SECTION 932
NONMETALLIC ACCESSORY MATERIALS FOR CONCRETE PAVEMENT AND CONCRETE STRUCTURES

932-1 Joint Materials.

932-1.1 Preformed Joint Filler for Pavement and Structures: Preformed joint filler shall meet the requirements of AASHTO M153 or AASHTO M213, or cellulose fiber types meeting all the requirements of AASHTO M213 (except for the asphalt content) is acceptable provided they contain minimums of 0.2% zinc borate as a preservative and 1.5% waterproofing wax. For AASHTO M153, unless a particular type is specified, either Type I, Type II or Type III may be used.

Preformed joint fillers shall have a thickness equal to the width of the joint required, and shall be furnished in lengths equal to the widths of the slabs in which they are to be installed, except that strips which are of a length not less than the distance between longitudinal joints, or between longitudinal joint and edge, may be used if laced or clipped together in a manner approved by the Engineer. The depth and shape of the joint filler shall conform to the dimensions shown in the Plans. For doweled joints, proper provision shall be made for the installation of the dowels.

932-1.1.1 Certification: The Contractor shall ~~provide~~submit to the Engineer a certification ~~conforming to the requirements of Section 6 from the manufacturer,~~ confirming that the preformed joint filler meets the requirements of this Section. The certification shall conform to the requirements of Section 6.

932-1.2 Joint Sealer for Pavement and Structures:

932-1.2.1 General: This Specification covers joint sealer intended for use in sealing joints in asphaltic concrete pavement and portland cement concrete pavement. These materials may also be used to seal joints in portland cement concrete bridges and other structures.

932-1.2.2 Material: The joint sealant shall be composed of a mixture of materials, typically but not limited to bituminous based, that will melt when heated for application and then solidify to form a resilient and adhesive compound capable of sealing joints in portland cement concrete and asphaltic concrete against the infiltration of moisture and foreign materials throughout normal pavement conditions and at ambient temperatures. The manufacturer shall have the option of formulating the material according to their Specifications. However, the requirements delineated in this Specification shall apply regardless of the type of formulation used. The material shall cure sufficiently to not flow from the joint or be picked up by vehicle tires after 3 hours at 77°F. The material shall be capable of a uniform application consistency suitable for filling joints without the inclusion of large air holes or discontinuities and without damage to the material.

Materials for pavement joints shall be tested according to ASTM D5329.

932-1.2.2.1 Physical Requirements of Joint Sealants for Portland Cement Concrete Only:

Parameter	Limits
Pour Point	At least 20°F lower than the safe heating temperature as stated by the manufacturer.
Cone-Penetration, Non-	Less than or equal to 90 mm

Parameter	Limits
immersed at 77°F, 150 g, 5 s	
Flow at 140°F, 5 h	Less than or equal to 5.0 mm
Bond, Non-immersed, 0°F for 5 cycles*	No cracking, separation, or opening that at any point is over 1/4 inch deep, in the sealant or between the sealant and the substrate.
*The depth of a crack, separation or opening shall be measured perpendicular to the side of the sealant showing the defect. At least two test samples in a group of three representing a given sample of sealant shall meet this requirement.	

932-1.2.2.2 Physical Requirements of Joint Sealants for Portland Cement Concrete and/or Asphaltic Concrete:

Parameters	Limits
Pour Point	At least 20° lower than the safe heating temperature as stated by the manufacturer.
Cone-Penetration, Non-immersed at 77°F, 150 g, 5 s	Less than or equal to 90 mm
Flow at 140°F, 5 h	Less than or equal to 3.0 mm
Bond, Non-immersed, -20°F for 3 cycles, 50% extension*	No cracking, separation, or opening that at any point is over 1/4 inch deep, in the sealant or between the sealant and the substrate.
Resilience at 77°F	Recovery greater than or equal to 60%
Asphaltic Concrete Compatibility at 140°F	No failure in adhesion, formation of an oily exudates at the interface between the sealant and the asphaltic concrete, or softening or other deleterious effects on the asphaltic concrete or sealant.
*The depth of a crack, separation or opening shall be measured perpendicular to the side of the sealant showing the defect. At least two test samples in a group of three representing a given sample of sealant shall meet this requirement.	

932-1.2.3 Approved Product List (APL): The joint sealant materials used shall be one of the products listed on the Department's APL. Manufacturers seeking evaluation of their products shall submit product datasheets, performance test reports from an independent laboratory showing the product meets the requirements of this section, and a APL application in accordance with Section 6. Information on the APL application must identify the sealant type.

