeters) conduit will be provided on two sides and the bottom. The box shall have a removable cover, fastened with stainless steel bolts.

The concrete that is used in the installation of the pavement box shall be a fast-setting high-strength type. The concrete shall be hard enough in one hour to allow traffic to pass over it. It shall be a type acceptable to the Engineer.

The proper operation of the magnetic detector shall not be affected by extreme temperature or humidity.

2. The amplifier unit shall be fully transistorized utilizing open type printed wiring panels and high-grade silicon transistors. The printed circuits shall be of extra heavy (1 ounce (29 grams) or better) copper.

All circuits shall be designed to provide stable operation within an ambient temperature range of -30° F to +180° F (-34° C to 82° C).

The magnetic detector amplifier shall be designed for operation on a nominal 120-volt 60-cycle, single-phase A.C. supply. Nominal power consumption shall not exceed 2 watts.

The unit shall be housed in a durable finished fabricated sheet aluminum case. Removal of the unit from its case shall require the use of simple tools. When the unit is removed from the case, it shall be possible to gain access to the printed circuit panel and components.

Electrical connections of both the incoming and outgoing circuits shall be made by means of a suitable plug.

The unit shall be replaceable with a similar unit without the necessity of disconnecting or reconnecting individual wires leading therefrom.

The plug shall be of protected male construction and rigidly fixed to the front of the unit.

The mating plug receptacle shall be attached to one end of a connecting cable at least 24 inches (610 millimeters) long. The other end of the connecting cable shall have

color-coded leads, each of which shall be fitted with a spade lug for easy attachment to terminal blocks.

The sensitivity of the unit shall be dial adjustable, and continuous over the full range. On the front of the unit adjacent to the adjustment dial and connector plug there shall be mounted two jacks for the purpose of checking the proper adjustment of the sensitivity knob.

The registration of overlapping pulses from two detector amplifier units shall be ensured by the use of normally open and normally closed contacts provided on the output relay. Any contact that opens or closes in response to vehicle actuations shall be capable of making, breaking, and carrying 3 amperes at 120 volts A.C. The front panel of the detector amplifier unit shall contain a "Detection Indicator Lamp" that will pulse as each actuation is registered.

M.16.14—Control Cable: The materials for this work shall conform to the following requirements:

1. General: All cable and wiring to be used on this project shall conform to the appropriate articles of the NEC.

2. Conductors: Traffic control conductors shall be designed for 600 volts, AC and shall be of solid copper, having conductivity in accordance with IMSA and NEC standards.

The size of the conductors shall be as indicated on the plans.

3. Cable: Traffic control cable shall be multi-conductor and polyvinyl chloride or polyethylene sheathed. Insulation shall be polyethylene. Sheathed insulation and color coding shall conform in all respect to IMSA Specification No. 19-1 or No. 20-1, whichever is applicable. The Contractor shall furnish a manufacturer's warranty that the cable furnished is resistant to damage and deterioration by sustained contact with greases or oil.

Magnetic and loop detector lead-in cable shall be two conductor cable using stranded tinned copper conductors, color-coded polyethylene insulation, an aluminum backed mylar shield with a stranded tinned copper drain wire over the twisted pair, a black polyethylene outer jacket, and is listed under U.L. Style 2106. The loop lead-in cable shall conform to I.M.S.A. specification 50.2.

4. Number of Conductors: Sufficient signal light conductors shall be provided to perform the functional operation of the signal system. The number of conductors utilized shall be as indicated on the plans or as directed by the Engineer. Power supply cable between the sources of power and the controller shall consist of 600-volt, 2-conductor stranded wire of the size and type called for on the plans.

The number of conductors set forth in the plans is the minimum number that the Contractor shall supply. The Contractor may supply more than the specified number of conductors at his own expense.

5. Cable Closure: The cable closure shall be made of Neoprene construction. Internal brackets shall be aluminum and external parts shall be stainless steel or aluminum. The cable closure shall be provided with 4 entrances, each of which will accommodate cable with a diameter of .6 inches to 1 inch (15 millimeters to 25 millimeters). The size of the closure shall be as shown on the typical plan sheet. The cable closure shall be provided with the minimum number of terminal blocks shown on the plans. Each terminal block shall be provided with 12 brass studs, nuts, and 24 washers. The block shall be a solid injection molded ABS (acrylonitrite butadiene styrene) that has a low moisture absorbtion rate. The terminal blocks shall be approximately 3 1/4 inches wide x 1 1/2 inches high x 1/2 inch thick (83 millimeters wide x 38 millimeters high x 13 millimeters thick) and be provided with mounting studs.

M.16.15—Messenger and Span Wire: The materials for this work shall conform to the following requirements:

1. Messenger wire shall be a double galvanized, 7-strand steel wire cable not less than 3/16 inch (4.8 millimeters) in diameter and 2,400 pounds (10.7 kilonewtons) breaking strength, utilities grade.

2. Span wire shall be double galvanized 7-strand steel wire cable not less than 3/8 inch (9.5 millimeters) in diameter and 11,200 pounds (50 kilonewtons) breaking strength, utilities grade.

3. All hardware accessories as shown on the plans used in span wire or messenger mounting shall be of high strength, double galvanized, first quality materials.

