

DIVISION 700**MATERIALS**SECTION 700 GENERAL

700.01 GENERAL STATEMENT. Where the Contract requires that materials conform to AASHTO or ASTM specifications, the latest publications and all modifications thereto in effect on the date of the Invitation for Bids shall apply.

At the Engineer's discretion, testing of any material may be required either at the point of manufacture or after delivery to the site of the work. In such cases, the results of the tests shall govern the acceptance or rejection of the material tested.

In the case of small quantities of material having a cost of less than \$5,000 and that are not directly involved with the safety of the structure or the roadway, the Agency may waive the requirement for certification.

Whenever there is a Subsection entitled "General Requirements" within any Division 700 Section, that Subsection is applicable to all other Subsections in that Division 700 Section.

700.02 MATERIALS CERTIFICATIONS.

- (a) General. When these Specifications require a certification, the certification will be approved prior to use of the material, unless otherwise directed by the Engineer. In all cases, certifications must be approved prior to payment.

All material used on the basis of a materials certification may be sampled and tested at any time. The fact that a material is used on the basis of a certification shall not relieve the Contractor of responsibility for incorporating material in the work which conforms to the requirements of the Contract and any such material not conforming to such requirements will be subject to rejection whether in place or not.

New materials, purchased by the Contractor for use on an Agency contracted project, may be used on another Agency project. To do this, the Contractor must submit a sworn statement certifying such materials were part of the quantity purchased for use on another project. The sworn statement must identify the project and certify that the certifications were furnished to the Agency covering such materials for that project.

When Agency approval is given for Working Drawings under the requirements of Section 105 and the referenced drawings have identified a component of an item by a specific product name and/or number, the Engineer may waive all or part of any certification requirements for that particular product.

The Agency reserves the right to refuse the use of materials where acceptance is based only on certification.

Within each Subsection, materials designated to conform to another Subsection shall require the certification type of the referenced Subsection.

For steel and iron materials, the following requirements shall apply:

- (1) To comply with Buy America provisions, a manufacturer must certify that all manufacturing processes have occurred in the United States.

To identify a chain of custody documentation trail that the product meets the Buy America provisions, each supplier or fabricator involved in a product will be required to include in its certification a statement that each process performed by them was entirely done in the United States.

All certifications shall be forwarded to the Vermont Agency of Transportation Materials and Research Section.

- (b) Required Information. Certifications shall contain the following information, except as waived by the Agency:
 - (1) Project to which the material is consigned.
 - (2) Name of the contractor or supplier to which the material is supplied.
 - (3) Kind of material supplied.
 - (4) Means of identifying the consignment, such as label, marking, seal number, lot number, etc.
 - (5) Statement to the effect that the material has been tested and found in conformity with these Specifications.

- (6) Results of all tests including the chemical and physical analyses when required by a Type C Certification.
 - (7) Signature of a person having legal authority to bind the manufacturer. Signatures must be legally notarized or be signed by a person whose name has been submitted on a notarized, prefilled, signature list to the Agency's Materials and Research Section.
- (c) Types of Certifications. Unless otherwise specified, certifications shall be prepared by the manufacturer and shall be one of the following types:
- (1) Type A. A Type A Certification shall certify that the component materials, manufacturing operations, and finished products conform to all requirements of the Agency, the State, pertinent Plans, Special Provisions, and Specifications for the Contract item or items indicated.
 - (2) Type B. A Type B Certification shall certify that the material conforms to the requirements of the Agency, the State, current specifications, and is of the same formulation as that previously approved by the Agency.
 - (3) Type C. A Type C Certification shall consist of certified test results showing actual chemical and physical analysis of material used in the manufacture of products delivered to the project.
 - (4) Type D. A Type D Certification shall consist of both a Type A Certification and a Type C Certification.
 - (5) Type E. A Type E Certification shall consist of a yearly Type A Certification plus a certification prepared by the manufacturer indicating test results of the required chemical and physical properties of discrete, identifiable quantities of material. The manufacturer's measured test values may be compared against independent assurance test results.
- (d) List of Materials with Advanced Certification. Manufacturers of materials requiring either a Type A or a Type B Certification may submit their certifications annually at the beginning of each calendar year and, if approved, their products will be included on a list of materials with advanced certification. Materials that are

included on the List of Materials with Advanced Certification will not require separate certification for each project.

The Agency reserves the right to remove any manufactured product from the List of Materials with Advanced Certification at any time for just cause.

700.03 DEFINITION OF TERMS.

ADVANCED DECAY - In the case of wood, the older stage of decay in which the disintegration is readily recognized because the wood has become punky, soft, and spongy.

BEDROCK (LEDGE) - Rock of relatively great thickness and extent in its native location; any solid rock exposed at the surface of the earth or overlain by unconsolidated material.

BITUMINOUS MATERIAL - A substance which is characterized by the presence of bitumen, or one from which bitumen can be derived.

BOULDER - A rock fragment, usually rounded by weathering or abrasion, with an average dimension of 300 mm (12 inches) or more.

CAPILLARY ACTION (CAPILLARITY) - The rise or movement of water in the interstices of a soil due to capillary forces.

CHECK - In the case of wood, a separation of the wood grain due to internal stresses caused by severe moisture cycling.

CLAY (CLAY SOIL) - Fine-grained soil or the fine-grained portion of soil that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dried.

COBBLE (COBBLESTONE) - A rock fragment, usually rounded or semirounded, with an average dimension between 75 and 300 mm (3 and 12 inches).

COHESIONLESS SOIL - A soil that when unconfined has little or no strength when air-dried and that has little or no cohesion when submerged.

COHESIVE SOIL - A soil that when unconfined has considerable strength when air-dried and that has significant cohesion when submerged.

COMPACTION - Densification by means of mechanical manipulation.

COMPACTION CURVE (PROCTOR CURVE) (MOISTURE-DENSITY CURVE) - The curve on a graph that shows the relationship between the dry density and the water content of a soil for a given compactive effort.

COMPACTION TEST (MOISTURE-DENSITY TEST) - A laboratory procedure whereby a soil at a known water content is placed in a specified manner into a mold of given dimensions, subjected to a compactive effort of controlled magnitude, and the resulting unit mass (weight) determined.

COMPRESSIVE STRENGTH - The maximum compressive stress that a material is capable of sustaining.

CONSOLIDATION - Gradual reduction in volume of a soil mass.

CRUSHED GRAVEL - The product resulting from the mechanical crushing of gravel and cobblestones.

CRUSHED STONE - The product resulting from the mechanical crushing of blasted ledge, rocks, boulders, or cobblestones.

DENSITY - The density of a soil is measured in terms of the ratio of its mass (weight) per unit volume and usually expressed as kilograms of wet soil or dry soil per cubic meter (pounds per cubic foot). These ratios are designated as wet density and dry density respectively.

DRYING TIME -

Set to Touch - Film is “set to touch” when it still exhibits a tacky condition, but none of it adheres to the finger.

Dry to Recoat - Film is “dry to recoat” when the top coat can be applied without the development of film irregularities, such as lifting or loss of adhesion of the undercoat.

Dry Through (Dry to Handle) - Film is “dry through” when there is no loosening, detachment wrinkling, or other distortion of film under condition of test. Test conditions require full thumb pressure with twisting action.

ELONGATED PIECE - One in which the ratio of the length to width of its circumscribing rectangular prism is greater than five.

ELONGATION - The increase in gage length of a tension test specimen, usually expressed as a percentage of the original gage length.

FAMILY OF CURVES - A group of similar moisture-density curves assuming a characteristic shape.

FILTER (PROTECTIVE FILTER) - A layer or combination of layers of pervious materials designed and installed in such a manner as to provide drainage, yet prevent the movement of soil particles due to flowing water.

FINENESS MODULUS - An empirical factor obtained by adding the total percentages of a sample of the aggregate retained on each of a specified series of sieves, and dividing the sum by 100.

FINES - Portion of a material finer than a 75 μm (No. 200) sieve.

FLY ASH - Finely divided residue that results from the combustion of ground or powdered coal.

FRACTURED FACES - Faces on aggregate pieces with sharp and well defined edges.

FREEZING DEGREE-DAYS - The difference between the average temperature each day and 0 °C (32 °F). Freezing degree-days are positive for daily average temperatures above 0 °C (32 °F) and negative for those below.

FREEZING INDEX - The number of freezing degree-days between the highest and lowest points on the cumulative freezing degree-days/time curve for one freezing season.

GAGE LENGTH - The original length of that portion of the specimen over which strain or change of length is determined.

GLACIAL TILL (TILL) - Material deposited by glaciation, usually composed of a wide range of particle sizes, which has not been subjected to the sorting action of water.

GRADATION (GRAIN-SIZE DISTRIBUTION) (SOIL TEXTURE) - Proportion of material of each grain size present in a given material.

GRAIN-SIZE ANALYSIS (MECHANICAL ANALYSIS) - The process of determining gradation.

GRAVEL (AASHTO) - Rounded or semirounded particles of rock that will pass a 75 mm (3 inch) sieve and be retained on a 2.00 mm (No. 10) sieve.

HARDNESS - The resistance of a material to deformation, particularly permanent deformation, indentation, or scratching.

HARDPAN - Extremely dense, cemented soil, which does not soften when wet.

HEAVE - Upward movement of soil caused by expansion or displacement resulting from phenomena such as moisture absorption, removal of overburden, driving of piles, and frost action.

INCIPIENT DECAY - The early stage of decay that has not proceeded far enough to soften or otherwise perceptibly impair the hardness of wood.

LIQUID LIMIT - The water content corresponding to the arbitrary limit between the liquid and plastic states of soil.

LOAM - A mixture of sand, silt, or clay, or a combination of any of these, with organic matter. It is sometimes called topsoil in contrast to the subsoils that contain little or no organic matter.

MANUFACTURED SAND - The product resulting from the mechanical processing and crushing of gravel or cobbles in which at least 50 percent of the material passing the 2.36 mm (No. 8) sieve has two fractured faces as determined by ASTM C 295, as modified by the Agency's Materials and Research Section.

MODULUS OF RUPTURE IN BENDING - The value of maximum tensile or compressive stress (whichever causes failure) in the extreme fiber of a beam loaded to failure in bending.

MOISTURE CONTENT (WATER CONTENT) - The ratio, expressed as a percentage, of the mass (weight) of water in a given material to the mass (weight) of solid particles.

MSDS - Material Safety Data Sheet as required by OSHA.

MUCK - A soil of very soft consistency containing greater than 10 percent organic matter.

MUD - A mixture of soil and water in a fluid or weakly solid state.

NATURAL SAND - Any sand that is found to exist in a natural deposit.

OPTIMUM MOISTURE CONTENT (OPTIMUM WATER CONTENT) - The water content at which a soil can be compacted to the maximum dry density by a given compactive effort.

PEAT - A fibrous mass of organic matter in various stages of decomposition, generally dark brown to black in color and of spongy consistency.

PERCENT COMPACTION - The ratio, expressed as a percentage, of dry density of a soil to maximum density obtained in a laboratory compaction test.

PERMEABILITY - The property of a soil allowing it to transmit water; largely dependent upon the size and number of continuous soil pores.

pH - An index of the acidity or alkalinity of a soil where seven is neutral, below seven is acidic and above seven is alkaline.

PLASTICITY INDEX - Numerical difference between the liquid limit and the plastic limit.

PLASTIC LIMIT - The water content corresponding to an arbitrary limit between the plastic and the semisolid states of consistency of soil.

POZZOLANS - Siliceous or siliceous and aluminous materials which in themselves possess little or no cementitious value, but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form compounds possessing cementitious properties.

PVC - Polyvinyl chloride, a plastic polymer.

SAMPLING - The process of selecting a fraction of a total material that is similar in all respects to the total material.

SACK - A standard unit of dry powder cement with a mass (weight) of 42.64 kg (94 pounds).

SAND (AASHTO) - Particles of rock that will pass the 2.00 mm (No. 10) sieve and be retained on the 75 μm (No. 200) sieve.

SCREENED SAND - The product resulting from the mechanical screening of natural sands or gravels.

SILICA FUME - An extremely fine product of high amorphous silica content resulting from the condensation of rising vapor given off in the manufacture of ferrosilicon and metallic silicon in high temperature electric arc furnaces. This material is also referred to as Microsilica.

SILT - Material passing the 75 µm (No. 200) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air-dry.

STONE SCREENINGS - The product resulting exclusively from the mechanical crushing of quarried bedrock.

TENSILE STRENGTH - The maximum tensile stress that a material is capable of sustaining.

THIN PIECE - One for which the ratio of the width to thickness of its circumscribing rectangular prism is greater than five to one.

THIN AND ELONGATED PIECES - One in which the ratio of the length to the thickness of its circumscribed rectangular prism is greater than five to one.

WANE - Bark or lack of wood on the surface or edges of lumber.

YIELD STRENGTH - The stress at which a material exhibits a specified limiting deviation from the proportionality of stress to strain.

SECTION 701 - HYDRAULIC CEMENT

701.01 GENERAL REQUIREMENTS.

- (a) General. The Contractor shall provide suitable means for storing and protecting the cement against dampness. Cement which, for any reason, has become partially set or which contains lumps or is caked shall be rejected.

The mixing of different brands or types of portland cement, and the mixing of portland cement of the same brand or types from different mills, will not be permitted except by written permission of the Engineer.

- (b) Certification. A Type E Certification shall be furnished as specified in Subsection 700.02. A delivery slip or bill of lading shall accompany each transport identifying the manufacturer, whom the material was shipped to, date of delivery, and an identification number traceable to a discrete quantity of material with certified test results.

701.02 PORTLAND CEMENT. Portland cement shall conform to the requirements of AASHTO M 85, Type II, unless otherwise shown on the Plans or directed by the Engineer.

701.03 THIS SUBSECTION RESERVED

701.04 HIGH EARLY STRENGTH PORTLAND CEMENT. High early strength portland cement shall conform to the requirements of AASHTO M 85, Type III.

701.05 PORTLAND-POZZOLAN CEMENT. Portland-pozzolan cement shall conform to the requirements of AASHTO M 240, Type IP except that the pozzolan constituent shall be not more than 20 percent of the total mass (weight) of the portland-pozzolan cement.

701.06 BLENDED SILICA FUME CEMENT. Blended silica fume cement shall conform to the requirements of ASTM C 1157.

701.07 PORTLAND BLAST-FURNACE SLAG CEMENT. Portland Blast-furnace Slag Cement – Type IS shall conform to the requirements of AASHTO M 240, except that for concrete mixes complying with Tables 501.03A and 541.03A the slag constituent shall not be more than 25 percent of the total mass (weight) of the Portland Blast-furnace Slag Cement.

A Type D Certification shall accompany each shipment of blended silica fume cement identifying the percent, by mass (weight), of silica fume contained in the blend.

SECTION 702 - BITUMINOUS MATERIALS

702.01 GENERAL REQUIREMENTS.

- (a) Sampling. Bituminous materials shall be sampled at the delivery point from vehicle tanks, above ground stationary tanks, or asphalt plant feed lines in a manner that the samples will show the true nature and condition of the materials. Certification under part (e) below shall cover the material until test results are obtained for the material.

- (b) Sampling Valves. Sampling valves shall be installed in strategic locations, readily accessible so that representative samples of the required size can be obtained easily and quickly. The sampling valve shall be constructed of materials compatible with the product at the temperatures handled. The valve seat shall be either inside the tank or compartment or inside the insulating jacket. The flow shall be over a route that is as short and direct as practical. Pockets that will retain product will not be allowed. The outlet shall be a 20 mm (3/4 inch) DN pipe size. The outlet shall be provided with a chained cap or plug. The sampling valves shall conform to the requirements of AASHTO T 40.
- (c) Location of Sampling Valves. The recommended location and number of sampling valves needed is as follows:
- (1) Vehicle Tanks. The sampling valve shall be located below the horizontal mid line of the end head (rear preferred) at least 300 mm (12 inches) from the shell. The inlet to the sampling valve shall be at least 150 mm (6 inches) from walls or other internal surfaces, except that it shall be at least 300 mm (12 inches) from any heating surface.
 - (2) Horizontal Tanks. The location on horizontal tanks shall be below the horizontal mid line of an end bulkhead. The inlet of the sampling device shall be at least 1 m (3 feet) from the bottom and 300 mm (12 inches) from the shell.
 - (3) Vertical Tanks. On vertical tanks, where the contents can be agitated, one sampling device shall be required. It shall be located on the side, at least 1060 mm (42 inches) from the bottom.

On vertical tanks, not capable of being agitated, two sampling devices shall be required. They shall be located, with easy and safe access provided, on the side of the tank, as follows: One no closer than 900 mm (36 inches) from the top, and one no closer than 1060 mm (42 inches) from the bottom
 - (4) Asphalt Plant Feed Lines. The sampling valve should be located down stream of all additive lines and be 600

mm (24 inches) to 900 mm (36 inches) above the surface and preferably on a horizontal feed line.

Note: All sampling valves should be protected from inclement weather as not to spray hot liquid or introduce moisture.

- (d) Defective Sampling Valves. When there is an apparent defect in the sampling valve and a sample cannot be obtained as indicated, the following procedure shall be used:
- (1) The sample shall be taken directly from the tank, through the inspection access port or an alternate valve.
 - (2) A defective equipment tag shall be made out and attached to the valve and the plant manager or carrier shall be notified.
 - (3) A notation shall be made in the plant log or Engineer's daily report giving location of valve, date, storage tank, vehicle tank, or the asphalt plant number. The plant manager or carrier shall make the necessary repairs within 48 hours from the time notification is given.
 - (4) If, at the end of the repair period, the plant or tank valve is still found to be defective, the plant shall be shut down and not started again until repairs are made and inspected to the satisfaction of the plant engineer.
 - (5) Should the tanker return on a second trip and the defective tanker valve not be repaired, the load shall not be used but shall be returned to the sender.
- (e) Certification. No bituminous material will be used on any project until the required certifications covering the entire shipment have been received.

702.02 PERFORMANCE-GRADED ASPHALT BINDER (PREPARED FROM PETROLEUM).

- (a) Properties. The performance-graded asphalt binder shall be homogenous, free from water and shall not foam when heated to 175 °C (350 °F).

The various grades of performance-graded asphalt binder shall be performance grade (PG) as specified in AASHTO M 320. Specific requirements for the specified grade of performance-graded asphalt binder shall be as designated in Table 702.02A.

The performance-graded manufacturer/supplier shall furnish to the Agency viscosity temperature charts containing actual compaction and mixing temperatures for each grade of performance-graded asphalt binder supplied.

TABLE 702.02A PERFORMANCE-GRADED ASPHALT BINDER SPECIFICATION																					
Performance Grade	PG 46			PG 52					PG 58					PG 64							
	>-34	>-40	>-46	>-10	>-16	>-22	>-28	>-34	>-40	>-46	>-16	>-22	>-28	>-34	>-40	>-10	>-16	>-22	>-28	>-34	>-40
Average 7-day Maximum Pavement Design Temperature, °C ^a	<46			<52					<58					<64							
Minimum Pavement Design Temperature, °C ^a	>-34	>-40	>-46	>-10	>-16	>-22	>-28	>-34	>-40	>-46	>-16	>-22	>-28	>-34	>-40	>-10	>-16	>-22	>-28	>-34	>-40
Flash Point Temp, T48: Minimum, °C	Original Binder 230																				
Viscosity, AASHTO T 316: ^b Maximum, 3 Pa·s (3000 cP), Test Temperature, °C	135																				
Dynamic Shear, AASHTO T 315: ^c G*/sin δ ^d , Minimum, 1.00 kPa Test Temperature @ 10 rad/s, °C	46			52					58					64							
Mass Change, ^e Maximum, %	Rolling Thin-Film Oven Residue (AASHTO T 240) 1.00																				
Dynamic Shear, T 315: G*/sin δ ^d , Minimum, 2.20 kPa Test Temperature @ 10 rad/s, °C	46			52					58					64							
PAV Aging Temperature, °C ^f	90			90					100					100							
Dynamic Shear, T 315: G*/sin δ ^d , Maximum, 5000 kPa Test Temperature @ 10 rad/s, °C	10	7	4	25	22	19	16	13	10	7	25	22	19	16	13	31	28	25	22	19	16
Physical Hardening	Report																				
Creep Stiffness, T 313: ^g S, Maximum, 300 MPa m-valve, Minimum, 0.300 Test Temperature @ 60 s, °C	-24	-30	-36	0	-6	-12	-18	-24	-30	-36	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30
Direct Tension, T 314: ^g Failure Strain, Minimum, 1.0% Test Temperature @ 1.0 mm/min, °C	-24	-30	-36	0	-6	-12	-18	-24	-30	-36	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	-30

TABLE 702.02A PERFORMANCE-GRADED ASPHALT BINDER SPECIFICATION (Continued)																
Performance Grade	PG 70			PG 76			PG 82									
	-10-	-16	-22	-28	-34	-40	-10	-16	-22	-28	-34					
Average 7-day Maximum Pavement Design Temperature, °C. ^a	<70			<76			<82									
Minimum Pavement Design Temperature, °C. ^a	>-10	>-16	>-22	>-28	>-34	>-40	>-10	>-16	>-22	>-28	>-34	>-34				
Flash Point Temp, T48: Minimum, °C	Original Binder 230															
Viscosity, AASHTO T 316: ^b Maximum, 3 Pa·s (3000 cP), Test Temperature, °C	135															
Dynamic Shear, AASHTO T 315: ^c G*/sin δ ^d , Minimum, 1.00 kPa Test Temperature @ 10 rad/s, °C	70			76			82									
Mass Change, ^e Maximum, %	Rolling Thin-Film Oven Residue (AASHTO T 240) 1.00															
Dynamic Shear, T 315: G*/sin δ ^d , Minimum, 2.20 kPa Test Temperature @ 10 rad/s, °C	70			76			82									
PAV Aging Temperature, °C ^f	100(110)			100(110)			100(110)									
Dynamic Shear, T 315: G*/sin δ ^d , Maximum, 5000 kPa Test Temperature @ 10 rad/s, °C	34	31	28	25	22	19	37	34	31	28	22	40	37	34	31	28
Physical Hardening	Report															
Creep Stiffness, T 313: ^g S, Maximum, 300 MPa m-valve, Minimum, 0.300 Test Temperature @ 60 s, °C	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	0	-6	-12	-18	-24
Direct Tension, T 314: ^g Failure Strain, Minimum, 1.0% Test Temperature @ 1.0 mm/min, °C	0	-6	-12	-18	-24	-30	0	-6	-12	-18	-24	0	-6	-12	-18	-24

TABLE 702.02A PERFORMANCE-GRADED ASPHALT BINDER SPECIFICATION (Continued)
FOOTNOTES

a	Pavement temperatures are estimated from air temperatures using an algorithm contained in the LTPP Bind software program, may be provided by the specifying agency, or by following the procedures as outlined in AASHTO M 323 and AASHTO R 35.
b	This requirement may be waived at the discretion of the Agency if the supplier warrants that the performance graded asphalt binder can be adequately pumped and mixed at temperatures that meet all applicable safety standards
c	For quality control of unmodified performance-graded asphalt binder production, measurement of the viscosity of the original asphalt binder may be used to supplement dynamic shear measurements of $G^*/\sin \delta$ at test temperatures where the asphalt is a Newtonian fluid
d	$G^*/\sin \delta$ = high temperature stiffness and $G^*\sin \delta$ = intermediate temperature stiffness.
e	The mass change shall be less than 1.00 percent for either a positive (mass gain) or a negative (mass loss) change
f	The PAV aging temperature is based on simulated climatic conditions and is one of three temperatures: 90 °C, 100 °C, or 110 °C. Normally the PAV aging temperature is 100 °C for PG 58-xx and above.
g	If the creep stiffness is below 300 MPa, the direct tension test is not required. If the creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used in lieu of the creep stiffness requirement. The m-value requirement must be satisfied in both cases

- (b) Pretest. Failure of performance-graded asphalt binder from any one source to meet the Specifications may require placing this source on Pretest Status. This will require that samples from the source be tested in the Agency's Materials and Research Laboratory and accepted prior to being used on a project.
- (1) The Pretest Status will remain in effect for three consecutive samples meeting AASHTO M320 specifications or until the Engineer is satisfied there is no longer any reason to continue on a Pretest Status.
- (c) Certification. A Type E Certification shall be furnished in accordance with Subsection 700.02.

702.03 THIS SUBSECTION RESERVED

702.04 EMULSIFIED ASPHALT. Emulsified asphalt shall be homogeneous. It shall show no separation of asphalt at the time of use and shall be used within 30 calendar days after delivery from the manufacturer/supplier.

Emulsified asphalt shall not be allowed to freeze.

- (a) Properties. Emulsified asphalt shall conform to the requirements of AASHTO M 140 or AASHTO M 208, as appropriate.
- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

702.05 TAR EMULSION

- (a) Properties. This material shall conform to the requirements of ASTM D 3320 except that paragraph 4.3 shall not apply.
- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

702.06 APPLICATION TEMPERATURES. Bituminous materials for the applications specified in the Specifications shall be applied within the temperature ranges designated the following table:

TABLE 702.06A - APPLICATION TEMPERATURES

Performance -Graded Asphalt Binder	°C				°F			
	Spray		Mix		Spray		Mix	
	Min	Max	Min	Max	Min	Max	Min	Max.
Asphalt Treated Permeable Base, Section 303	---	---	116	138	---	---	240	280
Marshall Bituminous Concrete Pavement, Section 406	---	---	---	*	---	---	---	*
Superpave Bituminous Concrete Pavement, Section 490	---	---	---	*	---	---	---	*
Emulsified Asphalt								
RS-1	21	60	---	---	70	140	---	---
RS-2, CRS- 1	49	71	---	---	120	160	---	---
CRS-2	60	79	---	---	140	175	---	---
SS-1h, CSS1h	24	54	10	54	75	130	50	130
MS-2h, CMS-2h	---	---	24	60	---	---	75	140

*As required to achieve a kinematic viscosity of 170 ± 20 centistokes.

702.07 ANTI-STRIP ADDITIVES. Anti-strip additives shall be capable of improving the bonding properties of the cutback asphalt or the performance-graded asphalt binder to the aggregates in the presence of moisture and shall also be capable of reducing film stripping.

- (a) **Performance-Graded Asphalt Binder.** The additive used in performance-graded asphalt binder shall be heat stable for all temperature ranges prescribed for such performance-graded asphalt binder. The additive shall not alter the material properties nor change the grade of the performance-graded asphalt binder when added in the recommended proportions. The additive shall be capable of thorough dispersion in the performance-graded asphalt binder and capable of remaining in

the performance-graded asphalt binder, in storage, and at temperatures specified for the mix without losing its effectiveness.

- (b) Testing Procedures. Testing of anti-strip additives shall be in accordance with, and meet the requirements of, Vermont Agency of Transportation Test Procedures MRD-1 and MRD-10.

The percentage of anti-strip additive shall be a minimum of 0.5 percent of the asphalt content and shall be adjusted, as required, above this amount to meet testing requirements. Prior to the use of any anti-strip additive, the Contractor shall submit for testing and approval samples of the specific aggregates, the specific asphalt and the specific anti-strip additive proposed for the mix design.

To identify any change in effectiveness, the asphalt and the anti-strip additive being used shall acceptably pass the requirements of the MRD-10 test procedure on a daily basis.

702.08 SILICONE ADDITIVE. Silicone additive shall be a silicone material of the dimethyl polysiloxane type with a viscosity grading of 1000 ± 200 centistokes at 25 °C (77 °F). It shall be added to the liquid performance-graded asphalt binder at hot mix plants in amounts not to exceed five parts per million. After addition of the silicone additive, the performance-graded asphalt binder shall be thoroughly mixed by mechanical means to ensure complete dispersal.

Other types of silicone material, or the addition of amounts in excess of five parts per million, must be approved by the Engineer before being used in the work.

SECTION 703 - SOILS AND BORROW MATERIALS

703.01 CLASSIFICATION OF SOILS Based upon their field performance, soils shall be classified into seven groups that shall be designated as A-1, A-2, A-3, A-4, A-5, A-6, and A-7. This classification shall be based upon the results of tests made in accordance with AASHTO M 145, as designated in the following table:

TABLE 703.01A - CLASSIFICATION OF SOILS

General Classification	Granular Materials			Silt-Clay Materials								
	A-1		A-3	A-2				A-4	A-5	A-6	A-7	
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5	A-7-6
Sieve Analysis, percent passing: 2.00 mm (No. 10) 425 µm (No. 40) 75 µm (No. 200)	50-	---	---	---	---	---	---	---	---	---	---	---
	30-	50-	50+	---	---	---	---	---	---	---	---	---
	15-	25-	10-	35-	35-	35-	35-	36+	36+	36+	36+	36+
Characteristics of fraction passing 425 µm (No. 40) sieve: Liquid Limit Plasticity Index	---	---	NP	40-10-	41+10-	40-11+	41+11+	40-10-	41+10-	40-11+	41+11+	
Usual Types of Soils	Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clay Soils		

+ indicates that value shown is the minimum allowable.
 - indicates that value shown is the maximum allowable.
 NP indicates non-plastic.
 Plasticity Index of A-7-5 subgroup is equal to or less than Liquid Limit minus 30.
 Plasticity Index of A-7-6 subgroup is greater than Liquid Limit minus 30.

Classification Procedure. With the required data, proceed from left to right on above chart, and the correct group will be found by the process of elimination. The first group from left into which the test data will fit is the correct classification.

Where the Unified classification of soils is referenced in the Contract, it shall be based on the Soil Classification Chart in ASTM D 2487.

703.02 EARTH BORROW. Earth borrow shall be material of a quality approved by the Agency as meeting the requirements for the particular embankment, backfill, or other use for which the material is intended, and shall show evidence of satisfactory compaction when placed in embankments.

The natural moisture content shall be less than the laboratory optimum moisture content as determined in accordance with AASHTO T 99, Method C.

703.03 SAND BORROW AND CUSHION. Sand borrow and sand cushion shall consist of material reasonably free from silt, loam, clay, or organic matter. It shall be obtained from approved sources and shall meet the requirements of the following table:

TABLE 703.03A - SAND BORROW AND CUSHION

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
50 mm (2 inch)	100
37.5 mm (1 1/2 inch)	90 to 100
12.5 mm (1/2 inch)	70 to 100
4.75 mm (No. 4)	60 to 100
150 µm (No. 100)	0 to 20
75 µm (No. 200)	0 to 8

703.04 GRANULAR BORROW. Granular borrow shall be obtained from approved sources, consisting of stone and sand reasonably free from loam, silt, clay, and organic material and shall meet the requirements of the following table:

TABLE 703.04A - GRANULAR BORROW

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
4.75 mm (No. 4)	20 to 100
75 µm (No. 200)	0 to 12

The maximum size of stone particles in the granular borrow shall not exceed 67 percent of the thickness of the layer being spread.

703.05 ROCK BORROW. Rock borrow shall consist of blasted rock broken into various sizes that will form a compact embankment with a minimum of voids. The maximum size shall be 900 mm (36 inches) in its widest dimension and that size which may be incorporated in a 600 mm (24 inch) layer of rock embankment.

SECTION 704 – AGGREGATES

704.01 FINE AGGREGATE FOR CONCRETE. Fine aggregate for concrete shall consist of natural sand washed in an approved manner or a combination of washed natural sand and stone screenings. The stone screenings shall not exceed 50 percent by mass (weight) of the combination.

Fine aggregate shall consist of clean, hard, durable grains, uniformly graded from coarse to fine, and shall be free from injurious amounts of organic matter or other harmful substances.

- (a) Grading. Fine aggregate for concrete shall meet the gradation requirements of the following table as determined in accordance with AASHTO T 27:

TABLE 704.01A - FINE AGGREGATE FOR CONCRETE

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
9.5 mm (3/8 inch)	100
4.75 mm (No. 4)	95 to 100
1.18 mm (No. 16)	50 to 80
600 µm (No. 30)	25 to 60
300 µm (No. 50)	10 to 30
150 µm (No. 100)	2 to 10

The fineness modulus on that portion of material passing the 9.5 mm (3/8 inch) sieve shall be determined by laboratory sieve test. This fineness modulus is defined as the summation of the percentages of sand retained on the following sieve sizes: 150 µm (No. 100), 300 µm (No. 50), 600 µm (No. 30), 1.18 mm (No. 16), 2.36 mm (No. 8), and 75 mm (No. 4), divided by 100. The minimum and maximum fineness moduli shall be 2.60 and 3.10, respectively. Fine aggregate from any one source for any one designated mix having a variation in fineness modulus greater than ±

0.20 from the fineness modulus of a representative sample proposed for use may be rejected.

- (b) Organic Impurities. Fine aggregate for concrete shall show a color of not greater than two as determined in accordance with AASHTO T 21.
- (c) Compressive Strength of Mortar. When sand or a combination of stone screenings and sand is mixed with portland cement in the proportion of one part of cement to three parts of sand (or of the combination of stone screenings and sand) by mass (weight), according to the standard method of making 50 mm (2 inch) cubes, the resulting mortar at the age of three and seven days shall have a compressive strength of at least 100 percent of that developed in the same time by mortar of the same proportions and flow, made of the same cement and graded Ottawa sand, when tested in accordance with the requirements of AASHTO T 106M/T 106. Only one series of mortar cube compressive strength tests will be required for each fine aggregate source in any one calendar year unless the Engineer deems additional testing necessary.
- (d) Soundness. When there is any question of either soft or laminated pieces being detrimental to any aggregate, a soundness test shall be performed on the aggregate in accordance with AASHTO T 104. The weighted average percentage of loss shall be not more than 8 percent by mass (weight) when subjected to five cycles of the sodium sulfate soundness test.

704.02 COARSE AGGREGATE FOR CONCRETE. Coarse aggregate for concrete shall consist of clean, hard, crushed stone or washed crushed gravel, uniformly graded. The blending of crushed stone and crushed gravel in the stockpile shall not be permitted. It shall be free from deleterious material and pieces that are structurally weak, and when proportioned in concrete shall not adversely affect the structural integrity or durability of the concrete when subjected to freezing and thawing. It shall also meet the following requirements:

- (a) Grading. Coarse aggregate for concrete shall be furnished in the required separate size(s) for the specified class of concrete and shall meet the gradation requirements of the following tables as determined in accordance with AASHTO T 27:

TABLE 704.02A - GRADATION REQUIREMENTS
FOR 9.5 MM (3/8 INCH) STONE

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
12.5 mm (1/2 inch)	100
9.5 mm (3/8 inch)	85 to 100
4.75 mm (No. 4)	10 to 30
2.36 mm (No. 8)	0 to 10
1.18 mm (No. 16)	0 to 5

TABLE 704.02B - GRADATION REQUIREMENTS
FOR 19.0 MM (3/4 INCH) STONE

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
25.0 mm (1 inch)	100
19.0 mm (3/4 inch)	90 to 100
9.5 mm (3/8 inch)	20 to 55
4.75 mm (No. 4)	0 to 10
2.36 mm (No. 8)	0 to 5

TABLE 704.02C - GRADATION REQUIREMENTS
FOR 37.5 MM (1 1/2 INCH) STONE

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
45 mm (1 3/4 inch)	100
37.5 mm (1 1/2 inch)	90 to 100
25.0 mm (1 inch)	20 to 55
19.0 mm (3/4 inch)	0 to 15
9.5 mm (3/8 inch)	0 to 5

- (b) **Percent of Wear.** When the coarse aggregate is composed of crushed stone or crushed gravel, the percent of wear of the aggregate shall not be more than 35 percent when tested in accordance with AASHTO T 96. When the coarse aggregate is composed of crushed igneous rock, the percent of wear of the aggregate shall not be more than 50 percent when tested in accordance with AASHTO T 96.

- (c) Fractured Faces. When crushed gravel is used as coarse aggregate, at least 50 percent by mass (weight) of the material coarser than the 4.75 mm (No. 4) sieve from each stockpile shall have at least one fractured face.
- (d) Thin and/or Elongated Pieces. Not more than 10 percent by mass (weight) of the material coarser than the 4.75 mm (No. 4) sieve from each stockpile shall consist of thin and/or elongated pieces.
- (e) Soundness. Soundness shall meet the requirements of Subsection 704.01(d).
- (f) Aggregate Failure. Coarse aggregate that fractures when used in a test cylinder, at a strength less than the minimum compressive strength of the class of concrete tested, may be rejected.

704.03 AGGREGATE FOR ASPHALT TREATED PERMEABLE BASE. Aggregate for Asphalt Treated Permeable Base shall consist of clean, hard, crushed stone or crushed gravel. The blending of crushed stone and crushed gravel may be permitted if, in the opinion of the Engineer, the materials to be blended are equal in quality and are compatible. The several aggregate fractions shall be sized, uniformly graded, and combined in such proportions that the resulting gradation meets the requirements of Subsection 303.02. The aggregate shall be reasonably free from dirt, deleterious material, and pieces that are structurally weak and shall meet the following requirements:

- (a) Percent of Wear. When the coarse aggregate is composed of crushed stone or crushed gravel, the percent of wear of the aggregate shall not be more than 35 percent when tested in accordance with AASHTO T 96. When the aggregate is composed of crushed igneous rock, the percent of wear of the aggregate shall not be more than 50 percent when tested in accordance with AASHTO T 96.
- (b) Fractured Faces. When crushed gravel is used, at least 75 percent by mass (weight) of the material coarser than the 4.75 mm (No. 4) sieve from each stockpile shall have at least two fractured faces.
- (c) Thin and/or Elongated Pieces. Not more than 10 percent by mass (weight) of the material coarser than the 4.75 mm (No. 4)

sieve from each stockpile shall consist of thin and/or elongated pieces.

- (d) Soundness. Soundness shall meet the requirements of Subsection 704.01(d).

704.04 GRAVEL FOR SUBBASE. Gravel for subbase shall consist of material reasonably free from silt, loam, clay, and organic matter. It shall be obtained from approved sources and shall meet the following requirements:

- (a) Grading. Gravel for subbase shall meet the gradation requirements of the following table as determined in accordance with AASHTO T 27 and AASHTO T 11:

TABLE 704.04A - GRAVEL FOR SUBBASE

Sieve Designation	Percentage By Mass (Weight) Passing Square Mesh Sieves
4.75 mm (No. 4)	20 to 60
150 µm (No. 100)	0 to 12
75 µm (No. 200)	0 to 6

The gravel shall be uniformly graded from coarse to fine. The maximum size stone particles shall not exceed 67 percent of the thickness of the layer being placed.

- (b) Percent of Wear. Percent of wear shall not be more than 50 percent when tested in accordance with AASHTO T 96.

704.05 CRUSHED GRAVEL FOR SUBBASE. Crushed gravel for subbase shall be produced from natural gravels or crushed quarried rock and shall be a material reasonably free from silt, loam, clay, or organic matter. It shall be obtained from approved sources and shall meet the following requirements:

- (a) Grading. Crushed gravel for subbase shall be uniformly graded from coarse to fine and shall meet the gradation requirements of the following table as determined in accordance with AASHTO T 27 and AASHTO T 11:

TABLE 704.05A - CRUSHED GRAVEL FOR SUBBASE

Grading	Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
Coarse	100 mm (4 inch)	95 to 100
	4.75 mm (No. 4)	25 to 50
	150 μ m (No. 100)	0 to 12
	75 μ m (No. 200)	0 to 6
Fine	50 mm (2 inch)	100
	37.5 mm (1 1/2 inch)	90 to 100
	4.75 mm (No. 4)	30 to 60
	150 μ m (No. 100)	0 to 12
	75 μ m (No. 200)	0 to 6

- (b) Percent of Wear. Percent of wear shall not be more than 40 percent when tested in accordance with AASHTO T 96.
- (c) Fractured Faces. At least 50 percent by mass (weight) of the material coarser than the 4.75 mm (No. 4) sieve shall have at least one fractured face.

704.06 DENSE GRADED CRUSHED STONE FOR SUBBASE. Dense graded crushed stone for subbase shall consist of clean, hard, uniformly graded, crushed stone. It shall be sufficiently free from dirt, deleterious material, and pieces that are structurally weak and shall meet the following requirements:

- (a) Source. This material shall be obtained from approved sources. The area from which this material is obtained shall be stripped and cleaned before blasting.
- (b) Grading. Dense graded crushed stone for subbase shall meet the gradation requirements of the following table as determined in accordance with AASHTO T 27 and AASHTO T 11:

TABLE 704.06A - DENSE GRADED CRUSHED
STONE FOR SUBBASE

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
90 mm (3 1/2 inch)	100
75 mm (3 inch)	90 to 100
50 mm (2 inch)	75 to 100
25.0 mm (1 inch)	50 to 80
12.5 mm (1/2 inch)	30 to 60
4.75 mm (No. 4)	15 to 40
75 µm (No. 200)	0 to 6

- (c) Percent of Wear. The percent of wear of the crushed stone shall be not more than 40 percent when tested in accordance with AASHTO T 96. When the aggregate is composed of crushed igneous rock, the percent of wear of the crushed stone shall be not more than 50 percent when tested in accordance with AASHTO T 96.
- (d) Thin and/or Elongated Pieces. Not more than 30 percent by mass (weight) of the material coarser than the 4.75 mm (No. 4) sieve shall consist of thin and/or elongated pieces.
- (e) Filler. Filler shall be obtained from approved sources and shall consist of clean, hard, uniform graded, crushed stone and/or stone screenings produced by the crushing process. The material shall consist of hard, durable particles sufficiently free from dirt, organic material, structurally weak pieces, and other deleterious materials and shall comply with the requirements of parts (a), (c), and (d) above.

