**SPECIAL PROVISION**

**SECTION 0XXXXX**

**REINFORCING FIBERS FOR ASPHALT**

1. DEFINITIONS
2. Reinforcing Fibers: High tensile strength aramid fiber blend specially formulated to reinforce hot mix asphalt.
3. Fiber reinforced asphalt concrete (FRAC): A mixture of hot or warm mix asphalt and reinforcing fibers that has greater resistance to rutting, thermal cracking, fatigue cracking, and reflective cracking as compared to conventional non-fiber asphalt mixes.
4. Aramid Dispersion State Ratio (ADSR): A measure of the dispersion efficiency of the Reinforcing Fibers within asphalt mixes. ADSR is calculated by comparing the mass of aramid in the individual state to the total mass of extracted aramid fibers, expressed as a percentage.
5. REFERENCES
6. ASTM D2172, Standard Test Methods for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
7. ASTM D6931, Standard Test Method for Indirect Tensile (IDT) Strength of Bituminous Mixtures.
8. AASHTO T322, Determining the Creep Compliance and Strength of Hot-Mix Asphalt (HMA) Using the Indirect Tensile Test Device.
9. AASHTO TP79, Standard Method of Test for Determining the Dynamic Modulus and Flow Number (FN) for Asphalt Mixtures Using the Asphalt Mixture Performance Tester.
10. Zeiada, W., Underwood, S., Stempihar, J., “Extraction of Aramid Fibers from Fiber Reinforced Asphalt Concrete – Special Test Method”, Arizona State University, May 11, 2016.
11. SUBMITTALS
12. Submit the following as part of the bid package:
	1. Representative fiber product sample.
13. Fiber product data sheet and certification from the Manufacturer that the fiber product supplied meets the requirements of this specification.
14. Manufacturer’s instructions and general recommendations.
15. Performance test results of ADSR testing from a minimum of three separate laboratory trials to validate Dispersion Efficiency.
16. Performance test results of IDT testing from a minimum of three separate laboratory trials to validate Cracking Resistance.
17. Performance test results of FN testing from a minimum of three separate laboratory trials to validate Rutting Resistance.

**\*\*NOTE: Testing is NOT required on samples from the job mix, submit previously completed lab testing only.**

1. Submit a minimum of five unique project examples and references where the reinforcing fiber product was used within 250 miles of the project location.
2. MATERIALS AND PERFORMANCE
3. Reinforcing Fiber Properties
	1. Provide a reinforcing fiber blend of Virgin Polyolefins and Virgin Aramids that meets the requirements in Table 1 and Table 2 below.

Table 1

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| --- |
| **Reinforcing Fiber Material Properties** |
| **Property** | **Test Method** | **Polyolefin** | **Aramid** |
| Form | Manufacturer Certification | Serrated | Monofilament |
| Nominal Specific Gravity | ASTM D276 | 0.91 | 1.44 |
| Tensile Strength (psi) | ASTM D7269 | NA1 | 400,000 |
| Length (in) | Manufacturer Certification | 0.75 | 0.75 |

1. Polyolefin fibers will melt or become plastically deformed during production

Table 2

|  |
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| **Reinforcing Fiber Performance Properties** |
| **Performance Measure** | **Test Method** | **Standard** | **Requirement** |
| Dispersion Efficiency | Aramid Dispersion State Ratio (ADSR) | Modified ASTM D2172 | ≥ 85% |
| Cracking Resistance | Indirect Tensile Strength (IDT) | AASHTO T322 or ASTM D6931 | ≥ 20% increase |
| Resistance to Permanent Deformation (Rutting) | Flow Number (FN) | AASTHO TP79 | ≥ 35% increase |

* 1. FORTA-FI®, provided by the Forta Corporation, is an acceptable product and meets the performance and material properties outlined in this section.
	2. If a different aramid-based fiber blend is proposed, performance test results complying with Section D.2 below must be submitted at least two weeks prior to bid date for approval by engineer.

* 1. Non-aramid fiber blends will not be considered as acceptable alternatives to this specification.
1. Performance Testing Requirements

Testing shall be from previously completed laboratory trials performed on plant mixed FRAC. **Testing is NOT required on samples from the job mix.**

Performance Testing must be from laboratory trials at a fiber dosage rate equal to the rate proposed for the project. Tests must be performed by an AASHTO accredited laboratory or nationally recognized university testing lab and must be reviewed and approved by the project engineer.