M.16.16—Vacant

M.16.17—Illuminated Signs: The sign shall be a blank-out type which shall display the type of message specified, through the use of light-transmitting fiber optic bundles.

The legend displayed shall be in accordance with the plans. Shop drawings of the front panel showing the lettering, and the type of visor shall be submitted for approval. The message shall be clearly legible under any lighting condition without the need for a visor or hood and attract attention at full intensity, anywhere within a 20-degree cone centered about the optical axis. The message shall be blank when not illuminated.

The non-lensed bundles shall be fully bifurcated for burnout protection with 8 lamps. The diameter of the fiber bundles shall be as shown on the plans. There shall be a separate fiber bundle, from each of the light sources, displayed in a row along the bottom of the sign to indicate lamp outage. All fiber optics, transformers and lamps shall be mounted on the hinged door of the unit. The blank-out sign assembly shall display

the message in "Lunar White." Type "ENL" quartz-halogen lamps shall be used to illuminate the message. These lamps shall operate between 10.5 and 10.8 volts via the supplied step-down transformers. Average lamp life shall be not less than 8,000 hours. The lamps shall be mounted horizontally. "Overhead Illuminated 'Stop Ahead' Signs" shall have an 8-lamp minimum.

The electrical connection shall be provided by an internal barrier-type strip for connecting the electrical service wires. There shall be a 15 amp A.C. snap switch mounted in a utility box on the inside of the sign, enabling the sign to be shut off during maintenance. Power consumption for the message shall be less than 500 Watts.

A weatherproof housing of the dimensions specified on the plans shall be provided to enclose the fiber optic module assembly with bifurcated output fiber bundles, color filters, light sources and transformers. The sign housing frame shall be manufactured from extruded aluminum, 6061-T6, ASTM B-221. This assembly shall be provided with a hinged access door. The hinge shall be stainless steel piano type hinge mounted on the left side of the door. All external hardware shall be stainless steel, internal hardware shall be corrosion resistant. The housing shall have a minimum of four 1-inch (25-millimeter) diameter drainage holes. The entire front face of the sign shall be protected by a 1/8 inch (3.2 millimeter) thick sheet of clear polycarbonate mounted in the door frame. The housing shall be Federal Yellow according to Federal Standard 595 Color No. 13538 and the aluminum front panel shall be flat black according to Federal Standard 595 Color No. 37031 unless otherwise specified on the plans. The complete sign assembly shall not have a mass of more than 150 pounds (68 kilograms).

The legend displayed for an "Overhead Illuminated 'Stop Ahead' Sign" shall consist of letters 12 inches (305 millimeters) high and approximately 9 inches (230 millimeters) wide formed by fiber optic bundles spaced approximately 1.5 inches (38 millimeters) apart. The sign shall be supplied completely assembled and ready to be checked out.

SECTION M.17

ELASTOMERIC MATERIALS

M.17.01—Elastomeric Bearing Pads: Elastomeric bearing pads shall be of the compound known as neoprene. All laminated bearings, and unlaminated bearings more than 1 inch (25 millimeters) thick, shall be individually cast in molds under pressure and heat and shall be of the size and grade indicated on the plans. Unlaminated bearings of 1 inch (25 millimeters) or less in thickness may be cut from sheet stock. All elastomeric bearing pads shall meet the requirements listed herein. Test specimens shall be in accordance with ASTM Method D 15, Part B.

1. Elastomer:

(a) Physical Properties

Grade (Durometer)	50	60	70
Original Physical Properties Hardness ASTM D 2240	50±5	60±5	70±5
Tensile strength, minimum psi (megapascals) ASTM D412	2,500 (17)	2,500 (17)	2,500 (17)
Elongation at break, minimum %	400	350	300
Accelerated Tests to Determine Long-Term Aging Characteristics Oven Aged-70 hrs./212° F (100°C)., ASTM D 573			
Hardness, points change, maximum	+15	+15	+15
Tensile strength, % change, maximum	–15	–15	–15
Elongation at break, % change, maximum	–40	–40	–40
Ozone-1PPM in Air by Volume- 20% Strain -100± 2° F (38±1°C) ASTM D 1149* 100 Hours	No Cracks	No cracks	No cracks
Compression Set-22 Hrs./212° F (100°C), ASTM D 395-Method B, % maximum ASTM D 746-Procedure B	35	35	35
Brittleness at -40°F (–40°C.)	No failure	No failure	No failure

*Samples to be solvent wiped before test to remove any traces of surface impurities.

**Effective rubber thickness.

(b) Oil Swell Test: The volume of elastomer, when submerged in ASTM Oil No. 3 for 70 hours at 212° F (100° C) shall not increase by more than 120% as tested by the procedure contained in ASTM D 471.

2. Laminae:

(a) Laminae where so noted on the plans, shall be of the thickness, material and number noted. Steel laminae shall be blast cleaned before being cast integrally with the elastomer, and shall be ASTM A 36 steel or an approved steel equivalent. Aluminum laminae shall be pickled before being cast integrally with the elastomer and shall meet the requirements of AAA 6061-T6. Cut edges or perforations of the laminae shall be at least as smooth as USASI 250 finish.

