ALDOT-361-88

RESISTANCE OF COMPACTED HOT-MIX ASPHALT TO MOISTURE INDUCED DAMAGE

1. Scope

1.1. This method covers preparation of specimens and measurements of the change of diametral tensile strength resulting from the effects of saturation and accelerated water conditioning of compacted hot-mix asphalt in the laboratory. The results may be used to predict long-term stripping susceptibility of the hot-mix asphalt, and evaluating liquid anti-stripping additives that are added to the asphalt cement of pulverulent solids, such as hydrated lime, which are added to the mineral aggregate.

2. References

2.1. AASHTO T 166, Standard Method of Test for Bulk Specific Gravity of Compacted Hot-mix Asphalt (HMA) Using Saturated Surface-Dry Specimens.

2.2. AASHTO T 167, Standard Method of Test for Compressive Strength of Hot-Mix Asphalt Mixtures.

2.3. AASHTO T 168, Standard Method of Test for Sampling Bituminous Paving Mixtures.

2.4. AASHTO T 209, Standard Method of Test for Theoretical Maximum Specific Gravity and Density of Hot-mix Paving Mixtures.

2.5. AASHTO T 245, Standard Method of Test for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus.

2.6. AASHTO T 269, Standard Method of Test for Percent Air Voids in Compacted Dense and Open Asphalt Mixtures.

2.7. AASHTO T 283, Standard Method of Test for Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage.

2.8. ASTM D 3549, Standard Test Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens.

2.9. ALDOT 324, Plant Requirements for Plants Producing Hot-Mix, Hot-Laid Asphalt Mixtures.

2.10. ALDOT 384, Mix Design Procedure for Superpave Level I.

2.11. Alabama Department of Transportation Standard Specifications for Highway Construction.

3. Significance and Use

3.1. As noted in the scope, this method is intended to evaluate the effects of saturation and accelerated water conditioning of compacted hot-mix asphalt in the laboratory. This method can be used (a) to test hot-mix asphalt in conjunction with mixture design in accordance with the “Alabama Department of Transportation Standard Specifications for Highway Construction,” (b) to test hot-mix asphalt produced at mixing plants in accordance with ALDOT 324, and, (c) to test the asphalt concrete cores obtained from completed pavements of any age.

3.2. Numerical indices of retained indirect tensile properties are obtained by comparing the retained indirect properties of saturated, accelerated water-conditioned laboratory specimens with the similar properties of dry specimens.

4. Summary of Method

4.1. Six test specimens for each set of mix conditions, such as, plain asphalt, asphalt with anti-stripping agent, or aggregate treated with lime, are tested. Each set of specimens is divided into two subsets. One subset is tested in the dry condition for indirect tensile strength. The other subset is subjected to vacuum saturation and then tested for indirect tensile strength. Numerical indices of retained indirect tensile strength properties are computed from the test data obtained on the two subsets: dry and conditioned.

4.2. It is recommended that two additional specimens are made for the set of six. These specimens can then be used to establish the vacuum saturation technique as given in Section 9.3, if a specimen is damaged.

4.3. As part of this procedure, the maximum specific gravity, bulk specific gravity, and percent air voids must be determined for each mix.

5. Apparatus

5.1. Equipment for preparing and compacting the specimens (AASHTO T 245).

5.2. Vacuum container, preferably Type D, (AASHTO T 209) or water aspirator (AASHTO T 209) and a vacuum pump, including a manometer or vacuum gauge.

5.3. Balance and water bath (AASHTO T 166).

5.4. Water bath capable of maintaining a temperature of 140 ± 2ºF (60 ± 1ºC) (AASHTO T 245).

5.5. Forced-air draft oven capable of maintaining a temperature of 140 ± 2ºF (60 ± 1ºC).

5.6. Loading jack and ring dynamometer (AASHTO T 245), or a mechanical or hydraulic testing machine (AASHTO T 167) to provide a range of accurately controllable rates of vertical deformation, including two inches (50 mm) per minute.

5.7. If used, steel loading strips with a concave surface having a radius of curvature equal to the nominal radius of the test specimen. For specimens 4 in (100 mm) in diameter the loading strips shall ½ in (13 mm) wide, and for specimens 6 in (150 mm) in diameter the loading strips shall be ¾ in (19 mm) wide. The length of the loading strips shall exceed the diameter of the specimens. The edges of the loading strips shall be rounded by grinding.

6. Preparation of Laboratory Test Specimens

6.1. Obtain mix samples for this procedure and also mix samples to determine the maximum theoretical specific gravity (AASHTO T 209) and bulk specific gravity (AASHTO T 166).