932-1.2.4 Shipment: The material shall be delivered in containers plainly marked with the manufacturer's name or trademark product name, LOT number and date of expiration.

932-1.2.5 Bond Breaker Rod: The bond breaker rod shall be a closed cell, expanded polyethylene foam rod of the size and dimensions shown in the Plans. It shall be compatible with the joint sealant and no bond or reaction shall occur between the rod and the sealant.

All bond breaker rods installed shall be covered by a sealant at the end of each work day.

Bond breaker tape approved by the sealant manufacturer may be used in lieu of bond breaker rod when sealing random cracks.

932-1.3 Low Modulus Silicone Sealant Materials:

932-1.3.1 Low Modulus Silicone Sealants: Silicone sealant shall be furnished in a one part or pre-measured two part formulation meeting the requirements specified herein.

Acetic acid cure sealants are not acceptable. A primer as specified in 932-1.4 for bonding sealant to concrete shall be used if required by the manufacturer. When a manufacturer's product is tested and approved by the Department using a primer, primer will be required for project installation.

Do not use Low Modulus Silicone Sealants Types A, B or C for bridge expansion joints.

Silicones shall be identified in the following manner:

Type A - A low modulus, non-sag (non-self-leveling) silicone formulation, used in sealing horizontal and vertical joints in cement concrete pavements and bridges (i.e., concrete-concrete joints). Tooling is required.

Type B - A very low modulus, self-leveling silicone formulation, used in sealing horizontal joints (including joints on moderate slopes) in cement concrete pavements and bridges (i.e., concrete-concrete joints). Tooling is not normally required.

Type C - An ultra-low modulus, self-leveling silicone formulation, used in sealing horizontal joints (including joints on moderate slopes) in cement concrete pavements and bridges (i.e., concrete-concrete joints). It can also be used to seal the joints between cement concrete pavements and asphalt concrete shoulders (including asphalt-asphalt joints). Tooling is not normally required.

Type D - An ultra-low modulus, self-leveling silicone formulation, cold-applied, rapid-cure, used to seal expansion joints that experience both thermal and/or vertical movements. The material must cure by chemical reaction and not by evaporation of solvent or fluxing of harder particles. Tooling shall not be required. Use according to Design Standards, Index No. 21110 for bridge deck expansion joints with backer rods or as shown in the Plans for other joints with or without backer rods.

932-1.3.2 Physical Requirements:

Silicone Sealant Type	Test Method	Type A	Type B	Type C	Type D
Flow	ASTM D5893	No Flow			
Slump (maximum)	ASTM D2202	0.3 inches			
Extrusion rate (minimum)	ASTM C1183, Procedure A	20 ml/min	20 ml/min	20 ml/min	20 ml/min
Tack-free time at 77 ± 3ºF and 45 to 55% Relative Humidity	ASTM C679	90 minutes maximum	180 minutes, maximum	180 minutes, maximum	20 – 60 minutes
Specific gravity	ASTM D792, Method A	1.1 to 1.515	1.10 to 1.40	1.1 to 1.5	1.26 to 1.34
Durometer hardness, Shore A	ASTM D2240	10-25			

Silicone Sealant Type	Test Method	Type A	Type B	Type C	Type D
(Cured seven days at 77 ± 3ºF and 50 ± 5% Relative Humidity)					
Durometer hardness, Shore 00 (Cured 21 days at 77 ± 3ºF and 50 ± 5% Relative Humidity)	ASTM D2240		40-80	20-80	
Tensile stress (maximum) at 150% elongation	ASTM D412 (Die C)	45 psi	40 psi	15 psi	
Elongation (Cured seven days at 77 ± 3ºF and 50 ± 5% Relative Humidity)	ASTM D412 (Die C)	800% minimum			600% minimum
Elongation (Cured 21 days at 77 ± 3ºF and 50 ± 5% Relative Humidity)	ASTM D412 (Die C)		800% minimum	800% minimum	
Ozone and Ultraviolet Resistance	ASTM C793	No chalking, cracking or bond loss after 5,000 hours, minimum.			
Bond to cement mortar briquets (primed if required)	AASHTO T132	50 psi minimum			