(b) The length and width of the laminae shall be 3/8 inch (9.5 millimeters) (± 1/16 inch (1.6 millimeters)) less than the pad dimension. The thickness of the laminae shall be as shown on the plans +0.012 inch (+0.3 millimeter). The vertical dimensions for the position of the laminae shall be as shown on the plans ± 1/16 inch (1.6 millimeters). The vertical dimension between the bottom of the pad and any point on a particular laminae shall not vary by more than 1/16 inch (1.6 millimeters). The laminae shall have a minimum 1/16-inch (1.6-millimeter) side cover after the pad is manufactured.

3. Fabricated Pads:

(a) The elastomeric bearing pads shall conform to the following requirements:

1. The finish, flash and bond of laminated bearings shall conform to the following requirements as noted in RMA, Rubber Handbook, latest edition.

Symbol	**Requirements & Reference**
F3	Finish—Table V
T.063	Flash—Table VI

B2 Grade 2, Method B Rubber to Metal Bonding, Tables VII and VIII

(2) The dimensional tolerances of plain and laminated bearings shall conform to the dimensions and configurations required by the plans and these specifications with the following permissible variations.

1. Overall Vertical Dimensions Average Total Thickness 1 1/4 inch (32 millimeters) or less	– 0,+1/8 inch (3.2 millimeters)
Average Total Thickness over 1 1/4 inches (32 millimeters)	– 0,+1/4 inch (6.4 millimeters)
2. Overall Horizontal Dimension 36 inches (914 millimeters) and less	– 0,+1/4 inch (6.4 millimeters)
Over 36 inches (914 illimeters)	– 0,+1/2 inch (12.5 millimeters)
3. Thickness of Individual Layers of Elastomer (Laminated Bearings Only)	±1/8 inch (3.2 millimeters)
4. Variation from a Plane Parallel to the Theoretical Surface (as determined by measurements at the edges of the bearings)	
Top	1/8 inch (3.2 millimeters)
Sides	1/4 inch (6.4 millimeters)
Individual Non-Elastic Laminates	1/8 inch (3.2 millimeters)
5. Position of Exposed Connection Members	1/8 inch (3.2 millimeters)
6. Edge Cover of Embedded Laminates or Connection Members	– 0,+1/8 inch (3.2 millimeters)
7. Size of Holes, Slots or Inserts	± 1/8 inch (3.2 millimeters)
8. Position of Holes, Slots or Inserts	± 1/8 inch (3.2 millimeters)

Buffing, cutting, or any other attempt to alter the size of the pads, for the purpose of meeting the tolerances stated herein will not be permitted.

(b) The following values shall be met under laboratory testing conditions of full size bearings:

(1) Compressive strain of any layer of an elastomeric bearing shall not exceed 7% at 800 psi (5.5 megapascals) average unit pressure, or at the design dead load plus live load pressure if so indicated on the plans.

(2) The shear resistance of the bearing shall not exceed 50 psi (345 kilopascals) for 50 durometer, 75 psi (517 kilopascals) for 60 durometer or 110 psi (758 kilopascals) for 70 durometer at 25% strain of the total effective rubber thickness after an extended 4-day ambient temperature of -20° F (-29° C).

(c) A minimum of 30 days prior to the installation of the elastomeric bearing pads, the Contractor shall deliver to the job site the required number of pads for installation plus the required number of test pads. Pads shall be packed in containers holding not more than 10 pads. The pads in one container shall be of the same type, size and shall be for one structure only. The containers shall be plainly marked with the type and number of pads, the project number, the bridge number, the name of the manufacturer and the lot number. A lot of elastomeric bearing pads is defined as the number of pads manufactured from one batch of elastomer. A batch of elastomer is defined as the amount of elastomer prepared and compounded at one time. The Contractor shall furnish Certified Test Reports and Materials Certificates for each lot in conformance with the requirements set forth in Article 1.06.07.

(d) For structures requiring less than 50 pads, one test pad shall be furnished. For structures requiring more than 50 pads, 1 extra test pad shall be furnished for each additional 50 pads or part thereof. If there are two or more types of pads in one structure, and only one test pad is required, the test pad will be furnished for the type of which there are the greater number. All test pads shall be furnished without charge.

(e) All of the pads on one structure shall be manufactured by the same firm.

(f) Pad Identification: Each pad shall have embossed on it the following: the word "Conn." the project number, the manufacturer's identification code, the pad type number, and the month and year of manufacture. The pad shall also have stenciled on it, with indelible ink the bridge number, the lot number and the pad number. The location of the identification shall be as shown on the plans.

4. Adhesive for Bonding:

(a) The adhesive for bonding the elastomeric bearing pads to steel or to the concrete surfaces where indicated on plans shall be an approved type and shall be a controlled setting adhesive made of such materials that it is compatible with the elastomeric pads, steel and concrete.

(b) The adhesive shall be a two-component, contact, long-lasting, high bonding strength material and shall be an air curing adhesive meeting the following requirements:

Property	**Requirement**	**ASTM Test Procedure**
Tensile Strength, min., psi (megapascals)	1800 (12.5)	D 412
Elongation before breaking, min., %	750	D 412
Brookfield Viscosity @ 77° F (25°C), #2 Spindle @ 10 rpm, pascal·seconds	2500 - 3500 (2.5-3.5)	D 1084
Average Mass per gallon, pounds (liter, kilogram)	7.60 $\pm$ (0.91)±5%	

The 90° peel-pull test is described in MIL-R-15058G (ships) shall exceed 35 psi (241 kilopascals). If the adhesive which is applied to the bonded surfaces requires a primer, the primer shall be supplied by the manufacturer of the adhesive.