Filler material shall meet the gradation requirements of the following table as determined in accordance with AASHTO T 27 and AASHTO T 11:

TABLE 704.06B - FILLER

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
19.0 mm (¾ inch)	100
12.5 mm (½ inch)	70 to 100
4.75 mm (No. 4)	50 to 90
150 µm (No. 100)	0 to 12
75 µm (No. 200)	0 to 6

704.07 GRAVEL BACKFILL FOR SLOPE STABILIZATION. Gravel backfill for slope stabilization shall meet the requirements of Subsection 704.04(a).

704.08 GRANULAR BACKFILL FOR STRUCTURES. Granular backfill for structures shall be obtained from approved sources. It shall consist of satisfactorily graded, free draining granular material reasonably free from loam, silt, clay, and organic material.

Granular backfill for structures shall meet the gradation requirements of the following table as determined in accordance with AASHTO T 27 and AASHTO T 11:

TABLE 704.08A -
GRANULAR BACKFILL FOR STRUCTURES

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
75 mm (3 inch)	100
4.75 mm (No. 4)	45 to 75
150 µm (No. 100)	0 to 12
75 µm (No. 200)	0 to 6

704.09 BACKFILL FOR MUCK EXCAVATION. Backfill for muck excavation shall consist of granular material or blasted rock broken into various sizes that will form a compact embankment with a minimum of voids.

When granular material is used, it shall meet the requirements of Subsection 703.04.

704.10 AGGREGATE FOR BITUMINOUS CONCRETE PAVEMENT.

- (a) Aggregate for Marshall Bituminous Concrete Pavement. Coarse aggregate for Marshall bituminous concrete pavement shall consist of clean, hard, crushed stone or crushed gravel, and be uniformly graded. The blending of crushed stone and crushed gravel may be permitted only in the binder course if, in the opinion of the Engineer, the materials to be blended are equal in quality and are compatible. All aggregate shall be free from dirt, deleterious material, and pieces that are structurally weak. "Coarse Aggregate" shall mean that portion of material coarser than the 2.36 mm (No. 8) sieve.

Fine aggregate for Marshall bituminous concrete pavement shall consist of stone screenings or a combination of stone screenings, screened natural and/or manufactured sands, and other fine aggregates, such that at least 95 percent of any individual stockpile of the fine aggregate shall pass a 9.5 mm (3/8 inch) sieve. The minimum percentage by mass (weight) of the blended material passing the 2.36 mm (No. 8) sieve that must be stone screenings shall be as shown in Table 406.03B of Subsection 406.03(b), unless otherwise authorized in writing by the Engineer.

Manufactured sand may be substituted for stone screenings when 100 percent of the material passing the 2.36 mm (No. 8) sieve has two or more fractured faces as determined in accordance with ASTM C 295 Modified.

(1) Grading.

- a. Coarse aggregate. Coarse aggregate shall be furnished in at least three nominal sizes for Mix Type I and in at least two nominal sizes for Mix Types II and III.

The gradation of the coarse aggregate shall be such that when combined with the fine aggregate, the composite aggregate meets the gradation requirements for bituminous concrete pavement specified in Subsection 406.03(a). The process of blending coarse and fine aggregates shall be accomplished through

the use of separate bins. Blending in the stockpile shall not be permitted.

- b. Fine Aggregate. The gradation of the fine aggregate shall be such that, when combined with a coarse aggregate, the composite aggregate meets the gradation requirements for bituminous concrete specified in Subsection 406.03(a). The process of blending fine and coarse aggregates shall be accomplished through the use of separate bins. Blending in the stockpile shall not be permitted.

The percentage of fine aggregate passing the 2.36 mm (No. 8) sieve shall remain uniform within a tolerance of ± 15 percent for any one mix design. Material produced that does not meet this tolerance may be stockpiled separately and used after an appropriate change is made in the mix design.

- c. Recycled Asphalt Pavement (RAP). When RAP is used to produce bituminous concrete pavement, the resulting mixture shall meet all specification requirements for the type(s) of mix specified.

The bitumen component of the RAP shall be free of significant contents of solvents, tars, or other contaminating substances that will make the RAP unacceptable for recycling as determined by the Engineer.

Should the characteristics of any proposed material for recycling be such that an acceptable mixture cannot be produced and/or maintained, the recycled mix will not be allowed for use on the project.

The Contractor may blend, crush, or prepare the proposed RAP(s) into one or more homogenous stockpiles.

When a bituminous concrete pavement is proposed using RAP, the Contractor shall submit, with the mix design information, an

analysis of the RAP material. The analysis of the RAP material shall include an extracted aggregate gradation, coarse aggregate specific gravity, fine aggregate specific gravity, asphalt content, and recovered binder values. The recovered binder values will be obtained by AASHTO M 320 testing for the designated project PG grade. The M 320 testing will consist of Dynamic Shear Rheometer (DSR) values tested under Original, Rolling Thin Film Oven (RTFO) residue and Pressure Aging Vessel (PAV) residue parameters, and Bending Beam Rheometer (BBR) values. The recovered asphalt will be aged with the RTFO and the PAV for this testing. A minimum of four samples shall be analyzed (or tested) to produce design data. The analysis shall be valid for a 12 month period.

The gradation of the RAP shall be such that, when combined with a coarse and fine aggregate, the composite aggregate shall meet the specified gradation requirements for bituminous concrete in Subsection 406.03(a). The process of blending the RAP, fine aggregate, and coarse aggregate shall be accomplished through the use of separate bins. Blending of these materials in the stockpiles shall not be permitted.

- (2) Percent of Wear. When the coarse aggregate is composed of crushed stone or crushed gravel, the percent of wear of the aggregate shall not be more than 35 percent when tested in accordance with AASHTO T 96. When the coarse aggregate is composed of crushed igneous rock, the percent of wear of the aggregate shall not be more than 50 percent when tested in accordance with AASHTO T 96.
- (3) Fractured Faces. When crushed gravel is used as coarse aggregate, at least 75 percent by mass (weight) of the material coarser than the 4.75 mm (No. 4) sieve shall have at least two fractured faces.

- (4) Thin and/or Elongated Pieces. Not more than 10 percent by mass (weight) of the material coarser than the 4.75 mm (No. 4) sieve from each stockpile shall consist of thin and/or elongated pieces.
- (5) Mineral Filler. Mineral filler shall consist of approved limestone dust, talc dust, or other approved materials and shall be added to the aggregate if required.
- (6) Soundness. Soundness shall meet the requirements of Subsection 704.01(d), except the percentage of loss shall not be more than 12 percent by mass (weight) and shall apply to wearing course aggregates only.
- (7) Control of Aggregate Stockpiles. Before the start of bituminous concrete paving operations and throughout the duration of the paving operation, the cold feed aggregate stockpiles shall each contain at least 1000 metric tons (1000 tons) of accepted aggregate, or the amount required for the job when less than 1000 metric tons (1000 tons).

The addition of unacceptable material to an accepted stockpile shall result in the rejection of the entire stockpile.

The stockpiles shall be separated by partitions or otherwise separated to the satisfaction of the Engineer to prevent intermixing.

All stockpiles shall be maintained at the mixing plant site unless otherwise authorized in writing by the Engineer.

The respective sources of all aggregates to be used in the wearing course shall remain the same for the entire project, unless otherwise authorized in writing by the Engineer.

- (b) Aggregate for Superpave Bituminous Concrete Pavement. Coarse aggregate for Superpave bituminous concrete pavement shall consist of clean, hard, crushed stone, crushed gravel, or crushed igneous rock, and be uniformly graded. The blending of crushed stone, crushed gravel, and/or crushed igneous rock may be permitted only in the binder course if, in the opinion of the Engineer, the materials to be blended are equal in quality and are

compatible. All aggregate shall be free from dirt, deleterious material, and pieces which are structurally weak. "Coarse Aggregate" shall mean that portion of material coarser than the 2.36 mm (No.8) sieve.

Fine aggregate for Superpave bituminous concrete pavement shall consist of stone screenings or a combination of stone screenings, screened natural sand and/or manufactured sands, and other fine aggregates, such that at least 95 percent of any individual stockpile of the fine aggregate shall pass a 9.50 mm (3/8 inch) sieve. "Fine Aggregate" shall mean that portion of material finer than the 2.36 mm (No.8) sieve.

(1) Grading.

- a. Coarse Aggregate. Coarse aggregate shall be furnished in at least three nominal sizes for Mix Type IS and in at least two nominal sizes for Mix Types IIS and IIIS.

The gradation of the coarse aggregate shall be such that when combined with the fine aggregate, the composite gradation shall meet the gradation requirements for Superpave bituminous concrete pavement specified in Subsection 490.03(a). The process of blending coarse and fine aggregates shall be accomplished through the use of separate bins. Blending in the stockpile shall not be permitted.

- b. Fine Aggregate. The gradation of the fine aggregate shall be such that, when combined with a coarse aggregate, the composite aggregate meets the gradation requirements for Superpave bituminous concrete pavement specified in Subsection 490.03(a). The process of blending fine and coarse aggregates shall be accomplished through the use of separate bins. Blending in the stockpile shall not be permitted.

The percentage of fine aggregate passing the 2.36mm (No.8) sieve shall remain uniform within a tolerance of ± 15 percent for any one mix design. Material produced that does not

meet this tolerance may be stockpiled separately and used after an appropriate change is made in the mix design.

- c. Recycled Asphalt Pavement (RAP). RAP shall be permitted to be used in Superpave bituminous concrete pavement. The percentage of RAP, when stated as a percentage of the total mix, shall be limited to a maximum of 15 percent for both design and production purposes.

When RAP is used to produce Superpave bituminous concrete pavement, the resulting mixture shall meet all specification requirements for the type of mix specified.

The bitumen component of the RAP shall be free of significant contents of solvents, tars, or other contaminating substances that will make the RAP unacceptable for recycling as determined by the Engineer.

Should the characteristics of any proposed material for recycling be such that an acceptable mixture cannot be produced and/or maintained, the recycled mix will not be allowed for use on the project.

The Contractor may blend, crush, or prepare the proposed RAP(s) into one or more homogenous stockpiles.

When a Superpave bituminous concrete pavement is proposed using RAP, the Contractor shall submit, with the mix design information, an analysis of the RAP material. The analysis of the RAP material shall include an extracted aggregate gradation, coarse aggregate specific gravity, fine aggregate specific gravity, asphalt content, and recovered binder values. The recovered binder values will be obtained by AASHTO M 320 testing for the designated project PG grade. The M 320 testing will consist of Dynamic Shear Rheometer (DSR) values tested under

Original, Rolling Thin Film Oven (RTFO) residue and Pressure Aging Vessel (PAV) residue parameters, and Bending Beam Rheometer (BBR) values. The recovered asphalt will be aged with the RTFO and the PAV for this testing. A minimum of four samples shall be analyzed (or tested) to produce design data. The analysis shall be valid for a 12 month period.

The gradation of the RAP shall be such that, when combined with a coarse and fine aggregate, the composite aggregate meets the gradation requirements for Superpave bituminous concrete pavement specified in Subsection 490.03(a). The process of blending the RAP, fine aggregate, and coarse aggregate shall be accomplished through the use of separate bins. Blending in the stockpile shall not be permitted.

- (2) Percent of Wear. When the coarse aggregate is composed of crushed stone or crushed gravel, the percent of wear of the aggregate shall not be more than 35 percent when tested in accordance with AASHTO T 96. When the coarse aggregate is composed of crushed igneous rock, the percent of wear of the aggregate shall not be more than 50 percent when tested in accordance with AASHTO T 96.
- (3) Fractured Faces. For Superpave bituminous concrete pavements the following design criteria must be met:

Angularity.

- a. Coarse Aggregate. Coarse aggregate angularity criterion relates to a one or two fractured face count, as a percentage by mass (weight) of material coarser than the 4.75 mm (No. 4) sieve based on traffic (ESALs) and usage (depth) in the pavement structure. A fractured face for this purpose is defined as an angular, rough, or broken surface of an aggregate created by any means. A face is considered a “fractured face” only if it has a

projected area at least as large as 25 percent of the maximum projected area when viewed directly on and the face has sharp and well defined edges. Measurement is made using test method ASTM D 5821 "Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate." Measurement is based on the blended aggregate and is used for design and field control to monitor aggregate production.

Coarse Aggregate Angularity Criteria (Minimum) -
Fractured Face Count

Traffic (ESALs)	Depth From Surface	
	<= 100 mm (4 inches)	> 100 mm (4 inches)
< 300,000	55/--	--/--
300,000 to < 3,000,000	75/--	50/--
3,000,000 to < 10,000,000	85/80 ⁽¹⁾	60/--
10,000,000 to < 30,000,000	95/90	80/75
>= 30,000,000	100/100	100/100

⁽¹⁾ 85/80 denotes that 85 percent of the coarse aggregate has one fractured face and 80% has two or more fractured faces.

Note 1: If less than 25 percent of a layer is within 100 mm (4 inches) of the surface, the layer may be considered to be below 100 mm (4 inches) for mixture design purposes.

- b. Fine Aggregate. Fine aggregate angularity criteria is defined as the percent of air voids in loosely compacted aggregate that passes the 2.36 mm (No.8) sieve based on traffic (ESALs) and usage (depth) in the pavement structure. Measurement is made using

AASHTO Standard: “Standard Test Method for Uncompacted Void Content of Fine Aggregate; T 304, Method A”, and is based on the blended aggregate. Results are used for design purposes, not as a field control tool.

Fine Aggregate Angularity Criteria (Minimum) -
Uncompacted Void Content

Traffic (ESALs)	Depth From Surface	
	<= 100 mm (4 inches)	> 100 mm (4 inches)
< 300,000	--	--
300,000 to < 3,000,000	40	40
3,000,000 to < 10,000,000	45	40
10,000,000 to < 30,000,000	45	40
>= 30,000,000	45	45

Note 1: If less than 25 percent of a layer is within 100 mm (4 inches) of the surface, the layer may be considered to be below 100 mm (4 inches) for mixture design purposes.

- (4) Thin and Elongated Pieces. Not more than 10 percent by mass (weight) of the blended material coarser than the 4.75 mm (No.4) sieve shall consist of aggregates which have a ratio of maximum to minimum dimensions greater than five (5). Measurement is made using test method ASTM D 4791 “Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregates, Section 8.4.” This criterion is used for design and field control to monitor aggregate production.

- (5) Mineral Filler. Mineral filler shall consist of approved limestone dust, talc dust, or other approved materials and shall be added to the aggregate if required.
- (6) Soundness. Soundness shall meet the requirements of Subsection 704.01(d), except the percentage of loss should not be more than 12 percent by mass (weight) and shall apply to wearing course aggregates only.
- (7) Control of Aggregate Stockpiles. Before the start of bituminous concrete paving operations and throughout the duration of the paving operation, the cold feed aggregate stockpiles shall each contain at least 1000 metric tons (1000 tons) of accepted aggregate, or the amount required for the job when less than 1000 metric tons (1000 tons).

The addition of unacceptable material to an accepted stockpile shall result in the rejection of the entire stockpile.

The stockpiles shall be separated by partitions or otherwise separated to the satisfaction of the Engineer to prevent intermixing.

All stockpiles shall be maintained at the mixing plant site unless otherwise approved in writing by to Engineer.

The respective sources of all aggregates to be used in the wearing course shall remain the same for the entire project unless otherwise approved in writing by the Engineer.

- (8) Clay Content. Clay content criterion is a measure of the amount of clay material in the portion of blended aggregate finer than the 4.75 mm (No. 4) sieve based on traffic (ESALs). Measurement is made using AASHTO T 176. Results are used for design purposes and field control to monitor aggregate production.

Clay Content Criteria (Minimum) - Sand Equivalent

Traffic (ESALs)	Sand Equivalent
< 300,000	40
300,000 to < 3,000,000	40
3,000,000 to < 10,000,000	45
10,000,000 to < 30,000,000	45
> 30,000,000	50

704.11 AGGREGATE FOR BITUMINOUS SURFACE TREATMENT.

The peastone and stone grits shall consist of washed crushed gravel or crushed stone and shall be reasonably free from dirt, deleterious material, and pieces that are structurally weak.

The sand shall be washed, natural sand and shall consist of clean, hard, durable grains, reasonably free from dirt and deleterious material.

- (a) Grading. The peastone, stone grits, and sand shall meet the gradation requirements of the following table as determined in accordance with AASHTO T 27 and AASHTO T 11:

TABLE 704.11A - AGGREGATE FOR BITUMINOUS
SURFACE TREATMENT

	Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
Peastone	19.0 mm (3/4 inch)	100
	16.0 mm (5/8 inch)	90 to 100
	4.75 mm (No. 4)	0 to 5
Stone Grits	12.5 mm (1/2 inch)	100
	9.5 mm (3/8 inch)	90 to 100
	2.36 mm (No. 8)	0 to 10
	75 µm (No. 200)	0 to 3
Sand	16.0 mm (5/8 inch)	100
	4.75 mm (No. 4)	90 to 100
	150 µm (No. 100)	0 to 8

- (b) Percent of Wear.
- (1) Crushed Gravel. When the aggregate is composed of crushed gravel, the percent of wear shall not be more than 35 percent when tested in accordance with AASHTO T 96. No wear requirements shall apply when grits are used as a shoulder treatment.
 - (2) Crushed Stone. When the aggregate is composed of crushed stone, the percent of wear of the aggregate shall not be more than 35 percent when tested in accordance with AASHTO T 96. No wear requirements shall apply when grits are used as a shoulder treatment.
- (c) Fractured Faces. When crushed gravel is used at least 50 percent by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve from each stockpile shall have at least one fractured face.
- (d) Thin and/or Elongated Pieces. Not more than 15 percent by mass (weight) of the material coarser than the 4.75 mm (No. 4) sieve shall consist of thin and/or elongated pieces.

704.12 AGGREGATE FOR SURFACE COURSE AND SHOULDERS.

Aggregate for surface course and shoulders shall consist of clean, hard gravel, crushed gravel, or crushed stone. It shall be reasonably free from silt, loam, clay, or organic matter. It shall be obtained from approved sources and shall meet the following requirements:

- (a) Grading. Aggregate for surface course and shoulders shall be uniformly graded from coarse to fine and shall meet the gradation requirements of the following table as determined in accordance with AASHTO T 27 and AASHTO T 11:

TABLE 704.12A - AGGREGATE FOR SURFACE COURSE AND SHOULDERS

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
37.5 mm (1 1/2 inch)	100
25.0 mm (1 inch)	90 to 100
4.75 mm (No. 4)	45 to 65
150 µm (No. 100)	0 to 15
75 µm (No. 200)	0 to 12

- (b) Percent of Wear. The percent of wear when tested in accordance with AASHTO T 96 shall be not more than 40 percent for material used as aggregate surface course or not more than 50 percent for material used as aggregate shoulders.

704.13 SAND FOR CEMENT MORTAR. Sand for cement mortar shall be a washed natural sand and shall consist of clean, hard, durable grains. It shall be uniformly graded from coarse to fine, and shall be free from injurious amounts of organic matter or other harmful substances.

- (a) Grading. Sand for cement mortar shall meet the gradation requirements of the following table as determined in accordance with AASHTO T 27 and AASHTO T 11:

TABLE 704.13A - SAND FOR CEMENT MORTAR

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
2.36 mm (No. 8)	100
300 µm (No. 50)	15 to 40
150 µm (No. 100)	0 to 10
75 µm (No. 200)	0 to 5

- (b) Organic Impurities. The sand shall show a color of not greater than two when determined in accordance with AASHTO T 21.

704.14 LIGHTWEIGHT COARSE AGGREGATE FOR STRUCTURAL CONCRETE. Lightweight coarse aggregate for structural concrete shall be clean, hard, and uniformly graded. It shall be reasonably free from dirt, deleterious material, and pieces that are structurally weak. It shall meet the following requirements:

- (a) General Characteristics. Two general types of lightweight aggregates may be used:
- (1) Aggregates prepared by expanding, calcining, or sintering products such as blast furnace slag, clay, shale, or slate. Other raw materials may be used if the resulting prepared aggregates meet the requirements of these specifications.
 - (2) Aggregates prepared by crushing, screening, and cleaning natural lightweight materials such as pumice, scoria, or tuff.
- (b) Grading. Grading shall meet the requirements specified in Table 704.02B as determined in accordance with AASHTO T 27.
- (c) Percent of Wear. Percent of wear shall not be more than 50 percent when tested in accordance with AASHTO T 96.
- (d) Thin and/or Elongated Pieces. The thin and/or elongated pieces shall conform to the requirements specified in Subsection 704.02(d).
- (e) Soundness. Soundness shall meet the requirements of Subsection 704.01(d).
- (f) Density. The maximum dry loose density of the lightweight coarse aggregate shall not exceed 880 kg/m³ (55 pounds per cubic foot) when tested in accordance with AASHTO T 19/T 19M. The density of lightweight aggregate shall not differ by more than 10 percent from samples submitted for acceptance tests.

704.15 QUARTZITE OR GRANITE AGGREGATE USED IN PAVEMENTS. The Agency has identified a potential stripping problem with some granite and quartzite aggregates used in the production of bituminous concrete pavement. Until additional research can determine a

more finite evaluation of the problem or identify optional corrective alternatives, any material supplied under Sections 303, 406, or 490 that contains aggregates from monomineralic (a rock consisting essentially of one mineral) quartzite sources or granite sources will require the addition of a minimum of 0.5% (by percentage of asphalt weight) of an anti-strip additive. Anti-strip additives shall comply with the requirements of Subsection 702.07. The Agency reserves the option to require the use of an anti-strip additive at any time that a potential stripping problem is observed.

704.16 DRAINAGE AGGREGATE. Rock for drainage applications shall be produced from natural gravels or crushed quarried rock and shall consist of clean, hard, sound, and durable material.

- (a) Drainage aggregate shall be uniformly graded from coarse to fine and shall meet the gradation requirements of the following table as determined in accordance with AASHTO T 27:

TABLE 704.16A – DRAINAGE AGGREGATE

Sieve Designation	Percent By Mass (Weight) Passing the Square Mesh Sieves
25.0 mm (1 inch)	100
19.0 mm (¾ inch)	90 to 100
9.5 mm (⅜ inch)	20 to 55
4.75 mm (No. 4)	0 to 10
2.36 mm (No. 8)	0 to 10

- (b) Percent of Wear. Percent of wear shall not be more than 40 percent when tested in accordance with AASHTO T 96.
- (c) Soundness. Soundness shall conform to the requirements of Subsection 704.01(d).

704.17 AGGREGATE FOR EROSION PREVENTION AND SEDIMENT CONTROL. Aggregate for erosion prevention and sediment control shall consist of clean, hard, crushed stone or crushed gravel. It shall be reasonably free from dirt and deleterious material. It shall be

uniformly graded and meet the gradation requirements of the following table as determined in accordance with AASHTO T 27:

TABLE 704.17A – AGGREGATE FOR EROSION PREVENTION AND SEDIMENT CONTROL

Sieve Designation	Percentage by Mass (Weight) Passing Square Mesh Sieves
100 mm (4 inch)	80 to 100
75 mm (3 inch)	40 to 60
50 mm (2 inch)	0 to 20

- (a) Vehicle Tracking Pad. Stone for Vehicle Tracking Pad shall meet the gradation requirements of Table 704.17A.
- (b) Stone Check Dam, Type I. Stone for Stone Check Dam, Type I with a drainage area of less than 0.4 hectare (1 acre) shall meet the gradation requirements of Table 704.17A. Stone for Stone Check Dam, Type I with drainage area between 0.4 and 2 hectares (1 and 5 acres) shall meet the requirements of stone for Stone Fill, Type I. If filtering is desired, aggregate meeting the gradation requirements of Table 704.02B can be added to the upstream surface of the check dam.
- (c) Stone Check Dam, Type II. Stone for Stone Check Dam, Type II on grades of 3% or less shall meet the gradation requirements of Table 704.02C. Stone for Stone Check Dam, Type II on grades greater than 3% shall meet the gradation requirements of Table 704.17A.
- (d) Inlet Protection Device, Type I. Stone for Inlet Protection Device, Type I shall meet the gradation requirements of Table 704.02C.

SECTION 705 - MASONRY UNITS

705.01 BRICK.

- (a) Clay or Shale Manhole Brick. Brick used for sewer manhole inverts shall conform to AASHTO M 91, Grade MS.

- (b) Clay or Shale Building Brick. Building brick shall be used in masonry construction where a high degree of resistance to frost action is desired and the exposure is such that water permeating the brick may be frozen. It shall conform to the requirements of AASHTO M 114, Grade SW.
- (c) Clay or Shale Sewer Brick. Brick used for construction where resistance to the action of sewage is needed shall conform to the requirements of AASHTO M 91, Grade SM.
- (d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

705.02 CONCRETE MASONRY BLOCKS.

- (a) Properties. Concrete masonry blocks intended for use in the construction of catch basins or manholes shall conform to the requirements of ASTM C 139 (solid, precast units) or ASTM C 90, Grade N, Type I or Type II (hollow, precast units).
- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

705.03 CONCRETE UNITS FOR SLOPE PAVING. Concrete units for slope paving shall be solid precast units of uniform quality and appearance, with all faces smooth and flush, reasonably free from surface defects and shall conform to the following requirements:

- (a) Size. The concrete units shall conform to the details shown on the Plans as to size, shape, and, if required, placement of bar reinforcement.
- (b) Materials. The concrete shall have a minimum compressive strength of 20.7 MPa (3000 psi). Bar reinforcement, when required, shall conform to the requirements of Subsection 713.01.
- (c) Curing. The concrete units shall be cured in accordance with the requirements of ASTM C 478M, Section 8, and for a sufficient length of time so that the concrete will develop the specified compressive strength at 28 days or less.
- (d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

705.04 PRECAST DROP INLETS, CATCH BASINS, AND MANHOLES. Precast drop inlets, catch basins, and manholes shall conform to the requirements of AASHTO M 199M/M 199 with the following notes or exceptions:

- (a) Reinforced Concrete Pipe. Reinforced concrete pipe for drop inlets shall conform to the requirements of Subsection 710.01. It shall be of the tongue and groove type with positive connection between sections.
- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

SECTION 706 - STONE FOR MASONRY, RIPRAP,
AND OTHER PURPOSES

706.01 STONE FOR MASONRY. Stone for masonry shall be quarry stone, field stone, or rock fragments approximately rectangular in shape and of a hard, sound, and durable quality acceptable to the Engineer. The stone shall be free from structural defects or imperfections that would tend to destroy its resistance to the weather.

At least 80 percent of the individual stones in a unit shall have a thickness of not less than 200 mm (8 inches) and a width of not less than 150 percent of the thickness. The minimum size of the other stones in the unit shall have a thickness of not less than 100 mm (4 inches) and a width of not less than 150 percent of the thickness.

706.02 STONE FOR MASONRY FACING. Stone for masonry facing shall be irregularly shaped or roughly rectangular quarried granite, marble, or other approved quarried stone.

Stone for capping shall conform to the dimensions shown on the Plans unless changes are ordered in writing by the Engineer.

The stone shall be of approved quality, tough, sound, and durable, resistant to weathering action, uniform in color, free from seams, cracks, laminations, pyrite inclusions, and minerals or other structural defects which, by weathering, would cause discoloration or deterioration and shall be thoroughly cleaned of any iron or rust particles. Stone shall be of such character that it can be wrought to such lines and surfaces, whether curved or plane, as required. Any stone having defects that have been repaired with cement or other materials shall be rejected.

The stone shall be kept free from dirt, oil, and any other injurious material that may prevent the proper adhesion of the mortar or detract from the appearance of the exposed surfaces.

The front face of the facial stone, including capstones when required, shall be smooth, quarry-split, free from drill holes in the exposed face, with no projections or depressions greater than 25 mm (1 inch) measured from the vertical plane of the face of the stone.

The capstone shall have a top surface sawed to an approximately true plane. The front and back arris lines of the capstones shall be pitched straight and true.

706.03 STONE FOR RIPRAP. Stone for riprap shall be approved, rough, unhewn quarry stone, as nearly rectangular in section as practical. The stones shall be hard, sound, and resistant to the action of water and weathering. They shall be of a rock type other than serpentine rock containing the fibrous variety chrysotile (asbestos) and suitable in every respect for the purpose intended.

- (a) **Heavy Type.** The individual stones shall have a depth equal to the thickness of the course of riprap. At least 75 percent of the volume of the riprap, complete in place, shall consist of stones that have a minimum volume of 0.5 m³ (16 ft³).
- (b) **Light Type.** The individual stones shall have a depth equal to the thickness of the course of riprap. The riprap, complete in place, shall consist of stones that have a minimum volume of 0.015 m³ (1/2 ft³).

706.04 STONE FOR STONE FILL. Stone for stone fill shall be approved, hard, blasted, angular rock other than serpentine rock containing the fibrous variety chrysotile (asbestos). The least dimension of the stone shall be greater than 33 percent of the longest dimension. The stone fill shall be reasonably well graded from the smallest to the maximum size stone specified so as to form a compact mass when in place.

- (a) **Type I.** The longest dimension of the stone shall vary from 25 to 300 mm (1 to 12 inches), and at least 50 percent of the volume of the stone in place shall have a least dimension of 100 mm (4 inches).
- (b) **Type II.** The longest dimension of the stone shall vary from 50 to 900 mm (2 to 36 inches), and at least 50 percent of the volume

of the stone in place shall have a least dimension of 300 mm (12 inches).

- (c) Type III. The longest dimension of the stone shall vary from 75 to 1200 mm (3 to 48 inches), and at least 50 percent of the volume of the stone in place shall have a least dimension of 400 mm (16 inches).
- (d) Type IV. The longest dimension of the stone shall vary from 75 to 1500 mm (3 to 60 inches), and at least 50 percent of the volume of the stone in place shall have a least dimension of 500 mm (20 inches).

706.05 STONE FOR SLOPE PAVING. Stone for slope paving shall be approved, rough, unhewn quarry stone or field stone, approximately rectangular in shape and shall be free from structural defects or imperfections.

The individual stones shall have one reasonably flat face for the exposed portion and shall not be less than 130 mm (5 inches) in thickness perpendicular to the exposed face, which thickness shall be the least dimension of the stone.

Seventy-five percent of the stones shall have a minimum volume of 0.055 m³ (2 ft³). The minimum volume of other stones shall be 0.015 m³ (1/2 ft³).

706.06 ROCK FILL FOR GABIONS. Rock fill for gabions shall be well graded, hard, sound, durable, and free from cracks and other structural defects that may cause it to deteriorate. It shall not contain any material that easily disintegrates. In addition to the following requirements, the size shall be such that a minimum of two layers of rock can be achieved when filling any gabion.

- (a) Grading. The rock size shall be 100 mm (4 inches) minimum to 200 mm (8 inches) maximum when measured in accordance with ASTM D5519. A tolerance of 5% undersize and 5% oversize rock by number of particles shall be allowed. In addition, the rock shall be large enough to prevent individual pieces from passing through the gabion mesh openings.
- (b) Soundness. Soundness shall meet the requirements of Subsection 704.01(d).

SECTION 707 - JOINT MATERIALS

707.301 MORTAR, TYPE I. Type I mortar is generally used as a joint filler between curb stones, for stone slope edging, and for the grouting of dowels. It shall be used in small quantities as needed and shall not be retempered or used after it has begun to set.

The mortar shall be composed of one part cement and one part sand, and shall be mixed with sufficient water to form a plastic composition. For grouting, sufficient water shall be added to provide the required consistency.

The cement, sand, and water shall meet the following requirements:

- (a) Cement. Cement shall conform to the requirements of Subsection 701.02.
- (b) Sand. Sand shall conform to the requirements of Subsection 704.13 or 704.01, as appropriate.
- (c) Water. Water shall conform to the requirements of Subsection 745.01.

707.02 MORTAR, TYPE II. Type II mortar is generally used as a joint filler for concrete and clay pipes, stone and brick masonry, and for repointing. It shall be used in small quantities as needed and shall not be retempered or used after it has begun to set.

The mortar shall be composed of one part cement and two parts sand, and shall be mixed with sufficient water to form a plastic composition.

The cement, sand, and water shall meet the requirements of Subsection 707.01.

707.03 MORTAR, TYPE IV. Type IV mortar is used when a non-shrinking cement mortar is required.

- (a) Packaging. The manufacturer's name, product designation, and recommendations for surface preparation, mixing, placing, finishing, and curing shall be clearly indicated on the product packaging. Handling precautions and toxicity warnings shall be printed on all containers. The expiration date and lot number shall appear on each package of material delivered to the project site.

- (b) Sampling and Testing. Upon request, the Agency's Materials and Research Section will furnish a list of products that have been tested and are considered satisfactory. Should the Contractor wish to use a product not included on the Agency's Approved Products List, an alternate product may be submitted for consideration. Application for alternate material approval shall be submitted to the Agency's Materials and Research Section accompanied by a 45 kg (100 pound) sample of the product and complete Material Safety Data Sheet (MSDS) information. Upon approval, the product name and manufacturer will be placed on the Agency's Approved Products List. A minimum period of two months shall be allowed for testing purposes.
- (c) Performance Requirements.
- (1) Compressive Strength. The neat material shall exhibit a minimum three-day compressive strength of 17.2 MPa (2500 psi), a minimum seven-day compressive strength of 24.1 MPa (3500 psi) and a minimum 28-day compressive strength of 34.5 MPa (5000 psi) when tested in accordance with AASHTO T 106.
 - (2) Freeze-Thaw Durability. Resistance to rapid freezing and thawing shall be determined in accordance with AASHTO T 161, Procedure A, as modified by the Agency's Materials and Research Section for use of a 3 percent sodium chloride solution. The material shall exhibit no more than an 8 percent loss in mass (weight) after 300 cycles.
 - (3) Volume Stability. The material shall exhibit a maximum height change of +0.3 percent and a minimum height change of 0.0 percent when tested in accordance with ASTM C 1090.
- (d) Other. Instead of a commercially prepared product, the Contractor may produce a non-shrinking cement mortar composed of one part cement, one part sand, and aluminum powder mixed with sufficient water to form a plastic composition as follows:

From 2 to 4 g (0.07 to 0.14 ounces) of the superfine unpolished variety of aluminum powder shall be added for each sack of cement used in the mortar. The exact amount of aluminum powder shall be as directed by the Engineer. The dosage per

batch of mortar shall be carefully measured. The aluminum powder shall be blended with pozzolan or pumicite in the proportion of one part aluminum powder to 50 parts pozzolan or pumicite by mass (weight). The blend shall be thoroughly mixed with the cement and sand before water is added to the batch, as it has a tendency to float on water. The amount of the blend used shall vary from 128 g (4.5 ounces) per sack of cement for a placing temperature of 21 °C (70 °F) to 198 g (7 ounces) per sack of cement for a placing temperature of 5 °C (40 °F). After all ingredients are added, the batch shall be mixed for three minutes. Batches of mortar shall be placed within 45 minutes after mixing, as the action of the aluminum powder becomes very weak after this time, and it shall not be retempered or used after it has begun to set.

The cement, sand, and water shall meet the requirements of Subsection 707.01.

707.04 JOINT SEALER, POURABLE.

- (a) Joint Sealer, Hot Poured. This material shall consist of a hot applied, single-component, low-modulus, elastic sealant meeting the requirements of AASHTO M 324. The sealant shall allow up to 200 percent elongation at temperatures down to -29 °C (-20 °F) when placed in a typical joint configuration.
- (b) Joint Sealer, Cold Poured. This material shall consist of a cold applied, two-component, low-modulus, elastic sealant capable of 200 percent elongation at temperatures down to -29 °C (-20 °F) when placed in a typical joint configuration.
- (c) Backer Rod. Backer rod shall be 100 percent watertight, closed-cell, non-gassing, polyethylene, polyolefin, or other suitable material that does not react chemically with the sealant. It shall be compatible with the sealant applied at temperatures up to 210 °C (410 °F), shall remain stable down to -29 °C (-20 °F), and shall not cause bubbling of the sealant bead. The backer rod shall be approximately 3 mm (1/8 inch) larger in diameter than the width of the joint in which it is used.
- (d) Certification. Either a Type B or a Type C Certification shall be furnished in accordance with Subsection 700.02.

707.05 JOINT SEALER, POLYURETHANE. Polyurethane joint sealer shall consist of a single or a two-component, cold-applied, polyurethane, elastomeric compound for use in expansion joints in widths up to 150 mm (6 inches). The sealer shall be suitable for installation at temperatures above 7 °C (45 °F) and below 27 °C (80 °F), self-leveling where used in horizontal joints, capable of filling the joint completely without the formation of air holes or other discontinuities, and non-sagging or not subject to flow when placed in vertical or inclined joints.

The sealer shall cure by chemical reaction between the two components or by reaction with moisture from the atmosphere.

- (a) **Primer.** When recommended by the manufacturer, a primer system shall be used to ensure adhesion to steel, concrete, epoxy, epoxy mortar, or granite under all conditions. The primer system shall be furnished by the sealer manufacturer.
- (b) **Filler Material.** A foam spacer (backing) or filler material shall be used where shown on the Plans. The foam spacer shall be a closed-cell polyethylene or PVC foam, recommended by the manufacturer of the joint sealer and acceptable to the Engineer.
- (c) **Bond Breaker.** A suitable bond breaker shall be applied to those surfaces shown on the Plans. The bond breaker shall be polyethylene-coated tape or other substitute acceptable to the Engineer.
- (d) **Proportioning and Mixing.** When required, proportioning and mixing shall be accomplished strictly according to the manufacturer's instructions.
- (e) **Packaging.** The joint sealer materials shall be delivered to the project in suitable containers for handling and shall be sealed or otherwise protected from contamination.

The containers shall be clearly labeled with the following information:

Name and Address of Manufacturer
 Name of Product or Component Identification
 Batch Number
 Date of Manufacture

The manufacturer shall furnish with each shipment complete instructions for its storage, proportioning, mixing, handling, joint preparation, and joint installation procedures and complete

MSDS information. A copy of these instructions shall be furnished to the Engineer.

- (f) Performance Requirements for Two-Component Materials. The joint sealer system, consisting of sealer and primer, shall meet the requirements of the following:

Sealer system shall meet the performance requirement of Federal Specification TT-S-00227E, Sealing Compound, Elastomeric Type, Class A.

- (g) Performance Requirements for Single-Component Materials. The joint sealer system shall meet the requirements of the following:

Sealer system shall meet the performance requirement of Federal Specification TT-S-00230C, Sealing Compound, Type II, Class B.

- (h) Certification. Either a Type B or a Type C Certification shall be furnished in accordance with Subsection 700.02.

707.06 JOINT SEALER, PREFORMED NEOPRENE.

- (a) Properties. Preformed neoprene joint sealer shall conform to the requirements of AASHTO M 220. The lubricant-adhesive shall be of the formulation recommended by the manufacturer for the kind of material adjacent to the joint sealer.

The Contractor shall furnish representative samples of joint sealer, lubricant-adhesive, or other components at no additional cost to the Agency for laboratory testing, when requested by the Engineer.

Any material not conforming to this Subsection at the time of application or which has been improperly stored or which has exceeded the stated shelf life will be rejected.

Lubricant-adhesive shall not be used beyond one year following its date of manufacture or if the container has been previously opened.

- (b) Certification. Either a Type B or a Type C Certification shall be furnished in accordance with Subsection 700.02.

707.07 PREFORMED FABRIC MATERIAL.

- (a) Properties. Preformed fabric material shall be a multi-layered sheet composed of multi-ply of $510 \text{ g/m}^2 \pm 5$ percent (15 ounces per square yard ± 5 percent) polyester fabric laminated with butadiene acrylonitrile, vulcanized to form an integral laminate.

Physical properties of the laminate shall meet the following requirements:

	Number of Plies		
	2	3	5 to 8
Minimum Mass (Weight) per Unit Area of laminate, kg/m^2 (lbs/ft ²)	3.65 (0.75)	4.15 (0.85)	19.50 (4.0)
Minimum Thickness, mm (in)	3.2 (1/8)	4.0 (5/32)	19.0 (3/4)
Minimum Ultimate Tensile Strength of laminate, kN/m (lbs/in) of width	140 (800)	210 (1200)	350 (2000)
Maximum Elongation at Ultimate Tensile	30%	30%	30%
Maximum Elongation at 10% of Ultimate Tensile	3%	3%	3%

- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

707.08 PREFORMED JOINT FILLER, CORK AND ASPHALT-TREATED FELT.

- (a) Properties. Preformed cork joint filler shall conform to the requirements of AASHTO M 153, Type II unless otherwise specified. Asphalt-treated felt shall conform to the requirements of ASTM D 226 unless otherwise specified.
- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

707.09 PREFORMED JOINT FILLER, CLOSED-CELL FOAM.

- (a) Properties. Preformed joint filler shall be a closed-cell polyethylene or PVC foam, premolded to a semi-rigid consistency.