Silicone Sealant Type	Test Method	Type A	Type B	Type C	Type D
(Cured seven days at 77 ± 3ºF and 50 ± 5% Relative Humidity)					
Bond to cement mortar briquets (Cured 21 days at 77 ± 3ºF and 50 ± 5% Relative Humidity)	AASHTO T132		40 psi minimum	35 psi minimum	
Movement Capability	ASTM C719	No adhesive or cohesive failure and adhesion, 10 cycles at -50 to +100%			No adhesive or cohesive failure and adhesion, 10 cycles at +100/-50 %

Portland Cement Mortar: Briquets shall be molded and cured 28 days minimum in accordance with AASHTO T132. Saw cut cured briquets in half, clean, and dry at 230°, plus or minus 5ºF. Bond the two halves together with a thin section of sealant. After cure of sealant, briquets shall be tested in accordance with AASHTO T132.

932-1.3.3 Field Cure: Six-inch samples of the sealant shall be taken by the Engineer from the joint at the end of a two week curing period and tested for durometer hardness (by FM ANSI/ASTM D2240), except that the requirements of a 1 inch sample width shall not apply. A minimum hardness of 7.0 is required as evidence of adequate cure.

932-1.3.4 Approved Product List: The low modulus silicone sealant used shall be one of the products listed on the APL. Manufacturers seeking evaluation of their products shall submit product datasheets, performance test reports from an independent laboratory showing the product meets the requirements of this Section, an infrared identification curve (2.5 to 15 µm) and an APL application in accordance with Section 6. Information on the APL application must identify the sealant type.

932-1.3.5 Shipment: The material shall be delivered in containers plainly marked with the manufacturer's name or trademark product name, LOT number and date of expiration.

932-1.3.6 Primer: When required by the manufacturer's product, a primer shall be used.

The manufacturer shall perform quality control tests on each LOT of sealant primer material furnished to each project and ~~furnish~~submit a certified report that each

LOT of primer material furnished to a project meets thise company's specifications for that product and the primer is suitable for its intended use.

Sealant primer material shall be delivered in containers plainly marked with the manufacturer's name or trademark and product name, LOT number and date of expiration.

932-1.3.7 Backer Rod and Tape Bond Breakers: Backer rods and tape shall be compatible with the joint sealant and approved by the sealant manufacturer. No bond or reaction shall occur between the rod and the sealant.

932-1.3.8 Installation: Installation, material selection, joint dimensions, bond breaker suitability (by type and project) shall be in agreement with the requirements of the Design Standards, Index Nos. 305 and 21110. Any modifications or exceptions to these requirements shall be shown in the Plans.

For new construction projects or general use where the joints to be sealed have uniform width, a closed cell, expanded polyethylene foam backer rod bond breaker shall be required. For rehabilitation projects and similar joint seals where the joints to be sealed have irregular width, an open cell, expanded polyethylene foam backer rod bond breaker with an impervious skin shall be required.

The backer rod shall be compatible with the joint sealant. No bond or reaction shall occur between the rod and the sealant.

Tape bond breaker approved by the sealant manufacturer may be used in lieu of backer rod bond breaker when sealing joints and/or random cracks, as required.

Type D Silicone sealant shall be placed when the ambient temperature is rising and is between 55°F and 85°F and the temperature is expected to rise for the next three hours minimum to provide to adequate joint opening and compression of the sealant during curing.

All installed bond breakers shall be covered by sealant at the end of each work day.

A tolerance in cross-sectional height at midpoint of minus 1/16 inches to plus 3/16 inches will be allowed to the nominal values shown for each joint width on the plan sheet. The Engineer shall check one joint for each 1,000 feet of roadway by cutting out specimens. If the cross section of the cut specimen is out of the allowable range, additional specimens shall be taken as follows:

One joint every 100 feet of pavement, not to exceed 500 feet.

If the average of the specimens is out of tolerance, the Contractor shall remove and replace the entire 500 foot section at no additional expense to the Department.

Installation tolerance shall be verified at 1,000 foot intervals.

932-1.4 Pre-cured Silicone Sealant:

932-1.4.1 General: Pre-cured silicone sealants are intended for sealing vertical joints on concrete surfaces. Type V1 sealant is intended for contraction joints or joints with movements less than 1/4 inches. Type V2 sealant is intended for expansion joints not exceeding 200% of the nominal joint opening. Type V2 sealant may be substituted for Type V1 sealant. The joint sealant must be listed on the APL.

