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DIVISION OF ENGINEERING SERVICES
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METHOD OF TEST FOR RESISTANCE OF COMPACTED BITUMINOUS MIXTURE TO MOISTURE INDUCED DAMAGE

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read "**SAFETY AND HEALTH**" in Section J of this method. It is the responsibility of the user of this method to consult and use departmental safety and health practices and to determine the applicability of regulatory limitations before any testing is performed.

A. SCOPE

This method covers preparation of specimens and measurement of the change of diametral tensile strength resulting from the effects of saturation and accelerated water conditioning of compacted bituminous mixtures in the laboratory. The results may be used to predict long-term stripping susceptibility of the bituminous mixtures, and to evaluate liquid anti-stripping additives that are added to the asphalt cement or solids that can be reduced to a fine powder, such as hydrated lime, and which are added to the mineral aggregate.

B. SIGNIFICANCE AND USE

1. As noted in the scope, this method is intended to evaluate the effects of saturation and accelerated water conditioning of compacted bituminous mixtures in the laboratory. This method can be used to test bituminous mixtures in conjunction with mixture design testing.
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.

C. SUMMARY OF METHOD

Test specimens for each proposed mix design are tested. Each set of specimens is divided into two subsets. One subset is tested in dry condition for indirect tensile strength. The other subset is subjected to vacuum saturation, followed by a freeze cycle and a warm water cycle, before being 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. All test data and related information are to be recorded on Figure 1.

D. APPARATUS

1. Balance and water bath from AASHTO T 166.
2. Water bath capable of maintaining a temperature of $60 \pm 1^\circ\text{C}$.
3. Freezer maintained at $-18 \pm 3^\circ\text{C}$.
4. A supply of plastic film for wrapping, heavy-duty leak-proof plastic bags to

enclose the saturated specimens, and masking tape.

5. 10 mL graduated cylinder.
6. Metal pans having a surface area of 48 400 – 64 500 square millimeters in the bottom and a depth of approximately 25 mm.
7. Forced air draft oven capable of maintaining a temperature of $60 \pm 1^\circ\text{C}$.
8. Loading jack and ring dynamometer from AASHTO T 245, or a mechanical or hydraulic testing machine from AASHTO T 167 to provide a range of accurately controllable rates of vertical deformation, including 50 mm per minute.
9. Breaking Heads; Lottman Breaking Heads equivalent to Gilson MS-35.

E. PREPARATION OF LABORATORY TEST SPECIMENS

1. Obtain samples of the aggregate, additives (if any), and the asphalt binder that will be used on the project in accordance with California Test 125.
2. Make at least twelve specimens (NOTE 1) for each test; half of the specimens are to be tested dry and the other half are to be tested after partial saturation and moisture conditioning with a freeze-thaw cycle.

NOTE 1: It is recommended that two additional specimens for the set be prepared. These specimens can then be used to establish the vacuum saturation technique as given in Section G.3.
3. Specimens 101.6 mm in diameter and 63.5 mm thick are used.
4. Individually batch laboratory prepared specimens in accordance with California Test 304 at the optimum binder content. The

approximate quantity of AC mixture needed to batch a single specimen shall be determined by the following formula:

$$\text{Mass (g)} = (G_{\text{mm}} \times 477.8) - 15 \text{ g}$$

Where:

G_{mm} = theoretical maximum
specific gravity of mixture
by California Test 309.

Some adjustment of mass may be required to achieve target height and voids.

5. After mixing, place the mixture in a metal pan having a surface area of 48 400 to 64 500 square millimeters in the bottom and a depth of approximately 25 mm, and cool at room temperature (NOTE 2) for 2 ± 0.5 hrs. Place the mixture in a $60 \pm 1^\circ\text{C}$ oven for 16 ± 1 hr for curing. The pans should be placed on spacers to allow air circulation under the pan if the shelves are not perforated.

NOTE 2: Room temperature for the purposes of this test method is defined as between 17°C and 28°C .

6. After curing, place the mixture in an oven at 110°C for 2 hrs prior to compaction. Then, place the mixture in the mold and rod in accordance with California Test 304 (a mechanical spader shall not be used; "hand rod" material only). Apply 25 tamping blows at a pressure of 1.7 MPa with the shims in place. Remove the mold and specimen from the compactor and apply a leveling load with a fixed head compression machine until a specimen height of 63.5 ± 3 mm is achieved, then release the load. During application of the leveling load, place the mold directly on the lower platen of the compression machine (do not use a follower between the mix and platen). It is recommended to scribe a mark

on the metal follower 63.5 mm from each end. Place the scribed metal follower in the mold on top of the specimen. Lower the upper platen, at a rate of 6 mm per minute until the scribed mark on the follower meets the top of the mold. If a spherical seat or floating head is attached to the upper platen of the compression machine, it must be shimmed while applying the leveling load. This leaves 63.5 mm between the follower and the lower platen. The mixture shall be compacted to between 6.5% and 7.5% air voids.