When tested in accordance with ASTM D 3575, the premolded foam shall have the following physical properties:

Property	Test Procedure	Minimum	Maximum
Density, kg/m ³ (lbs/ft ³)	Test C	48 (3)	80 (5)
Buoyancy, kg/m ³ (lbs/ft ³)	Test AA	830 (52)	930 (58)
Tensile Strength, kPa (psi)	Test E	240 (35)	---
Water Absorption, % by volume	Test G	---	0.5
Tensile Elongation, %	Test E	65	75
Compressive Strength, kPa (psi)	Test B @ 25%	70 (10)	100 (15)
Compressive Strength, kPa (psi)	Test B @ 50%	140 (20)	170 (25)
Compressive Set Not Recovered, % original thickness	Test A	10	15

- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

707.10 POLYVINYL CHLORIDE (PVC) WATERSTOP. PVC waterstop shall be manufactured from virgin PVC resin with the addition of only those plasticizers, stabilizers, or other materials needed to ensure that, when the material is compounded, it will meet the requirements of this Subsection. No reclaimed, scrap, or reprocessed PVC shall be used.

- (a) Physical Properties. The finished waterstop shall conform to the requirements of the following table:

TABLE 707.10A - PVC WATERSTOP

Property	ASTM Procedure	Minimum	Maximum
Tensile Strength, kPa (psi)	D 412	9650 (1400)	---
Ultimate Elongation, %	D 412	250	---
Low Temperature Brittleness	D 746	*	---
Durometer Hardness – Shore Type A	D 2240	60	80
Stiffness in Flexure, kPa (psi)	D 747	2750 (400)	---
Alkali Resistance (10% NaOH) Mass (Weight) Change, %	D 543	-0.10	+0.25
Durometer Hardness Change	---	-5	+5

* No cracking or chipping permitted on three specimens at -29 °C (-20 °F).

- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

707.11 RUBBER GASKETS.

- (a) Properties. Rubber gaskets for culvert pipe joints shall conform to the requirements of AASHTO M 198, Type A.
- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

707.12 JOINT SEALER, BUTYL RUBBER TAPE.

- (a) Properties. Butyl rubber joint sealer tape shall be a flexible plastic gasket conforming to AASHTO M 198, Type B. The sealant shall be in roll form with release paper backing dimensioned to the width and thickness specified.
- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

707.13 ALUMINUM IMPREGNATED CAULKING COMPOUND.

Aluminum impregnated caulking compound is generally used to protect the surfaces of aluminum alloy in contact with other metals, wood, or portland cement concrete. The compound shall be impregnated with aluminum flake or powder and shall be of such consistency and properties

that it can be readily applied with a trowel, putty knife, or caulking gun without pulling or drawing. The material shall meet the approval of the Engineer.

707.14 PREFORMED JOINT FILLER, BITUMINOUS TYPE.

- (a) Properties. Bituminous type preformed joint filler shall conform to the requirements of AASHTO M 33 or AASHTO M 213.
- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

707.15 ASPHALTIC PLUG BRIDGE JOINT. Acceptable Asphaltic Plug Bridge Joint systems shall be those included on the Approved Products List on file with the Agency's Materials and Research Section.

SECTION 708 - PAINTS, STAINS, AND TRAFFIC
MARKING MATERIALS

708.01 GENERAL REQUIREMENTS.

- (a) General. All paints shall be ready-mixed in accordance with the specific formulas from ingredients that meet the requirements described below. The paints shall be free of coarse particles, skins, and water, and other foreign and objectionable matter except where tolerances have been allowed. The paints shall not skin over, thicken, liver, settle out excessively, or cake in the container in storage and shall be readily broken up with a paddle into a smooth, uniform consistency.

No rosin or rosin derivatives shall be added to the paints, but beneficial agents such as antioxidants or wetting aids may be added.

Ready-mixed paints that have hardened on standing or otherwise deteriorated to any extent will not be acceptable.

All paints shall be suitable for use in airless spray equipment.

The paint, when applied by brush or spray to a smooth vertical metal surface at a wet film thickness of 75 μm (3 mils), shall dry without running, streaking, or sagging.

- (b) Packaging. Ready-mixed paints shall be shipped in strong, new, airtight containers. All containers of paint shall be clearly labeled with the following information:

Name and Address of Manufacturer
 Manufacturer's Batch Number
 Date of Manufacture
 Vermont Paint Number, Name, and Color
 Volume of Contents

Containers shall be clearly marked to indicate any hazards connected with the use of the paint and the protective measures that should be provided to prevent injury to the health of workers.

- (c) Sampling, Testing, and Certification. No paint or stain shall be used until it has been tested and approved by the Agency's Materials and Research Section.
- (1) Sampling. At least one sample, not less than 1 L (1 quart), shall be taken for each batch of paint or stain to be used regardless of whether or not the quality of the paint is certified by the manufacturer.
 - (2) Testing. Testing of paints shall be done in accordance with FED-STD-141C or ASTM test methods, at the discretion of the Agency's Materials and Research Section.
 - (3) Certification.
 - a. Shop and Field Primers Used on Aluminum and Galvanized Surfaces. Paints used under this Section shall be covered by a Type A Certification in accordance with Subsection 700.02.
 - b. Paint for Pavement Markings. Pigment and vehicle constituents used in the paints shall be covered by a Type A Certification in accordance with Subsection 700.02.
 - (4) Identification. To provide a means of identification for all paint, the applicable identification number and name taken from the following list shall be printed on all Test Reports and container labels.

- (5) Primer Coatings for Structural Steel and Other Metals.
For primer coatings, the identification number and the name for the primer used shall be the manufacturer's name, the manufacturer's name for the primer, and the manufacturer's lot number.
- (6) Intermediate Coatings for Structural Steel and Other Metals. For paint coatings, the identification number and the name for the intermediate coat used shall be the manufacturer's name, the manufacturer's name for the coatings, and the manufacturer's lot number.
- (7) Finish Coatings for Structural Steel and Other Metals.
For paint coatings, the identification number and the name for the finish coat used shall be the manufacturer's name, manufacturer's name for the coating, and the manufacturer's lot number.
- (8) Coatings for Wood.
VT 4.01 Dark Brown Oil Base Stain
- (9) Paint For Traffic Signs.
VT 5.01 Black Enamel
VT 5.02 Blue Enamel
VT 5.03 Green Enamel
VT 5.04 Red Enamel
VT 5.05 White Enamel
VT 5.06 Yellow Enamel
VT 5.07 Brown Enamel
VT 5.08 Orange Enamel
- (10) Paint For Traffic Control Signals.
VT 6.01 Flat Black Enamel
VT 6.02 Yellow Enamel
- (11) Paint For Pavement Marking.
VT 7.01 White Traffic Paint
VT 7.02 Yellow Traffic Paint
VT 7.05 White Traffic Paint, Fast Dry
VT 7.06 Yellow Traffic Paint, Fast Dry

- (12) Approved Coatings. Acceptable structural coatings shall be the coatings listed on the Qualified Products List on file with the Agency’s Materials and Research Section.

(d) Vehicle Constituents. RESERVED

708.02 THIS SUBSECTION RESERVED

708.03 APPROVED STRUCTURAL COATING SYSTEMS. Acceptable structural coating systems shall be the Structural Coating Systems listed on the Qualified Products List on file with the Agency’s Materials and Research Section.

Colors shall conform to federal standard No. 595:

<u>COLOR</u>	<u>COLOR CHIP NO.</u>
Green	14062
Black	27038
Brown	20059

708.04 GREASE RUSTPROOFING COMPOUND. Grease rustproofing compound shall be a soft film type material made from petroleum combined with special additives to enhance its moisture displacing capabilities. It shall contain effective rust inhibitors and conform to the following:

- Appearance (Color): Brown Green
- Flash, COC, Min.: 66 °C (150 °F)
- Undist. (D-127): 280.(30 units)
- Melting Point, Min.: 63 °C (145 °F)
- Thinner, Max. 20 % by mass (weight)
- Density, Min. 0.839 gm/ml at 16 °C (7.00 lb./gal at 60 °F)
- Approximate NLGI Grease Grade: No. 2 before solvent evaporation and No. 5 after solvent evaporation.

708.05 COATINGS FOR WOOD.

- (a) VT 4.01 Dark Brown Oil Base Stain. The stain is used as a protective coating for wood surfaces.

The stain shall conform to the requirements of Table 708.05A.

TABLE 708.05A - DARK BROWN OIL BASE STAIN

	Minimum	Maximum
Pigment:		
The pigment shall consist of pure mineral pigments combined in proportions necessary to match the specified color.		
Vehicle:		
Heavy Bodied Linseed Oil, %	15	---
Mineral Spirits, %	---	85
Stain:		
Pigment, %	15	---
Vehicle, %	---	85
Density, g/L (lb./gal)	910 (7.5)	---
Drying Time, hrs., dry to recoat	---	24
Fineness of Grind (Hegman Scale)	4	---
Color:		
Dark Brown to match color standard supplied by the Agency's Materials and Research Section.		

708.06 PAINT FOR TRAFFIC SIGNS. Paint for traffic signs shall consist of ready-mixed enamels suitable for exterior use on primed wood and metal surfaces and shall conform to the requirements of CID A-A-2962. The type of cure shall be as shown on the Plans. Porcelain enamels shall conform to the requirements of Porcelain Enamel Institute, Inc. Specification ALS-105.

The Color Tolerance Charts prepared by FHWA shall be used to determine acceptable color match for blue, brown, green, orange, red, and yellow traffic sign paints.

- (a) **VT 5.01 Black Enamel.** The color shall be an acceptable match to Chip No. 17038 in FED-STD-595B.
- (b) **VT 5.02 Blue Enamel.** The color shall be an acceptable match to Chip No. 15090 in FED-STD-595B.
- (c) **VT 5.03 Green Enamel.** The color shall be an acceptable match to Chip No. 14109 in FED-STD-595B.
- (d) **VT 5.04 Red Enamel.** The color shall be an acceptable match to Chip No. 11105 in FED-STD-595B.
- (e) **VT 5.05 White Enamel.** The color shall be an acceptable match to Chip No. 17875 in FED-STD-595B.

- (f) VT 5.06 Yellow Enamel. The color shall be an acceptable match to Chip No. 13538 in FED-STD-595B.
- (g) VT 5.07 Brown Enamel. The color shall be an acceptable match to a chip provided by the Agency's Materials and Research Section.
- (h) VT 5.08 Orange Enamel. The color shall be an acceptable match to a chip provided by the Agency's Materials and Research Section.

708.07 PAINT FOR TRAFFIC CONTROL SIGNALS. Paint for traffic control signals shall consist of ready-mixed enamels suitable for exterior use on primed metal surfaces.

- (a) VT 6.01 Flat Black Enamel. The color shall conform to the requirements of Federal Specification TT-E-527. The color shall be an acceptable match to Chip No. 37038 in FED-STD-595B.
- (b) VT 6.02 Yellow Enamel. The color shall conform to the requirements of CID A-A-2962. The color shall be an acceptable match to Chip No. 13538 in FED-STD-595B.

708.08 PAINT FOR PAVEMENT MARKINGS. Ready-mixed traffic paint suitable for marking on either bituminous or portland cement concrete pavements shall conform to the following requirements:

- (a) Polyurea Pavement Markings. Approved polyurea marking materials shall be one of the markings listed on the Approved Products List on file with the Agency's Materials and Research Section.
- (b) Low VOC Traffic Paint. Ready-mixed Low VOC Traffic Paint shall consist of 100% acrylic type, fast drying traffic paint that shall contain properly formulated pigment and vehicle to give the desired results.
 - (1) Materials. The paint shall be formulated and processed specifically for service as a binder for reflective beads, in such a manner as to produce maximum adhesion, refraction, and retroreflection. Any capillary action of the paint shall not be such as to cause complete coverage of the beads.

- a. The paint shall be well mixed in the manufacturing process and shall be properly ground when incorporating the pigments in order to conform to the requirements as specified.
- b. The paint shall not liver, thicken, curdle, gel, settle excessively, or otherwise show any objectionable properties during storage and shall be readily remixed manually to a smooth uniform consistency throughout.
- c. The paint shall dry on a road surface to a strongly adherent uniform noncracking film that will not turn dark in sunlight or show considerable discoloration with age. It shall be easily and uniformly applicable with mechanical line-marking equipment and shall meet the opacity (contrast ratio) properties specified herein. The paint shall be suitable for binding glass beads so as to produce a highly weather resistant traffic line.

- (2) Composition. The binder shall be tested according to ASTM D2621 (infrared analysis) or other standard ASTM methods designated herein and shall be a 100% acrylic binder. The composition of the paint shall comply with the following:

	<u>WHITE</u>	<u>YELLOW/BLUE/ GREEN</u>
Pigment Content, % by Mass (Weight) (ASTM D3723)	58% min. 62% max.	58% min 62% max.
Vehicle Content, % by Mass (Weight)	38% min. 42% max.	38% min. 42% max.
VOC Content, Mass (Weight) per Unit Volume (ASTM D3960)	150 g/L (1.25 lb/gal) max.	150 g/L (1.25 lb/gal) max.
Lead Content, %	0.005% max.	0.005% max.
Yellow Pigment	N/A	Yellow #65 or #75
Titanium Dioxide, Rutile Type II, (ASTM D1394)	120 g/L (1.00 lb/gal) max.	25 g/L (0.21 lb/gal) max.
Total Non-Volatile Content, % by Mass (Weight) (ASTM D2369)	42.0% min.	42.0% min.
Density, (ASTM D1475)	1.68 ± 0.04 kg/L (14.0 ± 0.33) lb/gal	1.62 ± 0.04 kg/L (13.5 +/- 0.33 lb/gal)
pH of the Paint	9.6 min.	9.6 min.
Close Cup Flash Point (ASTM D 3278)	60 °C (140 °F) min.	60 °C (140 °F) min.

(3) Laboratory Tests:

- a. Viscosity. The paint viscosity shall not be less than 78 nor more than 95 Krebs units at 25 °C (77 °F) when tested according to ASTM D562.
- b. Condition in Container. The paint as received shall show no gelling, skinning, mold growth, putrefaction, or hard settling of the pigment.

The paint shall not cause any corrosion of the container. Any settling shall be readily dispersed when stirred by hand with no persistent foaming.

- c. Fineness of Grind. The fineness of grind shall not be less than two Hegman units when tested in accordance with ASTM D1210.
- d. Drying Time (No Pick Up Time). The paint shall dry in not more than ten minutes at 23 ± 2.0 °C (73.5 ± 3.5 °F) and a relative humidity of 50 ± 5 %, when tested in accordance with ASTM D711 and drawn down to a wet film thickness of 380 microns (15 mils).
- e. No Track Time (Field Test). The paint shall dry to a “no track” condition in no more than three minutes when tested by driving a standard passenger vehicle across the line at 65 kilometers per hour (40 miles per hour). The “no tracking” condition shall be determined by actual application on the pavement at a wet film thickness of 508 microns (20 mils) with the paint covered with glass beads at a rate of 960 g/L (8 lb/gal). The paint lines for this test shall be applied with the striping equipment at the manufacturer’s recommended temperatures. The “no tracking” time shall be determined by passing over the paint line three (3) minutes after paint application, in a simulated passing maneuver at a constant speed of 50 to 65 kilometers per hour (30 to 40 miles per hour) with a passenger car. A line showing no visual deposition of the paint to the pavement surface when viewed from a distance of approximately 15.3 meters (50 feet) from the point where the test vehicle has crossed the line shall be considered as showing “no tracking” and conforming to the requirement for field drying conditions. This maximum tracking time shall not be exceeded when the pavement temperature varies from 10 °C (50 °F) to 49 °C (120 °F), and under humidity conditions of 80% or less providing

that the pavement is dry and shall be used for production samples only.

(4) Sampling and Testing.

- a. Sampling Size. The paint contractor shall submit two 500 ml (1 pint) samples of each traffic paint per batch, to be used under these specifications. The submission shall include a copy of a Material Safety Data Sheet (MSDS).
- b. 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, trade name and/or identification number, type of paint, number of liters (gallons), contact number, intended use, directions for application, and formula. Improperly labeled samples will be rejected.
- c. Sample Delivery. All samples shall be delivered to the Research and Testing Engineer, Vermont Agency of Transportation, Materials and Research Section, Barre-Montpelier Road, Montpelier VT 05633.

All samples shall be delivered at least five working days prior to use and at least three working days in advance of subsequent deliveries. Samples adequate for testing shall be furnished free of charge by the Contractor.

- d. Batch Sampling and Testing. Each batch of paint furnished under these specifications will be tested by the Vermont Agency of Transportation, Materials and Research Central Laboratory. Random samples at the point of delivery may be subjected to both chemical and physical analysis and if found to be of unsatisfactory quality, the materials they represent may be rejected. If the Engineer observes failure or other conditions during application which lead the Engineer to question whether or not the material meets

specification, further tests will be conducted on field samples taken at random.

- (c) Epoxy Paint. Epoxy Paint shall be one of the Epoxy Paints on the Approved Products List on file with the Agency's Materials and Research Section.
- (d) Waterborne Traffic Paint. Waterborne Traffic Paint shall consist of properly formulated pigment and vehicle to give the desired results. When used with reflecting glass beads it shall bind the beads in such a fashion that it will produce maximum adhesion, refraction, and reflection. The paint shall show the proper capillary action at the bead surface to provide anchorage, refraction, and reflection when beads are applied at the standard rate of 960 g/L (8 lb/gal) of paint.
 - (1) Materials.
 - a. Pigments. The pigments used shall be those designated which shall conform to the stated requirements.
 - b. Titanium Dioxide. Titanium Dioxide shall be of the rutile type and shall meet the requirements specified in ASTM designation D 476 (Latest Revision) Type II, Class II.
 - c. Vehicle. The vehicle will be water.

- (2) Composition. The composition of the waterborne paint shall be a 100% acrylic binder, as determined by infrared analysis according to ASTM D2621 or other standard ASTM methods designated herein. The composition of the paint shall comply with the following:

	<u>WHITE</u>	<u>YELLOW/BLUE/ GREEN</u>
Pigment Content, by mass (weight) (ASTM D3723)	58% min. 62% max.	58% min. 62% max.
Vehicle Content, by mass (weight)	38% min. 42% max.	38% min. 42% max.
VOC Content, by mass (weight) (ASTM D3960)	150 g/L max. (1.25 lb/gal)	150 g/L max. (1.25 lb/gal)
Lead Content, %	0.005% max.	0.005% max.
Titanium Dioxide Rutile Type II, (ASTM D1394)	120 g/L max. (1.00 lb/gal)	25 g/L max. (0.21 lb/gal)
Total Non-Volatile Content, by mass (weight) (ASTM D2369)	76.0% min.	76.0% min.
Total Volatile Content, by mass (weight) (ASTM D2369)	25% min.	25% min.
Total Non-Volatile, by volume (ASTM D2697)	62.0% min.	62.0% min.
Density, (ASTM D1475)	1.68 ± 0.04 kg/L (14.0 lb/gal ± 0.33)	1.63 ± 0.04 kg/L (13.6 lb/gal ± 0.33)
pH of the Paint	9.6 min.	9.6 min.
Close Cup Flash Point	60 °C (140 °F) min.	60 °C (140 °F) min.

(3) Laboratory Tests.

- a. Viscosity. The paint viscosity shall not be less than 78 nor more than 95 Krebs units at 25 °C (77 °F) when tested according to ASTM D562.
- b. Condition in Container. The paint as received shall show no gelling, skinning, mold growth, putrefaction, or hard settling of the pigment. The paint shall not cause any corrosion of the container. Any settling shall be readily dispersed when stirred by hand with no persistent foaming.
- c. Fineness of Grind. The fineness of grind shall not be less than two Hegman units when tested in accordance with ASTM D1210.
- d. Drying Time (No Pick Up Time). The paint shall dry in not more than 10 minutes at 23°C ± 2°C (71°F ± 6°F) and a relative humidity of 50 ± 5%, when tested according to ASTM D711 and drawn down to a wet film thickness of 380 microns (15 mils).
- e. No Track Time (Field Test). The paint shall dry to a “no track” condition in no more than three minutes when tested by driving a standard passenger vehicle across the line at 65 kilometers per hour (40 miles per hour). The “no tracking” condition shall be determined by actual application on the pavement at a wet film thickness of 508 microns (20 mils) with the paint covered with glass beads at a rate of 960 g/L (8 lb/gal). The paint lines for this test shall be applied with the striping equipment at the manufacturer’s recommended temperatures. The “no tracking” time shall be determined by passing over the paint line three minutes after paint application, in a simulated passing maneuver at a constant speed of 50 to 65 kilometers per hour (30 to 40 miles per hour) with a passenger car. A line showing no visual deposition of the paint to the pavement surface when viewed from a distance of

approximately 15.3 meters (50 feet) from the point where the test vehicle has crossed the line shall be considered as showing “no tracking” and conforming to the requirement for field drying conditions. This maximum tracking time shall not be exceeded when the pavement temperature varies from 10 °C (50 °F) to 49 °C (120 °F), and under humidity conditions of 80% or less providing that the pavement is dry and shall be used for production samples only.

(4) Sampling and Testing.

- a. Sampling Size. The paint Contractor shall submit two 500 ml (1 pint) samples of each traffic paint per batch, to be used under these specifications. The submission shall include a copy of a Material Safety Data Sheet (MSDS).
- b. 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, trade name and/or identification number, type of paint, number of liters (gallons), contact number, intended use, directions for application, and formula. Improperly labeled samples will be rejected.
- c. Sample Delivery. All samples shall be delivered to the Research and Testing Engineer, Vermont Agency of Transportation, Materials and Research Central Laboratory, Barre-Montpelier Road, Montpelier VT 05633.

All samples shall be delivered at least five working days prior to use and at least three working days in advance of subsequent deliveries. Samples adequate for testing shall be furnished free of charge by the Contractor.

- d. Batch Sampling and Testing. Each batch of paint furnished under these specifications will be tested by the Vermont Agency of Transportation, Materials and Research Central Laboratory. Random samples at the point of delivery may be subjected to both chemical and physical analysis and, if found to be of unsatisfactory quality, the materials they represent may be rejected. If the Engineer observes failure or other conditions during application which lead the Engineer to question whether or not the material meets specification, further tests will be conducted on field samples taken at random.
- (d) Methyl-methacrylate Paint. Approved Methyl-methacrylate Paint shall be one of the Methyl-methacrylate Paints listed on the Approved Products List with the Agency's Materials and Research Section.

708.09 GLASS BEADS.

- (a) Properties. Glass beads for pavement markings shall conform to the requirements of AASHTO M247, Type 1, unless otherwise specified.
- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

708.10 THERMOPLASTIC PAVEMENT MARKINGS. Crushed glass shall be incorporated into the thermoplastic material at a rate of between 9 to 10 percent by mass (weight) of the combined material. The crushed glass will be used as a substitute for an equal amount by mass (weight) of the filler material. The crushed glass shall be produced from cullet of clear glass, with a maximum size of 850 microns (33 mils) [100 percent passing by mass (weight)] and a minimum size of 425 microns (17 mils) [0-2 percent passing by mass (weight)].

Thermoplastic composition shall be as follows:

Binder	18% Minimum
Filler	35% Maximum
Crushed Glass	10%
Glass Beads	30%

Acceptable Thermoplastic Pavement Markings shall be one of the Thermoplastic Pavement Markings on the Approved Products List on file with the Agency's Materials and Research Section.

708.11 RAISED PAVEMENT MARKERS. Acceptable Raised Pavement Markers shall be one of the Raised Pavement Markers on the Approved Products List on file with the Agency's Materials and Research Section.

708.12 PAVEMENT MARKING TAPE.

- (a) Pavement Marking Tape, Type I. Type I Pavement Marking Tape shall be one of the Non-Removable Pavement Marking Tapes on the Approved Products List on file with the Agency's Materials and Research Section.
- (b) Pavement Marking Tape, Type II. Type II Pavement Marking Tape shall be one of the Removable Pavement Marking Tapes on the Approved Products List on file with the Agency's Materials and Research Section.
- (c) Pavement Marking Mask. Pavement Marking Mask shall be one of the Masking Marking Tapes on the Approved Products List on file with the Agency's Materials and Research Section.

708.13 PREFORMED TRAFFIC MARKINGS AND SYMBOLS. Preformed traffic markings made of the same material as that of an approved permanent Type I tape will be accepted under a Type B Certification provided by the manufacturer identifying that the material is the same as the approved product.

708.14 LINE STRIPING TARGETS. Line Striping Targets shall be one of the Line Striping Targets on the Approved Products List on file with the Agency's Materials and Research Section.

SECTION 709 - LUMBER AND TIMBER

709.01 STRUCTURAL LUMBER AND TIMBER. Structural lumber and timber shall conform to the species and stress-grades specified in the Contract and shall be acceptable to the Engineer.

- (a) Grading. Structural lumber and timber shall be graded in accordance with the requirements of AASHTO M 168. Lumber ordered in multiple lengths shall be graded after having been cut to lengths.
- (b) Moisture Content.
 - (1) Untreated Lumber and Timber. The maximum moisture content of material entering into a finished structure shall be 19 percent.
 - (2) Treated Lumber and Timber. The maximum moisture content of material prior to treatment shall be 19 percent. Material treated with water-borne preservatives in accordance with AWWA standards shall be dried after treatment to a moisture content not exceeding 19 percent and shall be maintained at a moisture content of 19 percent or less until it is incorporated into the work.
- (c) Minimum Stress Requirements. Unless otherwise specified in the Contract, lumber and timber shall meet the following minimum requirements:
 - (1) Southern and Western Material. The material shall meet the allowable unit stress requirements for “No. 1 Grade” material as specified in the *AASHTO Standard Specifications for Highway Bridges*.
 - (2) Eastern (Local) Material. The material shall meet the allowable unit stress requirements for “No. 1 Grade” material as specified in the *AASHTO Standard Specifications for Highway Bridges*.
- (d) Lumber Dimensions.
 - (1) Full-Sawn. Minimum full-sawn lumber sizes are nominal dimension sawn sizes after seasoning. Pieces shall be sawn to obtain the full nominal dimensions specified with only occasional slight variation

permitted. Thickness and width dimensions are somewhat variable depending upon the sawmill equipment used.

- (2) Rough-Sawn. Rough-dry sized lumber is minimally 3 mm (1/8 inch) larger in each dimension than standard (seasoned) dressed sized lumber. Thickness and width dimensions are somewhat variable depending upon the sawmill equipment used.
 - (3) Dressed. Dressed lumber sizes are the finished planed dimensions of material after seasoning. Minimum net finished dimensions for dressed lumber shall be 13 mm (1/2inch) less than nominal dimension, except that the minimum net width of dressed lumber exceeding 152 mm (6 inches) shall be 19 mm (3/4 inch) less than nominal dimension.
- (e) Lumber Finish. As specified per AASHTO M 168 for manufacturing classifications: e.g., Rough Lumber or Dressed (Surfaced) Lumber.
 - (f) Soundness. Material shall be sound and free from any incipient or advanced form of decay.
 - (g) Preservative Treatment. Preservative treatment of lumber and timber materials shall conform to Subsection 726.01. Unless otherwise specified, the treatment for lumber and timber materials shall conform to Type II preservative.
 - (h) Miscellaneous Hardware, Shapes, and Fabricated Materials.
 - (1) Structural steel shapes and metal fabricated materials shall conform to the requirements of the Contract and the specific material requirements as specified in Sections 714 and 715.
 - (2) Unless otherwise specified, bolts, studs, threaded rods, nuts, and washers shall conform to the requirements of ASTM F 568M, Class 4.6 (ASTM A 307). Carbon steel nuts (unless otherwise specified) shall conform to the requirements of AASHTO M 291M (AASHTO M 291).
 - (3) Nails and spikes shall conform to the requirements of ASTM F 1667.

- (4) Lag screws shall be of low to medium carbon steel and shall be of good commercial quality.
- (5) Unless otherwise specified, all steel hardware and fabricated materials shall be galvanized in accordance with AASHTO M 111M/M 111 or AASHTO M 232M/M 232, whichever is applicable. When Alkaline Copper Quat preservative is specified for members per Subsection 726.01, and metal fasteners are required, stainless steel fasteners shall be used for lumber and timber connectors.
- (i) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

709.02 NONSTRUCTURAL LUMBER. Material furnished under this Subsection shall be for non load-carrying, structural applications with a maximum nominal thickness of 50 mm (2 inches) (e.g. boarding, siding, trim, etc.). Lumber shall be seasoned or kiln dried Spruce, Eastern White Pine, Eastern Hemlock, Southern Pine, or Western Fir, unless otherwise specified in the Contract.

- (a) Grade. The grade classification of Yard Lumber, whether Common or Select, shall be as specified in the Contract. Structural lumber meeting the requirements of Subsection 709.01 and 50 mm (2 inches) thickness may be used for nonstructural lumber applications. Except with the written permission of the Engineer, lumber which has not been grade classified or stress-graded shall not be used for nonstructural lumber.
- (b) Moisture Content. The moisture content shall be as specified in Subsection 709.01 (b)
- (c) Dimensions.
 - (1) Full-Sawn. When required in the Contract, lumber shall be furnished to the minimum full-sawn (nominal) dimensions specified. See Subsection 709.01 (d) for a full definition of full-sawn lumber dimensions.
 - (2) Dressed. Unless otherwise specified, all lumber shall be S4S. See Subsection 709.01 (d) for a full definition of dressed lumber dimensions.

- (d) Finish. Rough Lumber or Dressed (Surfaced) Lumber, per AASHTO M 168 manufacturing classifications.
- (e) Soundness. Lumber shall be sound and free from any incipient or advance form of decay.
- (f) Preservative Treatment. Preservative treatment of lumber shall conform to Subsection 726.01. Unless otherwise specified, the treatment shall conform to Type IV preservative.
- (g) Hardware, Shapes, and Fabricated Materials. Hardware, shapes, and fabricated materials shall be as specified in Subsection 709.01 (h).
- (h) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

709.03 STRUCTURAL GLUED LAMINATED TIMBER.

- (a) Material. Unless otherwise specified, structural glued laminated timber shall be fabricated from Southern Pine, Coastal Douglas Fir, Western Hemlock, or Western Larch and shall meet the requirements of Division II, Section 16 of the AASHTO *Standard Specifications for Highway Bridges*.

Adhesives used in the lamination process shall be for wet-use conforming to ASTM D 2559 and shall comply with all other requirements of ANSI/AITC A190.1.

Unless otherwise specified, the appearance grade of the finished glulam products shall be "Industrial."

- (b) Seasoning. Unless otherwise specified, all material shall have a moisture content not exceeding 16 percent at the time of gluing laminations.
- (c) Preservative Treatment. Unless otherwise specified, all glued laminated timber shall be treated with Type II pentachlorophenol preservative (heavy oil solvent) conforming to Subsection 726.01. Also, unless otherwise specified, all material shall be shop fabricated prior to treatment. Any field treatment required by the Engineer shall be performed in accordance with AWWA Standard M4.
- (d) Miscellaneous Hardware, Shapes, and Fabricated Materials.

- (1) Structural steel shapes and metal fabricated materials shall conform to the requirements of the Contract and the specific material requirements as specified in Sections 714 and 715.
 - (2) Unless otherwise specified, bolts, studs, threaded rods, nuts, and washers shall conform to the requirements of ASTM F 568M, Class 4.6 (ASTM A 307). Stainless steel fasteners shall conform to the requirements of ASTM F 568M, Property Class A1-70, Condition CW, with nuts conforming to ASTM F 836M, Property Class A1-70, Condition CW.
 - (3) All welding shall conform to the requirements of Subsection 506.10.
 - (4) Nails and spikes shall conform to the requirements of ASTM F1667.
 - (5) Lag screws shall be of low to medium carbon steel and shall be of good commercial quality.
 - (6) Unless otherwise specified, all steel hardware and fabricated materials shall be galvanized in accordance with AASHTO M 111M/M 111 or AASHTO M 232M/M 232, whichever is applicable.
- (e) Dimensions. The designated dimensions for glued laminated timber shall be taken as the actual net dimensions.
- (f) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.
- (g) Handling. Glued laminated timber shall be carefully handled to avoid damaging the edges and surfaces. The handling, transit, and erection procedures shall meet the requirements of specification AITC 111-79.

SECTION 710 - CULVERTS, STORM DRAINS, AND
SEWER PIPES, NONMETAL

710.01 REINFORCED CONCRETE PIPE. Reinforced concrete pipe shall conform to the requirements of AASHTO M 170M (AASHTO M 170) with the following notes or exceptions:

- (a) Design Requirements. The circumferential reinforcement in Table 3 of AASHTO M 170M (AASHTO M 170) for 600 mm (24 inch), Class III, Wall B pipe shall be $210 \text{ mm}^2/\text{m}$ ($0.1 \text{ in}^2/\text{ft}$) of pipe wall. Elliptical reinforcement shall not be used in circular pipes.
- All pipe 600 mm (24 inches) in diameter or smaller shall be of the bell and spigot type. Pipes larger than 600 mm (24 inches) in diameter may be either of the tongue and groove or bell and spigot type.
- In all sizes of bell and spigot pipe, and in tongue and groove pipe 750 mm (30 inches) in diameter and larger, there shall be a line of circumferential reinforcement in the bell or groove, equal in area to that of a single line within the barrel of the pipe.
- (b) Marking. The exterior and interior of each length of pipe shall be clearly marked with the following data: pipe class; day, month, and year of manufacture; and name or trademark of the manufacturer. The method shall be by either clear, legible impressions in the pipe, or by clear, legible data stencilled with waterproof paint.
- (c) Basis of Acceptance. All pipe shall be accepted on the basis of plant load bearing tests, material tests, and inspection of manufactured pipe for visual defects and imperfections.
- (d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02 for the pipe. Certifications for constituent materials shall be furnished in accordance with normal requirements for those types of materials.

710.02 REINFORCED CONCRETE PIPE END SECTIONS.

Reinforced concrete pipe end sections shall conform to the requirements of Subsection 710.01. Where two cages of reinforcement are required in accordance with AASHTO M 170M (AASHTO M 170), they shall be placed in the barrel of the end section only. Reinforcement of the apron section shall be equal in area to the inner cage of the barrel reinforcement.

Certification. Certification shall conform to the requirements of Subsection 710.01(d).

710.03 CORRUGATED POLYETHYLENE PIPE. Corrugated polyethylene pipe and fittings shall conform to the latest revisions of AASHTO M 294, Type S or AASHTO M 252, Type SP as appropriate. Acceptable corrugated polyethylene pipe shall be one of the corrugated

polyethylene pipe products on the Approved Products List on file with the Agency's Materials and Research Section.

710.04 VITRIFIED CLAY PIPE. Vitricified clay pipe shall conform to the requirements of ASTM C 700.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

710.05 ACRYLONITRILE-BUTADIENE-STYRENE (ABS) PLASTIC PIPE. ABS pipe shall conform to the following requirements:

Storm or Sanitary Sewer Pipe (solid wall):	ASTM D 2751
Storm or Sanitary Sewer Pipe (composite wall):	AASHTO M 264

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

710.06 POLYVINYL CHLORIDE (PVC) PLASTIC PIPE. PVC pipe shall conform to the following requirements:

Smooth wall, perforated or unperforated

100 to 400 mm (4 to 16 inches):	AASHTO M 278
450 to 700 mm (18 to 28 inches):	ASTM F 679*

Corrugated, with smooth interior

All sizes:	ASTM F 949 ASTM F 794
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* Pipe with other cell classifications that meet or exceed the performance requirements of ASTM D 3034 will be permitted provided the wall thickness is not less than 94 percent of that specified in AASHTO M 278.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

SECTION 711 - CULVERTS, STORM DRAINS AND
SEWER PIPES, METAL

711.01 CORRUGATED STEEL PIPE, PIPE ARCHES, AND UNDERDRAINS. Corrugated steel pipe, elbows, end sections, reducer units, pipe arches, underdrain, risers, flushing basins, and coupling bands shall conform to the requirements of AASHTO M 36. Material furnished under this Subsection shall be formed from sheet material coated in accordance with AASHTO M 218, M 274, or M 289.

- (a) Coupling Bands. Coupling bands shall conform to AASHTO M 36, with the following modifications:
- (1) Coupling bands and their connections shall be of such dimensions as required to meet the “Erodible Special Joint” category criteria of Division II of the AASHTO *Standard Specifications for Highway Bridges*. Structural steel for band connections shall conform to ASTM A 36/A 36M.
 - (2) The only approved methods of connection and connection details at the ends of the bands shall be:
 - a. 51 by 51 by 4.8 mm (2 × 2 × 3/16 inch) galvanized steel angles extending the full width of the band.
 - b. 2.77 mm (12 gage) die-cast angle with a configuration that provides at least the same section modulus as the 51 by 51 by 4.8 mm (2 × 2 × 3/16 inch) angle, extending the full width of the band.
 - c. Minimum of two bolts for a 180 mm (7 inch) wide band, three bolts for a 300 mm (12 inch) wide band, and five bolts for a 600 mm (24 inch) wide band, uniformly spaced. Bolts, nuts, and other threaded items used with coupling bands shall be coated by the electroplating process as provided in ASTM B 633, Class Fe/Zn 25, the zinc coating process

as provided in AASHTO M 232M/M 232 or the mechanical zinc coating process as provided in AASHTO M 298, Class 25.

- d. Angles will be connected to bands by one of the following:
1. spot welds spread over full width of the band,
 2. stitch-welded over the full width of the band, or
 3. attached by rivets.
- (3) Minimum band thickness shall be 1.63 mm (1/16 inch), and bands shall be no more than two nominal sheet thicknesses thinner than the wall thickness of the culvert or unit being connected. Coupling bands and die-cast angles may be formed from any one of the three types of sheet material specified above.
- (4) The use of projection pipe coupling (dimpled) bands or preformed channel bands is not allowed.
- (5) The Contractor may submit for approval to the Agency alternate coupling bands. The Contractor shall allow 30 days for a testing and evaluation period. Coupling bands shall not be shipped to projects until the Contractor has been notified that the proposed band has been approved by the Agency.
- (6) For attaching metal end sections to corrugated steel pipe, the Contractor may supply 25 mm wide by 2.77 mm thick (1 inch by 12 gage) galvanized straps connected by a 12 mm (1/2 inch) galvanized bolt and nut for 300 through 600 mm (12 through 24 inch) diameter round pipes, and for 710 by 510 mm (28 × 20 inch) pipe arches and smaller.
- (b) End Sections. Materials used in the manufacture of end sections shall conform to AASHTO M 36, except that the dimensions, thickness of metal, and fabrication shall be in accordance with the Contract.

- (c) Reducer Units. Materials used in the manufacture of concentric metal reducer units shall conform to AASHTO M 36, except that the maximum and minimum diameters, dimensions, thickness of metal, and fabrication shall be in accordance with the Contract.
- (d) Underdrain. Perforated underdrain including all lateral and special connections shall conform to AASHTO M 36. Minimum sheet metal thickness required is 1.32 mm (0.052 inch) for 150 mm (6 inch) diameter underdrain and 1.63 mm (0.064 inch) for 200 mm (8 inch) diameter and larger.
- (e) Underdrain Risers and Flushing Basins. Underdrain risers and flushing basins, including all connectors, fittings, and covers shall conform to AASHTO M 36, except that the dimensions, thickness of metal, and fabrication shall be in accordance with the Contract, and the pipe shall not be perforated.
- (f) Marking. All material furnished under this Subsection shall be clearly marked in an approved manner with the name or trademark of the pipe fabricator and the sheet metal thickness.
- (g) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

711.02 CORRUGATED ALUMINUM ALLOY PIPE, PIPE ARCHES, AND UNDERDRAINS. Corrugated aluminum alloy pipe, elbows, end sections, reducer units, pipe arches, underdrain, risers, flushing basins, and coupling bands shall conform to the requirements of AASHTO M 196.

- (a) Coupling Bands. Coupling bands shall conform to AASHTO M 196, with the following modifications:
 - (1) Coupling bands and their connections shall be of such dimensions as required to meet the “Erodible Special Joint” category criteria of Division II of the AASHTO *Standard Specifications for Highway Bridges*.
 - (2) Coupling band connections:
 - a. Shall be 51 by 51 by 6.4 mm ($2 \times 2 \times 1/4$ inch) aluminum angles (Alloy 6061-T6) extending the full width of the band or 2.77 mm (12 gage) minimum die-cast aluminum angles, extending the full width of the band.