(c) The Contractor shall deliver the adhesive and primer (if primer is required) to the job site a minimum of 30 days prior to installation. Each separate container of adhesive and primer shall be clearly tagged or marked with the manufacturer's name, trade-mark and batch number. A batch is defined as that amount of adhesive that can be prepared and compounded at one time. The Contractor shall furnish Certified Test Reports and Material Certificates for each batch in conformance with the requirements set forth in the Article 1.06.07.

M.17.02—Elastomeric Compression Seal: The material shall be a polychloroprene elastomer. It shall be resistant to heat, oil, and ozone, be resilient, and shall be compatible with concrete and steel. The elastomeric compression seal shall conform to the requirements of ASTM D 3542.

The compression seal in each lot shall be plainly marked with the manufacturer's name, trademark and lot number. A lot shall be defined as that amount of compression seal extruded from one batch of elastomeric compound for each width indicated on the plans. A batch shall be defined as that amount of elastomeric compound prepared and compounded at one time. The Contractor shall furnish Certified Test Reports and Materials Certificates for each lot in conformance with the requirements set forth in Article 1.06.07.

The Contractor shall deliver the compression seal to the job site a minimum of 15 days prior to installation. The compression seal shall be in a separate length or lengths for each joint as shown on the plans and each separate length shall be clearly marked for identification with the manufacturer's name, trade mark and lot number.

Prior to delivery of the compression seal the Contractor shall notify the Engineer of the date of shipment and the expected date of delivery. Upon delivery of the compression seal to the job site, the Contractor shall immediately notify the Engineer.

The Contractor shall furnish a 2-foot (610-millimeter) extra length of compression seal, identified by lot number, in each lot for purposes of inspection and testing by the Engineer. The Engineer may also inspect each separate piece of compression seal at each end to determine the conformance to the requirements stated herein.

The Engineer may reject any lot or portion of a lot that does not conform to the requirements stated herein. A rejected lot or portion of a lot may be resubmitted provided the Contractor has removed or corrected, in a manner acceptable to the Engineer, all nonconforming material.

Lubricant-Adhesive: The lubricant-adhesive shall be a controlled setting adhesive conforming to one of the following systems.

System A: The lubricant-adhesive shall be a 1-component polychloroprene compound containing only soluble phenolic resins blended together with anti-oxidents and acid acceptors in an aromatic hydrocarbon solvent mixture and shall have the following physical properties:

Average net weight per gallon (mass per liter)	7.84 pounds (0.94 kilograms) ± 5%
Solids Content	24% min. by weight (mass)
Brookfield Viscosity (77° F (25°C), #2 spindle at 10 RPM) or approved equal	6500 - 7500 centipoise second (6.5-7.5 pascal·seconds)
The adhesive shall remain fluid from	5° F to 120° F (–15°C to 49°C)
Film Strength (ASTM D 412) 750% min. elongation before breaking	2300 psi (16 megapascals) min.tensile strength

System B: The lubricant-adhesive shall be a one-part moisture curing polyurethane and hydrocarbon solvent mixture and shall have the following physical properties:

Average net weight per gallon (mass per liter)	8.00 pounds (0.96 kilograms) ± 10%
Solids Content	72-74% by weight (mass)
Adhesive to remain fluid from	5° F to 120° F (–15°C to 49°C)
Film Strength (ASTM D 412)	1200 psi (8.5 megapascals)
Elongation	350%

Only one system shall be used in a project.

The adhesive shall be stored at a temperature of 50° F to 80° F (10° C to 27° C).

Any adhesive not used within 270 days of its manufacture shall be unacceptable.

Each batch of the lubricant-adhesive shall be delivered in containers plainly marked with the manufacturer's name or trade mark and batch number. A batch shall be defined as that amount of lubricant-adhesive compounded at one time. The Contractor shall furnish

Certified Test Reports and Materials Certificates for each batch in conformance with the requirements set forth in Article 1.06.07.

SECTION M.18

SIGNING

M.18.01—Overhead Sign Support:

1. Pipes and Flanges

A. Overhead Truss Supports

Pipes for end support posts shall conform to the requirements of ASTM A 53, Grade B. Pipes for all overhead truss members and end support web members shall conform to the requirements of ASTM A 53, Grade B.

150 pounds and 300 pounds (68 kilograms and 136 kilograms) ASA Flanges for truss chord splices shall be lap joint type and shall conform to the requirements of ASTM A 181, Grade II. 400 pounds (182 kilograms) ASA lap joint flanges for truss chord splices shall conform to the requirements of ASTM A 105/A 105M, including the Supplementary Chemical Requirements of Table 1 and the Mechanical Properties of Table 2, of ASTM A 105.

B. Overhead Cantilever Supports

Pipes for posts, truss chords and truss web members shall conform to the requirements of ASTM A 53, Grade B.