932-1.4.2 Physical Requirements: Sealant material shall be a nominal 1/16 inches thick, available in standard widths from 1 inch to 6 inches, colored to match the finish surface coating of the concrete, and meet the following minimum testing requirements:

TEST PROPERTY DESCRIPTION	TEST METHOD	TYPE V1	TYPE V2
Minimum Movement, Cohesion/Adhesion	ASTM C1523	100%	200%
Dry/Room Temperature Loss of Adhesion/Cohesion	ASTM C1523	None	None
Water Immersion Loss of Adhesion/Cohesion	ASTM C1523	None	None
Frozen Loss of Adhesion/Cohesion	ASTM C1523	None	None
Heat Loss of Adhesion/Cohesion	ASTM C1523	None	None
Artificial Weathering Loss of Adhesion/Cohesion	ASTM C1523	None	None
Tear Propagation	ASTM C1523	NT or PT (No Tear or Partial/Knotty Tear)	NT or PT (No Tear or Partial/Knotty Tear)
Ultimate Elongation	ASTM D412	250%	500%

932-1.4.3 Approved Product List: The pre-cured silicone sealant used shall be one of the products listed on the APL. Manufacturers seeking evaluation of their product shall submit an application in accordance with Section 6. Applications must include test results, an infrared identification curve (2.5 to 15 µm), and a product data sheet with the recommended adhesive and installation requirements.

932-1.5 Compression Seals and Adhesive Lubricant

932-1.5.1 Preformed Elastomeric Compression Seals: Preformed Elastomeric Compression Seals shall meet the requirements of ASTM D2628 except that immersion oil IRM 903 may be substituted for Oil No. 3 in the Oil Swell test procedure.

932-1.5.2 Compression Seal Adhesive Lubricant: Compression seal adhesive lubricant shall meet the requirements of ASTM D4070. The material shall be fluid from 5°F to 120°F (-15°C to 49°C).

932-1.5.3 Certification: The manufacturer shall ~~provide~~submit a certified test report for each lot of material furnished to each project along with a statement certifying that the material conforms to this specification and identifying the project number and manufacturer's lot number.

932-1.5.4 Verification Samples: Provide verification samples in accordance with Section 6.

932-2 Structure Bearing Pads.

932-2.1 General: Furnish elastomeric structure bearing pads as shown in the Contract Documents. Elastomeric bearings as defined herein shall include plain pads (elastomer only) and laminated bearings with steel or fabric laminates. Flash tolerance, finish and appearance of bearings shall meet the requirements of the latest edition of the Rubber Handbook as published

by the Rubber Manufacturer's Association, Inc. RMA-F3-T.063 for molded bearings, and RMA-F2 for extruded bearings.

932-2.2 Materials: Use elastomer that is Grade 2 or higher, as defined in the AASHTO LRFD Bridge Design Specifications, crystallization resistant, 100% virgin polychloroprene (neoprene). Use only new materials; reclaimed material is not allowed in the finished product. No wax, anti-ozonants, or other foreign material may accumulate or be applied to the surfaces of the bearing. The steel layers of the laminated pads shall utilize 10 gauge steel sheet (0.1345 inches thick). The steel utilized for the steel layers and for external load bearing plates (if specified) shall meet the requirements of ASTM A36 or ASTM A1011 Grade 36 Type I steel sheet. External load bearing plates shall be finished or machined flat to within 0.01 inches. The bottom surfaces of external load plates (masonry plates) designed to rest on bearing pads shall not exceed an out of flatness value of 0.0625 inches. External load bearing plates shall be protected from rust until all exposed surfaces can be field painted. Any rust inhibitor shall be removed from all surfaces prior to welding.

932-2.3 Sampling: A sampling LOT shall consist of a maximum of 100 bearing pads of a single type of bearing (plain, steel laminates, fabric laminates), of the same design, materials, thickness, and manufacturer, referred to here as "like pads", delivered to the project site or to an offsite storage facility within the State of Florida in reasonable proximity to the project site as determined by the Engineer. Organize stockpiled pads into groups of like pads by LOT so that they can be readily identified and sampled by the Engineer.

932-2.3.1 Ancillary Structure Pads: Sampling is not required and acceptance is by certification.