- b. Shall have a minimum shear strength capacity of 28.1 kN (6.3 kips).
 - c. Shall be connected with a minimum of two bolts for a 180 mm (7 inch) wide band, three bolts for a 300 mm (12 inch) wide band and five bolts for a 600 mm (24 inch) wide band. Bolts shall be uniformly spaced across the width of the band. Bolts, nuts, and other threaded items shall be coated in accordance with the requirements of Subsection 711.01(a)(2)c.
 - d. Shall have angles attached to the bands by stitch welding over the full width of the band or by rivets uniformly spaced across the width of the band.
- (3) Minimum band thickness shall be 1.52 mm (0.06 inch), and bands shall be no more than two nominal sheet thicknesses thinner than the wall thickness of the culvert being connected.
 - (4) Alternate coupling bands may be submitted for approval as specified in Subsection 711.01(a)(5).
- (b) End Sections. Materials used in the manufacture of end sections shall conform to the requirements of AASHTO M 196, except that the dimensions, thickness of metal, and fabrication shall be in accordance with the Contract.
 - (c) Reducer Units. Materials used in the manufacture of concentric reducer units shall conform to the requirements of AASHTO M 196, except that the maximum and minimum diameters, dimensions, thickness of metal, and fabrication shall be in accordance with the Contract.
 - (d) Underdrain Risers and Flushing Basins. Underdrain risers and flushing basins including all connectors, fittings, and covers shall conform to the requirements of AASHTO M 196, except that the dimensions, thickness of metal, and fabrication shall be in accordance with the Contract, and the pipe shall not be perforated.

- (e) Marking. All material furnished under this Subsection shall be clearly marked in an approved manner with the name or trademark of the pipe fabricator and the sheet metal thickness.
- (f) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

711.03 POLYMERIC COATED CORRUGATED STEEL PIPE AND PIPE ARCHES. Polymeric coated corrugated steel pipe, elbows, reducer units, and pipe arches shall conform to AASHTO M 245. Polymeric coating shall conform to AASHTO M 246, Grade 250/250.

- (a) Coupling Bands. Coupling bands shall conform to the requirements of Subsection 711.01(a) modified as follows:
 - (1) Coupling bands and die-cast angles shall be formed from sheet material coated in accordance with AASHTO M 218, M 245, M 274, or M 289.
 - (2) Coupling bands formed from AASHTO M 274 or M 289 material shall be not more than one nominal sheet thickness thinner than the wall thickness of the culvert or unit being connected.
 - (3) Coupling bands formed from AASHTO M 245 material shall be not more than two nominal sheet thicknesses thinner than the thickness of the culvert or unit being connected. Angles must be attached to the band by rivets.
 - (4) Coupling bands formed from AASHTO M 218 material shall be the same nominal sheet thickness as the culvert or units being connected. Angles must be attached to the band with rivets or by stitch-welding over the full width of the band.
- (b) End Sections. Materials used in the manufacture of end sections shall conform to Subsection 711.01(b).
- (c) Reducer Units. Materials used in the manufacture of concentric reducer units shall conform to AASHTO M 245, except that the maximum and minimum diameters, dimensions, thickness of metal, and fabrication shall be in accordance with the Contract.

- (d) Marking. All material furnished under this Subsection shall be clearly marked in an approved manner with the name or trademark of the pipe fabricator and the sheet metal thickness.
- (e) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

711.04 BITUMINOUS PAVING FOR PIPE INVERTS. When shown on the Plans, inverts of polymeric coated corrugated steel units shall be paved with bituminous material in accordance with AASHTO M 190, as follows:

Pipe:	Type B Coating
Pipe Arches:	Type B Coating
Reducer Unit:	Type B Coating
Elbows:	Type B Coating
Couplings:	Uncoated
End Sections:	Uncoated

Wherever Type B coating is specified, coating on the exterior of the pipe may be omitted.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

711.05 COAL-TAR BASED COATING. Coal-tar based coating used to repair damaged areas of polymeric coating shall meet the requirements of AASHTO M 243.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

711.06 STRUCTURAL PLATES, BOLTS, AND NUTS. Structural steel plates, bolts, and nuts for pipe, pipe-arches, arches, and box culverts shall conform to the requirements of AASHTO M 167M/M 167.

Structural aluminum alloy plate, bolts, and nuts for pipe, pipe-arches, arches, and box culverts shall conform to the requirements of AASHTO M 219.

- (a) Dimensions. The thickness of the plates or sheets and the radius of curvature shall be as specified in the Contract. Each plate or sheet shall be curved to one or more circular arcs.
- (b) Fabrication. Plates shall be formed to provide lap joints. The bolt holes shall be punched so that all plates having like

dimensions, curvature, and the same number of bolts per meter (foot) of seam shall be interchangeable. Each plate shall be curved to the proper radius so that the cross-sectional dimensions of the finished structure will be as specified in the Contract.

Bolt holes along those edges of the plates that form longitudinal seams in the finished structure shall be in two rows. Bolt holes along those edges of the plates that form circumferential seams in the finished structure shall provide for a bolt spacing of not more than 300 mm (12 inches). The minimum distance from center of hole to edge of the plate shall not be less than 1.75 times the diameter of the bolt. The diameter of the bolt holes in the longitudinal seams shall not exceed the diameter of the bolt by more than 3 mm (1/8 inch).

Cut edges shall be free from oxide and burrs. Legible identification numerals shall be placed on each plate to designate its proper position in the finished structure.

Unless otherwise specified in the Contract, plate pipes shall be elongated so that the finished pipe is elliptical in shape with the vertical diameter approximately 5 percent greater than the nominal diameter of the pipe. Pipe arches shall not be elongated.

- (c) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

SECTION 712 - CRIBBING MATERIALS

712.01 METAL BIN-TYPE RETAINING WALL.

- (a) Galvanized Metal Units. The various units of metal bin-type retaining wall shall conform to the requirements of AASHTO M 218. The metal sheets used to form the members of the metal wall shall be of the thickness indicated in the Contract.
- (b) Bolts and Nuts. Bolts and nuts shall conform to the requirements of Subsection 714.08 and shall be galvanized in accordance with the requirements of AASHTO M 232M/M 232.
- (c) Fabrication. All units shall be fabricated so that units of the same nominal size shall be interchangeable. Drilling, punching, or drifting to correct defects in manufacture will not be permitted. Any units improperly manufactured shall be replaced at the Contractor's expense.

Whenever possible in the manufacture of the units, a minimum forming radius of 25 mm (1 inch) shall be maintained. All units that are formed with less than a 25 mm (1 inch) radius shall be hot-dip galvanized after forming.

- (d) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

712.02 CONCRETE BIN-TYPE RETAINING WALL. The materials, design details, and dimensions shall be as shown on the Plans and approved Working Drawings.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

712.03 TIMBER CRIBBING.

- (a) Material. Dimensional timber furnished for cribbing shall be seasoned Red (Norway) Pine, White Pine, Eastern Hemlock, or Southern Pine, straight, sound, and cut from live timber. Red Pine, White Pine, and Eastern Hemlock shall meet number 1 grade requirements specified by the Northeastern Lumber Manufacturers Association (NELMA). Southern Pine shall meet number 2 grade requirements specified by the Southern Pine Inspection Bureau (SPIB).

Structural timber furnished for glue laminated members shall be seasoned Southern Pine, Coastal Douglas Fir, or Hem-Fir meeting the requirements of Division II of the AASHTO *Standard Specifications for Highway Bridges*, with a minimum fiber stress in bending, about either axis, of 8.3 MPa (1200 psi).

Dimensional timber shall be full-sawn S2E (uniformly surfaced two edges to the dimensions specified).

Structural glued laminated timber shall be S4S (uniformly surfaced four sides to the dimensions specified). Surfaces to be exposed in the finished product shall be uniformly rough finish, coarse texture. Maximum unevenness in surface shall be 6 mm (1/4 inch) (process to be performed prior to preservative treatment).

Adhesive used in the lamination process shall be for wet-use conforming to ASTM D 2559 and shall comply with all other requirements of AITC A190.1.

- (b) Seasoning. All material shall have a moisture content not exceeding 20 percent prior to preservative treatment.
- (c) Preservative Treatment. Timber cribbing shall be pressure treated in accordance with AASHTO M 133 and AWWA Standards C1, C2, and C14 using a preservative as specified in Subsection 726.01.

Treatment, inspection, and testing of the treated timber materials shall conform to the requirements of Subsection 728.01.

- (d) Miscellaneous Hardware.
 - (1) Connection and washer plates shall be fabricated from material conforming to Subsection 714.02 and galvanized in accordance with AASHTO M 111M/M 111.
 - (2) Bolts, nuts, and washers shall conform to Subsection 714.04 and shall be galvanized in accordance with AASHTO M 232M/M 232.
 - (3) Threaded rods with nuts shall be either material conforming to Subsection 714.04 and be galvanized in accordance with AASHTO M 232M/M 232 or stainless steel conforming to ASTM F 738M, Property Class A1-70, Condition CW, with nuts conforming to ASTM F 836M, Property Class A1-70, Condition CW.
 - (4) Bolts and threaded rods shall have a minimum of 100 mm (4 inches) of thread. Threads shall be wrapped with a minimum of two layers of Teflon tape prior to installation. All threads shall be Metric Coarse, 6g (UNC 2).
 - (5) Sleeve nuts may conform to Subsection 714.04 and be galvanized or may be fabricated from stainless steel rod ASTM A 276, Type 304.
 - (6) All nuts shall be the heavy hex type.
 - (e) Certification. A Type D Certification shall be furnished for all treated timber in accordance with Subsection 700.02. A Type A Certification shall be furnished for all miscellaneous hardware in accordance with Subsection 700.

712.04 GABION BASKETS

- (a) Wire for Gabion Baskets. Gabion baskets shall be manufactured from woven wire mesh. All steel wire used in the manufacture of gabion baskets shall be galvanized and PVC coated. All tests on the wire mesh shall be performed prior to manufacturing the mesh.
- (1) Coating. The steel wire shall be galvanized in accordance with ASTM A 641, Class III soft temper coating. The adhesion of the galvanized coating shall be such that when the wire is wrapped six turns around a mandrel having four times the diameter of the wire, it does not flake or crack when rubbing it with a bare finger in accordance with ASTM A 641.
 - (2) Tensile Strength. Both the wire used for the manufacture of the gabions and lacing wire shall have a tensile strength of 372 MPa (54,000 psi) minimum and 483 MPa (70,000 psi) maximum when tested in accordance with ASTM A 641.
 - (3) Elongation. The steel wire shall have a minimum elongation of not less than 12% in accordance with ASTM A 370.
- (b) PVC Coating for Gabion Baskets.
- (1) Color. The PVC coating shall be gray
 - (2) Coating Thickness. The nominal thickness shall be 0.51 mm (0.020 inches) with a minimum thickness of 0.38 mm (0.015 inches).
 - (3) Tensile Strength. The tensile strength of the PVC coating shall not be less than 20.6 MPa (2985 psi) when tested in accordance with ASTM D412.
 - (4) Abrasion Resistance. Weight loss shall be less than 12% when tested in accordance with ASTM D 1242.
 - (5) Ultraviolet (UV) Resistance. When subjected to 3000 hours using apparatus Type E in accordance with ASTM D 1499 and ASTM G 23, the coating shall not crack, strip, develop air bubbles or show appreciable variation in color. Variation in the tensile strength of

the coating shall not exceed 25% and variation in the abrasion resistance shall not exceed 10%.

- (6) Salt Spray Test. When subjected to 3000 hours when tested according to ASTM B 117, the coating shall not crack, strip, develop air bubbles or show appreciable variation in color. Variation in the tensile strength of the coating shall not exceed 25% and variation in the abrasion resistance shall not exceed 10%.

(c) PVC Coated Galvanized Gabion Mesh, 8 x 10 Type.

- (1) Mesh Wire. The mesh diameter shall be 2.69 mm (0.106 inches) plus PVC coating.
- (2) Selvedge Wire. The selvedge wire shall have a minimum diameter of 3.40 mm (0.134 inches) plus PVC coating.
- (3) Mesh Opening. The mesh shall have a nominal opening of 82.55 x 114.30 mm (3.25 x 4.5 inches).
- (4) Lacing wire. Lacing wire and internal stiffener wire shall have a minimum diameter of 2.21 mm (0.087 inches) plus PVC coating.
- (5) Tolerances.
- a. Wire. In accordance with ASTM A 641, Table 3.
- b. Gabion Baskets. $\pm 5\%$ on the length, width, and height.
- c. Mesh Opening. Tolerances on the hexagonal, double twisted wire mesh opening shall not exceed $\pm 10\%$ on the nominal opening.

- (d) Certification. A Type A certification shall be furnished in accordance with Subsection 700.02.

SECTION 713 - REINFORCING STEEL AND WIRE ROPE

713.01 BAR REINFORCEMENT. Bar reinforcement for concrete structures shall be Grade 420 (Grade 60) conforming to AASHTO M 31M/M 31, including supplementary requirements.

Samples. Where indicated in the Contract, samples of bar reinforcement at least 1.5 m (60 inches) long shall be submitted to the laboratory for testing.

713.02 MECHANICAL SPLICES FOR BAR REINFORCEMENT. Mechanical splices for bar reinforcement shall develop, in tension or compression, a minimum of 125 percent of the specified yield strength of the bar intended to be spliced. The coating requirement for the mechanical splices shall match the bars that they are intended to splice. Mechanical splices shall be installed in accordance with the manufacturer's recommendations or as ordered by the Engineer.

The Contractor shall make three test splices in the presence of the Engineer for each of the bar sizes to be connected by a mechanical splice. The test splices shall be submitted to the Agency's Materials and Research Section for tensile testing to determine acceptance of the system.

713.03 WIRE ROPE OR CABLE. Wire rope or cable for guardrail shall conform to the requirements of AASHTO M 30, Type I, 19 mm (3/4 inch), Class A coating.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

713.04 COLD DRAWN STEEL WIRE. Cold drawn steel wire shall conform to the requirements of AASHTO M 32M/M 32.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

713.05 WELDED STEEL WIRE FABRIC. Welded steel wire fabric shall conform to the requirements of AASHTO M 55M/M 55.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

713.06 PRESTRESSING STRAND. Prestressing elements shall be uncoated, high tensile strength, seven “low relaxation” wire strand of the grade and diameter shown on the Plans and shall conform to the requirements of AASHTO M 203M/M 203. Wire for post tensioning shall conform to the requirements of AASHTO M 204M/M 204.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

713.07 COATED BAR REINFORCEMENT. Coated bar reinforcement shall conform to the applicable requirements of Sections 507 and 713, and to the following requirements:

- (a) Galvanizing. Where shown on the Plans, galvanizing shall conform to the requirements of AASHTO M 111M/M 111.
- (b) Epoxy Coating. Where shown on the Plans, reinforcing steel shall have an electrostatically applied organic epoxy protective coating, which has been prequalified, fabricated, tested, and installed in accordance with AASHTO M 284M/M 284.
- (c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02 for the coating and coating process.

SECTION 714 - STRUCTURAL STEEL

714.01 GENERAL REQUIREMENTS. Structural steel and other related materials shall conform to the requirements specified in this Section. All main load carrying members and components of rolled or welded sections subject to tensile stress shall meet the longitudinal Charpy V-Notch impact requirements specified in AASHTO M 270M/M 270, Supplementary Requirement tables for nonfracture critical steel and fracture critical steel, for Zone 2. Impact test sampling and testing procedures shall be in accordance with AASHTO T 243.

Main members are tension members and members subject to reversals of stress including stringers, girders, cover plates, rigid frames, floor beams, and curved girder cross frames. Other members may be indicated in the Contract as main load carrying members.

References to AASHTO sections in this Section refer to the AASHTO *Standard Specifications for Highway Bridges*.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

714.02 STRUCTURAL STEEL. Structural carbon steel shall conform to the requirements of AASHTO M 270M/M 270, Grade 250 (Grade 36).

714.03 HIGH-STRENGTH LOW-ALLOY STRUCTURAL STEEL. High-strength low-alloy structural steel with a 345 MPa (50 ksi) minimum yield point up to 100 mm (4 inches) in thickness shall conform to the requirements of AASHTO M 270M/M 270, Grade 345 (Grade 50) and/or Grade 345W (Grade 50W) as required.

714.04 CARBON STEEL BOLTS AND NUTS. Carbon steel bolts shall conform to the requirements of ASTM F 568M, Class 4.6 (ASTM A 307). Carbon steel nuts shall conform to the requirements of AASHTO M 291M (AASHTO M 291).

714.05 HIGH-STRENGTH BOLTS, NUTS, AND WASHERS. High-strength bolts, nuts, and circular washers shall conform to the requirements/dimensions of AASHTO M 164M (AASHTO M 164).

Bolts for structural components that have been painted prior to being erected shall be Type 1 or Type 2, shall be provided with appropriate nuts and washers, as required, and the combination of bolt, nut, and washer shall be coated in accordance with AASHTO M 298, Class 50, Type I.

Bolts, nuts, and washers shall be Type 3 for all unpainted applications of AASHTO M 270M/M 270, Grade 345W (Grade 50W) steel.

All high-strength bolts, nuts, and washers furnished for Agency projects shall be manufactured in the United States only. All bolts, nuts, and washers furnished for a particular application shall be furnished by a single supplier.

All bolts, nuts, and washers shall have identifiable manufacturer's marking(s) on each piece.

Nuts for galvanized fasteners shall be overtapped a minimum amount to ensure fastener assembly.

All galvanized nuts shall be lubricated with a lubricant containing a visible dye that will provide visual verification of the lubricant during installation. Black bolts must be "oily" to the touch when installed. Bolts and nuts not properly lubricated shall be cleaned and re-lubricated prior to installation.

Certification and Test Requirements. A Type D Certification is required and shall be provided by the manufacturer, the fabricator, or the supplier, or some combination of two or more of these parties. The complete Type

D Certification shall cover the entire assembly provided, as well as the individual units.

The Type A Certification(s) provided shall identify the corresponding lot number(s) of the material(s) represented by the shipping invoice(s); the corresponding manufacturer's identification marking(s); and the corresponding Type C Certification(s); as well as providing all the information required under Subsection 700.02(b).

Each combination of bolt production lot, nut lot, and washer lot shall be tested as an assembly. Where washers are not required by the installation procedures, they need not be included in the lot identification. A separate rotational-capacity lot number shall be assigned to each combination of lots tests. The minimum frequency of testing shall be two assemblies per rotational-capacity lot.

All required tests for galvanized bolts, nuts, and washers shall be performed after they have been galvanized.

In addition to all the information required under Subsection 700.02(b), the Type C Certification(s) provided shall identify the corresponding Type A Certification(s); shall show the name of the entity performing each chemical or physical analysis or test on the supplied material(s) and the place(s) and date(s) of performance; and shall include the results of the following tests, in addition to any other analyses or test results required:

- (a) Rockwell Hardness Test. Each lot of bolts shall be tested for hardness. The hardness of high-strength bolts shall be within the limits indicated for Rockwell C Hardness in AASHTO M 164M (AASHTO M 164).
- (b) Tensile Strength Test. Each lot of bolts shall be tested for tensile strength. The tensile strength of the furnished bolts shall meet the requirements of AASHTO M 164M (AASHTO M 164).
- (c) Rotational-Capacity Test. Except as modified below, each lot of fasteners, black or galvanized, shall be subject to the rotational-capacity test specified in AASHTO M 164M (AASHTO M 164), and shall meet the following requirements:
 - (1) Each test specimen shall be rotated from a snug tight condition (plies of joint are in firm contact) the following number of turns in a Skidmore-Wilhelm Calibrator or equivalent tensioning device, without stripping or failure:

Bolt Length (Under Head to End of Bolt)	Number of Turns (Snug Tight)	Number of Turns Beyond Snug Tight
0 to 4 diameters	1/3 turn (120°)	2/3 turn (240°)
4 to 8 diameters	1/2 turn (180°)	1 turn (360°)
8 to 12 diameters	2/3 turn (240°)	1 1/3 turns (480°)

- (2) At the required test rotation, the maximum recorded tension shall be equal to or greater than the following:

Bolt Diameter (mm)	Tension (kN)	Bolt Diameter (inches)	Tension (kips)
		1/2	13.8
M16	105	5/8	21.9
M20	163	3/4	32.2
M22	202	7/8	44.9
M24	236	1	58.7
M27	307	1 1/8	64.4
M30	375	1 1/4	81.7
		1 3/8	97.8
M36	546	1 1/2	118.5

- (3) The torque measured to produce the required fastener tension shall not exceed the following values:

Bolt Diameter (mm)	Torque = the measured bolt tension in kilonewtons times the following factor:	Bolt Diameter (inches)	Torque = the measured bolt tension in pounds times the following factor:
		1/2	0.0104
M16	4.0	5/8	0.0130
M20	5.0	3/4	0.0156
M22	5.5	7/8	0.0182
M24	6.0	1	0.0208
M27	6.75	1 1/8	0.0234
M30	7.5	1 1/4	0.0260
		1 3/8	0.0286
M36	9.0	1 1/2	0.0313
	yielding a result expressed in joules (J)		yielding a result expressed in pounds-force foot (lbf•ft)

- (d) Proof Load Tests. Proof load tests for bolts are required and shall be performed in accordance with ASTM F 606M (ASTM F 606), Method 1.
- (1) Proof load tests for nuts are required and shall be performed in accordance with ASTM F 606M (ASTM F 606). Galvanized nuts shall be tested after the nuts have been overtapped, galvanized, and lubricated.
- (e) Wedge Test. Wedge tests for tensile strength of full size bolt specimens are required and shall be performed in accordance with AASHTO M 164M (AASHTO M 164).
- (f) Zinc Thickness Test. Zinc coating thickness shall be measured on all galvanized bolts, nuts, and washers. The measurements shall be made on a minimum of three test specimens randomly selected from each lot supplied. Zinc coating thickness shall conform to the requirements of AASHTO M 232M/M 232.

714.06 HEAT-TREATED STRUCTURAL BOLTS. Heat-treated steel structural bolts, with 1040 MPa (150 ksi) minimum tensile strength, nuts, and washers shall conform to the requirements of AASHTO M 253M (AASHTO M 253).

Bolts, nuts, and washers shall be Type 3 for all unpainted applications of AASHTO M 270M/M 270, Grade 345W (Grade 50W) steel.

All heat-treated structural steel bolts furnished for Agency projects and nuts and washers furnished with them shall be manufactured in the United States only. All bolts, nuts, and washers furnished for a particular application shall be furnished by a single supplier.

All bolts, nuts, and washers shall have identifiable manufacturer's marking(s) on each piece.

All galvanized nuts shall be lubricated with a lubricant containing a visible dye that will provide visual verification of the lubricant during installation. Black bolts must be "oily" to the touch when installed. Bolts and nuts not properly lubricated shall be cleaned and re-lubricated prior to installation.

Certification and Test Requirements. A Type D Certification is required and shall be provided by the manufacturer, the fabricator, or the supplier, or some combination of two or more of these parties. The complete Type D Certification shall cover the entire assembly provided, as well as the individual units.

The Type A Certification(s) provided shall identify the corresponding lot number(s) of the material(s) represented by the shipping invoice(s); the corresponding manufacturer's identification marking(s); and the corresponding Type C Certification(s); as well as providing all the information required under Subsection 700.02(b).

Each combination of bolt production lot, nut lot, and washer lot shall be tested as an assembly. Where washers are not required by the installation procedures, they need not be included in the lot identification. A separate rotational-capacity lot number shall be assigned to each combination of lots tested. The minimum frequency of testing shall be two assemblies per rotational-capacity lot.

All required tests for galvanized bolts, nuts, and washers shall be performed after they have been galvanized.

In addition to the information required under Subsection 700.02(b), the Type C Certification(s) provided shall identify the corresponding Type A

Certification(s); shall show the name of the entity performing each chemical or physical analysis or test on the supplied material(s) and the place(s) and date(s) performed; and shall include the results of the following tests in addition to any other analyses or test results required:

- (a) Rockwell Hardness Test. Each lot of bolts shall be tested for hardness. The hardness of heat-treated structural bolts shall be within the limits indicated for Rockwell C Hardness in AASHTO M 253M (AASHTO M 253).
- (b) Tensile Strength Test. Each lot of bolts shall be tested for tensile strength. Acceptable bolts shall have a value which is at least 1040 MPa (150 ksi) and which is not greater than 1200 MPa (175 ksi).
- (c) Rotational-Capacity Test. Except as modified below, each lot of fasteners, black and galvanized, shall be subject to the rotational-capacity test specified in AASHTO M 164M (AASHTO M 164), and shall meet the following requirements:
 - (1) Each test specimen shall be rotated from a snug tight condition (plies of joint are in firm contact) the following number of turns in a Skidmore-Wilhelm Calibrator or equivalent tensioning device, without stripping or failure:

Bolt Length (Under Head to End of Bolt)	Number of Turns (Snug Tight)	Number of Turns Beyond Snug Tight
0 to 4 diameters	1/3 turn (120°)	2/3 turn (240°)
4 to 8 diameters	1/2 turn (180°)	1 turn (360°)
8 to 12 diameters	2/3 turn (240°)	1 1/3 turns (480°)

- (2) At the required test rotation, the maximum recorded tension shall be equal to or greater than the following:

Bolt Diameter (mm)	Tension (kN)	Bolt Diameter (inches)	Tension (kips)
		1/2	17.3
M16	131	5/8	27.6
M20	205	3/4	40.3
M22	254	7/8	56.4
M24	295	1	73.6
M27	384	1 1/8	92.0
M30	469	1 1/4	117.3
		1 3/8	139.2
M36	684	1 1/2	170.2

- (3) The torque measured to produce the required fastener tension shall not exceed the following values:

Bolt Diameter (mm)	Torque = the measured bolt tension in kilonewtons times the following factor:	Bolt Diameter (inches)	Torque = the measured bolt tension in pounds times the following factor:
		1/2	0.0104
M16	4.0	5/8	0.0130
M20	5.0	3/4	0.0156
M22	5.5	7/8	0.0182
M24	6.0	1	0.0208
M27	6.75	1 1/8	0.0234
M30	7.5	1 1/4	0.0260
		1 3/8	0.0286
M36	9.0	1 1/2	0.0313
	yielding a result expressed in joules (J)		yielding a result expressed in pounds-force foot (lbf•ft)

- (d) Proof Load Tests. Proof load tests for bolts are required and shall be performed in accordance with ASTM F 606M (ASTM F 606), Section 3.2.1, Method 1. Proof load tests for nuts are required and shall be performed in accordance with ASTM F

606M (ASTM F 606), Section 4.2. Galvanized nuts shall be tested after the nuts have been overtapped, galvanized, and lubricated.

- (e) Wedge Test. Wedge tests of full size bolt specimens are required and shall be performed in accordance with AASHTO M 253M (AASHTO M 253).
- (f) Zinc Thickness Test. The thickness of the zinc coating shall be measured on all galvanized bolts, nuts, and washers. The measurements shall be made on a minimum of three test specimens randomly selected from each lot supplied. The thickness of the zinc shall conform to the requirements of AASHTO M 232M/M 232.

714.07 ANCHOR BOLTS, BRIDGE RAILING. Anchor bolts for bridge railing shall conform to the requirements of either AASHTO M 164M (AASHTO M 164) or ASTM F 568M, Property Class 8.8 (ASTM A 449). Nuts and washers shall conform to the requirements of AASHTO M 164M (AASHTO M 164).

All anchor bolts for bridge railing furnished for Agency projects shall be manufactured in the United States only. All bolts, nuts, and washers furnished for a particular application shall be furnished by a single supplier.

All bolts, nuts, and washers shall have identifiable manufacturer's marking(s) on each piece.

All galvanized nuts shall be lubricated with a lubricant containing a visible dye that will provide visual verification of the lubricant during installation. Black bolts must be "oily" to the touch when installed. Bolts and nuts not properly lubricated shall be cleaned and re-lubricated prior to installation.

All bolts, nuts, and washers furnished under this Subsection as meeting the requirements of AASHTO M 164M (AASHTO M 164) shall meet all the requirements, including testing and certification, specified in Subsection 714.05.

714.08 ANCHOR BOLTS, BEARING DEVICES. Anchor bolts for bridge bearings shall conform to the requirements of ASTM F 568M, Class 4.6 (ASTM A 307). Nuts shall be heavy hex and conform to the requirements of AASHTO M 291M (AASHTO M 291), and washers shall conform to the requirements of ASTM A 36/A 36M or AASHTO M

270M/M 270, Grade 250 (grade 36). Washers shall be a minimum of 10 mm (3/8 inch) in thickness.

All anchor bolts for bearing devices furnished for Agency projects shall be manufactured in the United States only. All bolts, nuts, and washers furnished for a particular application shall be furnished by a single supplier.

All bolts, nuts, and washers shall have identifiable manufacturer's marking(s) on each piece.

All galvanized nuts shall be lubricated with a lubricant containing a visible dye that will provide visual verification of the lubricant during installation. Black bolts must be "oily" to the touch when installed. Bolts and nuts not properly lubricated shall be cleaned and re-lubricated prior to installation.

When the bolts furnished under this Subsection are required to conform to the requirements of ASTM F 568M, Class 4.6 (ASTM A 307), the bolts, nuts, and washers furnished shall be tested and certified as meeting the requirements of the Zinc Thickness Test as specified in Subsection 714.05, in addition to any other test and certification requirements.

If bolts furnished for use under this Subsection are required to conform to the requirements of ASTM F 568M, Class 8.8 (ASTM A 449, Type 1), then all bolts, nuts, and washers furnished shall meet all the requirements, including testing, specified in the appropriate fastener specifications and the certification requirements of Subsection 714.05.

Anchor bolts shall be swedged or threaded and shall conform to the shape, length, and diameter specified in the Contract.

714.09 ANCHOR BOLTS, TRAFFIC SIGNALS, LIGHTING, AND OVERHEAD SIGN STRUCTURES. Anchor bolts and washers shall be an austenitic grade of stainless steel conforming to the chemistry of ASTM A 276, Type 304 with the following physical properties:

Tensile Strength, Minimum:	550 MPa (80,000 psi)
Yield Strength, Minimum:	380 MPa (55,000 psi)
Elongation in 50 mm (2 inches), Minimum:	30 percent
Rockwell B Hardness, Minimum:	86
or	
Charpy V-Notch, Minimum:	20.5 N•m at 5 °C
(AASHTO T 243M/T 243 using "H" frequency testing)	(15 lbf•ft at 40 °F)

Nuts for anchor bolts shall be the heavy hex type conforming to the requirements of AASHTO M 292M/M 292, Grade 8 and dimensions of ANSI B18.2.4.6M.

All anchor bolts for traffic signal, street lighting, and overhead sign installations furnished for Agency projects shall be manufactured in the United States only. All bolts, nuts, and washers furnished for a particular application shall be furnished by a single supplier.

All bolts, nuts, and washers shall have identifiable manufacturer's marking(s) on each piece.

714.10 WELDED STUD SHEAR CONNECTORS. Shear connectors shall conform to the requirements of Division II of the AASHTO *Standard Specifications for Highway Bridges* and ANSI/AWS D1.5.

Prior to installation of any shear connectors by a fabricator in a shop or by a Contractor in the field the Engineer shall be furnished:

- (a) The stud manufacturer's certification that the studs, as delivered, conform to the applicable requirements of ANSI/AWS D1.5.
- (b) Certified copies of the stud manufacturer's test reports of in-plant quality control mechanical tests as specified by ANSI/AWS D1.5.

Studs that do not meet the above requirements will be rejected.

714.11 STEEL TUBING. Steel tubing shall conform to the requirements of ASTM A 500, Grade B, or ASTM A 501.

714.12 DIRECT TENSION INDICATORS. Direct Tension Indicators shall be Compressible-Washer-Type Direct Tension Indicators conforming to the requirements of ASTM F 959M, Type 8.8 (ASTM F 959, Type 325).

714.13 TENSION CONTROL ASSEMBLIES. Tension Control Assemblies shall be "Twist Off" Type Tension Control Structural Bolt/Nut/Washer Assemblies conforming to the requirements of ASTM F 1852.

SECTION 715 - MISCELLANEOUS METALS

715.01 IRON CASTINGS.

- (a) General Requirements. Castings shall be true to pattern in form and dimensions, free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended.

Castings shall be boldly filleted at angles and the arises shall be sharp and perfect. The surfaces shall have a blemish free finish.

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

- (b) Gray Iron Castings. Gray iron castings shall conform to the requirements of AASHTO M 105, Class No. 30B, unless otherwise specified.

- (c) Ductile Iron Castings. Ductile iron castings for frames and covers shall conform to the requirements of ASTM A 536, Grade 65-45-12. They shall meet the following mechanical strength and design criteria:

- (1) Mechanical Strength Criteria. The castings shall be capable of supporting a load of 391 kN (88,000 pounds) when tested in accordance with Vermont Test Method (VTM) VT-AOT-MRD #43.

- (2) Design Criteria. The dimensions of the frames and covers shall substantially conform to the dimensions for cast iron covers and frames as shown in the Plans. The covers shall be flush with the upper surface of the frame when seated. The seatings shall be machined or made quiet by the use of a gasket cushioning insert or supported by a three point triangular suspension. The minimum depth of insertion of the cover into the frame shall be ± 50 mm (± 2 inches).

- (3) Covers used on storm drainage systems shall be identified by the words "STORM SEWER" in raised cast letters.

As a minimum, the covers and frames shall meet the M-18 (H 20) loading requirements of AASHTO and the proof load requirements of Federal Specification A-A-60005.

Ductile iron castings for uses other than frames and covers shall conform to the requirements of ASTM A 536, Grade 60-40-18. In addition to the specified test coupons, test specimens from parts integral with the castings, such as risers, shall be tested for castings with a mass (weight) of more than 450 kg (1000 pounds) to determine that the required quality is obtained in the castings in the finished condition.

- (d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

715.02 BRONZE CASTINGS. Bronze castings shall conform to the requirements of AASHTO M 107, Copper Alloy C91300 or Alloy C91100.

Self-lubricating bronze bearing plates shall conform to the following requirements:

- (a) The bronze alloy shall conform to the requirements of AASHTO M 107, Copper Alloy C91100, except that a maximum lead content of 2.5 percent is allowable.
- (b) The lubricant shall be of the solid type and shall consist of graphite, metallic substances having lubricating properties and a lubricating binder. Materials that do not have lubricating qualities or promote chemical or electrolytic reactions will not be acceptable. The lubricant shall be integrally molded and compressed into the lubrication recesses with hydraulic pressure of at least 41.5 MPa (6000 psi) to form a dense, non-plastic lubricant.
- (c) The recesses for the lubricant shall be arranged in a geometric pattern such that successive rows shall overlap in the direction of motion and the distance between extremities of recesses shall be closer in the direction of motion than that perpendicular to motion. The entire bearing area of all surfaces that have

provision for motion shall be lubricated by means of these lubricant filled recesses. The total area of these recesses shall comprise not less than 25 or more than 35 percent of the total bearing area of the plate.

- (d) The bearing plates shall be furnished to the sizes shown on the Plans. Bearing surfaces shall be machine finished and the surface roughness shall not exceed 3 μm (125 micro inches) when measured in accordance with ANSI B46.1. The bearing surfaces of the opposing steel plates shall also be finished as above. The lay of the tool marks shall be in the direction of motion. All machine surfaces shall be flat within 0.05 percent tolerance of length and width.
- (e) For mating curved surfaces of steel and bronze, the concave surface shall have a positive tolerance not exceeding 250 μm (10 mils) and the convex surface shall have a negative tolerance of 250 μm (10 mils).
- (f) The coefficient of friction between the bronze self-lubricating plates and the steel plates in contact with them shall not exceed 0.10 when subjected to the designed unit loading and also at twice the designed unit loading.
- (g) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

715.03 CAST IRON PIPE. Cast iron pipe and fittings shall conform to either the requirements of ASTM A 74 or the requirements of ASTM A 377, unless otherwise specified.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

715.04 ALUMINUM ALLOY. Material shall be fabricated from Alloy 6061-T6.

- (a) Sheet and Plate. Aluminum alloy sheet and plate shall conform to the requirements of ASTM B 209M (ASTM B 209).
- (b) Drawn Seamless Tubes. Aluminum alloy drawn seamless tubes shall conform to the requirements of ASTM B 210M (ASTM B 210).

- (c) Bars, Rods, and Wire. Aluminum alloy bars, rods, and wire shall conform to the requirements of ASTM B 211M (ASTM B 211).
- (d) Extruded Bars, Rods, Shapes, and Tubes. Aluminum alloy extruded bars, rods, shapes, and tubes shall conform to the requirements of ASTM B 221M (ASTM B 221).
- (e) Seamless Pipe and Seamless Extruded Tube. Aluminum alloy seamless pipe and seamless extruded tube shall conform to the requirements of ASTM B 241/B 241M.
- (f) Welding Rods and Electrodes. Aluminum and aluminum alloy welding rods and bare electrodes shall conform to the requirements of AWS.
- (g) Standard Structural Shapes. Aluminum alloy standard structural shapes, rolled or extruded, shall conform to the requirements of ASTM B 308/B 308M.
- (h) Extruded Structural Pipe and Tube. Aluminum alloy extruded structural pipe and tube shall conform to the requirements of ASTM B 429.
- (i) Sand Castings. Aluminum alloy sand casting shall conform to the requirements of ASTM B 26/B 26M.
- (j) Permanent Mold Castings. Aluminum alloy permanent mold castings shall conform to the requirements of ASTM B 108.
- (k) Rivets. Aluminum alloy rivet shall conform to the requirements of ASTM B 316/B 316M.
- (l) Bolts, Nuts, and Screws. Aluminum alloy bolts, nuts, and screws shall be made from rod conforming to the requirements of ASTM B 211M (ASTM B 211). Bolt heads shall conform to the American Standard heavy hexagon, ANSI B18.2.3.6M (ANSI B18.2.1), and nuts shall conform to ANSI B18.2.4.6M in accordance with ANSI B18.2M (ANSI B18.2.1 and B18.2.2). Bolt threads shall conform to ANSI B1.13M (ANSI B1.1). Both bolts and nuts shall be given an anodic coating at least 5 μm (0.2 mil) in thickness with dichromate or boiling water seal.
- (m) Washers and Shims. Aluminum alloy washers shall be made from aluminum alloy sheet conforming to the requirements of ASTM B 209M (ASTM B 209).

Aluminum alloy shims shall be made from aluminum alloy sheet or plate conforming to the requirements of ASTM B 209M (ASTM B 209) or ASTM B 221M (ASTM B 221).

- (n) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

SECTION 719

THIS SECTION RESERVED

SECTION 720 - GEOTEXTILES

720.01 GENERAL. The geotextile shall be composed of a polymeric yarn or fiber oriented into a stable network, which retains its relative structure during handling, placement, and design service life. Geotextiles may be rejected by the Engineer if dimensional stability or resistance of the geotextile to ambient temperatures, acid and alkaline conditions, and micro-organisms/insects does not appear to be satisfactory for the intended purpose. The geotextile shall meet or exceed the properties specified below and in the Contract. The geotextile shall be free of any chemical treatment or coating which might significantly reduce permeability. The selvage of geotextiles shall be finished such that the outer fibers are prevented from pulling away from the fabric. The geotextile shall be free of defects or tears. The material shall be protected from damage and deterioration until incorporated into the project.

720.02 DEFINITIONS.

- (a) Geotextile. A fabric manufactured specifically for use in civil engineering applications. Fibers used in the manufacture of geotextiles shall consist of long chain synthetic polymers. At least 85 percent by mass (weight) of the long chain polymers shall be polyolephins, polyesters, or polyamides.
- (1) Drainage Geotextile. Geotextile for installation in underdrains or other drainage locations as directed by the Engineer.
- (2) Stone Fill or Riprap Geotextile. Geotextile for installation behind and beneath stone fill or riprap and other erosion prevention and sediment control applications, rock placed for slope stabilization, and rock shear keys.
- (3) Subgrade Geotextile. Geotextile for installation on roadway subgrades, under railroad ballast, and in other material separation applications.
- (b) Machine Direction. The long (or warp) direction of the geotextile. The cross-machine (or fill) direction is perpendicular to the machine direction.
- (c) Minimum Average Roll Values. The minimum average roll value of any specific geotextile property is the minimum average of the test results from any roll within a lot.

- (d) Nonwoven Geotextile. A textile produced by bonding or interlocking of fibers, or both, accomplished by mechanical, heat, or chemical means.
- (e) Seam Allowance. The minimum distance from the edge of a geotextile to the stitch line nearest to that edge.
- (f) Seam Type. A designation relating to the essential characteristics of geotextile positioning and rows of stitching in a specified sewn seam, as shown on the Plans.
- (g) Selvage. The finished edge of a geotextile parallel to the machine direction.
- (h) Stitch Type. A designation relating to the essential characteristics of the interlacing of sewing thread(s) in a specified seam, as shown on the Plans.
- (i) Woven Geotextiles. A textile comprising two or more sets of filaments or yarns interlaced in such a way that they result in a uniform pattern.