1. Indirect Tensile (IDT) Strength Tests from a minimum of three (3) separate laboratory trials.
	* + 1. Perform IDT tests using the protocol from AASHTO T322 or ASTM D6931.
			2. Tests results shall include a control and a fiber reinforced mix. FRAC mix shall be identical to control mix except for the inclusion of fibers added at the same dosage as proposed on the project.
			3. IDT results from fiber specimens shall show an average tensile strength increase of 20 percent over control specimen with no less than 15 percent increase of average tensile strength.
2. Aramid Dispersion State Ratio (ADSR) Tests from a minimum of three (3) separate laboratory trials.
3. Perform ADSR test based on modified ASTM D2172 procedures as provided in the document entitled “Extraction of Aramid Fibers from Fiber Reinforced Asphalt Concrete – Special Test Method”. A copy of the modified extraction methodology can be obtained by making an inquiry to the Pavement and Materials Laboratory at Arizona State University at NCE@asu.edu.
4. To validate ADSR results, average extracted aramid fiber quantity must equal 0.007 percent by total sample weight with no individual result less than 0.005 percent of the total sample weight.
5. All tested fiber mixes must achieve a minimum ADSR of 85%.
6. Flow Number (FN) Tests from a minimum of three (3) separate laboratory trials.
7. Perform FN tests using the protocol from AASHTO TP79.
8. Tests results shall include a control and a fiber reinforced mix. FRAC mix shall be identical to control mix except for the inclusion of fibers added at the same dosage as proposed on the project.
9. Results from fiber specimens shall each show an average FN increase of at least 35% over control specimens.
10. DELIVERY, STORAGE, AND HANDLING
11. Deliver fiber-reinforcement in sealed, undamaged containers with labels intact and legible, indicating material name and lot number.
12. Deliver fiber-reinforcement to location where it will be added to each batch or loaded into the mixer.
13. Store materials covered and off the ground. Keep sand and dust out of boxes and do not allow boxes to become wet.
14. MIXING AND PRODUCTION
	1. Add aramid and polyolefin reinforcing fiber blends at a dosage rate of one (1) pound fiber per one (1) ton of asphalt.
	2. Add alternative aramid fiber blends at a rate proposed by the manufacturer that achieves the ADSR, IDT, and FN results required by Section D.
	3. Have a fiber manufacturer’s representative on site during mixing and production. This requirement can be waived if fiber manufacturer and asphalt producer can supply evidence of manufacturer’s brand of fiber being successfully produced a minimum of three times at the asphalt plant to be used for the project.
	4. Batch Plant. When a batch plant is used, add fiber to the aggregate in the weigh hopper and increase both dry and wet mixing times. Ensure that the fiber is uniformly distributed before the injection of asphalt cement into the mixture.
	5. Drum Plant:
		* 1. Inject fibers through the RAP collar manually or by feeding them with a metered air blown system to promote rapid and complete fiber dispersion. Rate the feeding of fibers with the rate the plant is producing asphalt mix. If there is any evidence of fiber bundles at the discharge chute, increase the mixing time and/or temperature or change the angle of the fiber feeder line to increase dry mixing time.
			2. Add fibers continuously and in a steady uniform manner. Provide automated proportioning devices and control delivery within ±10% of the mass of the fibers required. Perform an equipment calibration to the satisfaction of the fiber manufacturer’s representative to show that the fiber is being accurately metered and uniformly distributed into the mix.

 Include the following with the air blown system:

* + - * + Low level indicators
				+ No-flow indicators
				+ A printout of feed rate status in pounds/minute
				+ A section of transparent pipe in the fiber supply line for observing consistency of flow or feed.
				+ Manufacturer’s representative’s approval of fiber addition system
1. PLACEMENT

Follow manufacturer’s and engineer’s recommendations for placement of FRAC.

1. QUALITY CONTROL
	1. Aramid Dispersion Visual Test: Collect a 10kg sample of mix from the discharge chute during first 50 tons of production. Visually assess the state of aramid fibers in the sample according to Reference 4 (Section B of this specification) and rate the sample as “Pass” or “Fail”.
		1. “Pass” = All fibers exist in an Individual State and no Undistributed Clips or Agitated Bundles of fiber are detected.
		2. “Fail” = One or more Undistributed Clips or Agitated Bundles are detected.
	2. If a sample is rated as “Fail”, adjust mixing operations to improve fiber dispersion and repeat Step 1 above.
	3. If Visual Test results in three consecutive “Fail” ratings, plant mix samples should be sent to a third party laboratory for complete ADSR testing before production is allowed to commence.
	4. In addition to Visual Test, use a shovel to inspect FRAC mix in the back of first three trucks and every tenth truck thereafter to confirm adequate blending of the fiber.
	5. Remove any observed fiber bundles from placed mixture and adjust operations per the manufacturer’s recommendation to eliminate future fiber bundle development, and repeat Steps 1 through 3 above to confirm adequate aramid fiber dispersion.
2. PAYMENT

Payment shall be based on per ton of asphalt mix.