6.2. Specimens 4 in (100 mm) in diameter and 2 ½ in (63 mm) thick are usually used in this procedure. However, specimens 6 in. (150 mm) in diameter and 4 in (100 mm) thick (either by compaction or sawing) are used in all Superpave mixes and in mixes with aggregate retained on the 1 in (25 mm)sieve. Cores tensile strength ratio (TSR) tested do not have a standard thickness.

6.3. Place the mixture in an oven at 276ºF (130ºC) for one-half hour (30 minutes) prior to compaction. The mixture shall be compacted to a 7 ± 1.0 percent air void level or a void level expected in the field. This level of voids can be obtained by adjusting the number of blows in AASHTO T 245.

6.4. For Superpave mixes, use the conditioning time and compaction temperature as per ALDOT-384. Adjust the number of gyrations to achieve 7 ± 1.0 percent air voids.

6.5. After extraction from the molds, allow the test specimens to cool to room temperature.

7. Preparation of Core Test Specimens

7.1. Select locations on the completed pavement to be sampled, and obtain cores as directed by the Engineer. The number of cores shall be at least six for each set of mix conditions for this procedure. Obtain additional cores to determine maximum theoretical specific gravity and bulk specific gravity.

7.2. Separate core layers as necessary by sawing or other suitable means, and store the layers to be tested at room temperature.

8. Evaluation of Test Specimens and Grouping

8.1. Determine the theoretical maximum specific gravity of mixture (AASHTO T 209).

8.2. Determine the specimen thickness (ASTM D 3549).

8.3. Determine the bulk specific gravity (AASHTO T 166).

8.4. Calculate the air voids (AASHTO T 269).

8.5. Sort specimens into two subsets of three specimens each so that average air voids of the two subsets are approximately equal.

9. Preconditioning of Test Specimens

9.1. One subset will be tested dry and the other will be preconditioned before testing.

9.2. The dry subset will be stored at room temperature until testing. Each specimen shall then be placed in a 77ºF (25ºC) water bath for one hour and then tested as described in Section 10.

9.3. For the other subset, condition each specimen in the vacuum container supported above the container bottom by a spacer. Fill the container with distilled water at room temperature so that the specimen has at least one inch of water above its surface. Apply partial vacuum, such as 30 in. (500 mm) Hg for a short time, like two (2) minutes. Remove the vacuum and let the specimen remain submerged in water for five (5) minutes.

9.4. Determine bulk specific gravity (AASHTO T 166). Compare saturated surface-dry weight with the dry weight determined in Section 8.3. Calculate the volume of absorbed water.

9.5. Determine the degree of saturation by comparing the volume of absorbed water with the volume of air voids from Section 8.4. If the volume of water is between 55 percent and 80 percent of the volume of air, proceed to Section 9.6 If the volume of water is less than 55 percent, repeat the procedure, beginning with Section 9.3 using more vacuum and/or time. If volume of water is more than 80 percent, the specimen has been damaged and it shall be discarded. Repeat the procedure beginning with Section 9.3 using less vacuum and/or time.

9.6. Place the specimens into a 140± 2ºF (60 ± 1ºC) water bath filled with distilled water for 24 hours.

9.7. After 24 hours in the 140ºF (60ºC) water bath, remove the specimens and place them in a water bath already at 77±1ºF (25 ± 0.5ºC) for one hour. It may be necessary to add ice to the water bath to prevent the water temperature from rising above 77ºF (25ºC). Not more than 15 minutes should be required for the water bath to reach 77ºF (25ºC). Test the specimens as described in Section 10.

10. Testing

10.1. Determine the indirect tensile strength of dry and conditioned specimens at 77ºF (25ºC).

10.2. Remove a conditioned specimen from 77ºF (25ºC) water bath and place it between the two bearing plates in the testing machine. Care must be taken so that the load will be applied along the diameter of the specimen. Apply the load to the specimen by means of the constant rate of movement of the testing machine head of two inches (50 mm) per minute.

10.3. If steel loading strips are used, record the maximum compressive strength noted on the testing machine, and continue loading until a vertical crack appears. Remove the specimen from the machine and pull it apart at the crack. Inspect the interior surface for stripping and record the observations.

11. Calculations

11.1. Calculate the tensile strength as follows:

$$St = \frac{2P}{t\ D\ 3.14}$$

where:
St = tensile strength, psi (pascals)
P = maximum load, pounds (Newton)
t = specimen thickness, inches (mm)
D = specimen diameter, inches, (mm)

11.2. Express the numerical index or resistance of the asphalt mixture to the detrimental effect of water as the ratio of the original strength that is retained after the warm water conditioning. Calculate TSR as follows:

$$\text{Tensile Strength Ratio (TSR)} = \frac{S2}{S1}$$

where:
S1 = average tensile strength of dry subset, and
S2 = average tensile strength of conditioned subset.