720.03 FACTORY SEAMS. Where factory seams are made, the sheets of geotextile shall be sewn together using a lock-type stitch. The seams shall be sewn with a polymeric thread, i.e., at least 85 percent by mass (weight) of the long chain polymers shall be polyolephins, polyesters, or polyamides, and shall be as resistant to deterioration as the geotextile being sewn. Nylon threads will not be allowed. The strength of the seam shall be determined by the wide strip tensile test method and shall be at least equal to the larger of the minimum required tensile strengths for the intended application.

720.04 SAMPLING, TESTING, AND ACCEPTANCE REQUIREMENTS.

- (a) Sampling. The manufacturer shall sample all geotextiles in accordance with ASTM D 4354. The production unit used for sampling shall be a roll.
- (b) Testing. Tests shall be performed to determine geotextile properties specified below for the intended application(s). All geotextile property requirements are average minimum roll values. The tensile strengths shall be determined in both machine and cross-machine directions.

- (c) Acceptance Requirements. If the average minimum roll value for any lot is less than the average minimum roll value specified for the application, then the lot shall be rejected. All rolls shall be clearly labeled as being part of a lot that has been certified as meeting all applicable requirements below.

- (d) Minimum Average Roll Value. Average minimum roll values of each of the geotextiles used shall meet the requirements specified in the following table:

TABLE 720.04A - VAOT MINIMUM AVERAGE ROLL VALUES FOR GEOTEXTILES (METRIC)

Geotextile Property	Test Method	Elongation (Note 2)								Pay Item 649.41 For Underdrain Trench Lining (Note 3)	Pay Item 649.51 For Silt Fence	Pay Item 649.61 For Filter Curtains
		Pay Item 649.11 For Roadbed Separator	Pay Item 649.21 Under Railroad Ballast	Pay Item 649.31 Under Stone Fill	<50%	≥50%	<50%	≥50%	<50%			
Elongation Criteria at Failure (Note 1)	ASTM D 4632	<50%	≥50%	<50%	≥50%	<50%	≥50%	<50%	≥50%	20% Min.	(Note 4)	20% Max.
1. Grab Tensile Strength (N)	ASTM D 4632	1100	700	1400	900	1400	900	1400	900	400	400	900
2. Burst Strength (kPa)	ASTM D 3786	2700	1300	3500	1700	3500	1700	3500	1700	580	650	1425
3. Puncture (N)	ASTM D 4833	400	250	500	350	500	350	500	350	115	180	360
4. Trapezoidal Tear Strength (N)	ASTM D 4533	400	250	500	350	500	350	500	350	110	135	225
5. Apparent Opening Size (mm)	ASTM D 4751	0.42 Max.		0.21 Max.		0.21 Max.		0.21 Max.		0.21 Max.	0.60 Max.	0.21 Max.
6. Permittivity (s ⁻¹)	ASTM D 4491	0.02		0.3		0.4		0.5		0.5	0.05	0.4
7. UV Resistance (% Strength Retained)	ASTM D 4355	50% @ 500 hours		50% @ 500 hours		50% @ 500 hours		50% @ 500 hours		50% @ 500 hours	70% @ 500 hours	70% @ 500 hours
8. Other				Woven or Nonwoven:		Woven or Nonwoven:		Nonwoven only, slit film not		Nonwoven only, slit film not	Woven only	Woven only

1. Elongation corresponds to Maximum Grab Tensile Strength as measured in accordance with ASTM D 4632.

2. Only one criteria applies per Pay Item.

3. Where angular aggregate larger than 100 mm size or sharp objects come in contact with the geotextile, or if the trench is deeper than 10 feet, then the minimum Grab Tensile, Burst, Puncture, and Trapezoid Tear Strengths shall be increased to 800 N, 2000 kPa, 360 N, and 225 N, respectively.

4. Where Elongation is ≥50%, post spacing shall not exceed 1.2 m. Where Elongation is <50%, post spacing shall not exceed 2 m.

TABLE 720.04A - VAOT MINIMUM AVERAGE ROLL VALUES FOR GEOTEXTILES (ENGLISH)

Geotextile Property	Test Method	Pay Item 649.11 For Roadbed Separator		Pay Item 649.21 Under Railroad Ballast		Pay Item 649.31 Under Stone Fill		Pay Item 649.41 For Underdrain Trench Lining (Note 3)	Pay Item 649.51 For Silt Fence	Pay Item 649.61 For Filter Curtains
		<50%	≥50%	<50%	≥50%	<50%	≥50%			
Elongation (Note 2)										
Elongation Criteria at Failure (Note 1)	ASTM D 4632	<50%	≥50%	<50%	≥50%	<50%	≥50%	20% Min.		20% Max.
1. Grab Tensile Strength (lbs.)	ASTM D 4632	250	160	315	200	315	315	90	90	200
2. Burst Strength (psi)	ASTM D 3786	390	190	510	250	510	510	85	95	205
3. Puncture (lbs.)	ASTM D 4833	90	55	110	80	110	110	25	40	80
4. Trapezoidal Tear Strength (lbs.)	ASTM D 4533	90	55	110	80	110	110	25	30	50
5. Apparent Opening Size	ASTM D 4751	16.5 Max.		8.3 Max.		8.3 Max.		8.3 Max.		8.3 Max.
6. Permittivity (s ⁻¹)	ASTM D 4491	0.02		0.3		0.4		0.5		0.4
7. UV Resistance (% Strength)	ASTM D 4355	50% @ 500 hours		50% @ 500 hours		50% @ 500 hours		50% @ 500 hours		70% @ 500 hours
8. Other						Woven or Nonwoven; slit film not permitted		Nonwoven only, slit film not permitted		Woven only

1. Elongation corresponds to Maximum Grab Tensile Strength as measured in accordance with ASTM D 4632.

2. Only one criteria applies per Pay Item.

3. Where angular aggregate larger than 4 inch size or sharp objects come in contact with the geotextile, or if the trench is deeper than 10 feet, then the minimum Grab Tensile, Burst, Puncture, and Trapezoid Tear Strengths shall be increased to 180 lbs, 290 psi, 80 lbs, and 50 lbs, respectively.

4. Where Elongation is ≥50%, post spacing shall not exceed 4 feet. Where Elongation is <50%, post spacing shall not exceed 6 feet.

- (e) Manufacturer's Certification. The Contractor shall furnish the geotextile manufacturer's certified test results attesting that the geotextile and all factory seams meet the requirements stated in these specifications. A Type D Certification shall be furnished that provides the information required under Subsection 700.02, including minimum average roll values for each type of geotextile used.

720.05 PREFABRICATED CHECK DAM. Acceptable Prefabricated Check Dam(s) shall be one of the Prefabricated Check Dam(s) on the approved list on file at the Agency's Materials and Research Section.

720.06 INLET PROTECTION DEVICE, TYPE II. Acceptable Inlet Protection Device(s) shall be one of the Inlet Protection Device(s) on the approved list on file at the Agency's Materials and Research Section.

720.07 FILTER BAG. Acceptable Filter Bag(s) shall be one of the Filter Bag(s) on the approved list on file at the Agency's Materials and Research Section.

SECTION 725 - CONCRETE CURING MATERIALS
AND ADMIXTURES

725.01 CONCRETE CURING MATERIALS.

- (a) White Burlap-Polyethylene Sheet. White burlap-polyethylene sheet shall conform to the requirements of AASHTO M 171.
- (b) Burlap Cloth. Burlap cloth shall conform to the requirements of AASHTO M 182. Worn burlap cloth with holes, or burlap cloth reclaimed from uses other than that of curing concrete, will not be permitted. The burlap cloth shall be free of any ingredients that may damage or be detrimental to concrete.
- (c) White Polyethylene Sheeting. White polyethylene sheeting (film) shall conform to the requirements of AASHTO M 171.
- (d) Liquid Membrane-Forming Compounds. Liquid membrane-forming compounds shall conform to the requirements of AASHTO M 148, Type 1-D or Type 2, Class B.

- (1) Sampling and Testing. Upon request, the Agency will furnish a list of products on the Approved Products List that have been previously evaluated and are considered satisfactory. Should the Contractor wish to use a product other than those included on this list, a 4 L (1 gallon) sample of the product shall be submitted to the Agency's Materials and Research Section for testing purposes. A minimum period of 30 days shall be allowed for testing purposes. Tests for daylight reflectance will not be required.
- (2) Certification. A Type B Certification shall be furnished in accordance with Subsection 700.02.

725.02 CHEMICAL ADMIXTURES.

- (a) General.
 - (1) Packaging. The admixture shall be delivered in the manufacturer's original containers that shall be marked with the manufacturer's name and trade name of the material. Bulk deliveries will be allowed provided a copy of the delivery slip accompanies the manufacturer's certification or sample submitted for testing.
 - (2) Sampling and Testing. Upon request, the Agency will furnish a list of products on the Approved Products List that have been previously tested and are considered satisfactory. Should the Contractor wish to use a product other than those included on this list, a 4 L (1 gallon) sample or the equivalent in powder form shall be submitted to the Materials and Research Section for testing purposes. Tests for bleeding and length change will not be required. A minimum period of 60 days shall be allowed for testing purposes.
 - (3) Certification. A Type B Certification shall be furnished in accordance with Subsection 700.02.
- (b) Air-Entraining Admixtures. Air-entraining admixtures shall conform to the requirements of AASHTO M 154.
- (c) Retarding Admixtures. Retarding admixtures shall conform to the requirements of AASHTO M 194M/M 194, Type B.

- (d) Latex Admixture. The formulated latex admixture shall be a homogeneous, nontoxic, film-forming, polymeric emulsion to which all stabilizers have been added at the point of manufacture.

When some degree of flexibility of the composition is considered desirable in the intended use, it shall conform to the requirements of the following table or shall have been approved by the FHWA Fairbank Research Station:

TABLE 725.02A - LATEX ADMIXTURE A

Physical Properties	Min.	Max.
Polymer Type	Styrene butadiene	---
Stabilizers:		
(a) Latex	Nonionic surfactants	---
(b) Portland cement composition	Polydimethyl siloxane	---
Solids, %	46.0	49.0
Density, kg/L at 25 °C (lbs./gal at 77 °F)	1.0 (8.3)	---
Color	White	---

Latex admixture shall be stored in suitable enclosures which will protect it from freezing and from prolonged exposure to temperatures in excess of 30 °C (86 °F). It shall not be used after two years from the date of manufacture.

- (e) Silicone Admixture. The formulated admixture shall be of a liquid silicone type that conforms to the following chemical description: N-beta (aminoethyl) gamma-Aminopropyltrimethoxy-silane. Its use is intended to prolong the life of portland cement concrete by increasing its resistance to deicing chemicals and by reducing spalling, scaling, and surface failure due to freeze-thaw cycling.

Silicone admixture shall be stored in suitable containers that prevent contamination of any kind. It shall not be used after one year from the date of manufacture or if the liquid is cloudy or milky in color.

- (f) Water-Reducing Admixtures. Water-reducing admixtures shall conform to the requirements of AASHTO M 194M/M 194, Type A.
- (g) Water-Reducing and Retarding Admixtures. Water-reducing and retarding admixtures shall conform to the requirements of AASHTO M 194M/M 194, Type D.
- (h) Water-Reducing, High Range Admixtures. Water-reducing, high range admixtures shall conform to the requirements of AASHTO M 194, Type F.
- (i) Water-Reducing, High Range, and Retarding Admixtures. Water-reducing, high range, and retarding admixtures shall conform to the requirements of AASHTO M 194M/M 194, Type G.
- (j) Accelerating Admixtures. Accelerating admixtures shall conform to the requirements of AASHTO M 194M/M 194, Type C.
- (k) Water-Reducing and Accelerating Admixtures. Water-reducing and accelerating admixtures shall conform to the requirements of AASHTO M 194M/M 194, Type E.

725.03 MINERAL ADMIXTURES.

- (a) Pozzolans. Pozzolans and fly ash shall conform to the requirements of AASHTO M 295. The supplier shall provide the State with the test results of the ten consecutive samples preceding the one submitted for approval to demonstrate compliance with the uniformity requirements shown in Table 2 of AASHTO M 295.

The Contractor shall provide suitable means for storing and protecting the pozzolans from contamination with foreign materials. Fly ash containing oil shall be rejected.

The combining of different types of fly ash or the mixing of the same type of fly ash from different sources will not be permitted.

- (b) Silica Fume. Silica fume shall conform to the following chemical and physical requirements:

Silicon Dioxide (SiO ₂), Minimum %:	85.0
Sulfur Trioxide (SO ₃), Maximum %:	3.0
Moisture Content, Maximum %:	3.0
Loss on Ignition, Maximum %:	6.0
Available Alkalies as Na ₂ O, Maximum %:	1.5
Specific Surface, Air Permeability, m ² /kg:	6000
Pozzolanic Activity Index:	
With portland cement, at 28 days when tested in accordance with ASTM C 311, Minimum, % control:	100
Soundness:	
Autoclave expansion or contraction, Maximum %:	0.8
Specific Gravity, Maximum variation from average, %:	5

When silica fume is delivered in packages or drums, the name brand of the manufacturer and the mass (weight) of the silica fume, if dry, or the concentration, if a slurry, shall be clearly marked on the package or drum.

- (c) Ground Granulated Blast-Furnace Slag (GGBFS). Ground granulated blast-furnace slag (GGBFS) shall conform to the requirements of AASHTO M 302.

The Contractor shall provide suitable means for storing and protecting the GGBFS from contamination by foreign materials and/or moisture.

- (d) Certification. All mineral admixtures shall be certified by submittal of a Type D Certification in accordance with Subsection 700.02 for each shipment of mineral admixture. If the supplier's operations do not permit strict compliance with the above requirements, alternate procedures for certification, if approved, may be established with the Agency Materials and Research Section at the request of the supplier.

SECTION 726 – PROTECTIVE COATINGS AND
WATERPROOFING MATERIALS

726.01 TIMBER PRESERVATIVE. Preservatives and pressure treatment processes for lumber and timber shall conform to the requirements of AASHTO M 133. Preservatives acceptable for treatment are as follows with retentions and penetrations as specified for ground contact in AWPA Standard C 14:

<u>Preservative Type</u>	<u>AWPA Standard</u>
I. Creosote	
(a) Creosote	P1
(b) Creosote – Coal Tar Solution	P2
(c) Creosote – Petroleum Solution	P3
II. Pentachlorophenol	P8
Solvent – Heavy Oil Hydrocarbon Solvent, Type A	P9
III. Pentachlorophenol	P8
Solvent – Light Oil Hydrocarbon Solvent, Type C	P9
IV. Chromated Copper Arsenate	P5
V. Alkaline Copper Quat	P5

Glued laminated timber shall be treated in compliance with AWPA Standard C28 with retentions and penetrations specified for ground contact.

Any field treatment required by the Engineer shall be performed in accordance with the provisions of AWPA Standard M4. Prior to the delivery of preservative material, a copy of the Material Safety Data Sheet for the product shall be provided to the Resident Engineer.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

726.02 BOILED LINSEED OIL. Boiled linseed oil shall conform to the requirements of ASTM D 260.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

726.03 MINERAL SPIRITS. Mineral spirits shall conform to the requirements of ASTM D 235.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

726.04 COPPER NAPHTHENATE SOLUTION. Copper naphthenate solution shall meet the requirements of a good quality commercially available product, as approved by the Engineer.

726.05 WATERPROOFING PITCH. Waterproofing pitch shall conform to the requirements of ASTM D 450. Type II pitch shall be furnished.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

726.06 WOVEN COTTON FABRIC. Bitumen saturated woven cotton fabric shall conform to the requirements of ASTM D 173.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

726.07 WOVEN GLASS FABRIC. Coated woven glass fabric shall conform to the requirements of ASTM D 1668.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

SECTION 727 - FENCING MATERIALS

727.01 WOVEN WIRE FENCE.

- (a) Woven Wire Fabric for Fencing and Gates. Woven wire fabric shall be rectangular mesh and shall conform to the requirements of AASHTO M 279, Class 3 coating, Design Number 939-6-11. At the option of the Contractor, the woven wire fabric may be aluminum coated and shall conform to the requirements for ASTM A 584, Class 2 coating.
- (b) Barbed Wire. Barbed wire shall conform to the requirements of AASHTO M 280, two strand, standard size 2.51 mm (0.099 inch or 12 1/2 gage) diameter, Coating Class 3, with four point, 2.03 mm (0.08 inch or 14 gage) diameter, round barbs spaced at approximately 125 mm (5 inch) intervals.

The Contractor may also elect to furnish aluminum coated barbed wire, which shall conform to the requirements of ASTM A 585, Class 2 aluminum coating.

- (c) Wood Posts and Braces. Wood posts shall be seasoned Red (Norway) Pine or Southern Pine, straight, sound, and cut from live timber.

If round posts are used they shall conform to the diameter and length shown on the Plans. In all cases, they shall be not less than 115 mm (4 1/2 inches) in diameter at the small end after removal of the bark. They shall be shaved to an even surface and be free from bark or skin.

If sawn posts are used, the nominal dimensions shall be at least 100 mm (4 inches) square and of the length shown on the Plans.

The types of wood to be used for bracing shall be similar to those required for the posts. The braces shall conform to the dimensions shown on the Plans.

All wood posts and braces shall be treated full length with a preservative as specified in Subsection 726.01. Any cut portions shall receive a field application of copper naphthenate solution.

Steel Posts and Braces. Intermediate or line posts shall be standard commercial T-Type steel posts conforming to the length shown on the Plans, and shall have a nominal mass (weight) of 2 kg/m (1.3 pounds per linear foot) of post length.

End posts, corner posts, and pull posts shall be standard rolled steel angles, 64 by 64 by 6.4 mm (2 1/2 × 2 1/2 × 1/4 inch). They shall conform to the length shown on the Plans and shall have a nominal mass (weight) of 6.1 kg/m (4.1 pounds per linear foot).

Braces shall be standard rolled steel angles 51 by 51 by 4.8 mm (2 × 2 × 3/16 inch) having a nominal mass (weight) of 3.63 kg/m (2.44 pounds per linear foot).

The nominal masses (weights) stated for the several types of posts do not include anchors, plates, or other metal fittings. Intermediate posts or line posts shall be provided with an anchor plate having a length and/or width of 100 to 130 mm (4 to 5 inches) with a net area of not less than 12 900 mm² (20 square

inches). The anchor plates shall be securely fastened to the post by welding or by a minimum of two rivets per plate.

All posts, braces, anchors, plates, and other metal fittings shall be zinc coated on all inner and outer surfaces in accordance with the requirements of AASHTO M 111M/M 111 or AASHTO M 232M/M 232, whichever is applicable.

- (d) Miscellaneous Hardware. Miscellaneous hardware such as, but not limited to, wire, clips, nails, bolts, nuts, washers, hinges, latches, and staples shall be of low to medium carbon steel, galvanized, and shall be of good commercial quality. Staples shall be at least 38 mm (1 1/2 inches) long of 3.76 mm (0.1483 inch) diameter (9 gage) galvanized wire. Galvanizing shall be in accordance with AASHTO M 232M/M 232, where applicable. Galvanized wire and clips produced from galvanized wire shall have a Class 1 coating in accordance with AASHTO M 279.
- (e) Gates. Frames, diagonal tie bars, braces, and hardware for gates shall conform to the design shown on the Plans and shall be zinc coated on all inner and outer surfaces in accordance with ASTM A 53/A 53M, AASHTO M 111M/M 111, or AASHTO M 232M/M 232, whichever is applicable. Woven wire fabric used for gates shall be of the same material used in fences.
- (f) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

727.02 CHAIN-LINK FENCE. Chain-link fence shall conform to the requirements of AASHTO M 181. The chain-link fence shall conform to the design, dimensions, and details shown on the Plans.

- (a) Chain-Link Fabric. Chain-link fabric shall consist of 3.76 mm (0.1483 inch) diameter (9 gage) wire woven into a 50 mm (2 inch) mesh. The bottom selvage of all chain-link fabric shall be knuckled. When the height of the fabric is 1.2 m (4 feet) or less, the top edge shall also be knuckled. When vinyl coated fabric is used, the wire shall be 3.76 mm (0.1483 inch) diameter (9 gage) prior to coating with vinyl. Galvanized chain-link fabric shall be Type I, Class D, as specified in AASHTO M 181.
- (b) Posts, Gate Frames, Rails, Braces, and Miscellaneous Hardware. Posts, gate frames, rails, braces, and miscellaneous hardware furnished for use in conjunction with zinc or vinyl coated steel fabric shall be of zinc coated steel. Zinc coated steel shall

conform to the requirements of AASHTO M 181, Grade 1 or Grade 2.

Posts, gate frames, rails, braces, and miscellaneous hardware shall conform to the requirements of the following table:

TABLE 727.02A - ZINC COATED STEEL MATERIAL (METRIC)

Use and Section		Outside Diameter or Dimensions (mm)	Nominal Mass per Meter (kg)
End, Corner, and Pull Post for fabric heights:			
Less than 1.8 m:	Round, Grade 1	60.3	5.43
	Round, Grade 2	60.3	4.64
	Square	50.8 by 50.8	5.36
	Roll Formed	88.9 by 88.9	7.59
1.8 m and greater:	Round, Grade 1	73.0	8.62
	Round, Grade 2	73.0	6.91
	Square	63.5 by 63.5	8.48
	Roll Formed	88.9 by 88.9	7.59
Line Posts for fabric heights:			
Less than 1.8 m:	Round, Grade 1	48.3	4.05
	Round, Grade 2	48.3	3.39
	Roll Formed	47.6 by 41.3	3.39
	H-Section	57.2 by 43.2	4.85
1.8 m and greater:	Round, Grade 1	73.0	5.43
	Round, Grade 2	48.3	4.64
	Roll Formed	47.6 by 41.3	3.39
	H-Section	57.2 by 43.2	4.85
Gate Posts for nominal width of gate, single gate, or one leaf of double gate:			
1.8 m and less:	Round, Grade 1	73.0	8.62
	Round, Grade 2	73.0	6.91
	Square	63.5 by 63.5	8.48
	Roll Formed	88.9 by 88.9	7.54
Over 1.8 to 4.0 m:	Round, Grade 1	101.6	13.54
	Round, Grade 2	88.9	8.47
	Square	76.2 by 76.2	13.54
Over 4.0 to 5.5 m:	Round	168.3	28.23
Over 5.5 m:	Round	219.1	36.76
Gate Frames for fabric heights:			
Less than 1.8 m:	Round, Grade 1	42.2	3.38

TABLE 727.02A - ZINC COATED STEEL MATERIAL (METRIC)
(Continued)

Use and Section		Outside Diameter or Dimensions (mm)	Nominal Mass per Meter (kg)
	Round, Grade 2	42.2	2.74
	Square	38.1 by 38.1	2.83
1.8 m and greater:	Round, Grade 1	48.3	4.05
	Round, Grade 2	48.3	3.39
	Square	50.8 by 50.8	3.13
Top Rails and Brace Rods:	Round, Grade 1	42.2	3.38
	Round, Grade 2	242.2	2.74
	Roll Formed	41.3 by 31.8	2.00
Truss Rods:	Round with Turnbuckle	9.5	---
Tension Wire:	Wire	3.8	---
Tension Bars:	Bar	6.4 by 19.1	---

TABLE 727.02A - ZINC COATED STEEL MATERIAL (ENGLISH)

Use and Section		Outside Diameter or Dimensions (inches)	Weight Per Foot (pounds)
End, Corner, and Pull Post for fabric heights:			
Less than 6 feet:	Round, Grade 1	2.375	3.65
	Round, Grade 2	2.375	3.12
	Square	2.00 × 2.00	3.60
	Roll Formed	3.50 × 3.50	5.14
6 feet and greater:	Round, Grade 1	2.875	5.79
	Round, Grade 2	2.875	4.64
	Square	2.50 × 2.50	5.70
	Roll Formed	3.50 × 3.50	5.14
Line Posts for fabric heights:			
Less than 6 feet:	Round, Grade 1	1.90	2.72
	Round, Grade 2	1.90	2.28
	Roll Formed	1.875 × 1.625	5.14
	H-Section	1.875 × 1.625 × 0.113	2.70
6 feet and greater:	Round, Grade 1	2.875	3.65
	Round, Grade 2	2.375	3.12
	Roll Formed	1.875 × 1.625	5.14
	H-Section	2.25 × 1.95 × 0.143	4.10

TABLE 727.02A - ZINC COATED STEEL MATERIAL (ENGLISH)
(Continued)

Use and Section		Outside Diameter or Dimensions (inches)	Weight Per Foot (pounds)
Gate Posts for nominal width of gate, single gate, or one leaf of double gate:			
6 feet and less:	Round, Grade 1	2.875	5.79
	Round, Grade 2	2.875	4.64
	Square	2.50 × 2.50	5.70
	Roll Formed	3.50 × 3.50	5.14
Over 6 to 13 feet:	Round, Grade 1	4.00	9.10
	Round, Grade 2	3.50	5.71
	Square	3.00 × 3.00	9.10
Over 13 to 18 feet:	Round	6.625	18.97
Over 18 feet:	Round	8.625	24.70
Gate Frames for fabric heights:			
Less than 6 feet:	Round, Grade 1	1.660	2.27
	Round, Grade 2	1.660	1.84
	Square	1.50 × 1.50	1.90
6 feet and greater:	Round, Grade 1	1.90	2.72
	Round, Grade 2	1.90	2.28
	Square	2.00 × 2.00	2.10
Top Rails and Brace Rods:	Round, Grade 1	1.660	2.27
	Round, Grade 2	1.660	1.84
	Roll Formed	1.625 × 1.25	1.34
Truss Rods:	Round with Turnbuckle	0.375	---
Tension Wire:	Wire	0.1483	---
Tension Bars:	Bar	1/4 × 3/4	---

- (c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

727.03 BARRIER FENCE. Barrier Fence shall be fluorescent yellow or orange, ultraviolet stabilized high density polyethylene mesh that will not rust, sag, corrode, rot, or conduct electricity. It shall have an effective temperature range of -50°C to 80°C (-60°F to 180°F) and a minimum tensile yield strength of 22 MPa (3200 PSI). Acceptable Barrier Fence shall be one of the Barrier Fences on the Approved Products List on file with the Agency's Materials and Research Section.

727.04 PROJECT DEMARCATION FENCE. Project Demarcation Fence shall be non-adhesive pigmented polyethylene or vinyl-coated polyester mesh tape. It shall have a minimum width of 75 mm (3 inches), a minimum thickness of 0.15 mm (6 mil), and a minimum tensile strength of 222 N (50 lbf). Acceptable Project Demarcation Fence shall be one of the Project Demarcation Fences included on the Approved Products List on file with the Agency's Materials and Research Section.

SECTION 728 - GUARDRAIL, GUIDE POSTS, AND BARRIERS

728.01 POSTS AND POST ACCESSORIES.

- (a) Wood Posts and Offset Blocks for Rail, Guardrail, Barriers, and Guide Posts. Wood posts and offset blocks shall be seasoned Red (Norway) Pine or Southern Pine, straight, sound, and cut from live timber. Red Pine shall meet number 1 grade requirements specified by the Northeastern Lumber Manufacturer's Association (NELMA). Southern Pine shall meet number 2 grade requirements specified by the Southern Pine Inspection Bureau (SPIB). Preservatives and pressure treatment shall conform to AASHTO M 133 and AWPA Standards C1, C2, and C14. Inspection of treated material shall, at a minimum, conform to AWPA Standards M2, M3, and M4.

Material shall be of the proper grade prior to beginning any fabrication operation.

Material shall be fabricated prior to treatment in conformance with the dimensions and details shown on the Plans.

Material shall be treated with a Type IV preservative as specified in Subsection 726.01.

Field repairs shall be made in accordance with AWPA Standard M4. Cuts, holes, and damaged areas shall be saturated with copper naphthenate solution. Bored holes shall be plugged with treated tight fitting wooden plugs.

Timber material shall be produced in accordance with American Lumber Standards Committee (ALSC) approved grading standards. Acceptable material shall be grade stamped with an appropriate tag or mark identifying conformance with ALSC requirements.

Retention by assay shall be not less than 9.6 kg/m³ (0.60 pound per cubic foot).

All lumber and timber shall be treated in a plant participating in an independent inspection program designed to provide continuous supervision, testing, and inspection for establishing acceptable quality control. Competency and performance of the inspection agency shall be overviewed by an approved organization, such as the American Wood-Preservers' Association (AWPA). Material meeting compliance with applicable specifications shall bear the quality mark of the authorized inspection agency.

Tags and marks identifying compliance shall, at a minimum, be placed on each post in a location that will be visible after installation.

Each and every charge of treated material shall be inspected in accordance with the applicable requirements for soil use specified in AWPA Standard C2. The treater shall perform laboratory analysis for measured penetration and retention of each charge. A copy of each analysis report shall accompany the certificates covered under Subsection 728.01(e).

It is the responsibility of the producer to arrange for all independent inspection. All inspection costs shall be included in the unit price of the material.

- (b) Wood Posts for Cedar Log Rail. Wood posts shall be seasoned Cedar, straight, sound, and cut from live timber. The posts shall conform to the diameter and length shown on the Plans. They shall be shaved to an even surface and shall be free from bark or skin.
- (c) Steel Posts and Post Accessories. Steel posts, offset blocks, splice plates, brackets, channel anchors, and other post accessories shall conform to the requirements of AASHTO M 270M/ M 270, Grade 250 (Grade 36). They shall conform to the details shown on the Plans. After fabrication, all posts, post accessories, and channel anchors shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111.
- (d) Alternative Blockouts. As an alternative to steel or wood blockouts in part (a) or (c) above, blockouts made of synthetic materials and appearing on the Approved Products List on file at the Agency's Materials and Research Section are allowed.

- (e) Certification. For wood posts and accessories, a Type D Certification shall be furnished in accordance with Subsection 700.02. For steel posts and accessories, a Type D Certification shall be furnished.

728.02 RAIL ELEMENTS.

- (a) Plank Rail. The plank for rail shall be seasoned Red (Norway) Pine or Southern Pine, planed on four sides, and of the dimensions shown on the Plans. Wood shall be treated full length in accordance with Subsection 726.01, Type I, II, III, or IV.
- (b) Log Rail. The log for rail shall be seasoned Cedar, straight, sound, and cut from live timber. The rail shall conform to the diameter and length shown on the Plans. The rail shall be shaved to an even surface and be free from bark or skin.
- (c) Cable Rail. Cable shall conform to the requirements of Subsection 713.03.
- (d) Steel Beam and Thrie Beam Rail. Steel beam (W-beam) and thrie beam rail elements shall conform to AASHTO M 180, Class A, Type II zinc coated, except that when a heavy duty steel beam is specified, the rail elements shall conform to AASHTO M 180, Class B, Type II.

When corrosion resistant steel is specified, Type IV rail having the corrosion resistance of AASHTO M 270M/M 270, Grade 345W (Grade 50W) shall be used.

- (e) Box Beam Rail. Box beam rail shall conform to the requirements of Subsection 714.11. The rail shall conform to the details shown on the Plans as to size and shape and all holes and slots shall be punched, drilled, burned, or cut as indicated. After fabrication, the rail shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111.
- (f) Certification. For Cedar log and cable rail, a Type A Certification shall be furnished in accordance with Subsection 700.02. For plank rail, a Type D Certification shall be furnished. For cable, beam, and box beam rail, a Type D Certification shall be furnished.

728.03 HARDWARE.

- (a) Hardware for Plank Rail. Miscellaneous hardware such as spikes, lag screws, bolts, nuts, and washers shall conform to the dimensions shown on the Plans. Hardware shall be of low to medium carbon steel, galvanized and shall be of good commercial quality. The metal brackets shall be fabricated from 6 mm (1/4 inch) steel plate and shall be galvanized after fabrication.
- (b) Hardware for Cedar Log Rail. Miscellaneous hardware such as lag screws shall be of low to medium carbon steel and shall be of good commercial quality. The metal straps shall be fabricated from 6 mm (1/4 inch) steel plate.
- (c) Hardware for Cable, Steel Beam, and Thrie Beam Rail. Miscellaneous hardware and fittings such as bolts, nuts, and washers, cable splices, hook bolts, anchor rod assemblies, and cable end units shall conform to the dimensions shown on the Plans. All cable fittings and anchorages shall be capable of developing the minimum tensile strength shown on the Plans when properly installed.

Bolts, nuts, and washers shall conform to the following:

- (1) Steel bolts shall conform to the requirements of ASTM F 568M, Class 4.6 (ASTM A 307, Grade A). Steel nuts shall conform to the requirements of AASHTO M 291M (AASHTO M 291). Steel washers shall conform to the requirements of ASTM F 436M (ASTM F 844).
- (2) Steel cast bolts, nuts, and washers shall conform to the requirements of ASTM A 27/A 27M, Grade 65-35 full annealed.

All hardware shall be galvanized in accordance with AASHTO M 232 M/M 232. All bolts, nuts, and washers shall be either hot-dip galvanized in accordance with the requirements of AASHTO M 232M/M 232 or mechanically galvanized using a mechanically deposited process conforming to the requirements of AASHTO M 298, Class 50.

When corrosion resistant steel Type IV rail is specified and galvanized hardware is not desirable, black, ungalvanized bolts shall be used and shall conform to

ASTM F 568M, Class 4.6 (ASTM A 307, Grade C); nuts shall conform to AASHTO M 291M (AASHTO M 291); and washers shall conform to ASTM F 436M (ASTM F 844); or bolts, nuts, and washers shall conform to ASTM A 27/A 27M, Grade 65-25, full annealed.

- (d) Hardware for Box Beam Rail. Bolts shall conform to the requirements of ASTM F 568M, Class 4.6 (ASTM A 307, Grade A); nuts shall conform to the requirements of AASHTO M 291M (AASHTO M 291); and washers shall conform to the requirements of ASTM F 436M (ASTM F 844). Bolts, nuts, and washers for rail splice connections shall conform to the requirements of AASHTO M 164M (AASHTO M 164). All bolts, nuts, and washers shall be either hot-dip galvanized in accordance with AASHTO M 232M/M 232 or mechanically galvanized using a mechanically deposited process conforming to the requirements of AASHTO M 298, Class 50.

All bolts, nuts, and washers required to conform to AASHTO M 164M (AASHTO M 164) shall meet all requirements of Subsection 714.05, except that the rotational capacity tests, the proof load tests, and the wedge tests will not be required.

- (e) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

728.04 DELINEATION DEVICES. Delineators for wood posts shall be an approved reflective sheeting conforming to Subsection 750.08.

Delineators for steel posts or guardrail shall be flat sheet aluminum conforming to Subsection 751.04 and the details shown on the Plans, or high impact polycarbonate thermoplastic conforming to Subsection 751.07 and the details shown on the Plans.

The face of each delineator shall be reflectorized with reflective sheeting conforming to Subsection 750.08 and of the type shown on the Plans.

As an aid to installation, reflectors for use in the valley of W-shaped steel beam guardrail may have a 19 mm (3/4 inch) slot extending horizontally from the bolt hole in the base to the end of the base away from the reflectorized surface or extending vertically down from the bolt hole to the lower edge of the base. The directions indicated are viewed looking at the installed reflector unit from the point on the roadway centerline, which is the intersection of the perpendicular to the centerline that passes through the reflector unit base.

The Contractor may propose other materials as backing for traffic barrier reflectors.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

728.05 CONCRETE ANCHORS. Precast or cast-in-place concrete anchors for guardrail shall conform to the details shown on the Plans as to the size, shape, and placement of the bar reinforcement.

- (a) Concrete. Concrete shall conform to Section 541 for Concrete, Class B.
- (b) Curing. The concrete anchors shall be subjected to any one of the methods of curing prescribed in AASHTO M 199M/M 199, for a sufficient length of time so that the concrete will develop the specified compressive strength within 28 days.
- (c) Bar Reinforcement. Bar reinforcement shall conform to Subsection 713.01.
- (d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02 for precast anchors.

728.06 MANUFACTURED TERMINAL SECTIONS. Acceptable Manufactured Terminal Sections shall be one of the Manufactured Terminal Sections on the Approved Products List on file with the Agency's Materials and Research Section.

SECTION 729 - CURB MATERIALS

729.01 VERTICAL GRANITE CURB. Vertical granite curb shall consist of hard, durable, quarried granite. It shall be gray in color, free from seams, cracks, or other structural defects, and shall be of a smooth splitting character. The curb may contain natural color variations that are characteristic of the granite source.

- (a) Source. The Contractor shall submit for approval the name of the quarry that is the proposed source of the granite for curb materials. 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. Samples of curbing shall be submitted for approval only when requested by the Engineer.

- (b) Finish and Surface Dimensions. The individual curb stones shall be of the dimensions shown on the Plans and shall be of uniform thickness in any continuous run. The individual curb stones shall be furnished in minimum lengths of 2 m (6 feet).

The top surface of the curb stones shall be sawed to an approximately true plane and shall have no projection or depression greater than 3 mm (1/8 inch).

The bottom surface may be sawn or split.

The top front arris line shall be rounded as shown on the Plans. The exposed arris lines shall be pitched straight and true, with no variations from a straight line greater than 3 mm (1/8 inch).

The front face shall be at right angles to the plane of the top and shall be smooth quarry split or sawn for the full depth. Drill holes in the exposed part of the face shall not be permitted. The front face shall have no projections greater than 25 mm (1 inch) or depressions greater than 13 mm (1/2 inch), measured from the vertical plane of the face through the top arris line for a distance of 200 mm (8 inches) down from the top. For the remaining distance, there shall be no projections or depressions greater than 25 mm (1 inch) measured in the same manner.

The back surface of the curb stones shall have no projection for a distance of 75 mm (3 inches) down from the top which would fall outside of a plane having a batter of one horizontal to three vertical from the back arris line.

The ends of all curb stones shall be square with the planes of the top and front face, and so finished that when the stones are placed end to end as closely as possible, no space more than 25 mm (1 inch) shall show in the joint for the full width of the top or down on the face for 200 mm (8 inches). The remainder of the end may break back a maximum of 150 mm (6 inches) from the plane of the joint.

Curbing stones to be set on a radius of 25 m (80 feet) or less shall be cut to the curve required, and their ends shall be cut on radial lines.

729.02 GRANITE BRIDGE CURB. Granite bridge curb shall consist of hard, durable, quarried granite. It shall be gray in color, free from seams, cracks, or other structural defects, and shall be of a smooth splitting character. The curb stones in any one structure shall be of uniform color

and acceptable to the Engineer. The curb stones shall be thoroughly cleaned of any iron rust or sand particles.

- (a) Source. The Contractor shall submit for approval the name of the quarry that is the proposed source of the granite for curb materials. 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. Samples of curbing shall be submitted for approval only when requested by the Engineer.
- (b) Finish and Surface Dimensions. The individual curb stones shall be of the dimensions shown on the Plans and shall be of uniform thickness on any one structure or in any continuous run. The individual curb stones shall be furnished in random lengths between 1 and 3 m (3 and 10 feet).

The top surface of the curb stones shall be sawed to an approximately true plane and shall have no projection or depression greater than 3 mm (1/8 inch). The bottom of the curb stones shall be parallel to the top and sawed or dressed to lay with not more than a 25 mm (1 inch) joint at the face for the full length of the stone. The remainder of the bottoms may break back not over 25 mm (1 inch).

The top front arris line shall be rounded as shown on the Plans. The exposed arris lines shall be pitched straight and true, with no variations from a straight line greater than 3 mm (1/8 inch).

The front face shall be battered as shown on the Plans and shall be smooth quarry split or sawed for the full depth. Drill holes in the front face shall not be permitted. The front face shall have no projections or depressions greater than 13 mm (1/2 inch), measured from the plane of the face through the top arris line for the full depth of the stone.

The back surface of the curb stones shall have no projections or depressions greater than 25 mm (1 inch), measured from the plane of the face through the top arris line for the full depth of the stone.

The ends of all curb stones shall be square with the planes of the top and front face, and so finished that when the stones are placed end to end as closely as possible, no space more than 10 mm (3/8 inch) shall show in the joint for the full width of the top and full depth of the front face. The remainder of the ends may

break back a maximum of 50 mm (2 inches) from the plane of the joint. Where shown on the Plans or where the curb butts metal expansion joints, the ends shall be sawed to an approximately true plane.

Curb stones to be set on a radius of 50 m (160 feet) or less shall be cut to the curve required, and their ends shall be cut on radial lines.

729.03 GRANITE SLOPE EDGING. Granite slope edging shall consist of hard, durable, quarried granite. It shall be gray in color, free from seams, cracks, or other structural defects, and shall be of smooth splitting character. The edging may contain natural color variations that are characteristic of the granite source.