Flanges for splices between outer and inner sections of truss chords shall be 150 pounds (68 kilograms) ASA Flanges, lap joint type, and shall conform to the requirements of ASTM A 181, Grade II. Special flanges and attached plates for truss chord to post attachment shall conform to the requirements of ASTM A 588 (A 588M).

2. Stainless Steel plates shall conform to the requirements of ASTM A 240, Type 304.

3. Base plates and attached stiffener plates shall conform to the requirements of ASTM A 588 (A 588M).

4. All other elements except bolts and nuts shall conform to the requirements of ASTM A 36 (A 36M).

5. After complete fabrication, each of the fabricated steel sections of all sign supports shall be hot-dip galvanized in accordance with the requirements of ASTM A 123(A 123M).

6. Nuts for anchor bolts shall conform to the requirements of ASTM A 563, Grade DH, self-locking type. Washers for anchor bolts shall conform to the chemical requirements of ASTM A 325, Type 1, and shall be quenched and tempered. Nuts and washers for anchor bolts shall be hot-dip galvanized in accordance with the requirements of ASTM A 153/A 153M, Class C. Nuts for anchor bolts shall be tapped oversize, after galvanizing, in accordance with ASTM A 563, Section 5.3, and shall be provided with a lubricant in accordance with the requirements of ASTM A 325.

High-Strength bolts, nuts and washers shall conform to the requirements of ASTM A 325, and shall be hot-dip galvanized in accordance with the requirements of ASTM A 153, Class C.

All nuts for high strength bolted connections including nuts for anchor bolts shall be "prevailing torque-reusable type" locking nuts.

7. All U-Bolts shall conform to the requirements of ASTM A 36/A 36M and shall be hot-dip galvanized in accordance with the requirements of ASTM A 153.

8. Square head bolts for supporting electrical equipment shall conform to the requirements of ASTM A 307.

9. Stainless Steel bolts shall conform to the requirements of ASTM A 193, Class 1, Grade B8. Stainless steel nuts shall conform to the requirements of ASTM A 194, Grade 8. Stainless steel lock washers shall conform to the requirements of ASTM A 167, Type 302.

M.18.02—Anchor Bolts: Anchor bolts shall conform to the requirements of ASTM A 449.

Leveling nuts and nuts for anchor bolt assemblies shall conform to the requirements of ASTM A 563, Grade DH. Leveling nuts and anchor bolt assemblies shall be hot-dip galvanized in accordance with the requirements of ASTM A 153/A 153M, Class C. Leveling nuts shall be tapped oversize, after galvanizing, in accordance with ASTM A

563, Section 5.3, and shall be provided with a lubricant in accordance with the requirements of ASTM A 325/A 325M.

The Pedestal grout leveling template shall conform to the requirements of ASTM A 36A 36M and shall be a minimum of 1/2 inch (12.5 millimeters) in thickness.

M.18.03—Vacant
M.18.04—Vacant
M.18.05—Vacant
M.18.06—Vacant

M.18.07—Delineators

1. Reflectors: The reflectors used in the delineator units shall have a reflective area, herein referred to as the lens, and a heat sealable plastic coated metallic foil back fused to the lens under heat and pressure around the entire perimeter of the lens to form a unit permanently sealed against dust, water and water vapor. The back and edge of the plastic shall be enclosed in an aluminum housing with a grommeted center mounting hole. Reflectors shall be either silver-white, amber or red as required.

The reflective lens shall be methyl methacrylate conforming to the requirements of FS L-P380B, 1968.

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

a. Testing:

Definitions:

Entrance Angle shall mean the angle at reflector between direction of light incident on it and direction of reflector axis.

Observation Angle shall mean the angle at reflector between observer's line of sight and direction of light incident on reflector.

Specific Brightness shall mean candela returned at the chosen observation angle by a reflector per square inch (millimeter) of reflecting surface for each foot-candle (lux) of illumination at the reflector.

Optical Testing Procedure—The reflector shall be tested at observation angle station 1/10° and at entrance angle degrees 0° and 20° on the Esna Reflex Photometer at the photometric distance of 10 feet (3 meters).

The specific intensity of each reflex reflector intended for use in delineators shall be equal to or exceed the following minimum values with measurements made with reflectors spinning.

		SPECIFIC INTENSITY CANDELA PER FOOT-CANDLE (LUX)		
OBSERVATION ANGLE DEGREE	ENTRANCE ANGLE DEGREE	SILVER-WHITE	AMBER	RED
1/10°	0°	119 (11)	71 (6.6)	29 (2.7)
1/10°	20°	47 (4.4)	28 (2.6)	11 (1.0)

Seal Test—Samples shall be submerged in a water bath at the room temperature. The submerged samples shall be subjected to a vacuum of 5 inches gage (127 millimeters of Hg) for 5 minutes. The submerged samples shall then be restored to atmospheric pressure and remain submerged for 5 minutes more. The samples shall then show no water intake upon examination.

2. Metal Delineator Posts:

The "Standard Metal Delineator Posts" having a weight (mass) of approximately 1.12 pounds (1.7 kilograms) per linear foot (meter) shall be made of structural steel conforming to the requirements of ASTM A 36. The posts shall conform to the dimensions shown on the plans. After delineator mounting holes have been made, the posts shall be galvanized in accordance with ASTM A 123/A 123M.