932-2.3.2 Bridge Structure Pads: For LOT sizes that exceed 10, a minimum of two bridge bearing pads per LOT will be selected by the Engineer, one for testing and one for confirmation in the event of a failing test result. LOTs will be sampled only after all like pads in the LOT are at the project site or in an offsite storage facility. When the total number of like pads consists of a single LOT of 10 or less, sampling is not required and acceptance is by certification. ~~Provide~~Submit to the Engineer a certification conforming to the requirements of Section 6 stating that the structure bearing pads meet the requirements of this Section. Samples shall consist of complete pads as detailed in the Plans. Furnish additional complete bridge bearing pads to replace those selected for testing. Bridge bearing pads shall be available for sampling a minimum of three weeks prior to their installation. The sample bridge bearing pads shall be tested by an independent laboratory approved by the Department.

932-2.4 Dimensional Tolerances: Fabricate elastomeric bearings within the dimensional tolerances specified below or as designated in the Plans. If any of the dimensions are outside the limits specified, the bearing pad shall be rejected.

Measurement		Tolerance (inches)
1. Overall vertical dimensions	Design thickness ≤1.25 inches	-0, +0.125
	Design thickness >1.25 inches	-0, +0.25
2. Overall horizontal dimensions	measurements ≤36 inches	-0, +0.25
	measurements >36 inches	-0, +0.50
3. Thickness of individual layers of elastomer (laminated bearings only) at any point within the bearing		±0.125
4. Variation from a plane parallel to the theoretical surface (as determined by	Top (slope relative to bottom)	≤0.005 radians
	Sides	0.25

Measurement	Tolerance (inches)
measurements at the edge of the bearings)	
5. Position of exposed connection members	±0.125
6. Edge cover of embedded laminates of connection members	-0, +0.125
7. Position and size of holes, slots, or inserts	±0.125
Note: If the variation in thickness of individual layers of elastomer is greater than that allowed in the tolerance for Measurement (3) (±0.125 in.), use the following equation to determine compliance: $7.5\theta + v/hr < 0.35$ provided $\theta \leq 0.02$ where θ (radians) and v (in) are absolute values of steel laminate rotation and vertical displacement. If the specified layer elastomeric layer thickness is h_r, the bearing length is L, and H_1 and H_2 are the measured maximum and minimum thicknesses at the edges of the layer, then $v=\|h_r-1/2(H_1+H_2)\|$ and $\theta=\|(H_1-H_2)/2L\|$ for interior layers and $\theta=\|(H_1-H_2)/L\|$ for top and bottom layers provided that the minimum elastomer layer thickness $H_2 \geq 0.2$ in.	

932-2.5 Ancillary Structures - Plain, Fiber Reinforced, or Fabric Laminated Bearing Pads:

932-2.5.1 Plain Pads: Plain pads shall be either molded, extruded, or vulcanized in large sheets and cut to size. Cutting shall not heat the material and shall produce a smooth finish conforming to ANSI B46.1, 6.3 µm (0.248 mils). Plain pads shall be molded or extruded to the finished thickness. Plying pads of lesser thickness together shall not be permitted. External load plates, when used, shall be protected from rusting and shall be hot bonded by vulcanization during the primary molding process. The finished pads shall withstand a minimum uniform compressive load of 1200 psi when tested in accordance with FM 5-598.

932-2.5.2 Fiber Reinforced or Fabric Laminated Pads: Fiber reinforced pads shall be constructed with a homogeneous blend of elastomer and random-oriented high strength synthetic fiber cords. Bearing pads may be molded and vulcanized in large sheets and cut to size. Cutting shall be performed so as to prevent heating and must produce a smooth finish conforming to ANSI B46.1.

Fabric laminated bearings shall be constructed of multiple layers of fabric and elastomer. The fabric shall be composed of 8 ounce cotton duck and the pads manufactured in accordance with Military Specification MIL-C-882. Ensure the fabric is free of folds or ripples and parallel to the top and bottom surfaces.

Fiber reinforced and fabric pads shall withstand a minimum uniform compressive load of 2,400 psi when tested in accordance with FM 5-598.

932-2.5.3 Certification: The Contractor shall ~~provide~~submit to the Engineer a certification conforming to the requirements of Section 6 stating that the ancillary structure pads meet the requirements of this Section and the physical and heat resistance properties of Section 6 of FM 5-598.

932-2.6 Bridge Structures - Elastomeric Bearing Pads: Bearings with steel laminates shall be cast as a unit in a mold and bonded and vulcanized under heat and pressure. Bearings with steel laminates which are designed to act as a single unit with a given shape factor must be manufactured as a single unit. The mold shall have a standard shop practice mold finish. The internal steel laminates shall be blast cleaned to a cleanliness that conforms to SSPC-SP6 at the time of bonding. Plates shall be free of sharp edges and burrs and shall have a minimum edge cover of 0.25 inches. External load plates (sole plates) shall be hot bonded to the bearing during vulcanization.