- (a) **Source.** The Contractor shall submit for approval the name of the quarry that is the proposed source of the granite for edging materials. 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. Samples of edging shall be submitted for approval only when requested by the Engineer.
- (b) **Finish and Surface Dimensions.** The individual edging stones shall be of the dimensions shown on the Plans and shall be of uniform thickness in any continuous run. The individual edging stones shall be furnished in minimum lengths of 600 mm (2 feet).

The tops and bottoms shall be not under the square more than 100 mm (4 inches), or over the square at the back more than 25 mm (1 inch), when so tested.

The exposed face shall be smooth quarry split or sawed. Drill holes will be permitted on the exposed face, but only along the bottom edge and then to extend upward from the edge not over 75 mm (3 inches). The exposed face shall have no projections or depressions greater than 25 mm (1 inch), measured from a 600 mm (24 inch) long straightedge placed as closely as possible on any part of the face.

The ends of all edging stones shall be square with the plane of the exposed face and so finished that when the stones are placed end to end as closely as possible, no space more than 25 mm (1 inch) shall show in the joint for the full depth of the face. The

arris lines at the ends shall be pitched with no variation from the plane of the face more than 5 mm (1/4 inch).

729.04 PRECAST REINFORCED CONCRETE CURB. Precast reinforced concrete curb shall be solid, precast, reinforced units of uniform quality and appearance. All curb shall be cast in steel or concrete forms which will produce a satisfactory surface requiring no further finishing, rubbing, or patching after the forms are removed, except for the removal of flash or excess material along the edges.

The precast curb shall conform to the following requirements:

- (a) **Dimensions.** The individual precast curb units shall be of the dimensions shown on the Plans and shall be cast in lengths of not less than 1 m (3 feet) or greater than 3 m (10 feet). Random lengths of curb of not less than 1 m (3 feet) in length may be obtained by sawing regular precast curb, if the Engineer determines it is necessary to meet field conditions. All curbs to be set on a radius of 50 m (160 feet) or less shall be precast to fit the curve as required.
- (b) **Marking.** Each pour shall be identified with a registration number cast in the curb showing the name or trademark of the manufacturer and the manufacturer's date of manufacture by a six digit number indicating in order the year, month, and day of month. A pour shall be considered as one day's production.
- (c) **Materials.** The concrete shall conform to the requirements of Section 540, and when sampled and tested in accordance with AASHTO T 22, shall have a minimum compressive strength of 35 MPa (5000 psi). The manufacturer shall obtain a minimum of one core per pour for testing purposes. The core specimens shall be taken horizontally below the exposed face. The core holes shall be backfilled with Type I mortar conforming to the requirements of Subsection 707.01. Bar reinforcement shall conform to the requirements of Subsection 713.01.
- (d) **Curing.** The precast curb units shall be subjected to any one of the methods of curing prescribed in AASHTO M 199M/M 199, for a sufficient length of time so that the concrete will develop the specified compressive strength at 28 days or less. Liquid membrane-forming compounds will not be allowed.
- (e) **Certification.** A Type D Certification shall be furnished in accordance with Subsection 700.02.

729.05 BITUMINOUS CONCRETE CURB. Bituminous concrete curb shall consist of blended aggregate, polyester fibers, performance-graded asphalt binder, and mineral filler if required, combined in such proportions that the resulting mixture conforms to the requirements of Subsection 406.03(a), Type IV except that the percent of performance-graded asphalt binder shall be between 7.0 and 9.0 percent.

- (a) Aggregate. The aggregate shall conform to the requirements of Subsection 704.10.
- (b) Performance-Graded Asphalt Binder. The grade of performance-graded asphalt binder shall be as directed by the Engineer and shall conform to the requirements of Section 702.
- (c) Polyester Fibers. The type of fiber used shall be approved by the Materials and Research Section. The fiber shall be uniformly incorporated into the dry mix. The fiber percent used shall be 0.25 percent per ton of mix. Dry mix times shall be increased to the satisfaction of the Engineer.

729.06 TREATED TIMBER CURB. Treated timber curb and stakes shall be either seasoned Red (Norway) Pine, Eastern (Northern) White Pine, or Southern Pine, straight, sound, and cut from live timber. Material shall be fabricated prior to treatment in conformance with the dimensions and details shown on the Plans. The sides of the planks may be either surfaced or rough-sawn. Treatment shall be performed, inspected, tested, and reported in accordance with the requirements of Subsection 728.01(a).

- (a) Miscellaneous Hardware. All spikes, U-bolts, nuts, and washers shall conform to the dimensions shown on the Plans. They shall be of low to medium carbon steel, either galvanized or corrosion resistance treated, and shall be of good commercial quality.
- (b) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

SECTION 730 – PILING

730.01 STEEL PILING. Steel piling shall be rolled steel sections of the mass (weight) and shape shown on the Plans. Piles, splice plates, and point reinforcement shall be new material conforming to the requirements of ASTM A572/A572M, Grade 345 (Grade 50). When cast steel shoes are used, they shall conform to the requirements of AASHTO M 103M/M 103, Grade 485-275 (Grade 70-40) or ASTM A 148/A 148M, Grade 550-275 (Grade 80-40).

Certification. A Type C Certification shall be furnished in accordance with Subsection 700.02.

730.02 STEEL SHEET PILING. Steel sheet piling shall be rolled steel sections of the type, shape, and mass (weight) shown on the Plans and shall be capable of being interlocked so that a continuous wall is formed when individual pieces are driven side by side. Permanent steel sheet piling shall be new material conforming to the requirements of AASHTO M 202M/M 202. Reconditioned steel sheet piling may be used if authorized by written order by the Engineer.

Certification. Permanent steel sheet piling furnished under this Subsection shall be covered by a Type C Certification in accordance with Subsection 700.02.

SECTION 731 - BEARING PADS FOR STRUCTURES

731.01 PREFORMED FABRIC BEARING PADS. Preformed fabric bearing pads shall be manufactured from all new materials comprised of multiple layers of prestressed duck impregnated and bound with high quality oil resistant rubber vulcanized and cured under pressure to form a resilient pad of uniform thickness. The duck material shall have a mass (weight) of at least 270 g/m² (8 ounces per square yard) with a filling of 50 ± 1 warp threads per 25 mm (1 inch) and a filling of 40 ± 2 woof threads per 25 mm (1 inch). The finished product shall have 64 plies per 25 mm (1 inch) of thickness and withstand a compressive load perpendicular to the plane of the laminations of 69 MPa (10,000 pounds per square inch). Load deflection shall not exceed 10 percent at 6.9 MPa (1000 pounds per square inch) and the material shall perform effectively from -54 to 93 °C (-65 to 200 °F). The test sample for measuring load deflection shall be 50 by 50 mm (2 × 2 inches).

Bearing pads over 13 mm (1/2 inch) in thickness may be manufactured by laminating vulcanized sheets together to obtain the designed pad thickness. The number of laminated joints shall not be greater than:

Bearing Pad Thickness		Number of Laminated Joints Permitted
Millimeters	Inches	
13 to 25	1/2 to 1	1
29 to 38	1 1/8 to 1 1/2	2
41 to 50	1 5/8 to 2	3
Over 50	Over 2	4

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

731.02 THIS SUBSECTION RESERVED.

731.03 ELASTOMERIC MATERIAL. Elastomeric material shall conform to the specifications contained in the latest edition of the AASHTO *Standard Specifications for Highway Bridges* and the AASHTO *LRFD Bridge Design Specifications*. Unless otherwise shown on the Plans or specified in the Contract, the elastomeric compound shall be neoprene conforming to AASHTO *Standard Specifications for Highway Bridges* (Division II) Table 18.4.5.1-1A with a Shore A Durometer hardness of 50 ±5 and AASHTO *LRFD Bridge Design Specifications* Subsection 14.7.4.2.

Plain and laminated elastomeric bridge bearings shall conform to the requirements of AASHTO M 251, except that the acceptance sampling and testing requirements of Parts 8 and 9 are waived.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

731.04 TFE MATERIAL. Tetrafluoroethylene (TFE) material incorporated in bearing devices shall be all new material consisting of 800 µm (1/32 inch) minimum thickness unfilled resin sheets conforming to the requirements of Division I, Section 15 and Division II, Section 18.8 of the AASHTO *Standard Specifications for Highway Bridges*.

TFE material used on guide bars or similar applications where it is required to sustain horizontal loading shall be glass fiber or carbon filled.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

731.05 STAINLESS STEEL. Stainless steel used as a mating surface with TFE and incorporated in bearing devices shall conform to the requirements of ASTM A 240/A 240M, Type 304.

The surface finish on the contact (sliding) face of the stainless steel shall have a mirror finish of less than 0.25 μm (10 micro inches) rms (Root Mean Square).

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

731.06 SOCKET-HEAD CAP SCREWS. Socket-head cap screws shall conform to the requirements of ASTM A 574M, with M profile thread series per ANSI B18.3.1M (ASTM A 574, with a Unified Coarse Thread series per ANSI B1.1).

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

731.07 BRASS RINGS. Brass bar material shall conform to ASTM B 19, Standard Temper H92 or ASTM B 36/B 36M, Copper Alloy UNS No. C26000, Standard Temper H02.

Brass rod material shall conform to ASTM B 16M (ASTM B16), Standard Temper H02.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

SECTION 732 - RAILING MATERIALS

732.01 METAL HAND RAILING. Material for metal hand railing and sleeves shall conform to ASTM A 53/A 53M.

732.02 ALUMINUM BRIDGE RAILING.

- (a) Aluminum Alloy. Aluminum alloy for aluminum bridge railing shall conform to the requirements of Subsection 715.04.
- (b) Stainless Steel Bolts, Nuts, Washers, and Set Screws. Bolts and washers for post, rail, and offset block connections shall conform to the requirements of ASTM F 738M, Property Class A1-50, Condition AF, Alloy 304 (ASTM A 593, Alloy Group 1, Condition AF, Alloy 304).

Nuts shall conform to the requirements of ASTM F 836M, Property Class A1-50, Condition AF, Alloy 304 (ASTM F 594, Alloy Group 1, Condition AF, Alloy 304).

Stainless steel set screws for use in aluminum bridge railing connections shall conform to the requirements of ASTM F 880M, Property Class A1-70, Condition CW, Alloy 304 (ASTM F 880, Alloy Group 1, Condition CW, Alloy 304).

Stainless steel anchor bolts and washers shall conform to the requirements of ASTM F 738M, Property Class A1-70, Condition CW, Alloy 304 (ASTM A 593, Alloy Group 1, Condition CW, Alloy 304). Heavy hex stainless steel nuts for stainless steel anchor bolts shall conform to the requirements of ASTM F 836M, Property Class A1-70, Condition CW, Alloy 304 (ASTM A 594, Alloy Group 1, Condition CW, Alloy 304).

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02 for any and all stainless steel bolts, nuts, washers, and set screws.

- (c) Structural Carbon Steel. Structural carbon steel for anchor channel bars, approach railing posts, offset brackets, and anchor bolt sleeve bases shall conform to the requirements of AASHTO M 270M/M 270, Grade 250 (Grade 36) or ASTM A 36/A 36M.
- (d) Steel Pipe. Steel pipe for anchor bolt sleeves shall conform to the requirements of Subsection 740.05.
- (e) Anchor Bolts, Nuts, and Washers. Anchor bolts, nuts, and washers shall conform to the requirements of Subsection 714.07.
- (f) Fabric Pads. Fabric pads for aluminum posts shall conform to the requirements of Subsection 731.01 or 731.02.
- (g) Aluminum Impregnated Caulking Compound. Aluminum impregnated caulking compound shall conform to the requirements of Subsection 707.13.

732.03 GALVANIZED BOX BEAM BRIDGE RAILING.

(a) Structural Steel Tubing. Tubing for posts and rails shall conform to ASTM A 500, Grade B, except as modified below:

(1) General Requirements for Rail and Post Sections.

- a. The manufacturer shall test both welded and formed tubular material for the physical properties specified. Results of all tests shall be submitted with material certifications.
- b. Longitudinal welds may be made by the resistance, gas shielded arc, submerged arc, or plasma arc process. Welds shall be sound, free from defects, and have no repairs. Transverse mill welds will not be permitted.
- c. Longitudinally welded tubing shall have a tensile strength of 400 MPa (58,000 psi) when tested in accordance with AASHTO T 68M (AASHTO T 68).
- d. Fabrication welding shall comply with the requirements of Subsection 506.10.
- e. A traceable identification number shall be placed on each piece of material in a form that can be read after the galvanizing process.

(2) Post Sections.

- a. Post and baseplate material (ASTM A 500, AASHTO M 270M/M 270, Grade 250 (Grade 36) , ASTM A 36/A 36M, ASTM A 588/A 588M, or other material as specified) shall be tested for impact properties in accordance with the requirements for Charpy Impact Testing in ASTM A 370, using a Type A specimen. Tubular posts that are fine grained fully aluminum-killed ASTM A 500 material with a minimum aluminum content of 0.025 percent by heat analysis will not require testing for impact properties.

- b. Sampling procedure shall be in accordance with AASHTO T 243M/T 243 using frequency “H” testing.
- c. Full size [10 by 10 mm (3/8 × 3/8 inch)] specimens shall be used whenever thickness permits. Subsize specimens may be used when material thickness is less than 10 mm (3/8 inch).
- d. To qualify, the average energy absorbed by a full size specimen shall be not less than 33.9 J at 5 °C (25 pounds-force foot at 40 °F). The average energy absorbed by a subsize specimen shall be prorated for the actual thickness of the specimen.

(3) Rail Sections.

- a. Material shall be tested in accordance with ASTM E 436. Test samples shall be galvanized in accordance with AASHTO M 111M/M 111 prior to testing.
- b. Sampling procedure shall be in accordance with AASHTO T 243M/T 243 with one test (a set of three specimens) for each heat.
- c. Tests shall be conducted at -18 °C (0 °F), without removing the galvanizing.
- d. Specimens shall be 50 by 230 mm (2 × 9 inches) supported at a span of 180 mm (7 inches).
- e. The percent shear area shall be determined from testing nine specimens, three from each of three sides not containing a weld.
- f. The final percent shear area shall be an average of the two sides having the highest average shear.
- g. The minimum average shear area shall be 50 percent.

- h. If any ASTM E 436 test averages between 30 and 50 percent shear, the manufacturer will be permitted to retest the heat. For each original heat test, three sets of nine specimens shall be retested. For the heat to be accepted, each set must show a minimum average shear of 50 percent for the two best sides.
- (4) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.
- (b) Structural Carbon Steel. Structural carbon steel for plates and angles shall conform to the requirements of AASHTO M 270M/M 270, Grade 250 (Grade 36) or ASTM A 36/A 36M.
- (c) Bolts, Nuts, and Washers. Bolts, nuts, and washers for railing and rail to post connections shall conform to the requirements of Subsection 714.04.
- (d) Anchor Bolts, Nuts, and Washers. Anchor bolts, nuts, and washers shall conform to the requirements of Subsection 714.07.

732.04 STEEL BEAM BRIDGE RAILING.

- (a) Beam Guardrail. Beam guardrail for bridge railing shall conform to the requirements of Subsection 728.02. The beam rail shall be Class B.
- (b) Steel Posts and Components. Posts, baseplates, offset blocks, brackets, washers, and other steel components shall be structural carbon steel conforming to the requirements of AASHTO M 270M/M 270, Grade 345W (Grade 50W); ASTM A 588/A 588M; ASTM A 572/A 572M, Grade 345 (Grade 50); or AASHTO M 270M/M 270, Grade 345 (Grade 50).
- (c) Steel Pipe. Steel pipe for anchor bolt sleeves shall conform to the requirements of Subsection 740.05.
- (d) Anchor Bolts, Nuts, and Washers. Anchor bolts, nuts, and washers shall conform to the requirements of Subsection 714.07.
- (e) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02 for the materials supplied under part (b) above.

SECTION 735 - INSULATING MATERIALS

735.01 POLYSTYRENE INSULATION BOARD. Polystyrene insulation board shall conform to the requirements of AASHTO M 230. It shall be formed by the expansion of polystyrene base resin in an extrusion process and shall be homogeneous and unicellular. It shall be furnished in nominal 600 by 2400 mm (2 × 8 foot) boards and shall be of the thickness shown on the Plans.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

735.02 BLANKET INSULATION MATERIAL. Blanket insulation material shall consist of mats of fiberglass, rock wool, balsam wool, or other approved insulating materials completely enclosed on all sides within weatherproof facings of reinforced, coated, kraft paper or polyethylene sheeting.

The thermal conductivity of the blanket insulation material shall not exceed 0.039 W/[m•°C] (0.27 BTU inch per hour square foot degree Fahrenheit) at a mean temperature of 24 °C (75 °F).

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

SECTION 740 - WATER LINES AND APPURTENANCES

740.01 PLASTIC PIPE, FLEXIBLE. Flexible plastic pipe shall be polyethylene plastic pipe suitable for the transportation of potable water and shall conform to the requirements of AWWA C 901. The material grade selected shall be capable of withstanding a minimum sustained water pressure of 1.1 MPa at 23 °C (160 psi at 73 °F). The pipe shall be inside diameter controlled. Fittings may be either nylon, copper, or bronze. Clamps shall be stainless steel.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.02 PLASTIC PIPE, RIGID (PVC). Rigid PVC plastic pipe shall be suitable for the transportation of potable water and shall conform to the requirements of ANSI/AWWA C 900. The material grade selected shall be capable of withstanding a minimum sustained water pressure of 1.1 MPa at 23 °C (160 psi at 73 °F). Fittings shall be PVC plastic conforming to ANSI/AWWA C 110/A 21.10.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.03 THIS SUBSECTION RESERVED

740.04 COPPER TUBE, SEAMLESS. Seamless copper water tube shall conform to ASTM B 88M (ASTM B 88), Type K.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.05 STEEL PIPE, GALVANIZED. Galvanized steel pipe shall be suitable for the transportation of potable water and shall be the standard weight class conforming to ASTM A 53/A 53M.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.06 PLASTIC TUBING, FLEXIBLE. Tubing shall be a flexible transparent PVC material meeting the following requirements:

Property	Test Method	Requirement
Inside Diameter	---	13 mm (1/2 inch)
Wall Thickness	---	4 mm (5/32 inch)
Color	---	clear
Durometer Hardness (Shore A)	ASTM D 2240	55 to 65
Tensile Strength	ASTM D 638	11 to 14.5 MPa (1600 to 2100 psi)
Ultimate Elongation	ASTM D 638	450%

The material shall have an operating temperature range between -43 and 65 °C (-45 and 150 °F).

Shop or field splices of tubing will not be permitted when installation lengths are less than 150 m (500 feet). When installation lengths in excess of 150 m (500 feet) are required, one field splice per each 150 m (500 feet) length, or fraction thereof, will be allowed. Splices shall be made with 13 mm (1/2 inch) inside diameter by 75 mm (3 inch) long nipple inserts. Inserts may be stainless steel or copper tubing with a minimum wall thickness of 1.25 mm (0.049 inch). Inserts shall be centered on the splice and fastened each side with stainless steel clamps.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.07 DUCTILE IRON PIPE, CEMENT LINED. Ductile iron pipe shall be cement lined and centrifugally cast in metal or sand-lined molds. It shall conform to the requirements of ANSI/AWWA C 151/A 21.51. The class of pipe shall be as specified in the Contract.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.08 PIPE INSULATION. Thermal insulation for pipes shall be preformed to fit standard pipe sizes and may be supplied as either hollow cylindrical shapes (split in half lengthwise) or as curved segments. Insulation shall include all accessories complete with proper jackets or facings as required by the conditions. Multilayer insulation is acceptable provided the inside and outside diameters of each layer will ensure proper nesting.

The thermal conductivity of the insulation material shall not exceed 0.039 W/[m•°C] (0.27 BTU inch per hour square foot degree Fahrenheit) at a mean temperature of 24 °C (75 °F).

The thickness and jackets shall be as specified in the Contract.

Pipe insulation used as bond breakers for structures shall conform to the requirements of ASTM C 534.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

740.09 EXTENSION SERVICE BOX, CAST IRON. Cast iron extension service boxes shall conform to the dimensions specified in the Contract and shall be a standard commercial type. A suitable key or rod shall be furnished for removing the cover and operating the curb stop.

The type and details of extension service boxes shall be approved by the Engineer prior to purchase.

740.10 CURB STOP, BRASS. Brass curb stops shall be compatible with the pipe being used and be a standard commercial type.

The type and details of curb stops shall be approved by the Engineer prior to purchase.

740.11 GATE VALVES. Gate valves shall conform to the details specified in the Contract.

The type and details of gate valves shall be approved by the Engineer prior to purchase.

740.12 TAPPING SLEEVE. Tapping sleeves shall be compatible with the pipe being used and be a standard commercial type.

The type and details of tapping sleeves shall be approved by the Engineer prior to purchase.

740.13 HYDRANT. Hydrants shall conform to the details specified in the Contract.

The type and details of hydrants shall be approved by the Engineer prior to purchase.

740.14 CORPORATION STOPS. Corporation stops shall be a standard commercial type compatible with the water main and the service line pipes being used.

When used with seamless copper water tube service lines, the outlet shall have a copper compression joint with iron pipe threads under the tube nuts.

The type and details of corporation stops shall be approved by the Engineer after consultation with the utility owner before any purchase is made by the Contractor.

SECTION 741 - WELLS AND PUMPS

741.01 WELL CASING. Well casing shall conform to the requirements of ASTM A 53/A 53M.

Certification. A Type A Certification will be furnished in accordance with Subsection 700.02.

741.02 WATER PUMPS. Water pumps (jet, submersible, or shallow well) shall be of a standard commercial quality. The capacity of the pump shall be such that it will be capable of discharging water at the rate and pressure for the pumping depth specified for the installation.

The motor voltage of the pump shall be compatible with the voltage available at the electrical source.

The Contractor shall submit for approval to the Engineer five days before placing any purchase orders the name of the manufacturer, the specifications for the pump, accessories, and electrical equipment that is proposed to be furnished. .

741.03 WATER STORAGE TANKS. Water storage tanks shall be of steel (galvanized, vinyl or epoxy coated, and lined) or of molded fiber glass and shall be of a standard commercial quality. The tanks shall be capable of withstanding 1.1 MPa (160 psi) test pressure.

The Contractor shall submit for approval to the Engineer five days before placing any purchase orders the name of the manufacturer and the specifications for the water storage tank that is proposed to be furnished.

741.04 PRECAST REINFORCED CONCRETE WELL RINGS AND COVERS. Precast reinforced concrete well rings and covers shall conform to the requirements of Subsection 710.01, Class III pipe, with the following notes or exceptions:

Only one line of circumferential reinforcement will be required with an area of not less than $380 \text{ mm}^2/\text{m}$ ($0.18 \text{ in}^2/\text{ft}$) of wall.

Concrete covers shall be reinforced with one line of fabric reinforcement with an area of not less than $2800 \text{ mm}^2/\text{m}^2$ ($0.40 \text{ in}^2/\text{ft}^2$) of cross-sectional area. They shall have hand holes on both sides.

SECTION 742 - DISINFECTANTS

742.01 CHLORINE SOLUTION. Chlorine solution used for disinfecting springs, wells, and other water systems shall consist of a solution of water and liquid chlorine, sodium hypochlorite, calcium hypochlorite, or chloride of lime.

Liquid forms of chlorine or sodium hypochlorite and powder forms of calcium hypochlorite or chloride of lime shall be used according to the instructions supplied by the manufacturer and as recommended by the Vermont Department of Health.

If sodium hypochlorite is already in solution as a laundry bleach containing 5.25 percent sodium hypochlorite, it shall be used at the rate of one part per 12,000 parts of water to be disinfected. The dosage should be sufficient to produce a chlorine taste in the water.

742.02 SPACE DEODORIZER. Space deodorizer shall consist of a commercial liquid concentrate that, when applied at the dilution ratio recommended by the manufacturer, will suppress the obnoxious odors produced by the material to which it is applied. The deodorizer shall be nontoxic and nonirritating. It shall be approved by the Engineer before use.

Upon request, the Agency's Materials and Research Section will furnish a list of products that are considered satisfactory.

SECTION 745 - WATER

745.01 WATER. All water used shall be clear and free of harmful amounts of oil, salt, acids, alkalies, sugar, organic matter, or other substances injurious to the finished product, plant life, or the establishment of vegetation.

Where the source of water is relatively shallow, the intake shall be maintained at such a depth and so enclosed as to exclude silt, mud, grass, and other foreign materials.

No formal tests of water will be made unless the Engineer questions the quality of the water. Water known to be of potable quality may be used without tests.

If the quality of the mixing water for concrete or mortar is questioned, comparative tests will be made with distilled water. Any indication of unsoundness, a marked change in time of setting, or reduction of more than 10 percent in mortar cube compressive strength shall be sufficient cause for rejection of the water under test.

SECTION 746 - CALCIUM CHLORIDE

746.01 CALCIUM CHLORIDE. Calcium chloride shall conform to the requirements of AASHTO M 144. Either regular flake calcium chloride, Type S Grade 1, or concentrated flake, pellet, or other granular calcium chloride, Type S Grade 3, may be used.

SECTION 747 - SODIUM CHLORIDE

747.01 SODIUM CHLORIDE. Sodium chloride shall conform to the requirements of AASHTO M 143. Unless otherwise specified, Type I, Grade 1 shall be used.

- (a) Moisture Content. Moisture content shall not exceed 1 percent at the point of delivery.
- (b) Anti-Caking Agent. In order to retard caking while in storage, all bulk salt shall be uniformly treated with an approved anti-cake conditioner prior to delivery. The residual amount of anti-cake conditioner should not be less than 50 parts per million. The supplier shall notify the Agency's Materials and Research Section as to the anti-cake agent used and shall furnish the laboratory method for determining the presence of the anti-cake agent.

SECTION 750 - TRAFFIC SIGNS750.01 SIGN POSTS.

- (a) Steel Posts and Anchors. Steel posts and anchors shall conform to the following requirements:
 - (1) Structural steel tubing shall conform to Subsection 714.11. Steel posts consisting of standard rolled steel structural shapes shall conform to the requirements of AASHTO M 270M/M 270, Grade 250 (Grade 36). After fabrication, these posts shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111.
 - (2) Steel posts consisting of flanged channels shall conform to the mechanical requirements of ASTM A 499, Grade 60 and the chemical requirements of the 42.2 to 56.6 kg/m (85 to 114 lbs/yard) rail class in ASTM A 1. They shall conform to the details indicated on the plans as to size, shape, weight, hole punching, hole drilling, and other details. After fabrication, these posts shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111.
 - (3) Steel posts and anchors consisting of welded mechanical square tubes formed from hot rolled carbon steel sheet shall conform to the mechanical and

chemical requirements of ASTM A 1011/A 1011M, Grade 380 (Grade 55) or Grade 245 (Grade 40). They shall conform to the details indicated on the Plans as to size, shape, weight, hole punching, hole drilling, strength, and other details. The posts shall be fabricated in accordance with ASTM A 787, Type 2, and shall be galvanized with a G140 coating in accordance with ASTM A 653/A 653M. Alternatively, the posts shall be fabricated in accordance with ASTM A 787, Type 3, and shall be galvanized in accordance with AASHTO M 111M/M 111.

- (b) Aluminum Posts. Aluminum posts shall conform to the requirements of ASTM B 308/B 308M, Alloy 6061-T6 for structural shapes, rolled or extruded, and ASTM B 221M (ASTM B 211) extruded tubes. They shall conform to the details shown on the Plans as to size, shape, and mass (weight), and they shall be punched or drilled as shown on the Plans.
- (c) Wood Posts. Wood posts shall be seasoned Oak, Cedar, Spruce, Western Fir, or other approved wood, straight, sound, and cut from live timber. The posts shall conform to the dimensions shown on the Plans. They shall be shaved to an even surface and shall be free from bark or skin.

All wood posts shall be preservative treated over their full length as specified in Subsection 726.01. All cut ends or notches shall be field treated with copper naphthenate solution. Depending on size and location, wood posts may have to be drilled as shown on the Plans
- (d) Sleeves. Sleeves for sign posts consisting of structural tubing shall conform to the requirements of ASTM A 501. They shall conform to the details shown on the Plans as to size, shape, and mass (weight), and they shall be punched or drilled as shown on the Plans. After fabrication, all steel sleeves shall be galvanized in accordance with AASHTO M 111M/M 111.
- (e) Certification. A Type D Certification shall be furnished for steel posts and sleeves in accordance with Subsection 700.02. A Type A Certification shall be furnished for all other material.

750.02 EXTRUDED ALUMINUM PANELS. Extruded aluminum panels shall conform to the requirements of ASTM B 221M (ASTM B 221). Alloy 6063-T6 shall be used when reflective sheeting is to be applied to the face of the sign.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.03 FLAT SHEET ALUMINUM. Flat sheet aluminum shall conform to the requirements of ASTM B 209M (ASTM B 209) for either Alloy 6061-T6 or Alloy 5052-H38.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.04 GALVANIZED FLAT SHEET STEEL. Galvanized flat sheet steel shall conform to the requirements of ASTM A 606. Structural steel shapes and welded sections shall conform to the requirements of ASTM A 242/A 242M. The steel shall be galvanized in accordance with AASHTO M 111M/M 111 (ASTM A 123/A 123 M). The galvanized steel shall be given a light and tight phosphate coating by continuous mill process having not less than 1.1 g/m^2 (100 milligrams per square foot) of surface area.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

750.05 FORMED GALVANIZED STEEL PANELS. Formed galvanized steel panels shall conform to the requirements of ASTM A 606 or ASTM A 607, Grade 310 or Grade 340. The panels shall be galvanized in accordance with AASHTO M 111M/M 111. The galvanized panels shall be given a light and tight phosphate coating by continuous mill process having not less than 1.1 g/m^2 (100 milligrams per square foot) of surface area.

Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

750.06 HIGH DENSITY OVERLAID PLYWOOD. High density overlaid plywood shall consist of Douglas Fir plywood, exterior type, grade B or better, with both surfaces overlaid with cellulose fiber sheets or sheet, in which not less than 40 percent by mass (weight) of the laminate shall be a thermosetting resin of the phenol or melamine type. The resin impregnated material shall have not less than 300 g/m^2 (60 pounds per 1000 square feet) of single face before pressing. All materials and construction shall conform to the requirements of Voluntary Product Standard PS-1 published by the National Institute of Standards and Technology. The color of the overlay may be either natural or black.

No press caul, lubricants, release agents, or other contaminants shall be introduced during manufacture or subsequent handling of the high density

overlaid plywood, either within or on the surface, which will affect adhesion or cause discoloration or other degradation of retroreflective sheeting or plastic lettering film.

(a) Quality Assurance. The suitability of the plywood for application of retroreflective sheeting shall be verified by laboratory test:

(1) Adhesion Test. Panels of the plywood, approximately 300 by 300 mm (1 × 1 foot) shall be cut from the plywood to be tested. The application surfaces of the panels shall be cleaned as specified in Subsection 675.05. An application of retroreflective sheeting or plastic lettering film shall be made to completely cover the properly prepared, dust-free plywood surface in accordance with the recommendations of the sheeting or film manufacturer. The panels shall be submitted to accelerated conditioning in an oven for one hour at 66 °C (150 °F). Following conditioning, the panels shall be allowed to cool to room temperature. The adhesive bond of the sheeting or plastic lettering film shall resist removal, other than in small pieces, at the point of spatula impact when struck evenly with short, sharp jabs by a test spatula.

(2) Plywood Contamination Test. Panels of the plywood to be tested shall be cut 75 mm (3 inches) long and 50 mm (2 inches) wide. The panels shall be wiped with a tack rag to remove any dust or loose particles. Retroreflective sheeting of the type or types to be used shall be applied to both faces of the test panels. Following conditioning for 24 hours at room temperature, approximately 24 °C (75 °F), the test panels shall be placed in a pressure vessel and held submerged in cold tap water. A vacuum of 610 mm (24 inches) of mercury shall be drawn and maintained for 45 minutes. This shall be followed immediately by the application of 275 to 350 kPa (40 to 50 pounds per square inch) of water pressure for 45 minutes. Proper test procedures are assured if the panel does not float after the above treatment. Test panels shall then be removed and each shall be placed in a glass container (400 mL beaker) filled with approximately 50 mL of water. The container shall be covered with a glass lid such as a petri dish and placed in an oven at 66 °C (150

°F) for 24 hours. The panel shall be removed and the sheeting surface wiped to remove any residue. Upon examination, any evidence of staining, discoloration, or other degradation of the applied sheeting shall constitute failure of the plywood. Some bubbling of the applied sheeting shall be permissible.

- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.07 ACRYLIC PLASTIC REFLECTORS. Acrylic plastic reflectors shall consist of methyl methacrylate plastic conforming to the requirements of Federal Specification LS-500 A, Type I, Class 3.

They shall consist of a clear and transparent acrylic plastic face, hereinafter referred to as the lens, and an opaque acrylic 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. The reflectors shall be colorless, yellow or amber, red, blue, or green as shown on the Plans, and the colors shall conform to the standards approved by FHWA.

The lens shall consist of a smooth front surface free from projections or indentations other than for identification, and a rear surface bearing a prismatic configuration such that it will effect total internal reflection of light without the aid of any plating or separate reflector.

- (a) Optical Performance Requirements. The specific brightness of each colorless reflector shall be equal to or exceed the minimum values of the following table. All measurements shall be made with the reflectors spinning.

TABLE 750.07A - OPTICAL PERFORMANCE
REQUIREMENTS FOR COLORLESS REFLECTORS

Observation Angle (degrees)	Entrance Angle (degrees)	Specific Brightness (cd/m ² /lux)	Specific Brightness (candlepower/square inch/footcandle)
0.10	0	2020	14.0
0.10	20	810	5.6
0.17	0	1440	10.0
0.17	20	580	4.0
0.33	0	1010	7.0
0.33	20	400	2.8

Failure to meet the specific brightness minimum shall constitute failure of the reflector being tested; failure of more than two reflectors out of 50 subjected to testing shall constitute failure of the lot.

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 candelas (candlepower) returned at the chosen observation angle by a reflector per each 60 mm² (1 square inch) of reflecting surface for each lux (footcandle) of illumination at the reflector.

For yellow or amber reflectors, the specific brightness minimum shall be 60 percent of the value shown for colorless; for either red, blue, or green reflectors, the specific brightness minimum shall be 25 percent of the value shown for colorless.

The brightness of the reflectors totally wet, as by rain, shall be not less than 90 percent of the values specified above.

The reflector to be tested shall be located at a distance of 30 m (100 feet) from a single uniformly bright light source having an effective diameter of 50 mm (2 inches); the light source shall be operated at approximately normal efficiency. The return light from the reflector shall be measured by means of a photoelectric

photometer having a minimum sensitivity of 1.08×10^8 lux/mm (1×10^7 footcandles per millimeter) scale division.

The photometer shall have a receiver aperture of 13 mm (1/2 inch) diameter, shielded to eliminate stray light. The distance from light source center to aperture center shall be 53 mm (2.1 inches) for a 0.10 degree observation angle, 89 mm (3.5 inches) for a 0.17 degree observation angle, and 175 mm (6.9 inches) for a 0.33 degree observation angle. During testing, the reflectors shall be spun so as to average orientation effect.

If a test distance other than 30 m (100 feet) is used, the source and aperture dimensions and the distance between source and aperture shall be modified in the same proportion as the test distance.

(b) Physical Test Requirements. The reflectors shall withstand the following physical tests:

(1) Seal Test. Fifty reflectors out of any one shipment shall be selected at random for the following test:

Fifty reflectors shall be submerged in a water bath at room temperature. The submerged samples shall be subjected to a vacuum of 127 mm (5 inch) gage for five minutes. The atmospheric pressure shall then be restored and the samples left submerged for five minutes, after which they shall be examined for water intake. Failure of more than 2 percent of the number tested shall be cause for rejection.

(2) Heat Resistant Test. Three reflectors out of any one shipment shall be selected at random for the following test:

Three reflectors shall be tested for four hours in a circulating air oven at 80 °C (175 °F). The test specimens shall be placed in a horizontal position on a grid or perforated shelf permitting free air circulation. At the conclusion of the test, the samples shall be removed from the oven and permitted to cool in air to room temperature. The samples after exposure to heat shall show no significant change in shape and general appearance when compared with unexposed control standards. No failures will be permitted.

- (3) Corrosion Test. Fifty reflectors out of any one shipment shall withstand the corrosion test without any observable effects when tested in accordance with ASTM B 117. The exposure period shall be 48 hours.
- (c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.08 RETROREFLECTIVE SHEETING. Retroreflective sheeting shall conform to the applicable requirements of AASHTO M 268, except as follows:

Silver is an acceptable designation for white.

- (a) Packaging Requirements. Retroreflective sheeting shall be furnished in both rolls and sheets. The packaging in which the sheeting is shipped shall protect the sheeting from damage and/or distortion in accordance with commercially acceptable standards and shall be suitable for storing the sheeting until it is used.

When retroreflective sheeting is furnished in continuous rolls, the material shall have a maximum of three splices in any 45 m (50 yards) of length. Splices shall be butted or overlapped and shall be suitable for continuous application.

When stored under normal conditions, the retroreflective sheeting shall be suitable for use for a period of at least one year after purchase.

- (b) Classification. Retroreflective sheeting (white or colored) shall meet the requirements of the appropriate AASHTO M 268 (ASTM D 4956) classifications below:
- (1) TYPE I. A medium intensity retroreflective sheeting often referred to as “engineering grade.”
- (2) TYPE II. A medium-high intensity retroreflective sheeting often referred to as “super engineering grade.” The product exceeds the minimum requirements for Type I, but does not meet all TYPE III requirements.
- (3) TYPE III. A high intensity retroreflective sheeting often referred to as “high intensity.”

- (4) TYPE IV. A high intensity retroreflective sheeting typically referred to as “micro prismatic retroreflective element material.”
 - (5) TYPE V. A super high intensity retroreflective sheeting.
 - (6) TYPE VI. An elastomeric high-intensity retroreflective sheeting without adhesive. This is a vinyl material commonly used for traffic cone collars, post bands, etc.
 - (7) TYPE VII. A super-high-intensity retroreflective sheeting having highest retroreflectivity characteristics at long and medium road distances. This sheeting is typically an unmetallized microprismatic retroreflective element material.
 - (8) TYPE VIII. A super-high-intensity retroreflective sheeting having highest retroreflectivity characteristics at long and medium road distances.
 - (9) TYPE IX. A very-high-intensity retroreflective sheeting having highest retroreflectivity characteristics at short road distances.
- (c) Retroreflective Requirements. Retroreflective sheeting shall meet or exceed the minimum brightness and color requirements of AASHTO M 268.
 - (d) Physical Requirements. Retroreflective sheeting shall meet the physical requirements of AASHTO M 268.
 - (e) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.09 DEMOUNTABLE CHARACTERS. Individual letters, digits, symbols, and borders as shown on the Plans for the text of the sign shall be shaped from 810 µm (0.032 inch) sheet aluminum conforming to the requirements of ASTM B 209M (ASTM B 209), Alloy 3003-H12. The design of the characters or sections listed above shall conform to standards approved by FHWA.

Flat characters shall be reflectorized with white Type III retroreflective sheeting conforming to the requirements of Subsection 750.08. All characters with stroke width 19 mm (3/4 inch) or less shall be supplied with sealed edges.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.10 PLASTIC LETTERING FILM. Plastic lettering film shall consist of a smooth, flexible, pigmented plastic sheeting with a precoated adhesive on one side for application by the heat vacuum method. The plastic film shall be readily cut with scissors, knife blade, or shears without cracking, crazing, checking, or flaking to form the letters, digits, symbols, and borders comprising the text of the various types of signs shown on the Plans. The cutout shapes shall be free from ragged edges, cracks, scales, and blisters. The color of the plastic film shall be as shown on the Plans for the text of each sign involved and shall conform to the standards approved by FHWA. The thickness of the plastic film with adhesive shall not be less than 66 μm (2.6 mils).

The precoated adhesive shall have a mass (weight) of not less than per 68 $\mu\text{g}/\text{mm}^2$ (1.05 grams per 24 square inches) and shall have a minimum thickness of 50 μm (2.0 mils) when dry. It shall form a durable bond to clean well painted surfaces, unpainted high density overlaid plywood, retroreflective sheeting (flat surface), or unpainted corrosion-proof metals such as galvanized, phosphate coated steel, or aluminum. The precoated adhesive, after 48 hours of aging at 24 °C (75 °F) from the time of application, shall be strong enough to resist peeling the plastic lettering film from the application surface, tough enough to resist scuffing and marring during normal handling, elastic enough at low temperatures to resist shocking off when struck at -7 °C (20 °F), moisture resistant enough to withstand eight hours of soaking in water at 24 °C (75 °F) without appreciable decrease in adhesion, and heat resistant enough to retain adhesion to the application surface after eight hours at 49 °C (120 °F). The precoated adhesive shall have no staining effect on the plastic lettering film and shall be mildew resistant.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.11 EXTRUDED ALUMINUM MOLDING. Extruded aluminum molding to be used with extruded aluminum panel signs shall conform to the requirements of ASTM B 221M (ASTM B 221), Alloy 6063-T6. Moldings shall be finished with baked-on enamel or sheeting of the color shown on the Plans for the background of the sign. The molding shall be extruded in the standard commercial form to fit the type of extruded aluminum panel used.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

750.12 ASSEMBLY HARDWARE. Unless otherwise shown on the Plans, the assembly hardware used to fasten and support traffic sign components shall conform to the designs and sizes used in standard commercial practices for the materials involved.