3. Bridge Rail Mounting Brackets:

The bracket shall be made of 0.125-inch (3.2-millimeter) Aluminum Alloy 6061-T6 fabricated to the dimensions shown on the plans and shall be fastened to the metal bridge rail with two 3/8-inch (10-millimeter) diameter x 5/8-inch (16-millimeter) long cadmium plated steel box head self-tapping screws. Fasteners shall conform to the requirements indicated on the plans.

M.18.08—Paint for Sign Panel Overlay: The paint to be used for the finished coat shall be an extremely durable, highest quality, semi-gloss green enamel for use on plywood and metal signs and shall be resistant to air, sun and water.

It shall consist of pigments of the required fineness and composition ground in the required vehicle by a suitable grinding machine to the required fineness. All pigments,

resins, oils, thinners and driers used shall be of the best quality, free from adulterants of any kind, and shall comply with the requirements below.

	Min.	Max.
Enamel Composition		
Pigment, %	40	—
Vehicle, %	—	60
Volatile matter in vehicle, % by weight (mass)	—	55
Coarse particles and skins retained on #325 (45 microns) screen, based on pigment, %	—	0.5
Viscosity, Krebs units at 77° F (25°C)	65	75
Weight per gallon, pounds (Mass per liter, kilograms)	10.5 (1.3)	—
Fineness of grind (North Standard)	5	—
Pigment Composition		
Chrome green, %	57	—
Extender pigment, %	—	43

The chrome green shall be Imperial A 4464 Velvet Green or approved equal.

The extender pigments shall consist of any one of the following or combination thereof: magnesium silicate, barium sulfate, or diatomaceous silica. A ratio of 50% magnesium silicate and 50% diatomaceous silica has been found to produce the desired semi-gloss.

Vehicle—The vehicle shall contain not less than 45% solids by mass and shall be composed of a long oil soya modified alkyd resin solution or solutions, petroleum solvent thinners and driers. Rosin or rosin derivatives shall not be present. The alkyd resin solution or solutions shall conform to FS TT-R-266, Type I, Class A of latest issue.

Specular Gloss—The enamel shall be flowed on a tin panel and allowed to dry for 24 hours before measuring. The specular gloss at 60° angle of incident, ASTM D 523 shall be between 35 and 45.

Color—Standard color chips may be obtained from the Connecticut Department of Transportation Division of Materials Testing, 280 West Street, Rocky Hill, Connecticut.

Setting and Drying Time—This enamel shall set to touch in less than 5 hours. It shall dry hard and tough in not more than 24 hours.

Flash Point—Not below 86° F (30° C) when determined by the Pensky-Martin Closed Flash Tester.

Water Resistance—The enamel shall be flowed on a tin panel and allowed to dry for 48 hours. After being immersed for 18 hours in distilled water, it shall show no blistering or wrinkles upon removal and shall show no dulling or change in color after two hours recovery.

Skinning—This enamel shall not skin over within 48 hours in a three-quarters filled, closed container. Small amounts of anti-skinning agents, wetting agents, suspension agents, and anti-drier absorption agents may be added at the discretion of the manufacturer.

Working Properties—The enamel shall be well ground, shall not settle in the container, and shall be capable of being broken up with a paddle to a smooth uniform enamel of good brushing consistency, and shall have good flowing, covering and leveling properties.

M.18.09—Reflective Sheeting:

1. Reflective sheeting materials shall appear on the Department's Qualified Product List for the application intended.

2. Bright Wide Angle Retroreflective:

(1) **Description:** The retroreflective sheeting shall have a smooth surface with a distinctive interlocking diamond seal pattern and datum orientation marks visible from the face. The sheeting shall be precoated with a pressure sensitive adhesive backing protected by a removable liner. Bright wide angle retroreflective sheeting material shall appear on the Department's Qualified Products List for the application intended.

(2) **General Characteristics and Packaging**: The retroreflective sheeting as supplied shall be of good appearance, free from ragged edges, cracks and extraneous materials, and shall be furnished in either rolls or sheets.

When furnished in continuous rolls, the average number of splices shall not be more than 3 per 54.7 yards (50 meters) of material with a maximum of 4 pieces in any 54.7-yard (50-meter) length. Splices shall be butted or overlapped and shall be suitable for continuous application as furnished. When furnished as cut sheets or sign faces, the sheeting shall be packaged flat in accordance with commercially accepted standards. The sheeting shall be packed in accordance with commercially accepted standards. Each carton shall clearly stipulate the brand, quantity, size, lot or run number and color. Stored under normal conditions the retroreflective sheeting as furnished shall be suitable for use for a minimum period of 1 year.

M.18.10—Demountable Copy: The materials for this work shall conform to the following:

1. Reflex Reflector:

Demountable copy consisting of plastic reflectors mounted in embossed aluminum frames shall be used where shown on the plans. All letters, symbols, and borders shall be demountable copy of the size and design conforming to the "Manual of Signs and Pavement Marking of the National System of Interstate and Defense Highways."

Demountable copy with plastic reflex-reflectors shall consist of reflectors securely supported by individual embossed metal frames. The metal frames shall be fabricated of no thinner than 0.040-inch (1-millimeter) sheet aluminum for copy and 0.032-inch (0.8-millimeter) aluminum for border. Both shall be thoroughly cleaned after fabrication and treated for protection against corrosion. The frame shall be neatly finished in a workmanlike manner and shall have embossed edges.

