THE PROPOSED TEST SPECIFICATION FOR SPST

Test Procedure for

THE SIMPLE PUNCHING SHEAR TEST (SPST)

TxDOT Designation: Tex-2XX-F

Effective Date:

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1. SCOPE

1.1 This test method determines the shear properties of the compacted bituminous mixtures. The measurable and calculable shear parameters include shear strength, shear strain, shear modulus, shear strain energy, and shear strain energy index.

1.2 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

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2. APPARATUS

2.1 *Loading Press*, capable of applying a compressive load at a controlled deformation mode at the rate of 0.2 mm per second.

2.2 *Environmental chamber*, a temperature-controlled chamber capable of maintaining a temperature of up to 60°C.

2.3 *Loading Head*, a 1.5 in. diameter cylindrical metal head to be attached to the loading shaft of the Loading Press (Figure 1).

2.4 *Loading Base*, consisting of a 6.0 in. diameter cylindrical metal base with a 2.5 in. diameter concentric opening. The height of the Loading Base is at least 2.5 in. to allow enough space for accommodating the dislodged parts of the HMA (Figure 2).

2.5 *Sample Confinement*, made of a cylindrical enclosure and a collar strap to provide lateral confining pressure of about 20 psi to the sample (Figure 3).

2.6 *Torque Wrench*, with a torque capacity of 25 in-lb and appropriate socket drive handle.

Figure 1. Loading head.

Figure 2. Loading base pictorial illustration.

Figure 3. SPST sample confinement: Cylindrical enclosure and collar strap.

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3. SPECIMENS

3.1 *Laboratory-Molded Specimens*—prepare three specimens in accordance with Tex-241-F. Specimen diameter must be 6 in. (150 mm), and height must be 2.5±0.1 in. (63.5±2.5 mm). For consistency, test all specimens within 5 days of molding.

3.1.1 For WMA mixtures, select curing temperature and time according to binder grade, recycled materials, and target discharge temperature. Refer to Tex-241-F to mold WMA specimens.

Note 1—Cure WMA mixtures at 275°F for 4 hr±5 min. before molding. WMA is defined as HMA that is produced within a target temperature discharge range of 215°F and 275°F using WMA additives or processes.

3.1.2 Test specimen air void must be 7±1 percent, except for Permeable Friction Course (PFC) mixtures.

Note 2— Mixture weights for specimens prepared in the laboratory typically vary between 2400 and 2600 g to achieve the needed air-void due to different aggregate sources and mix types. A minimum of 3 pre-molded samples of different weight followed by interpolation to determine the actual weight that will produce samples with target density of 7±1 percent air void.

3.1.3 For PFC mixtures, mold test specimens to 50 gyrations (N_{design}).

Note 3— Select the mixture weight for the molded PFC specimens based on the weight used in the mix design.

3.2 *Core Specimens*–Specimen diameter must be 6±0.1 in. (150±2.5 mm), and height must be a minimum of 1.5 in. (38 mm). There is not a specific density requirement for core specimens.

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4. PROCEDURE

4.1 For laboratory-produced mixtures, proceed to Section 4.2. For plant-produced mixtures, proceed to Section 4.3. For roadway cores, proceed to Section 4.4.

4.2 Laboratory-Produced Mixtures:

4.2.1 Combine aggregates and prepare laboratory mixture as described in Tex-205-F.

4.2.2 Mold three specimens in accordance with Tex-241-F with the Superpave Gyratory Compactor (SGC).

4.2.3 Proceed to Section 4.4.

4.3 Plant-Produced Mixtures:

4.3.1 Sample the plant mixture in accordance with Tex-222-F.

4.3.2 Mold three specimens in accordance with Tex-241-F with the SGC.

4.3.3 Proceed to Section 4.4.

4.4 Measure and record the density, height, and diameter of each laboratory or plant-produced specimen or roadway core.

4.5 Place the specimens or cores, along with the testing apparatus (loading head, loading base, sample confinement), in the controlled temperature chamber for at

least 3 hours to ensure a consistent temperature of 50±1°C throughout. Always monitor the temperature using a dummy sample.

Note 4— For mixes to be placed in high-temperature areas, high shear stress locations, and urban stop-go environments (near intersections), test the samples at multiple temperatures (i.e., 50°C and 60°C), and report the test results for all tested temperatures.