Edges of the embedded steel laminates, including the laminate restraining devices and around holes and slots shall be covered with not less than 3/16 inches of elastomer or the minimum edge cover specified in the Plans. All exposed laminations or imperfections that result

in less than the specified elastomer cover of any surface of the steel laminations shall be repaired by the manufacturer at the point of manufacture. The repair shall consist of sealing the imperfections flush on the finished pads with a bonded vulcanized patch material compatible with the elastomeric bearing pad. Repairs employing caulking type material or repairing the bearings in the field will not be permitted.

932-2.6.1 Testing: Test bridge bearing pads in accordance with FM 5-598. Laminated bridge bearings must meet a minimum compressive load of 2,400 psi and non-laminated (plain) pads must meet a minimum compressive load of 1,200 psi. If any properties are identified as non compliant with the criteria specified, the bearing shall be rejected and the confirmation sample tested. If the confirmation sample test results are also non compliant, the LOT shall be rejected.

932-2.6.2 Marking: Each elastomeric bearing pad shall be permanently marked. The marking shall consist of the order number, LOT number, pad identification number, elastomer type, and shear modulus or hardness (when shear modulus is not specified). Where possible, the marking shall be on a face of the bridge bearing pad that will be visible after erection of the structure.

932-2.6.3 Certified Test Results: For bridge bearing pads, ~~provide~~submit a complete certified ~~copy of~~test results from the independent laboratory~~'s complete test results~~ for all tests specified, properly identified by LOT and project number, to the Engineer.

932-2.6.4 Certification: The Contractor shall ~~provide~~submit to the Engineer a certification conforming to the requirements of Section 6 stating that the bearing pads, (plain, fiber reinforced or elastomeric) meet the requirements of this Section. The certification shall designate the bearings in each LOT and state that each of the bearings in the LOT was manufactured in a reasonably continuous manner from the same batch of elastomer and cured under the same conditions.

932-3 Fiber Reinforced Polymer (FRP) Reinforcing Bars.

932-3.1 General: Use only solid round thermoset pultruded glass fiber reinforced polymer (GFRP) or carbon fiber reinforced polymer (CFRP) reinforcing bars. All FRP reinforcing bars shall meet the requirements of ACI 440.6 following the test methods from ACI 440.3. Use only GFRP bars manufactured using glass fibers classified as E-CR or R that meet the requirements of ASTM D578. Meet the additional requirements of this Section following the sampling frequency and number of specimens required by ACI 440.6.

932-3.2 Additional Requirements for Bar Size and Strength: The nominal diameter of FRP bars shall be in 1/8 inch increments as described in Table 3-1.

The measured cross-sectional area of FRP bars, including deformations, lugs, sand coating or any bond enhancing surface treatment shall be measured according to ASTM D7205 via the Archimedes method.

The minimum bar diameter, derived from the actual cross sectional area and calculated based on a circular cross section including any surface treatment, shall be greater than or equal to the nominal bar diameter given in Table 3-1.

The maximum bar diameter, derived from the actual cross sectional area and calculated based on a circular cross section including any surface treatment, shall be less than or equal to the maximum bar diameter derived from the maximum cross section area given in Table 3-1.

The nominal diameter and nominal cross-sectional area of an FRP bar shall be used as the bar size designation and for reinforced concrete design calculations and minimum mechanical properties.

Table 3-1
Size and Strength of FRP reinforcing bars

Bar Size Designation	Nominal Bar Diameter (in)	Nominal Cross Sectional Area (in^2)	Maximum Cross Sectional Area (in^2)	f^*_{fu}, Guaranteed Ultimate Tensile Strength (ksi)	
				GFRP Bars	CFRP Bars
2	1/4	0.049	0.058	125	210
3	3/8	0.110	0.132	120	190
4	1/2	0.196	0.234	110	170
5	5/8	0.307	0.367	95	160
6	3/4	0.442	0.529	92.5	160
7	7/8	0.601	0.721	90	-
8	1	0.785	0.942	85	-
9	1-1/8	0.994	1.192	82.5	-
10	1-1/4	1.227	1.472	80	-

932-3.3 Additional Requirements for Strength of Bar Bends: Meet the requirements of ACI 440.6, Section 10.2, except substitute Sections 10.2.2.1 and 10.2.2 with the following:

Extract straight portions from bent bars of sufficient length to be tested according to ASTM D7205. The tensile strength and tensile modulus of each specimen shall not be less than the guaranteed strength reported by the producer for a bar of that diameter, with minimum values as shown in Table 3-1.