Frames shall be painted with three coats of white baking enamel. Metal part of the letters, digits, symbols, and borders shall withstand 50 hours of salt spray in accordance with the requirements of ASTM B117 with no evidence of rusting or pin holing. The frames shall be fastened to the panel background with aluminum rivets. Rivets shall be of the pull through type and of the size and number designated by the demountable copy manufacturer. Wherever a directional arrow is to be installed on a sign, the arrow shall be installed in the field.

The round reflectors shall consist of a clear, transparent face, hereinafter called the lens and a 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, or water vapor. Reflector units assembled with gaskets will not be acceptable.

Seal Test—Samples shall be submerged in a water bath at room temperature. The submerged samples shall be subjected to a vacuum of 5 inches gage (127 millimeters of Hg) for 5 minutes. The submerged samples shall then be restored to atmospheric pressure and remain submerged for 5 minutes more. The samples shall then show no water intake upon examination.

The lens shall consist of a smooth front surface free from projections or indentations other than for identification and a rear surface having a configuration that will effect internal reflection of light without the aid of plating or separate reflector.

The specific brightness of reflex or reflex reflectors shall be equal to or exceed the following minimum values when measurements are made with the reflectors spinning.

Entrance Angle Degrees	Observation Angle Degrees	Specific Brightness Candle Power (Square Inch) Foot (Candela Power (Square Millimeter) Lux)
0^o	$1/10^o$	14.0
20^o	$1/10^o$	5.6

For the purpose of testing optical performance, as designated herein, the following definitions are established:

Entrance Angle-Angle at the reflector between direction of light incident on it and direction of reflector axis.

Observation Angle-Angle at the reflector between observer's line of sight and direction of light incident on reflector.

Specific Brightness-Candela returned at the chosen observation angle, per square inch (square millimeter) of reflecting surface for each foot candle (lux) of illumination, at the reflector.

Optical Testing Procedure—The reflector shall be tested at observation angle station 1/10° and at entrance angle degrees 0° and 20° on the Esna Reflex Photometer at a photometric distance of 10 feet (3 meters).

2. Type III Reflective Sheeting:

Demountable cutout letters, digits, border, corner radii and copy accessories shall consist of adhesive coated reflective sheeting permanently adhered to flat aluminum backing. The reflective sheeting shall conform to Section M.18.09.01. The design of letters and accessories shall conform to FHWA Standards for use on "National System of Interstate and Defense" highways.

Aluminum backing shall be a minimum of .032-inch (0.8-millimeter) thick aluminum sheet of 3003-H14 alloy. Aluminum sheeting shall be properly treated according to sheeting manufacturer's specifications.

The demountable copy shall be fastened to the sign panel with aluminum rivets. Rivets shall be of the pull through type and of the size and number designated by the demountable copy manufacturer.

3. Non-Reflective Plastic Sheeting:

Description: Demountable cutout letters, digits, border, corner radii and copy accessories shall consist of adhesive-coated, non-reflective plastic sheeting permanently adhered to flat aluminum backing.

The material shall consist of a flexible, pigmented, plastic film completely pre-coated with a solvent or heat-activated, tack-free adhesive. The adhesive shall be protected by a treated paper liner, which shall be removable without soaking in water or other solvents. The non-reflective plastic sheeting shall conform to the following:

Property Requirements:

A. Thickness: The thickness of the plastic film with adhesive shall be a minimum of 0.003 inch (76 microns) and a maximum of 0.004 inch (114 microns).

B. Film: The unapplied or applied film shall be readily processed with, and insure adequate adhesion of, process inks recommended by the manufacturer.

(1) Flexibility: The material shall be sufficiently flexible to permit application over and conform to moderately contoured surfaces.

(2) Gloss: The film shall have an initial 60-degree gloss value of 35 (minimum), when tested in accordance with ASTM D 523, measuring at least three portions of the film to obtain uniformity.

C. Adhesive: The pre-coated adhesive shall form a durable bond to smooth, clean, corrosion and weather-resistant surfaces, shall be of uniform thickness, non-corrosive to applied surfaces and shall have no staining affect on the film.

D. Adhesion: The material, applied according to Paragraph I "Preparation of Test Panels" shall have sufficient bond to prevent removal from the panel in one piece without the aid of a physical tool.

E. Exterior Exposure: The material shall withstand three years' vertical, south-facing exterior exposure at a sight acceptable to the Engineer, showing no appreciable discoloration, cracking, crazing, blistering, delamination, or loss of adhesion. A slight amount of chalking is permissible.

The film shall not support fungus growth.

F. Dimensional Stability: The material shall show no more than 0.02 inch (397 microns) shrinkage in any direction from edge of the panel when prepared in accordance with Paragraph I after being subjected to a temperature of 149° F (65° C) for 48 hours.

G. Heat Resistance: The material, applied according to Paragraph I, shall be heat-resistant enough to retain adhesion after 1 week at 149° F (65° C).

H. Solvent and Chemical Resistance: The material, when prepared in accordance with Paragraph I, shall withstand immersion in the following liquids at 70-90° F (21-32° C), showing no appreciable decrease in adhesion, color or general appearance.