4.6 Attach the Sample Confinement to the specimen.

4.7 Carefully place the confined specimen on the Loading Base. Make sure the Loading Base and the specimen are concentrically placed below the Loading Head (Figure 4).

Note 5— Keep track of the top and bottom of the specimen according to the direction of sample compaction or traffic loading in the case of field cores.

Figure 4. SPST specimen setup.

4.8 Slowly lower the loading head to lightly seat on the surface of the specimen.

4.9 Apply the load at a controlled deformation rate of 0.2 mm per second. Capture and save the complete load versus deformation (L-D) response curve for subsequent data analysis.

4.10 An operator shall observe the development of the load-deformation response curve in real time. The operator shall stop the test when the shear load passes the maximum point and has fallen back to zero point.

5. CALCULATIONS

5.1 Measure and record the following parameters from the load-displacement (L-D) response (Figure 5):

- Peak (failure) shear load, P_{max}
- Failure shear deformation at peak load, D@P_{max}
- Area under the shear L-D response curve = ∫f (x) dx

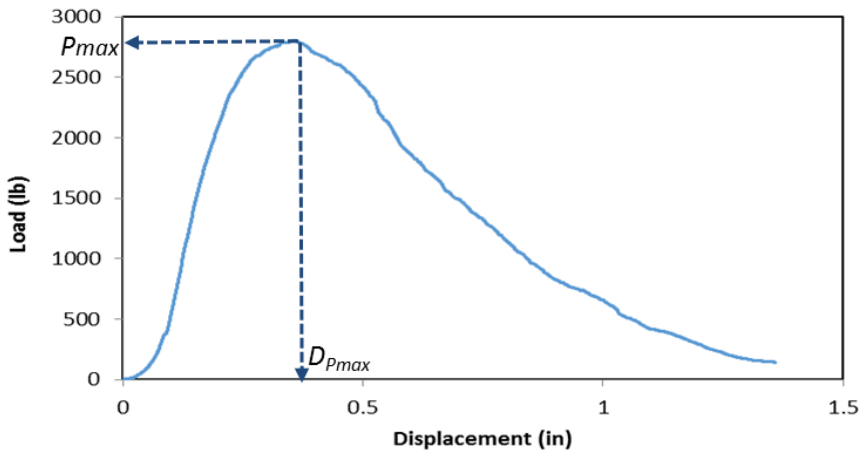

Figure 5. Typical SPST L-D curve.

Note 6— The Area under the shear L-D response curve, ∫f(x)dx may be approximated using trapezoidal rule *(Alternatively, Simpson's rule may be used to determine the area under the curve).*

$$\Delta A = \frac{N_d}{2n}[f(x_0) + 2f(x_1) + 2f(x_2) \ldots + 2f(x_{n-1}) + f(x_n)]$$

where $f(x_1)$ and $f(x_{i+1})$ are rut depth values at the left and right end of each trapezoid, respectively.

5.2 Calculate the HMA shear strength, τ (psi):

$$\tau = \frac{P_{max}}{\pi t d}$$

where, d = Diameter of the punching (loading) head = 1.5 in.

t = Thickness of the sample (in.)

5.3 Calculate the HMA failure shear strain at peak load, γ:

$$\gamma = \frac{D\ @\ P_{max}}{t}$$

where, D = Displacement (in.)

5.4 Calculate the HMA shear modulus, E (psi):

$$E = \frac{\tau}{\gamma}$$

5.5 Calculate the shear strain energy, SSE (KJ/m^2):

$$SSE = \frac{Area\ Under\ Curve}{Sheared\ Surface\ Area} = \frac{1}{\pi t d}\int f(x)dx$$

5.6 Calculate the SSE Index:

$$SSE\ index = 10^3 \times SSE\frac{\gamma}{t\tau}$$

Note 7— **Mixture selection criteria**: The shear strength of the mixtures shall not be less than 300 psi (or SSE ≥ 25 kJ/m^2) at 50°C. The shear strength shall not drop below 200 psi (or SSE ≥17 kJ/m^2) at 60°C; otherwise, the HMA mixture shall be deemed too sensitive to temperature changes.

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6. REPORT

6.1 Report the following for each specimen:

- Trimmed specimen density,
- Peak shear (failure) load,
- Failure shear deformation at peak load,
- HMA shear strength,
- HMA failure shear strain at peak load,
- HMA shear modulus,
- Shear strain energy,
- Shear strain energy index, and
- Additional comments.

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7. ARCHIVED VERSIONS

7.1 Archived versions are available.