When the bent shape does not allow for the tensile testing of one of its straight portions, a test specimen produced at the same time, during the same production lot, but of sufficient length to perform the required testing, may be used.

932-3.4 General Additional Requirements: Meet the applicable requirements of the Materials Manual and the additional requirements of Table 3-2 for qualification of producers of FRP reinforcing bars seeking approval to be placed on the Department's Production Facility Listing. Producers seeking evaluation of a product in accordance with this Specification must submit test reports conducted by an independent laboratory, qualified by an ISO 17025 accreditation agency, using personnel with actual experience running the test methods for FRP reinforcing bars. Submit the test reports to the State Materials Office.

Table 3-2
Additional Requirements for Qualification of Producers of FRP Reinforcing Bars

Property	Test Method	Requirement
Fiber Content	ASTM D2584 or ASTM D3171	>55% - volume >70% - weight
Moisture adsorption	ASTM D570	≤0.75% (long term immersion to full saturation) at 122°F
Resins Glass transition	ASTM E1640 – DMA	≥230°F

temperature (T_g)	or ASTM E1356 - DSC	≥212°F
Total enthalpy of polymerization (resin)	ASTM E2160	Report value for each resin system used
Minimum Mean Tensile Modulus of Elasticity	ASTM D7205	≥6,500 ksi - GFRP ≥18,000 ksi - CRFP
Alkali resistance without load	ASTM D7705	Tensile capacity retention ≥80% of ultimate tensile stress (UTS) after 90 days
Alkali resistance with load	ASTM D7705; set sustained tensile stress to induce tensile strain of 3000 micro-strain	Tensile capacity retention ≥70% of ultimate tensile stress (UTS) after 90 days
Strength of bent portion of a bar	ACI 440.3, Method B.5	>60% of straight portion of bar
Transverse Shear Strength	ASTM D7617	>22 ksi
Bond Strength	Block pull-out by ACI 440.3R, Method B.3	>1.1 ksi

932-3.4.1 Certification: Meet the testing requirements of Table 3-3 for product acceptance. Submit to the Engineer a certification from the producer of the FRP bars, confirming that the requirements of this Section are met. The certification shall conform to the requirements of Section 6. Submit one certification per LOT of FRP reinforcing bars. Test results must meet the requirements of Table 3-3 using an independent ISO 17025 accredited laboratory with actual experience running the test methods for FRP reinforcing bars.

932-3.4.2 Sampling: A minimum of six samples of reinforcing bars per LOT will be selected by the Engineer. The minimum sample length is seven feet. A LOT will be sampled only after the entire LOT is delivered to the project site or in an offsite storage facility. Furnish additional bar footage to account for samples selected for testing. FRP reinforcing bars shall be available for sampling a minimum of three weeks prior to their installation.

Table 3-3
Additional Requirements for FRP Reinforcing Bar Product Acceptance

Property	Test Method	Requirement
Degree of cure	ASTM E2160	≥95% of total polymerization enthalpy
Fiber content	GFRP – ASTM D2584 or ASTM D3171 CFRP - ASTM D3171	GFRP - Glass fiber weight fraction ≥70% when ASTM D2584 is used GFRP & CFRP - Volume fraction ≥55%
Void content	ASTM D2734	≤1%
Moisture absorption	ASTM D570	≤0.25% in 24 hours at 122°F
Bar Size - Actual Cross Sectional Area	ASTM D7205	See Table 3-1
Minimum & Maximum Bar Diameter	Calculated from Actual Cross Sectional Area	See Table 3-1

Guaranteed Ultimate Tensile Strength (f^*_{fu})	ASTM D7205	See Table 3-1
Minimum Mean Tensile Modulus of Elasticity	ASTM D7205	≥6,500 ksi GFRP ≥18,000 ksi CFRP

932-4 FRP Spirals for Concrete Piling.

Spirals for reinforcing in concrete piling shall be CFRP conforming to the requirements of ACI 440.6, following the test methods from ACI 440.3 and the material requirements of 932-3.