Liquids	Time/Hours
Reference Fuel (MIL-F-8799A) (15 parts xylol - 85 parts mineral spirits by mass)	1
Distilled Water	24
SAE #20 Motor Oil	24

I. Opacity: When applied, the material shall be sufficiently opaque to hide a contrasting black printed legend and white surface.

J. Preparation of Test Panels: Test panels shall be prepared using a 6.5 inch x 6.5 inch (165 millimeters x 165 millimeters) piece of the plastic film, applied to a clean 6.0 inch x 6.0 inch (150 millimeters x 150 millimeters) aluminum panel, premasked or as recommended by the manufacturer, trimmed evenly at the edge of the panel, and aged for 48 hours at 70 - 90° F (21-32° C).

K. Shelf-Life Storage: The material shall withstand one year's shelf life when stored in a clean area free from exposure to excessive heat, moisture and direct sunlight.

L. General Characteristics and Packaging: The plastic film shall be furnished in rolls, cut sheets or characters, as may be specified. The film, as supplied, shall be free from ragged edges, streaks, blisters, foreign matter or other surface imperfections which would make it unsuitable for the intended usage, and shall be readily cut with scissors, knife, blade, shears or other production tools. Complete and detailed instructions for mounting the plastic film shall be supplied with each package of material.

M. Quality Assurance: For the non-reflective plastic sheeting a Certified Test Report conforming to 1.06.07 shall be submitted.

M.18.11—Sign Panels-Extruded Aluminum: Sign panels (extruded aluminum) shall be of the butt type, alloy 6063-T6 ASTM B 221. Several extruded sections shall be joined with panel nuts, bolts, and washers to achieve the desired sign size. The extruded aluminum panels shall be of 6-inch and 12-inch (150-millimeter and 300-millimeter) heights to achieve sign panel vertical dimensions in increments of 6 inches (150 millimeters); however, no more than one 6-inch (150-millimeter) panel shall be used on any one sign. The weight (mass) and section properties of the 6-inch and 12-

inch (150-millimeter and 300-millimeter) extruded panels shall be as indicated on the plans.

On the vertical axis (the 6-inch or 12-inch (150-millimeter or 300-millimeter) dimension), the panel face shall be in the same plane within 0.015 inches (0.4 millimeters) in any six inches (150-millimeters). Extruded sections shall be mounted horizontally, and the panel faces shall be flush after the erection of the sign is complete.

Cleaning: Extruded aluminum sign panels shall be thoroughly cleaned and degreased by total immersion in an alkaline solution which is controlled and titrated to the solution manufacturer's recommendations. Immersion time shall be sufficient to completely remove all grease, dirt or other contaminants. After cleaning, the panels shall be thoroughly rinsed with clear running water.

Pretreatment: Sign panels shall be treated with a light, tightly adherent chromate conversion coating, free of any powdery residue, ranging in color from a silvery iridescent to a pale yellow, conforming with ASTM B 449, Class 2, 10-35 milligram/square foot (108-377 milligram/square meter), with 25 milligram/square foot (269 milligram/square meter) as the optimum coating weight.

M.18.12—Panel Bolt Assemblies and Post Clip Assemblies:

Panel Bolt Assembly: Aluminum hex head bolt, hex nut and washer shall be as shown on the plans and shall be used to unite several panels sections to conform to the designed sign size. Nuts shall be drawn tight. Bolt holes may be drilled or blanked to finished size.

Thread fit for bolts shall conform to class 2-A fit of American Standard Association.

Post Clip Assembly: Aluminum post clips square head bolt, lock nut and washer shall be as shown on the plans.

The shank of the post clip bolts shall fit tightly against the sign support flange after nuts have been tightened. The clip bolts shall be torqued to 225 inch-pounds (25.4 newton· meter) when using dry, clean, unlubricated threads.

M.18.13—Sign Face—Sheet Aluminum: Sheet aluminum sign blanks shall be constructed of sheet aluminum, alloy 6061-T6 or alloy 5052-H38. Sheet aluminum sign blanks shall conform to ASTM B 209. They shall be degreased and etched in accordance with the recommendations of the sheeting manufacturer or treated with a light, tightly adherent chromate conversion coating, free of any powdery residue, ranging in color from silvery iridescent to a pale yellow, conforming to ASTM B 449, Class 2 (10-35 milligrams/square foot) (108-377 milligrams/square foot) with 25 milligrams/square foot (269 milligrams/square meter) as the optimum coating. The thickness shall be as specified on the plans.

M.18.14—Metal Sign Posts: Metal sign posts, square tubular supports and parapet mounted sign supports shall conform to the requirements as noted on the plans. The size, shape and mass of posts and supports shall be as specified in the plans.

After fabrication of the posts and supports, including hole punching or drilling, they shall be galvanized as noted on the plans.

M.18.15—Sign Mounting Bolts: Bolts used for sign mounting shall be of aluminum alloy 2024-T4. Self-locking nuts shall be of aluminum alloy 2011-T3, 2014-T4 or 2017-T4. Aluminum alloys shall conform to the requirements of ASTM B 211.

Greater New Haven

Water Pollution Control Authority