- (a) Bolts, Nuts, and Washers. Bolts and washers shall be stainless steel conforming to the requirements of ASTM F 738M, Property Class A1-70, Condition CW. The alloy shall have a nickel content between 8.0 percent and 10.5 percent.

Nuts shall be stainless steel conforming to the requirements of and its supplementary requirements for S5. The alloy shall be ASTM F 836M, Property Class A1-70, Condition CW, Alloy 304.

- (b) Rivets. Rivets shall be of aluminum conforming to the requirements of ASTM B 316/B 316M, Alloy 6053-T61.

- (c) Clips. Clips used to fasten extruded aluminum panels to the supporting posts shall be of aluminum conforming to the requirements of ASTM B 108, Alloy 356-T6.

Clips used to fasten formed galvanized steel panels to the supporting posts shall be of aluminum conforming to the requirements of ASTM B 221M (ASTM B 221), Alloy 6063-T6 or of steel conforming to the requirements of ASTM A 242/A 242M that, after fabrication, is galvanized in accordance with the requirements of AASHTO M 232M/M 232 (ASTM A 153/A 153M).

- (d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

SECTION 751 - DELINEATORS751.01 DELINEATOR POSTS.

- (a) Steel Posts. Steel posts consisting of flanged channels shall conform to the mechanical requirements of ASTM A 499, Grade 60. The chemical requirements shall conform to the 45 to 60 kg/m (91 to 120 pounds per yard) rail class in ASTM A 1. They shall conform to the details shown on the Plans. After fabrication, all steel posts shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111 (ASTM A 123/A 123M).
- (b) Flexible Posts. Flexible posts shall conform to the type or types shown on the Plans.
- (c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

751.02 ACRYLIC PLASTIC REFLECTORS. Acrylic plastic reflectors shall conform to the requirements of Subsection 750.07. They shall be mounted in an aluminum housing with a center hole having an aluminum grommet for mounting purposes and shall conform to the details shown on the Plans. The aluminum housing shall conform to the requirements of Subsection 751.04.

751.03 RETROREFLECTIVE SHEETING. Retroreflective sheeting shall conform to the requirements of Subsection 750.08.

751.04 BACK PLATES AND HOUSING. Back plates and housing used for the mounting of retroreflective material shall consist of aluminum conforming to the requirements of ASTM B 209M (ASTM B 209), Alloy 3003-H14. They shall conform to the details shown on the Plans and shall be given a corrosion resistant finish after fabrication in accordance with standard commercial processes. They shall not be painted.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

751.05 PLAQUES. Plaques used for the numbering of delineators between distance markers shall conform to the design shown in the Plans.

The substrate shall be 1.6 mm (0.063 inches) thick aluminum sheet conforming to the requirements of Subsection 750.03 and fabricated in accordance with the requirements of Subsection 675.04.

Retroreflective sheeting shall be Type III or Type IX conforming to the requirements of Subsection 750.08. The text shall be 50 mm (2 inches) Series D Numerals conforming to the Standard Alphabets for Highway Signs and shall be silk screened lettering or plastic lettering film.

Colors shall be white background with green text and shall conform to the Standard Color Tolerance Charts approved by FHWA.

Application of the retroreflective sheeting and text shall conform to the requirements of Subsection 675.09.

Transportation and handling of the plaques after fabrication shall conform to the requirements of Subsection 675.10.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

751.06 ASSEMBLY HARDWARE. Unless otherwise shown on the Plans, the assembly hardware used for connecting the components of the housing, if required, and for fastening reflectors and plaques to posts shall conform to the designs and sizes used in standard commercial practices for the materials involved.

- (a) Bolts and Nuts. Bolts and nuts shall consist of aluminum conforming to the requirements of ASTM B 211M (ASTM B 211), Alloy 2024-T4. Both bolts and nuts shall be given another coating at least 5 μm (0.2 mil) in thickness with dichromate or boiling water seal.
- (b) Washers. Washers shall consist of aluminum conforming to the requirements of ASTM B 209M (ASTM B 209), Alloy 2024-T4.
- (c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

751.07 POLYCARBONATE SUBSTRATE FOR GUARDRAIL DELINEATORS.

- (a) Polycarbonate substrate for guardrail delineators shall conform to the following physical properties when tested as designated:

		ASTM
Thickness, Minimum	2 mm (79 mils)	N/A
Tensile Strength at Break	65 MPa (9.43 ksi)	D 638M
Elongation at Break	110%	D 638M
Tensile Yield Strength	62 MPa (9.0 ksi)	D 638M
Compressive Strength (Rupture Yield)	86 MPa (12.47 ksi)	D 695M
Flexural Strength	93 MPa (13.49 ksi)	D 790M
Tensile Module	2390 MPa (346.6 ksi)	D 638M
Rockwell Hardness	M 70	D 785
Specific Gravity	1.2	D 792

- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

751.08 DETECTABLE WARNING SURFACE. Acceptable detectable warning surfaces shall be those detectable warning surface products included on the Approved Products List on file with the Agency's Materials and Research Section.

SECTION 752 - TRAFFIC CONTROL SIGNALS

752.01 PEDESTAL POSTS AND BASES. Steel posts shall utilize cast iron bases; aluminum posts shall utilize cast aluminum bases.

- (a) Pedestal Posts.
- (1) Steel Posts. Steel posts shall consist of 115 mm (4 1/2 inch) outside diameter galvanized steel pipe conforming to the dimensional requirements of ASTM A 501 or ASTM A 53/A 53M, Type S, Grade B standard weight. The post shall have no taper and shall be threaded at the lower end to fit the base.
 - (2) Aluminum Posts. Aluminum posts shall consist of 115 mm (4 1/2 inch) outside diameter aluminum structural pipe conforming to the requirements of ASTM B 429, Alloy 6063-T6. Tapered aluminum posts may be used

if approved by the Engineer. Posts that have no taper shall be threaded at the lower end to fit the base.

(b) Bases.

(1) Cast Iron Bases. Cast iron bases shall conform to the requirements of AASHTO M 105, Class 20 or higher. Galvanized cast iron bases shall conform to the requirements of ASTM A 126, Class A. Galvanizing shall be in accordance with AASHTO M 111M/M 111 (ASTM A 123/A 123M). Bases shall be galvanized by the same procedure used for steel posts and may be galvanized with the posts.

(2) Cast Aluminum Bases. Cast aluminum bases shall conform to the requirements of ASTM B 26/B 26M or ASTM B 108, Alloy SG70A-T6.

(c) Certification. A Type D Certification shall be furnished for steel posts in accordance with Subsection 700.02. A Type A Certification shall be furnished for all other materials.

752.02 STRAIN POLES.

(a) Wood Poles. Wood poles for span wire mounted signal heads shall be either Western Red Cedar or Southern Pine. The poles to be used shall be Class 3 and shall be a minimum of 11 m (35 feet) in length, unless otherwise specified. The material requirements for the poles shall be in accordance with ANSI. Specifications and dimensions for wood poles shall be as approved by the National Electrical Code.

(1) Quality. Outer bark shall be completely removed from all poles. No patch or inner bark more than 25 mm (1 inch) wide and 150 mm (6 inches) long shall be left on the pole surface between the top and 600 mm (24 inches) below the groundline.

All poles shall be neatly sawed at the top and at the butt along a plane which shall not be out of square with the axis of the pole by more than one unit per six units of diameter of the sawed surface. Beveling is permitted at the edge of the sawed butt surface not more than 8.33 percent of the butt diameter in width, or an equivalent area unsymmetrically located.

Completely overgrown knots, rising more than 25 mm (1 inch) above the pole surface, branch stubs, and partially overgrown knots shall be trimmed close. Completely overgrown knots less than 25 mm (1 inch) high need not be trimmed. Trimming may be done by a shaving machine or by hand.

- (2) Dimensions. The dimensions for the poles required shall be not more than 75 mm (3 inches) shorter or more than 150 mm (6 inches) longer than the nominal length. The lengths shall be measured between the extreme ends of the pole.

The minimum circumference at 2 m (6 feet) from the butt shall be 950 mm (36 inches) for Western Red Cedar and 860 mm (34 inches) for Southern Pine. The minimum circumference at the top of the pole shall be 580 mm (23 inches) for both Western Red Cedar and Southern Pine. The circumference at 2 m (6 feet) from the butt of the pole shall be not more than 180 mm (7 inches) larger than the specified minimum. The top circumference requirements shall remain 580 mm (23 inches) at a point corresponding to the minimum length permitted for the pole.

The true circumference class shall be determined as follows: Measure the circumference at 2 m (6 feet) from the butt. This dimension will determine the true class, provided its top (measured at the minimum length point) is large enough. Otherwise, the circumference at the top will determine the true class, provided the circumference at 2 m (6 feet) from the butt does not exceed the specified minimum by more than 180 mm (7 inches).

- (3) Preservative Treatment. All wood posts shall be treated over their full length in accordance with Subsection 726.01, using Type I, II, III, or IV preservatives.

- (b) Steel Poles and Baseplates. Steel poles shall consist of tapered tubular shafts or a series of two to three different diameter pipes welded together with baseplates. The pole shall be of such length that the clearance from the pavement to the bottom of the lowest hanging mounted signal head shall be 5.0 m (16.5 feet), when span wire sag is within the allowable range of 5 to 7

percent of the span. The shafts after fabrication shall have at least a minimum yield strength of 330 MPa (48 ksi). The metal thickness shall be not less than 6.4 mm (0.25 inch) for tapered poles and not less than 7.6 mm (0.30 inch) for the bottom section of multiple pipes. The steel poles shall withstand the stringing tension of the span wire with its signal load without exceeding a deflection of 150 mm (6 inches) and a bending stress limit of 66 percent of yield strength.

The tapered shafts shall be formed, welded, and longitudinally cold-rolled under sufficient pressure to flatten the weld and form a smooth tapered tube. A reinforced handhole at least 100 by 150 mm (4 × 6 inches), complete with cover, shall be provided in the pole approximately 450 mm (18 inches) above the base and located at 90 degrees to the span wire on the side away from approaching traffic. A lip shall be provided around the handhole opening to prevent the cover from tipping and falling inside the hole. Stainless steel machine screws shall be provided for attaching the handhole cover. A steel cap shall be provided for the top of each pole with provision for an overhead wire entrance when needed. Stainless steel machine screws shall be provided for securely fastening the cap to the top of the pole. A 50 mm (2 inch) blind half-coupling shall be welded through the side of the shaft 150 to 300 mm (6 to 12 inches) below the span wire attachment height. A grounding nut shall be located inside the shaft easily accessible from the handhole. Each steel strain pole and the neutral or common grounding electrode conductor shall be bonded to a soft drawn, bare, copper wire with a cross-sectional area of 13.30 mm² (No. 6 AWG). The No. 6 AWG soft drawn, bare, copper wire shall be connected to a grounding electrode(s) which will be driven at each strain pole or steel pole with mast arm(s) location.

The baseplate shall be of adequate shape and size to carry the full bending moment of the pole at its yield point. It shall consist of heat treated cast steel conforming to the requirements of ASTM A 27/A 27M or steel plate conforming to the requirements of ASTM A 36/A 36M. The baseplate shall be attached to the shaft by two continuous electric welds, one inside the base at the end of the shaft and the other on the outside at the top of the base. The design shall be such that the welded connection shall develop the full strength of the adjacent shaft section. A four anchor bolt pattern shall be used, unless otherwise shown on the Plans.

After fabrication, the shaft and baseplates shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111 (ASTM A 123/A 123M).

Pole diameter height, yield, strength, and wall thickness shall be stamped on a metal tag attached near the handhole. If stepped poles are used, the stamping shall indicate the equivalent tapered pole.

- (c) Certification. A Type D Certification shall be furnished for steel poles and baseplates in accordance with Subsection 700.02. A Type A Certification shall be furnished for wood poles.

752.03 TRAFFIC SIGNAL POLES WITH MAST ARMS OR BRACKET ARMS.

- (a) Steel Poles and Baseplates. Steel poles shall consist of tapered tubular shafts or multiple pipe poles with baseplates and shall conform to the requirements of Subsection 752.02(b), except the minimum wall thickness shall be not less than 4.55 mm (0.179 inch or 7 gage).
- (b) Cantilever Mast Arms. Material for the mast arms shall conform to the requirements of Subsection 752.02(b) fabricated either as a tapered tube or multi-diameter pipe with a minimum metal thickness of 4.55 mm (0.179 inch or 7 gage). Both types shall have a flange plate welded on the large end for attaching to the vertical pole. A removable cap shall be attached to the far end. Wire outlets with rubber grommets shall be provided for each indicated signal location.
- (c) Aluminum Poles, Bases, and Mast Arms. Aluminum poles with anchor bases and mast arms shall conform to the requirements of Subsection 753.01(b).
- (d) Luminaire Bracket Arms. Luminaire bracket arms shall be the same type of material as the upright support. Steel brackets shall conform to the requirements of Subsection 753.01(c)(4), and aluminum brackets shall conform to the requirements of Subsection 753.01(b)(4). The bracket arms shall be either truss or tapered tubes as shown on the Plans. The main member of a truss-type arm shall be an oval shaped tapered tube securely joined by means of vertical struts to its companion member.
- (e) Identification. Pole diameter, height, yield strength, and wall thickness shall be stamped on a metal tag attached near the

handhole. Cantilever arm dimensions, length, and diameter/wall thickness shall also be included on the tag. If stepped poles are used, the stamping shall also indicate the equivalent tapered pole/arm.

- (f) Certification. A Type D Certification shall be furnished for steel poles, baseplates, mast arms, and luminaire bracket arms in accordance with Subsection 700.02. A Type A Certification shall be furnished for aluminum poles, baseplates, mast arms, and luminaire bracket arms.

752.04 SPAN WIRE. Span wire shall consist of 10 mm (3/8 inch) diameter galvanized steel cable conforming to the requirements of ASTM A 475, Class A coating, seven wire strand, utilities grade. The signal cable shall be attached to the span wire with a stainless alloy 1.2 mm (18 gage) lashing (spinning) wire.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.05 TRAFFIC SIGNAL HEADS. Traffic signal heads shall be self-contained assemblies that are expandable and adjustable. The signal heads may contain one or more signal faces as shown on the Plans. All traffic signal lenses shall be 305 mm (12 inches) in diameter, unless otherwise shown on the Plans.

Each traffic signal face shall consist of a number of signal sections rigidly fastened together in such a manner as to be watertight and dust proof. It shall be possible to assemble one or more signal faces into a multidirectional traffic signal head.

The components of the signal head; consisting of housings, doors, visors, optical units (lenses, reflectors, lamp sockets, and lamps), wiring, trunnions and brackets; shall conform to the latest requirements of the ITE technical report "Adjustable Face Traffic Control Signal Head Standards." Standard 8000-hour traffic signal lamps shall be used, unless otherwise specified. The Contractor shall use 116 W lamps in 305 mm (12 inch) units, unless otherwise specified. Lamp socket lead wires shall be stranded. The Contractor shall use 135 W lamps with internal reflector and 1750 rated initial lumen output for those faces having arrow lenses.

The components of the signal head shall be rigidly constructed of a diecast aluminum alloy in accordance with ASTM B 85, Alloys S-12A, S-12B, SC-84A, SC-84B, or SG-100B or polycarbonate with a smooth outer surface and shall be capable of holding the optical units securely in place. The polycarbonate material shall be such that it will withstand 95 J

(70 pounds-force foot) of impact without fracture or permanent deformation.

- (a) Polycarbonate Signal Heads. When a polycarbonate signal head is utilized, it shall conform to the following requirements:
- (1) Housing. The housing of each section shall be a one piece polycarbonate resin material with front, sides, top, and bottom integrally molded. The housing shall be of substantial thickness and shall be ribbed so as to produce the strongest possible assembly consistent with low density. Two sets of internal bosses shall be provided in each section for mounting of terminal strip facilities. The terminal bosses shall have threaded inserts sonically welded into each boss.
 - (2) Housing Door. The housing door of each signal section shall be of the same material as the housing.
- (b) Aluminum or Polycarbonate Traffic Signals. For either aluminum or polycarbonate traffic signals, all requirements of the ITE technical report "Adjustable Face Traffic Control Signal Head Standards" shall be met as well as the following:
- (1) Optical System. The optical system shall consist of a polycarbonate lens (red, yellow, or green) with a nominal size of 203 or 305 mm (8 or 12 inches).

The lenses and optical system shall be capable of withstanding continuous illumination from a 150 W standard traffic signal lamp without distortion of the lenses. Lens design shall be such that it conforms to American Standards Association #D-10.1-1958UDC 656.057 optical specifications.
 - (2) Wiring. Terminal blocks shall be placed in the center of a three section signal, unless otherwise specified, and shall be a five-position, ten-terminal, barrier type strip with the following terminal designations clearly marked "R-A-G-RC-AC." Terminal blocks shall be secured on both ends.
 - (3) Visors. Each signal door shall be equipped with a tunnel or cutaway type polycarbonate resin visor duralocked at four points to the door. The type shall be as shown on the Plans.

- (4) Traffic Signal Backplates. All backplates shall be louvered and painted or colored flat black.
 - (5) Signal Color. Signal color shall be Federal Yellow body, unless otherwise shown on the Plans, with dull black door, visor, and back plate.
 - (6) Signal Dimmer. When 305 mm (12 inch) diameter signal faces are specified, an integral means shall be provided for gradually regulating the intensity for nighttime operation to approximately 75 percent of that required for daytime operation. This shall apply only to the yellow lens and only when in the flashing mode.
- (c) Programmable Traffic Signal Heads. Where applicable, all requirements of ITE technical report “Adjustable Face Traffic Control Signal Head Standards” shall be met as well as those of part (b) above and the following:
- When shown on the Plans, programmed visibility traffic signal heads shall be furnished. A signal head may consist of a standard signal head with an optically programmed adapter in place of the lens or may be a commercial assembly designed to provide for programmed visibility. In either case, visibility of the signal indication shall be limited by optical methods and not by hoods or louvers. A rigid mounting attachment or method shall be provided for masked signal assemblies containing programmed visibility signal heads. The visibility of the signal indication shall be adjustable within the signal head to fit the approach to be controlled. During daylight hours the signal indications shall be visible only in those areas designated. During dusk and darkness, a faint glow is permissible when the signal is viewed from outside the designated area. External illumination shall not cause a signal indication, and a signal indication in one signal head shall not cause an indication in another signal head.
- When unprogrammed, the indication of each signal head shall be visible from anywhere within 15 degrees of the optical axis.
- (d) LED Signals. LED signal units shall be either complete 300 or 200 mm (12 or 8 inch) polycarbonate or aluminum sections for new installation or retrofit module kits for existing signal sections, as shown on the Plans. Each unit shall be a self-contained, sealed, dust and watertight enclosure not requiring on-site assembly prior to installation. New LED signal units

shall conform to the Institute of Traffic Engineers Performance Specification: Vehicle Traffic Control Signal Heads – Light Emitting Diode (LED) Circular Signal Supplement (dated June 27, 2005)

The installation of a retrofit replacement LED signal module into an existing signal housing shall require only removing the existing lens and incandescent bulb, fitting the new unit securely in the housing and connecting the module to the existing electrical wiring or a terminal block by means of simple connectors.

The LED signal module shall have a prominent and permanent directional marking(s), such as an UP arrow, for correct indexing and orientation within the housing.

The manufacturer's name, trademark, serial number, and other necessary identification shall be permanently marked on the back of the module. A label shall also be placed on the module certifying compliance with this specification.

- (e) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.06 TRAFFIC SIGNAL CONTROLLERS.

- (a) General. In order to prevent the State from becoming a testing ground for newly developed traffic signal equipment, it is required that the manufacturer provide certification that the particular type/model of controller to be used shall have been in actual field operation at a minimum of five locations for no less than one year each prior to its introduction in Vermont. This requirement does not apply to minor software updates of an existing unit.

Each controller shall be designated to operate on 115 V AC, 60 Hz, single-phase, and shall be delivered completely wired and enclosed in a weatherproof housing. Controllers shall be of the same type and manufacture conforming to the standard used by the town, city, or village when extensions or improvements of existing traffic control facilities are contracted.

Prior to bench testing, the Contractor shall provide the proposed controller settings for approval. Each controller shall be bench-tested with a NEMA test board that simulates all possible sequencing of signal intervals, corresponding to those for which

the controller is to be used, for at least seven continuous calendar days prior to installation. The manufacturer or distributor shall have such bench testing performed by an independent testing company which shall certify that such test has been made and that the controller functions properly. Copies of all test results and descriptions of all changes and repairs shall be submitted with the certification. A copy of the controller settings used for the test shall be included in the bench test results. These settings shall be retained in the controller through shipment and installation. A representative of the manufacturer shall be on the project site for turn-on of the unit(s).

The controller shall be bench tested after it has been completely installed in its cabinet and all wiring internal to the cabinet has been completed. The bench test results shall include actual test results for all functions that the Plans require the controller to be able to perform. Failure to test any required function will result in rejection of the controller without exception. Rejected controllers will not be permitted to remain on the project, and rejected controllers shall not be reworked and subsequently reinstalled on the project. The controller shall not be shipped until the manufacturer has received full written approval of all the bench tests results from the Agency. Shipment of the controller prior to receipt of full written approval for all bench test results will result in the suspension of all payments for the traffic control signal items in the Contract until a fully approved controller is completely installed in place and functioning properly.

Traffic signal equipment design and performance shall meet or exceed all requirements of the latest NEMA standards for traffic control systems. Performance of the equipment shall be consistent with the MUTCD. The controller along with all auxiliary equipment shall be capable of producing the timing plan(s) and coordination shown on the Plans.

- (1) Controller/Auxiliary Equipment. All controllers shall be actuated menu driven, keyboard entry and solid state. They shall have a minimum of twelve phases with dual maximum capabilities, and an internal time-based coordinator capable of providing at least four cycle lengths with multiple programs per cycle. The communication modem shall be approved over the same temperature range as the controller, -34 to 74 °C (-30 to 165 °F). All controllers at isolated intersections

shall have all necessary hardware/software for the connection of two-way telephone communications. For coordinated systems with hardwire and/or telemetry interconnect, communications capability is required only at the master cabinet. The controllers shall be programmed so as to automatically adjust for daylight savings time changes (April: first Sunday; October: last Sunday).

Each installation shall include the following:

- a. Twelve-channel conflict monitor or sixteen channel malfunction management unit (MMU) with stop timing function, liquid crystal display and the capability of recording at least nine "events,"
- b. Sufficient load switches and flash transfer relays for all twelve phases,
- c. LED display load switches (input side) labeled on the cabinet wall,
- d. Remote flasher, and
- e. Vehicle detector amplifiers. Rack mounted units must be used.

The conflict monitor/MMU and the controller shall be wired to ensure that the "events" logged by the conflict monitor/MMU and the controller indications at the time of failure can be uploaded directly to a computer.

- (2) Cabinets. The controller and all auxiliary equipment shall be enclosed within a pre-wired, rainproof NEMA (3R) controller cabinet. The cabinet(s) shall have a polished aluminum alloy natural finish and a police door. The size of the cabinet shall be such as to provide ample space for housing all equipment necessary to provide the timings shown on the Plans.

The cabinet shall have a main door within which an auxiliary door shall be placed. The auxiliary door (police door) shall house a compartment with the following switches: "Flash-Automatic;" "Power, On-Off;" "Signal, On-Off."

A metal plaque listing ownership and emergency telephone numbers shall be attached to the outside of the cabinet. The plaque is as shown in the Plans.

Each cabinet shall have a weatherproof plastic envelope of sufficient size, 450 by 600 mm (18 × 24 inches), to store wiring diagrams, program manuals, etc. The cabinet shall contain a suitably designed vent fan and thermostat [50 to 71 °C (120 to 160 °F)]. The thermostat shall be set initially to 50 °C (120 °F).

The controller cabinet shall contain a strong mounting table, sliding track, hinged adjustable fixed or a folding support of such construction that it will permit the controller or other equipment to be withdrawn from the cabinet for inspection or maintenance without breaking any electrical connection or interrupting normal operation of the controller.

A flexible arm lamp receptacle capable of illuminating all areas of the cabinet, two convenience outlets, ground fault interruption protection, and surge protection shall be provided.

A wiring panel shall be included in each cabinet mounted in such a way so as to provide visibility and accessibility. The lowest row of terminals shall be at least 75 mm (3 inches) from the bottom of the cabinet.

The main door lock of the cabinet shall be a #2 tumbler type lock as recommended by the manufacturer of the equipment. A police type lock shall be provided for the auxiliary door. The cabinet shall also be provided with a Master #3220 padlock. Two keys shall be furnished for each lock. The mounting of the cabinet shall be as shown on the Plans.

An intersection layout drawing to a scale of 1:500 (1:40) shall be taped to the inside of the door, in the proper orientation and covered with plastic. It shall indicate numbers for the vehicle heads, phases, load switches, detectors, loops, and any other pertinent information.

The Contractor shall indicate on the inside of the door, the date and time of signal turn-on for new installations

or switch-over for replacement installations. The door marking shall be permanent.

- (3) Spare Equipment. In addition to equipment furnished to provide a functional signal system, the Contractor shall supply one of each of the following spare parts in each cabinet:
- a. Flasher unit (independent of the controller),
 - b. Transfer relay,
 - c. EEPROM, programmed for the project intersection and stored in a protective container,
 - d. Cabinet lamp bulb,
 - e. Filter for ventilation system,
 - f. Relay,
 - g. Six spare bulbs (for optically programmed heads only), and
 - h. Loop amplifier with delay call capability.
 - i. Cabinet surge protector
 - j. Bus Interface Unit (BIU) in a protected container

This equipment may be used during the construction period to replace malfunctioning equipment but must be replaced and maintained in the cabinet prior to acceptance.

- (4) Wiring. All panel wiring shall be neat and firm and UL approved circuit breakers shall be provided

All field terminals shall be suitably identified.

The electrical connections from the controller and other accessory equipment to the outgoing and incoming circuits shall be made either by standard multiple plug or jack.

The outgoing traffic control signal circuits shall be of the same polarity as the line side of the power supply; the common return of the signal circuits shall be of the same polarity as the ground side of the power supply.

The ground side of the power supply shall be grounded to the controller cabinet in an approved manner.

All signals shall be wired such that no more than two through faces (north/south and/or east/west) are wired into one load switch even though the two approaches may time during the same phase.

- (5) Contacts. All contacts used in connection with interval indications shall be of pure coin silver or its equivalent and shall be capable of breaking and carrying 10 A at 125 V AC and shall be readily accessible and capable of being replaced in the controller without the use of any tools other than pliers and screwdrivers. Mercury tube contacts will not be accepted.
- (6) Relays. Relays shall not be used in connection with any automatic non-flashing red, yellow or green indications without the approval of the Engineer. All relays shall be jack mounted.
- (7) Motor and Lamp Leads. All motor and lamp leads shall be moisture and heat resistant type of flexible stranded copper 600 V wire meeting the requirements of the National Electrical Code.
- (8) Snap Switch. Each controller shall be equipped with a snap switch that will disconnect the timing mechanism and signal lights from all outside sources of electrical power.
- (9) Lightning Arrester. Each controller shall be equipped with a suitable effective lightning arrester that filters lightning or high voltages to ground protecting internal components of the controller.
- (10) Radio and Television Interference. Electrical equipment shall be protected against interfering with radio and television reception.

- (11) Wiring Diagram. Two internal connection wiring diagrams for all apparatus, and mounting and operating instructions shall be furnished.
- (12) Flasher. Each controller shall be equipped with a flashing mechanism capable of providing flashing operation at a rate of not less than 50 or more than 60 flashes per minute, part of which may be yellow and part red, or all red, as directed by the Engineer. The illuminated period of each flash shall be not less than 50 or more than 67 percent of the total cycle. Such flashing mechanism shall be in an encapsulated cube style configuration, shall be adequately housed and protected from the weather and shall be of such design as to be accessible for inspection, cleaning, and adjustment without disconnecting any part. It shall be capable of flashing two inductive or tungsten loads and shall operate within a line voltage range of 95 to 135 V AC. Alternately, a NEMA flasher meeting the same operational requirements may be provided. A mercury tube contact will not be accepted for flashing indications. Flashing operation shall begin automatically if the controller malfunctions and when called for by the timing plan. In addition, flashing shall be capable of being manually controlled by a switch in the police door. The controller itself need not be present to operate the signals in flashing mode.
- (13) All controllers, installed in areas where other signalized intersections are nearby and there is likelihood of future coordination, shall be capable of future interconnect either by cable connection, telemetry, spread spectrum radio or the use of time based coordination. Such modifications shall not require return of the controller to the manufacturer.
- (14) For semi-actuated controllers, in the absence of actuation, the right-of-way shall return to and remain on the non-actuated approach, or as shown on the Plans.
- (15) For fully-actuated controllers, in the absence of actuation, the right-of-way shall remain on the last actuated phase, or as specified.

- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.07 FLASHING BEACONS.

- (a) General Requirements. The applicable portions of Subsection 752.06 shall apply in addition to the specific functional requirements described below.
- (b) Flasher. The controller shall be equipped with a flashing mechanism capable of providing flashing operation at a rate of not less than 50 or more than 60 flashes per minute, part of which may be yellow and part red, or all red as directed by the Engineer. The illuminated period of each flash shall be not less than 50 and not more than 67 percent of the total cycle. The flashing mechanism shall be adequately housed and protected from the weather and shall be designed to be accessible for inspection, cleaning, and adjustment without disconnecting any part. A mercury tube contact will not be accepted for flashing indications. Time cycle variations shall not occur due to any change in outside temperature between the limits of -30 to 50 °C (-20 and 120 °F). For temperatures lower than -30°C (-20 °F) (a heater unit may be activated, if required, to keep the unit functioning.

Solid state flasher units shall meet or exceed all requirements of the latest NEMA standards.

The flashing mechanism shall be protected against interfering with radio and television reception by the use of a radio and television interference filter.

- (c) Cabinets. The complete flashing mechanism and related interference filters shall be enclosed within a rainproof, NEMA (3R), cast-aluminum cabinet or a glass meter socket housing, whichever is shown on the Plans. The size of the cabinet shall be such as to provide ample space for housing the flashing mechanism, filters, and fuse panel.

The cabinet shall have a main door and lock. The lock shall be a tumbler type lock as recommended by the manufacturer of the equipment. Two keys shall be furnished for the lock.

The cabinet shall contain a suitably designed vent.

The mounting of the cabinet shall be as shown on the Plans.

- (d) Flashing Beacon Signal Heads. Flashing beacon signal heads shall be self-contained assemblies that are expandable, adjustable, and may contain one or more signal faces as shown on the Plans.

The components of the signal head consisting of housings, doors, visors, optical units (consisting of lenses, reflectors, lamp sockets, and lamps), wiring, trunnions and brackets shall conform to the latest requirements of the ITE technical report "Adjustable Face Traffic Control Signal Head Standards," and the applicable portions of Subsection 752.05, unless otherwise specified.

- (e) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.08 ELECTRICAL CONDUIT. Electrical conduit shall conform to the following:

- (a) Rigid Polyvinyl Chloride (PVC) Electrical Conduit. Rigid PVC electrical conduit shall be Schedule 80 and shall meet or exceed the specifications of ASTM D 1784.
- (b) Polyethylene Plastic Pipe and Fittings (HDPE) Electrical Conduit. Polyethylene plastic pipe and fittings (HDPE) electrical conduit shall be Schedule 80 and shall meet or exceed the specifications of ASTM D 3350.
- (c) Plastic Coated, Galvanized Steel, Rigid Metallic Electrical Conduit. Plastic coated, galvanized steel, rigid metallic electrical conduit shall be hot-dip galvanized and shall have a plastic coating of at least 0.5 mm (20 mils) in thickness intimately bonded to both inside and outside galvanized surfaces. The conduit shall meet the requirements of ASTM A 53/A 53M.
- (d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.09 TRAFFIC SIGNAL CONDUCTOR CABLE.

- (a) Polyethylene-Insulated, Polyvinyl Chloride (PVC) Jacketed Signal Cable. Polyethylene-insulated, PVC jacketed signal cable for use in underground conduits or as an aerial cable supported by a span wire shall conform to the latest requirements of International Municipal Signal Association, Inc., Specification No. 19-1.

- (b) Polyethylene-Insulated, Polyethylene Jacketed Communication Cable. Polyethylene-insulated, polyethylene jacketed communication cable for use in underground conduits or as an aerial cable supported by a span wire shall conform to the latest requirements of International Municipal Signal Association, Inc., Specification No. 20-1.
- (c) Polyethylene-Insulated, Polyvinyl Chloride (PVC) Jacketed, Integral Messenger Signal Cable. Polyethylene-insulated, PVC jacketed signal cable with integral supporting span wire for aerial installation shall conform to the latest requirements of International Municipal Signal Association, Inc., Specification No. 19-3.
- (d) Polyethylene-Insulated, Polyethylene Jacketed, Integral Messenger Communication Cable. Polyethylene-insulated, polyethylene jacketed communication cable with integral supporting span wire for aerial installation shall conform to the latest requirements of International Municipal Signal Association, Inc., Specification No. 20-3.
- (e) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.10 DETECTORS. Vehicle detectors used for actuating traffic signal controllers shall be of the inductive loop type or as shown on the Plans.

- (a) Inductive Loop Detectors. Inductive loop detectors shall meet or exceed all requirements of the latest NEMA standards for traffic control systems. Each detector unit shall be capable of serving up to four loops.

The wire loops shall consist of 3.31 mm² (No. 12 gage) AWG minimum size, Type TW stranded wire with 600 V insulation. Loop feeder wire shall be in accordance with the loop detector manufacturer's recommendations. Loop feeder length capability shall be at least 230 m (755 feet) for one loop, or a combined total feeder length capability of at least 230 m (755 feet) for multiple loops. Single conductor shall consist of seven-strand tinned copper.

The configurations and installation of the wire loops and loop feeder wires shall be in accordance with the loop detector manufacturer's recommendations and/or as shown on the Plans. The loops shall be located as shown on the Plans.

Vehicle detector feeder wire (lead-ins) shall be enclosed in a nonmetallic conduit for underground travel from the curb to the controller.

752.11 VEHICLE DETECTOR SLOT SEALANT. Vehicle detector slot sealant material shall be a standard of the trade for this purpose, and it shall have the approval of the Engineer prior to being used.

752.12 JUNCTION BOX. Junction boxes shall be constructed of fiberglass, high density polyethylene (HDPE), or acrylonitrile-butadiene-styrene (ABS). They shall be high-impact resistant at temperatures ranging from -35 to 50 °C (-30 to 120 °F), ultraviolet stabilized, and fire retardant. The side wall shall be ribbed for strength. The cover shall be non skid and shall be held down with recessed hex-head bolts. The junction box shall be capable of withstanding a loading of 67 kN (15 kips) over any 250 by 250 mm (10 × 10 inch) area on the cover. The size of the box shall be as specified in the Contract.

Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.13 ACCESSIBLE PEDESTRIAN SIGNALS. Accessible Pedestrian Signals (APS) shall meet the standards of the American with Disabilities Act (ADA) and the most current edition of the Manual on Uniform Traffic Control Devices (MUTCD).

- (a) Wiring. The APS shall interface and be coordinated with the other features of a traffic control signal.
- (b) Audible Features. The APS shall include an audible indication of the Walk interval by either tone or voice and shall be audible from the near side of the associated crosswalk. If the tone for the Walk interval is the same as the locator tone of the pushbutton it shall have a faster repetition rate than the associated locator tone. The volume of the audible features shall have automatic volume adjustment based on the ambient noise levels. Audible features shall be no more than 5 dB louder than ambient sound up to a maximum volume of 89 dB measured at 36 inches (900mm) from the device. When voice messages are used, they shall include a clear message that the walk interval is in effect and shall indicate to which crossing it applies. Audible features may be integral to the Pedestrian Pushbutton Assembly (752.14) or through a separate speaker housing.

- (c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

752.14 PEDESTRIAN PUSHBUTTON ASSEMBLIES. Pedestrian pushbutton assemblies shall meet all ADA requirements. The plunger head shall have a minimum diameter of 50 mm (2 inches) and the force required to operate the plunger shall not exceed 22.2 N (5 pounds). The pushbutton shall activate both the Walk interval and the APS (if one is provided).

- (a) Color The color of the pushbutton shall contrast visually with the housing or mounting.
- (b) Audible Features. The pushbutton assembly shall include an integral locator tone. The locator tone shall have a duration of 0.15 seconds or less and shall repeat at 1 second intervals. The locator tone shall be 2 dB minimum and 5 dB maximum above ambient noise levels and shall be responsive to ambient noise levels.
- (c) Tactile Features The pushbutton assembly shall incorporate a raised arrow. The arrow shall be raised 0.8 mm (1/32 inch) minimum and shall be 38 mm (1 ½ inches) minimum in length. The arrow color shall contrast with the background. The pushbutton shall vibrate to indicate that the walk interval is in effect.
- (d) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

SECTION 753 - HIGHWAY ILLUMINATION

753.01 LIGHT STANDARDS.

- (a) General. The shafts of all light standards shall be designed to withstand an equivalent wind gust load of 160 km/h (100 miles per hour) velocity and when used with the listed bracket arm and luminaire, shall not produce an angular deflection of more than 70 minutes.

The bracket arms shall be able to withstand a vertical load of 450 N (100 pounds) and a horizontal load of 225 N (50 pounds) without fracture or permanent deformation.

The design of light standards shall conform to the latest edition of AASHTO *Standard Specifications for the Structural Supports for Highway Signs, Luminaires and Traffic Signals*.

Breakaway poles shall yield with a change in vehicle momentum of less than 4895 N-s (1100 pound-seconds) when struck by a 1020 kg (2250 pound) vehicle traveling at speeds from 32 to 97 km/h (20 to 60 miles per hour).

(b) Aluminum Poles.

- (1) Shafts. Aluminum shafts shall consist of tapered one-piece seamless tubes conforming to the requirements of ASTM B 221M (ASTM B 221), Alloy 6063-T6, 6061-T6, or 6005-T5. Minimum wall thickness shall be 3.2 mm (0.125 inch) for mounting heights of less than 6 m (20 feet) and 4.8 mm (0.188 inch) for mounting heights of 6 m (20 feet) or more.

When transformer bases are not shown on the Plans, a 100 by 150 mm (4 × 6 inch) reinforced handhole, complete with cover plate and stainless steel attachment screws, shall be located approximately 450 mm (18 inches) above the base at 90 degrees from the direction of the bracket arm on the side away from approaching traffic. A lip shall be provided around the handhole opening to prevent the cover from tipping and falling inside the hole. A grounding nut easily accessible from the handhole shall be located inside the shaft at each handhole. Each shaft shall be provided with a removable, ornamental, cast-aluminum, pole cap held securely in place.

- (2) Baseplates. Baseplates shall consist of a one-piece aluminum casting conforming to the requirements of ASTM B 26/B 26M or ASTM B 108, Alloy SG70A-T6, 356-T6. The baseplate shall be attached to the shaft by two continuous welds, one inside the base at the end of the shaft and the other on the outside at the top of the base. The welded connection shall develop the full strength of the adjacent shaft section.
- (3) Transformer Bases. Transformer bases shall consist of a one-piece aluminum casting conforming to the requirements of ASTM B 26/B 26M or ASTM B 108, Alloy SG70A-T6, 356-T6. The transformer base shall

be approximately 500 mm (20 inches) high, 400 mm (16 inches) square at the bottom, and 330 mm (13 inches) square at the top, unless otherwise specified. Each transformer base shall have an aluminum door attached with stainless steel screws. The bottom plate of the base shall have a grounding nut easily accessible from the door. Stainless steel bolts, nuts, and washers shall be provided to attach the transformer base to the shaft anchor base.

- (4) Bracket Arms. Bracket arms shall be a single member elliptical-type or truss-type as shown on the Plans. With the exception of davit-type poles, the main or wire-carrying member shall be ovalized at the shaft end. The shaft end of the arm shall have a cast aluminum fitting welded to it to permit attachment to the shaft. Single bracket arms and the main member of truss-type arms shall be tapered, seamless tube conforming to the requirements of ASTM B 221M (ASTM B 221), Alloy 6063-T6 or Alloy 6061-T6. Other members of truss-type arms shall conform to the requirements of ASTM B 221M (ASTM B 221), Alloy 6063-T6. The bracket arm shall be provided with a 50 mm (2 inch) slip-fit mounting of sufficient length to accommodate the luminaire.
- (5) Accessories. All screws, nuts, bolts, and other hardware including anchor bolts shall be stainless steel, unless otherwise specified.
- (6) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

(c) Steel Poles.

- (1) Steel shafts shall consist of:
 - a. A tapered one-piece tube fabricated from one length of steel sheet that shall have only one longitudinal automatically electrically welded joint. The shafts shall be formed, welded longitudinally, and cold-rolled under sufficient pressure to flatten the weld and form a smooth tapered tube. The shaft shall be uniformly tapered at a rate of approximately 11.7 mm/m

(0.14 inch per foot). The metal thickness shall not be less than 3.0 mm (0.119 inch).

- b. A series of two or three different diameter pipes welded together. The metal thickness shall not be less than 4.8 mm (0.188 inch) for the bottom section.

After fabrication, the shafts shall have a minimum yield strength of 330 MPa (48 ksi).

When transformer bases are not shown on the Plans, a 100 by 150 mm (4 × 6 inch) reinforced handhole, complete with cover plate and stainless steel attachment screws, shall be located approximately 450 mm (18 inches) above the base at 90 degrees from the direction of the bracket arm on the side away from approaching traffic. A lip shall be provided around the handhole opening to prevent the cover from tipping and falling inside the hole. A grounding nut shall be located inside the shaft easily accessible from the handhole.

- (2) Baseplates. Baseplates shall consist of steel plate conforming to the requirements of ASTM A 36/A 36M or ASTM A 242/A 242M, or of a one-piece steel casting conforming to the requirements of ASTM A 27/A 27M. The baseplate shall be attached to the shaft by two continuous electric welds, one inside the base at the end of the shaft and the other on the outside at the top of the base. The welded connection shall develop the full strength of the adjacent shaft section. When bolt covers are shown on the Plans, they shall be attached to the upright portion of the base with stainless steel screws.
- (3) Transformer Bases. Transformer bases shall consist of a one-piece steel casting conforming to the requirements of ASTM A 27/A 27M or shall be fabricated from steel plate conforming to the requirements of ASTM A 36/A 36M or ASTM A 242/A 242M.

When fabricated, the side plates shall have a minimum thickness of 4.5 mm (0.178 inch). The top and bottom plates shall have a minimum thickness of 19 mm (3/4 inch). The transformer base shall be approximately 500

mm (20 inches) high, 400 mm (16 inches) square at the bottom, and 330 mm (13 inches) square at the top, unless otherwise specified. Stainless steel bolts, nuts, and washers shall be provided to attach the transformer base to the anchor base. Each transformer base shall have a steel door attached with stainless steel screws. The bottom plate of the base shall have a grounding nut easily accessible from the door.

- (4) Bracket Arm. Bracket arms shall be fabricated from standard steel pipe, free from burrs and conforming to the requirements of ASTM A 120 or ASTM A 501. Single member arms and individual members of truss-type arms, when required, shall be of one-piece seamless pipe. The bracket arm shall be provided with a 50 mm (2 inch) slip-fit mounting of sufficient length to accommodate the luminaire. Bracket arm connections to the shaft shall be weather resistant.
- (5) Finish. After fabrication, shafts, baseplates, transformer bases, and bracket arms shall be galvanized in accordance with the requirements of AASHTO M 111M/M 111.
- (6) Certification. A Type D Certification shall be furnished in accordance with Subsection 700.02.

753.02 LUMINAIRES.

- (a) General. All luminaires, including lamps, ballasts, photoelectric control devices, and housings, shall include the latest design improvements available at the time the Contract is awarded. They shall include an aluminum housing with easy access to the ballast assembly, photoelectric control, filtered optical assembly, and regulator ballast for the appropriate voltage. The ballast shall be matched to its starting circuit. Wiring shall be neat, bundled, and kept away from excess heat. All light distribution types shown on the Plans shall be in accordance with the latest editions of the *American Standard Practice for Roadway Lighting* by the Illuminating Engineering Society (IES) and *An Informational Guide for Roadway Lighting* (AASHTO).
- (b) Mercury, Sodium and Metal Halide Luminaires. Luminaires shall be weatherproof with a detachable reflector gasketed to the refractor and shall be optically sealed to prevent visible light leaks. The refractor shall be of heat-resistant glass or as shown

on the Plans. Housings shall be of cast or formed aluminum. The unit shall be provided with a 50 mm (2 inch) slip-fitting for mounting onto a 50 mm (2 inch) bracket, unless otherwise specified. Wattage and type of light distribution to be provided shall be as shown on the Plans.

The ballast shall be of the regulated (constant wattage) type, internally mounted in the luminaire.

For a mercury vapor luminaire, the ballast shall regulate within ± 2 percent variation of the lamp wattage or a ± 13 percent variation in primary voltage. The ballast shall operate within the range of 5 percent voltage drop and have a guaranteed starting characteristic of $-30\text{ }^{\circ}\text{C}$ ($-20\text{ }^{\circ}\text{F}$).

For a high-pressure sodium luminaire, the ballast shall regulate within ± 5 percent variation of the lamp wattage or a ± 10 percent variation in primary voltage. The ballast shall operate within the range of 5 percent voltage drop and have a guaranteed starting characteristic of $-30\text{ }^{\circ}\text{C}$ ($-20\text{ }^{\circ}\text{F}$).

For a metal halide luminaire, the ballast shall regulate within ± 10 percent variation in primary voltage. The ballast shall operate within the range of 5 percent voltage drop and have a guaranteed starting characteristic of $-30\text{ }^{\circ}\text{C}$ ($-20\text{ }^{\circ}\text{F}$).

- (c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

753.03 PHOTOELECTRIC CONTROL DEVICES.

- (a) General. Unless otherwise shown on the Plans, a twist-lock type photoelectric control device shall be an integral part of each luminaire and shall operate at a temperature of $-30\text{ }^{\circ}\text{C}$ ($-20\text{ }^{\circ}\text{F}$). The photoelectric controls shall be of the cadmium-sulphide type, and the load capacity of the photoelectric cell relays shall be a minimum of 1000 W. They shall be suitable for operating a lighting system through load relays or oil switches when so shown on the Plans. The photoelectric cell circuitry shall be designed to be normally closed at night. The turn-on range shall be adjustable if shown on the Plans and shall be set by the Contractor as recommended by the manufacturer to meet local conditions. The turn-off setting shall be preset by the manufacturer. The relay shall have a time delay to avoid operation due to lightning and transient light. In the event of

failure, the relay shall fail safe, that is, the lights are left on in the event of any failure in the electronic circuit. A suitable bracket for mounting, to orient the photoelectric cell window toward the north sky, and a lightning arrester shall be included as part of the unit.

- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

753.04 HIGHWAY ILLUMINATION CONDUCTOR CABLE.

- (a) General. Highway illumination conductor cable shall be single conductors of stranded, soft-drawn copper or single conductors of stranded aluminum with a moisture and heat resistant thermoplastic insulation such as Type THW. It shall be rated for 600 V service at 75 °C (167 °F) for either dry or wet locations. UF cable shall be used in wet areas. Where the UF cable may extend into other conditions it shall be of a type approved for the additional use.

The electrical cable in a conduit shall be single conductors of stranded, soft-drawn copper or single conductors of stranded aluminum with a moisture and heat resistant thermoplastic insulation such as Type XHHW, Type THW, or equivalent. The electrical cable shall be rated for 600 V service at 75 °C (167 °F) for either dry or wet locations.

The cable shall not have any unnecessary kinks or bends put into the cable during installation. Any bends that are necessary shall be made according to the manufacturer's guidelines. End caps, when necessary, of the appropriate size for the service conductors shall be installed at all termination points in pull boxes, junction boxes, and pole bases. When a conduit splice is required near termination (such as at a sweep to a pole base or a pull box), the splice shall be made with a coupling of the same or similar material as directed by the Engineer.

The single conductors shall conform to the National Electrical Code for the intended wire use and existing field conditions. Wire size shall be such that no more than a 3 percent voltage drop will occur anywhere in the secondary circuit. All wiring shall be color-coded.

All conductors within the streetlight pole and bracket arm shall be No. 10 AWG stranded copper wire. Street lighting conductors within strain poles shall also be No. 10 AWG stranded copper wire.

Unless otherwise shown on the Plans, the multiple system of distribution shall be used.

- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

753.05 GROUNDING ELECTRODES.

- (a) General. Grounding electrodes shall be copperclad steel rods 16 mm (5/8 inch) in diameter by 2.4 m (8 feet) long, minimum, and shall conform to UL No. 467 (ANSI C33.8).

Grounding conductor shall be installed throughout the system back to the power source. The earth shall not be used as the sole equipment grounding conductor.

- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

SECTION 755 – LANDSCAPING MATERIALS

755.01 LANDSCAPE BACKFILL. The landscape backfill material shall be premixed, consisting of approximately 50% topsoil, 25% compost, and 25% native soil as approved by the Engineer. In cases where native soil meets the topsoil specification, the proportions of native soil may be adjusted to up to 75% as approved by the Engineer.

755.02 TOPSOIL. Topsoil shall be a natural, workable soil, free of refuse, roots, stones, brush, weeds, or other material that would be detrimental to the proper development of plant growth. Topsoil shall be screened, loose, and friable, free of subsoil, roots, noxious weeds, stones larger than 25 mm (1 inch), and other debris.

Topsoil shall be reasonably free draining (less than 27% clay), and contain 5-10% organic matter for woody plant materials as determined by the loss of ignition of oven dried samples. Topsoil for lawn areas shall have an organic content of at least 4%. Salinity (electrical conductivity) shall be less than 0.1 S/m as determined by a 1:2 (by volume) soil to water mix. Salt test samples shall not be oven dried. The acidity range of the topsoil shall be pH 5.5 to 7.0.

Topsoil shall be obtained from a source that has been approved by the Engineer and has demonstrated, by a healthy growth of grass, cultivated crops, or wild vegetation that it is of good quality. The Contractor shall provide a 0.5 kg (one pound) sample per each 190 m³ (250 yd³) of topsoil.

At least 30 days prior to delivery and use, the topsoil shall be submitted by the Engineer for testing to the University of Vermont Agricultural Extension Service or equivalent approved facility. Testing results shall be sent directly back to the Engineer for approval.

Testing shall be on dry material that has passed the #10 sieve with the following gradation:

SEIVE SIZE	PERCENT PASSING
No. 10	85-100
No. 40	35 – 85
No. 200	10- 35
< 20 um	<5

Soil analysis shall show recommendations for soil additives to correct soil deficiencies and for additives necessary to accomplish particular planting objectives noted.

Soil amendments shall be incorporated thoroughly into the topsoil to meet the specified requirements for topsoil prior to delivering the material on site.

755.03 SOD. Sod shall be live, fresh, and of suitable character for the soil in which it is placed. Sod shall be of a firm, even texture, show good root development, be reasonably free from noxious weeds, and shall have a compact growth of vigorous, dark green grass. Sod shall have a minimum 70 percent Kentucky Bluegrass, improved variety, and a 10 percent Red Fescue (*Festuca rubra*) improved variety.

Sods shall be 600 mm² (2 ft²) in area and shall be thick enough to contain all natural roots without mutilation. In no case shall sod be under 18 mm (3/4 inches) or over 25 mm (1 inch) thick, unless express written permission of the Engineer is procured.

The sod shall be approved by the Engineer prior to being cut and again before it is laid. Sod stored longer than 36 hours will not be allowed under any circumstances.

Certification: A Type A Certification shall be furnished in accordance with Subsection 700.02.

755.04 SEED. Seed shall be furnished in new, clean, sealed, and properly labeled containers, either separately or mixed, as appropriate, and shall conform to the seed formula shown on the Plans. Seed that has become wet, moldy, or otherwise damaged shall not be accepted.

- (a) Testing. The seed shall conform to all State and Federal regulations.
- (b) Labels. Labels shall conform to all State and Federal regulations and shall be clearly marked with the following:
- Seed name
 - Lot number
 - Percentage of germination
 - Percentage of purity
 - Percentage of weed seed content
- (c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

755.05 COMPOST. Compost shall be free of weed seeds and comply with EPA requirements for compost. The compost shall have a loose and granular texture with the following characteristics or properties:

Organic Matter Content	30-60%
Total Kjeldahl Nitrogen Content	0.5-2.0%
pH	6.5-7.5
Maximum Particle Size	<25 mm (1inch)
Soluble Salt Content	<5 mmhos/cm
Percentage of Human Inerts, by dry mass (weight)	<1.0%
Moisture Content	35 to 55%

Compost shall generally comprise 25 percent of the back fill material unless otherwise specified. The compost shall possess no objectionable odors and shall not resemble the raw material from which it was derived. The compost must meet US EPA Part 503 exceptional quality concentration limits for trace elements/heavy metals.

Certification: A Type A Certification shall be furnished in accordance with Subsection 700.02.

755.06 FERTILIZER. Fertilizer, if specified, shall be a standard commercial grade dry fertilizer and shall conform to the requirements of all State and Federal regulations and to the standards of the Association of

Official Agricultural Chemists. Fertilizer shall contain not less than the minimum percentage of nitrogen, phosphoric acid, and potash shown on the Plans.

- (a) Packaging. The fertilizer shall be furnished in new, clean, sealed, and properly labeled bags not exceeding 45 kg (100 pounds) each. Caked or otherwise damaged fertilizer shall not be accepted.

Labels shall be clearly marked with the following:

Manufacturer's name
Type
Mass (weight)
Guaranteed analysis

Unless otherwise specified fertilizer shall contain the following percentages by weight:

10 percent available Nitrogen (N)
10 percent available Phosphoric Acid P)
10 percent available Potassium (K)

50% available nitrogen shall be in a slow release form as is found in certain urea form products or natural organic forms or a combination of both.

- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

755.07 MYCORRHIZAL FUNGI PRODUCT. Mycorrhizal fungi product, if specified on the Plans and details, shall be of granular form and shall include Mycorrhizae spores to enhance root growth, nutrient uptake, and reduce transplant shock. All Mycorrhizal fungi products shall be administered per manufacturer's recommendations. Mycorrhizal fungi product shall be one of the Mycorrhizal fungi product(s) on the Approved Products List on file with the Agency's Materials and Research Section.

755.08 AGRICULTURAL LIMESTONE. Agricultural limestone shall be a calcitic or dolomitic ground limestone containing not less than 85 percent of total (calcium or magnesium) carbonates. The limestone shall conform to the requirements of all State and Federal regulations and to the standards of the Association of Official Agricultural Chemists.

- (a) Packaging. The limestone shall be furnished in new, clean, sealed, and properly labeled bags not exceeding 45 kg (100

pounds) each. Caked or otherwise damaged limestone shall not be accepted.

Labels shall be clearly marked with the following:

Manufacturer's name
Type
Mass (weight)
Guaranteed analysis

- (b) Sieve Analysis. Limestone shall meet the following sieve analysis: 100 percent shall pass the 2.00 mm (No. 10) sieve with a minimum of 40 percent passing the 150 μ m (No. 100) sieve.
- (c) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

755.09 LIQUID LIME. Liquid lime shall be a commercially formulated calcium carbonate lime mixture.

- (a) Packaging. Labels shall be clearly marked with the following:

Manufacturer's name
Type
Mass (Weight)
Guaranteed analysis

- (b) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

755.10 MULCH MATERIALS. Mulch materials shall conform to the following requirements:

- (a) Hay Mulch. Hay mulch shall consist of mowed and properly cured grass or legume mowings, reasonably free from swamp grass, weeds, twigs, debris, or other deleterious material and free from rot or mold. It shall be in an air-dry condition suitable for placing with mulch blower equipment and shall be acceptable to the Engineer.
- (b) Wood Chip Mulch. Wood chip mulch shall consist of hardwood chips, 3 to 6 mm (1/8 to 1/4 inch) nominal thickness, with 50 percent having an area of not less than 650 mm² (1 in²) or more than 4000 mm² (6 in²). All wood chip mulch shall be reasonably free from deleterious materials that are injurious to plant growth. Wood chip mulch may be used only for temporary applications

for erosion prevention and tree protection during construction. Wood Chip Mulch shall not be used for landscape plantings.

- (c) Bark Mulch. Mulch material used for landscape plantings shall consist of well composted shredded Cedar, Pine, or Spruce bark, 3 to 6 mm ($\frac{1}{8}$ to $\frac{1}{4}$ inch) nominal thickness, with 50 percent having an area of not less than 650 mm² (1 in²) or more than 4000 mm² (6 in²). All bark mulch shall be reasonably free from leaves, twigs, shavings, insect pests, eggs, larvae, or other deleterious material that is injurious to plant growth, and approved by the Engineer. The same type of material shall be used in all areas to provide visual uniformity. Bark Mulch shall be applied as detailed in the Contract Plans and on the landscape detail sheets.
- (d) Fiber Mulch. Fiber mulch shall be produced from natural or recycled (pulp) fiber, such as wood chips or similar wood materials or from newsprint, chipboard, corrugated cardboard, or a combination of these processed materials. Fiber mulch shall be free of synthetic or plastic materials, weed seed, and growth or germination inhibiting substances and shall be nontoxic to plant or animal life. Fiber mulch shall have a water-holding capacity by mass of not less than 900 percent and shall be of such character that the fiber will disperse into a uniform slurry when mixed with water. Water content of the fiber before mixing into slurry shall not exceed 12 +/- 3 percent of the dry mass of the fiber. Fiber shall have the moisture content of the fiber marked on the package. Fiber mulch shall be colored to contrast with the area on which it is to be applied, and shall not stain concrete or painted surfaces.
- Acceptable Fiber Mulch shall be one of the Fiber Mulch(es) on the Approved Products List on file with the Agency's Materials and Research Section.
- (e) Hydraulic Matrix. The hydraulic matrix shall consist of a mix of long strand, residual, wood fibers and a high-strength bonding agent. The matrix shall be 100% biodegradable over time, non-toxic to fish and wildlife, and it shall not contain any synthetic fibers. The hydraulic matrix shall be colored to contrast with the area on which it is to be applied, and shall not stain concrete or painted surfaces.

Acceptable Hydraulic Matrix shall be one of the Hydraulic Matrix(es) on the Approved Products List on file with the Agency's Materials and Research Section.

- (f) Tackifier. Tackifier for hay mulch may be guar based organic tackifier, starch based-agricultural tackifier or another type of mulch binder as approved by the Engineer. Tackifier for stabilization of bare soils, without mulch or other fiber incorporated, shall use materials and quantities specified by the manufacturer based on the results of soils, water, and site assessment. Tackifiers shall be nontoxic to plant or animal life and non-staining to concrete or painted surfaces. Tackifiers must be water soluble, "linear", and "non-crosslinked". Tackifiers shall be non-combustible and shall not change soil pH.

Acceptable Tackifier shall be one of the Tackifier(s) on the Approved Products List on file with the Agency's Materials and Research Section.

755.11 EROSION MATTING.

- (a) Temporary Erosion Matting. Temporary erosion matting shall conform to one of the following specifications and corresponding properties found in Table 755.11A.
- (1) Mulch Control Netting. A temporary degradable rolled erosion control product composed of planar woven natural fiber or extruded geosynthetic mesh netting.
 - (2) Open Weave Textile. A temporary degradable rolled erosion control product composed of processed natural or polymer yarns woven into a matrix.
 - (3) Erosion Control Blanket. A temporary degradable rolled erosion control product composed of processed natural or polymer fibers mechanically, structurally, or chemically bound together to form a continuous matrix.
- (b) Permanent Erosion Matting. Permanent erosion matting shall be a long-term non-degradable rolled erosion control product composed of UV stabilized, non-degradable, synthetic fibers, filaments, nettings and/or wire mesh processed into three dimensional reinforcement matrices conforming to one of the following specifications and corresponding properties found in Table 755.11B.

TABLE 755.11A - STANDARD SPECIFICATION FOR TEMPORARY
ROLLED EROSION CONTROL PRODUCTS

(For use where natural vegetation alone will provide
permanent erosion protection)

ULTRA SHORT-TERM - Typical 3 month functional longevity						
Type	Product Description	Material Composition	Slope Applications*		Channel Applications*	Minimum Tensile Strength ¹
			Maximum Gradient	C Factor ^{2,5}	Max. Shear Stress ^{3,4,6}	
1.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	5:1 (H:V)	≤0.10 @ 5:1	12 Pa (0.25 lbs/ft ²)	0.073 kN/m (5 lbs/ft)
2.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP.	4:1 (H:V)	≤0.10 @ 4:1	24 Pa (0.5 lbs/ft ²)	0.073 kN/m (5 lbs/ft)
3.C	Single-net Erosion Control Blankets & Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	3:1 (H:V)	≤0.15 @ 3:1	72 Pa (1.5 lbs/ft ²)	0.73 kN/m (50 lbs/ft)
4.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	2:1 (H:V)	≤0.20 @ 2:1	84 Pa (1.75 lbs/ft ²)	1.09 kN/m (75 lbs/ft)

TABLE 755.11A - STANDARD SPECIFICATION FOR TEMPORARY ROLLED EROSION CONTROL PRODUCTS (continued)

SHORT-TERM - Typical 12 month functional longevity						
Type	Product Description	Material Composition	Slope Applications*		Channel Applications*	Minimum Tensile Strength ¹
			Maximum Gradient	C Factor ^{2,5}	Max. Shear Stress ^{3,4,6}	
2.A	Mulch Control Nets	A photodegradable synthetic mesh or woven biodegradable natural fiber netting.	5:1 (H:V)	≤0.10 @ 5:1	12 Pa (0.25 lbs/ft ²)	0.073 kN/m (5 lbs/ft)
2.B	Netless Rolled Erosion Control Blankets	Natural and/or polymer fibers mechanically interlocked and/or chemically adhered together to form a RECP.	4:1 (H:V)	≤0.10 @ 4:1	24 Pa (0.5 lbs/ft ²)	0.073 kN/m (5 lbs/ft)
2.C	Single-net Erosion Control Blankets & Open Weave Textiles	Processed degradable natural and/or polymer fibers mechanically bound together by a single rapidly degrading, synthetic or natural fiber netting or an open weave textile of processed rapidly degrading natural or polymer yarns or twines woven into a continuous matrix.	3:1 (H:V)	≤0.15 @ 3:1	72 Pa (1.5 lbs/ft ²)	0.73 kN/m (50 lbs/ft)
2.D	Double-net Erosion Control Blankets	Processed degradable natural and/or polymer fibers mechanically bound together between two rapidly degrading, synthetic or natural fiber nettings.	2:1 (H:V)	≤0.20 @ 2:1	84 Pa (1.75 lbs/ft ²)	1.09 kN/m (75 lbs/ft)

TABLE 755.11A - STANDARD SPECIFICATION FOR TEMPORARY ROLLED EROSION CONTROL PRODUCTS (continued)

EXTENDED-TERM - Typical 24 month functional longevity						
Type	Product Description	Material Composition	Slope Applications*		Channel Applications*	Minimum Tensile Strength ¹
			Max Gradient	C Factor ^{2,5}	Max. Shear Stress ^{3,4,6}	
3.A	Mulch Control Nets	A slow degrading synthetic mesh or woven natural fiber netting.	5:1 (H:V)	≤0.10 @ 5:1	12 Pa (0.25 lbs/ft ²)	0.36 kN/m (25 lbs/ft)
3.B	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	1.5:1 (H:V)	≤0.25 @ 1.5:1	96 Pa (2.00 lbs/ft ²)	1.45kN/m (100lbs/ft)
4	Erosion Control Blankets & Open Weave Textiles	An erosion control blanket composed of processed slow degrading natural or polymer fibers mechanically bound together between two slow degrading synthetic or natural fiber nettings to form a continuous matrix or an open weave textile composed of processed slow degrading natural or polymer yarns or twines woven into a continuous matrix.	1:1 (H:V)	≤0.25 @ 1:1	108 Pa (2.25 lbs/ft ²)	1.82 kN/m (125 lbs/ft)

Notes:

"C" factor and shear stress for Types 1.A., 2.A., and 3.A mulch control nettings must be obtained with netting used in conjunction with pre-applied mulch material.

¹ Minimum Average Roll Values, Machine direction using ECTC Mod. ASTM D 5035.

² "C" Factor calculated as ratio of soil loss from RECP protected slope (tested at specified or greater gradient, h:v) to ratio of soil loss from unprotected (control) plot in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions using Erosion Control Technology Council (ECTC) Test Method # 2.

³ Required minimum shear stress RECP (unvegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in) soil loss) during a 30-minute flow event in large-scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council (ECTC) Test Method #3.

⁴ The permissible shear stress levels established for each performance category are based on historical experience with products characterized by Manning's roughness coefficients in the range of 0.01 - 0.05.

⁵ Acceptable large-scale test methods may include ASTM D 6459, Erosion Control Technology Council (ECTC) Test Method # 2, or other independent testing deemed acceptable by the Engineer.

⁶ Per the Engineer's discretion. Recommended acceptable large-scale testing protocol may include ASTM D 6460, Erosion Control Technology Council (ECTC) Test Method #3 or other independent testing deemed acceptable by the Engineer.

TABLE 755.11B - STANDARD SPECIFICATION FOR PERMANENT ROLLED EROSION CONTROL PRODUCTS

(For applications where vegetation alone will not sustain expected flow conditions and/or provide sufficient long-term erosion protection)

PERMANENT ¹ - All categories of TRMs must have a minimum thickness of 6.35 mm (0.25 inches) per ASTM D 6525 and U.V. stability of 80% per ASTM D 4355 (500 hours exposure).					
Type	Product Description	Material Composition	Slope Applications*	Channel Applications*	Minimum Tensile Strength ^{2,3}
			Maximum Gradient	Maximum Stress ^{4,5}	
5.A	Turf Reinforcement Mat	Turf Reinforcement Mat (TRM) – A rolled erosion control product composed of non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness. TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. Note: TRMs are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.	5:1 (H:V)	288 Pa (6.0 lbs/ft ²)	1.82 kN/m (125 lbs/ft)
5.B	Turf Reinforcement Mat		5:1 (H:V)	384 Pa (8.0 lbs/ft ²)	2.19 kN/m (150 lbs/ft)
5.C	Turf Reinforcement Mat		5:1 (H:V)	480 Pa (10.0 lbs/ft ²)	2.55 kN/m (175 lbs/ft)

Notes:

- ¹ For TRMs containing degradable components, all property values must be obtained on the non-degradable portion of the matting alone.
- ² Minimum Average Roll Values, machine direction only for tensile strength determination using ASTM D 6818 (Supersedes Mod. ASTM D 5035 for RECPs)
- ³ Field conditions with high loading and/or high survivability requirements may warrant the use of a TRM with a tensile strength of 44 kN/m (3,000 lb/ft) or greater.
- ⁴ Required minimum shear stress TRM (fully vegetated) can sustain without physical damage or excess erosion (> 12.7 mm (0.5 in.) soil loss) during a 30-minute flow event in large scale testing. These performance test values should be supported by periodic bench scale testing under similar test conditions and failure criteria using Erosion Control Technology Council (ECTC) Test Method #3.
- ⁵ Acceptable large-scale testing protocol may include ASTM D 6460, Erosion Control Technology Council (ECTC) Test Method #3, or other independent testing deemed acceptable by the Engineer.

755.12 PLANT MATERIALS. Plant materials shall conform to the following requirements:

- (a) Quality of Plant Material. All plants shall be first-class representatives of their normal species or varieties, unless otherwise specified as extra heavy or clump according to the particular exception.

All plant materials shall be nursery grown stock that have been transplanted or root-trimmed two or more times, according to the kind and size of plants. They shall have average or normal, well developed branches, together with vigorous root systems. Plant materials shall be free of insects, disease, sun scald, injuries, abrasions of the bark, knots, dead or dry wood, broken terminal growth, or other objectionable disfigurements. Thin, weak plants shall not be acceptable. Plant materials shall display the appearance of normal health and vigor in strict accordance with these Specifications.

Each shipment shall be accompanied by a description of all the included plant materials or an itemized bill of lading.

All plant materials furnished by the Contractor shall be grown within hardiness Zones 1 through 4 as established by The Arnold Arboretum (in Jamaica Plain, MA) and the plant suppliers shall certify that the stock has been grown under Zone 4 or hardier conditions. Plants that are not certified to have been grown under the designated hardiness zone conditions will not be accepted.

- (b) Plant Names. All scientific and common plant names of the items specified shall conform to the latest edition of *Standard Plant Names*, as adopted by the American Joint Committee on Horticultural Nomenclature. All plant materials delivered shall be true to name and legibly tagged with the names and sizes of materials. Should it be necessary to substitute a plant or plants of a different variety than the plant material specified, it will be necessary for the Contractor to secure written approval from the Engineer for the proposed substitution prior to digging the plants. An approved substitute plant shall be of a value at least equal to the specified plant for which the substitution is being made and then only when sufficient evidence is shown that the plant specified cannot be obtained.

- (c) Grading Standards. Grading of plant materials shall be accomplished according to ANSI Z60.1-2004 *American Standard for Nursery Stock* as approved by ANSI and published by the American Association of Nurserymen, Inc.

All plant measurements shall be made in conformance with the standard measurement methods in ANSI Z60.1-2004.

If balled and burlapped trees and shrubs are not available, container grown trees and shrubs may be supplied in accordance with the requirements and limitations of ANSI Z60.1-2004; however, all plants supplied shall be of the minimum size listed on the quantity sheet.

Unless designated multi-stemmed, the trunk of each tree shall be a single trunk growing from a single unmutilated crown of roots. The tree trunks shall be free from sunscald, frost cracks, or wounds resulting from abrasions, fire, or other causes. No pruning wounds shall be present having a diameter exceeding 50 mm (2 inches) and all allowable pruning wounds must show vigorous bark on all edges. Trees shall not be pruned prior to delivery. No trees with double-leaders or twin-heads shall be acceptable without the written approval of the Engineer. The Contractor shall reject such plants at time of delivery by the nursery/supplier unless such plants were previously selected by the Engineer as marked by tags and seals.

The height and spread of each shrub shall correspond to the specifications for Type 0 through Type 3 in ANSI Z60-2004. Single stemmed or thin plants will not be accepted. The side branches shall be generous, well-twiggged, and the plant, as a whole, well-branched to the ground. The plants shall be in a moist vigorous condition, free from dead wood, bruises, or other root or branch injuries. Plants shall not be pruned prior to delivery.

Vines and ground cover plants shall be of the size, age, and condition listed in the quantity sheet. Plants shall be healthy and free of insects and diseases. Ground cover plants shall be potted or in soil.

Container grown stock shall have been grown in a container long enough for the root system to have developed sufficiently to hold its soil together, firm and whole. No plants shall be loose in the container. No plants shall be root bound in the container. Such plants shall be rejected at delivery by the Contractor.

Plants delivered by truck and plants requiring storage on-site shall be properly wrapped and covered to prevent wind-drying and desiccation of branches, leaves, or buds. Plant balls shall be firmly bound, unbroken, and reasonably moist to indicate watering prior to delivery and during storage. Tree trunks shall be free from fresh scars and damage in handling. No plant material from cold storage will be accepted.

Evergreens shall be quality evergreens with a well-balanced form complying with the relationship requirements of ANSI Z60.1.

- (d) Nursery Inspection and Plant Quarantine. All plant materials shall be free from plant diseases and insect pests. All shipments of plants shall comply with all nursery inspection and plant quarantine regulations of the State of origin and the State of Vermont, as well as with Federal regulations governing interstate movement of nursery stock. A certificate of inspection shall accompany each package, box, bale, or carload of plant materials delivered and shall be provided to the Engineer.

The Contractor shall provide the Engineer with a copy of the installing Landscaper's License from the Vermont Department of Agriculture. Also, the Contractor shall provide the Engineer with a copy of the Nursery License and a copy of the Certificate of Nursery Inspection of each supplying nursery.

Particular attention is directed to the provisions of Title 6 VSA, Chapter 89 - Nursery Inspection, regarding the inspection of nurseries and nursery stock, and Vermont Department of Agriculture regulations regarding dealer's certificates.

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

All plants shall be moved with the root systems as solid units with balls of earth firmly wrapped with untreated burlap, Class 2, 248 g/m (8 ounces per yard), firmly held in place by a stout cord or wire. The diameter and depth of the balls of earth shall

be sufficient to encompass the fibrous and root feeding system necessary for the healthy development of the plant and in accordance with ANSI Z60.1. No plant shall be accepted when the ball of earth surrounding its roots has been badly cracked or broken preparatory to the process of planting or after the burlap, staves, ropes, or platform required in connection with its transplanting have been removed. The plants and balls shall remain intact during all operations. All plants that cannot be planted at once shall be heeled in by setting in the ground and covering the balls with soil and then watering them.

Any B & B designated plant material arriving at the project with broken or loose balls or balls manufactured on the root will not be acceptable and shall be rejected at delivery by the Contractor.

- (f) Certification. A Type A Certification shall be furnished in accordance with Subsection 700.02.

The plants shall be certified to have been grown under Zone 4 or hardier conditions, unless otherwise specified. A copy of this certification shall accompany each shipment of plant material and a copy of each shipment certification shall be attached to the Type A Certification submitted for the project. The certifications shall be identified in such a manner as to be directly traceable to the individual shipments.

755.13 ANTIDESICCANT. Antidesiccant shall be an approved emulsion that will provide a film over plant surfaces permeable enough to permit transpiration. An antidesiccant shall be used only after its use has been approved by the Engineer.

755.14 WIRE RODENT GUARDS. Wire rodent guards shall be galvanized steel wire fabric with 6 mm (1/4 inch) square openings and shall be of good commercial quality.

755.15 PLANT WRAPPING. Plant wrapping material shall be an approved waterproof paper in 100 mm (4 inch) wide rolls or an approved burlap in 150 mm (6 inch) wide rolls.

755.16 TREE WATERING BAGS. Tree watering bags are available in varying sizes and can be used together to accommodate tree trunk diameters. These waterproof bags are made of reinforced, UV treated polyethylene, reinforced with nylon webbing and are secured to the tree using heavy duty zippers located on each side of the bag. The adjustable drip holes at the base allow for water to flow at varying rates for specific needs.

Tree watering bags are on the Approved Products List on file with the Agency's Materials and Research Section.

755.17 Erosion Logs. Erosion logs shall be composed of woven coir, straw, or excelsior or other biodegradable filtering medium encased in photo degradable and/or biodegradable netting, having varying strengths for differing conditions.

755.18 Live Fascines. Live fascines shall consist of long bundles of live branch cuttings. Live fascines shall be prepared from freshly cut dormant plants. No leaf buds shall have initiated growth beyond 6 mm (1/4 inch) and the cambium layer of each cutting shall be moist, green, and healthy.

755.19 Live Stakes. Live stakes consist of branch cuttings from freshly cut dormant plants. Live cuttings shall be 12 to 25 mm (1/2 to 1.0 inch) diameter and 0.3 to 1.2 m (1 to 4 feet) long. Live stakes shall be 26 to 50 mm (1 to 2 inches) or 51 to 100 mm (2 to 4 inches) diameter and 1.5 to 1.8 m (5 to 6 feet) long. No leaf buds shall have initiated growth beyond 6 mm (1/4 inch) and the cambium layer shall be moist, green, and healthy. The live stakes shall have side branches cleanly removed and with the bark intact. The basal ends shall be cut at an angle for easy insertion into the soil and the top cut square.

See contract documents for plant species, size, spacing, and planting season specifications.

Plant material substitutions shall be approved by the Engineer prior to delivery to the project site.

755.20 Brush Layering. The branch cuttings shall be from freshly cut dormant plants. No leaf buds shall have initiated growth beyond 6 mm (1/4 inch) and the cambium layer shall be moist, green, and healthy. Live branch cuttings shall range from 12 to 50 mm (1/2 to 2 inches) in diameter and be long enough to reach the back of the bench. Side branches shall remain intact for installation.

Plant species, size, and planting season shall be as specified in the Contract Documents.

Plant material substitutions shall be approved by the Engineer prior to delivery or on-site harvesting.

SECTION 780 - CONCRETE REPAIR MATERIALS780.01 GENERAL REQUIREMENTS.

- (a) Packaging. The manufacturer's product designation and recommendations for surface preparation, mixing, placing, finishing, and curing shall be clearly outlined on the product packaging. Handling precautions and toxicity warnings shall be printed on all containers. The expiration date and a lot number shall appear on each package of material delivered to the project site. Liquid components which have been frozen shall not be used.
- (b) Sampling and Testing. Upon request, the Materials and Research Section will furnish a list of products that have been tested and are considered satisfactory. Should the Contractor wish to use a product not included on the Approved Products List, he/she may submit an alternate product. Application for material approval shall be submitted to the Materials and Research Section accompanied by a 45 Kg (100 lb.) sample of the product and complete material safety information. Upon approval, the product name and manufacturer will be placed on the Agency's approved list. A minimum period of two months shall be allowed for testing purposes.

780.02 OVERHEAD AND VERTICAL CONCRETE REPAIR MATERIAL. Overhead and vertical concrete repair material shall be a prepackaged material to be used for patching spalled areas of concrete that are either on vertical or overhead surfaces. Its use shall be limited to patches with an average layer thickness of 37.5 mm (1-1/2 inches) on vertical repairs and 25 mm (1 inch) on overhead repairs, as directed by the Engineer.

The product shall meet the following requirements:

- (a) Compressive Strength. The neat material shall exhibit a minimum seven day compressive strength of 13.8 MPa (2000 psi) and a minimum twenty-eight day strength of 27.6 MPa (4000 psi) when tested in accordance with AASHTO T 106M/T 106.
- (b) Flexural Bond Strength. The material shall exhibit a minimum bond strength of 1 MPa (150 psi) when tested in accordance with Vermont Agency of Transportation MRD-3.

- (c) Freeze-Thaw Durability. Resistance to rapid freezing and thawing shall be determined in accordance with AASHTO T 161 using Procedure A (Modified) for use of a 3% Sodium Chloride solution. The material shall exhibit no more than an 8% loss in weight after 300 cycles.
- (d) Volume Stability. The material shall exhibit expansion of not more than 0.40% and shrinkage of no more than 0.05% when tested in accordance with ASTM C 1090.
- (e) Placement. The material shall be capable of being placed in layers of at least 25 mm (1 inch) for overhead applications without the use of form work or anchoring devices.
- (f) Color and Texture. The material shall produce a finished patch of the same color and texture as the existing surface to the satisfaction of the Engineer.

780.03 RAPID SETTING CONCRETE REPAIR MATERIAL. Rapid setting concrete material shall be a prepackaged material to be used for patching horizontal concrete surfaces where rapid return of the structure to service is necessitated.

The product shall meet the following requirements:

- (a) Compressive Strength. The neat material shall exhibit a minimum two hour compressive strength of 8.3 MPa (1200 psi) and a seven day compressive strength of 34.5 MPa (5000 psi) when tested in accordance with AASHTO T 106M/T 106.
- (b) Time of Setting. When tested in accordance with AASHTO T 131 (Modified), the initial time of set shall not be less than 15 minutes. The material shall exhibit no more than an 8% loss in weight after 300 cycles.
- (c) Freeze-Thaw Durability. Resistance to rapid freezing and thawing shall be determined in accordance with AASHTO T 161 using Procedure A (Modified) for use of a 3% Sodium Chloride solution. The material shall exhibit no more than an 8% loss in weight after 300 cycles.
- (d) Volume Stability. The material shall exhibit expansion of not more than 0.4% and shrinkage of no more than 0.05% when tested in accordance with ASTM C 1090.

- (e) Flexural Bond Strength. The material shall exhibit a minimum bond strength of 0.7 MPa (100 psi) without the use of a special bonding agent when tested in accordance with Vermont Agency of Transportation MRD-3.

780.04 RAPID SETTING CONCRETE REPAIR MATERIAL WITH COARSE AGGREGATE. Rapid setting concrete material to contain coarse aggregate shall be a prepackaged material to be used for patching horizontal concrete surfaces where rapid return of the structure to service is necessitated. This material shall be formulated for the optional addition of 9.5 mm (3/8 inch) coarse aggregate to produce a rapid setting concrete mixture.

In addition to the material requirements of Subsection 780.03, the product shall meet the following requirements:

- (a) Compressive Strength. The neat material plus coarse aggregate shall exhibit a minimum four hour compressive strength of 13.8 MPa (2000 psi), a one day compressive strength of 20 MPa (2900 psi), and a seven day compressive strength of 34.5 MPa (5000 psi) when tested in accordance with AASHTO T 22.
- (b) Time of Workability. Time of workability as observed under laboratory conditions shall not be less than 15 minutes.
- (c) Freeze-Thaw Durability (Concrete Specimens). Resistance to rapid freezing and thawing shall be determined in accordance with AASHTO T 161 using Procedure A (Modified) for use of a 3% Sodium Chloride solution. The concrete shall exhibit no more than an 8% loss in weight after 300 cycles.