7. Store the test specimens in the molds at room temperature for 2 hrs before extraction.
8. After extraction from the molds, the test specimens shall be stored from 24 to 96 hrs at room temperature.

F. EVALUATION OF TEST SPECIMENS AND GROUPING

1. Determine theoretical maximum specific gravity of mixture by California Test 309.
2. Determine specimen thickness by ASTM D 3549.
3. Determine bulk specific gravity by AASHTO T 166 (Method A) after room temperature cure (24 to 96 hrs at room temperature). Express volume of specimens in cubic centimeters.
4. Calculate air voids by AASHTO T 269.
5. Sort specimens into two subsets of six specimens each so that average air voids of the two subsets are approximately equal.

G. PRECONDITIONING OF TEST SPECIMENS

1. One subset will be tested dry and the other will be preconditioned before testing.
2. The dry specimens will be stored at room temperature until testing. The

specimens shall be wrapped with plastic or placed in a heavy-duty leakproof plastic bag. The specimens shall then be placed in a $25 \pm 0.5^\circ\text{C}$ water bath for a minimum of 2 hrs and then tested as described in Section H.

3. The other specimens shall be conditioned as follows:
 - a. Place the specimen in the vacuum container supported above the container bottom by a spacer. Fill the container with water at room temperature so that the specimens have at least 25 mm of water above their surface. Apply a vacuum of 13 to 67 kPa absolute pressure (10 to 26 inches Hg) measured at the vessel chamber, which should correlate to 13 to 67 kPa as measured at the pump gauge, for a short time (5 to 10 minutes). Time duration for vacuum shall start when the residual manometer reaches the prescribed range. Remove the vacuum and leave the specimen submerged in water for a short time (5 to 10 minutes).
 - b. Immediately determine the bulk specific gravity by AASHTO T 166 (Method A). Compare saturated surface dry mass with dry mass in air determined in Section F.3. Calculate volume of absorbed water.
 - c. Determine the degree of saturation by dividing the volume of absorbed water from Section G.3.b by the volume of air voids from Section F.4 and express the result as a percentage. If the volume of water is between 70% and 80% of the volume of air, proceed to Section G.3.d. If the volume of water is less than 70%, repeat the procedure beginning with Section G.3.a and using either more vacuum and/or time. If volume of water is more than 80%, specimen has been damaged

- and shall be discarded. Repeat the procedure, beginning with Section G.3.a using less vacuum and/or time.
- d. Moisture condition the specimen using the following procedure:
- (1) Cover each of the vacuum-saturated specimens tightly with a plastic film (Saran Wrap or equivalent). Place each wrapped specimen in a plastic bag containing 10 mL of water and seal the bag. Place the plastic bags containing the specimens in a freezer at a temperature of $-18 \pm 3^{\circ}\text{C}$ for a minimum of 16 hrs. After removal from the freezer, place the specimens in a bath containing water at $60 \pm 1^{\circ}\text{C}$ for 24 ± 1 hrs. As soon as possible after placement in the bath, remove the plastic bag and film from each specimen.
 - (2) After 24 ± 1 hrs in the $60 \pm 1^{\circ}\text{C}$ water bath, remove the specimens and place them in a water bath already at $25 \pm 0.5^{\circ}\text{C}$ for 2 ± 1 hrs. It may be necessary to add ice to the water bath to prevent the water temperature from rising above $25 \pm 0.5^{\circ}\text{C}$. Not more than 15 minutes should be required for the water bath to reach $25 \pm 0.5^{\circ}\text{C}$. Test the specimens as described in Section H.
3. Lottman breaking heads equivalent to Gilson MS-35 shall be used to test indirect tensile strength. Record the maximum compressive load noted on the testing machine, and continue loading until a vertical crack appears. Remove the specimen from the machine and pull apart at the crack. Inspect the interior surface for stripping and record the observations. (Stripping is the separation of the binder from the aggregate surface.) Observations will include visual moisture damage and cracked or broken aggregate. All test data and related information are to be recorded on Figure 1.

I. CALCULATIONS (see Figure 1)

1. Calculate the tensile strength as follows:

$$S_t = \frac{2000 P}{\pi t D}$$

Where:

- S_t = tensile strength, kPa
 P = maximum load, N
 t = specimen thickness, mm
 D = specimen diameter, mm

2. Express the Tensile Strength Ratio (TSR), rounded to the nearest whole number, as follows:

$$\text{Tensile Strength Ratio (TSR)} = \frac{S_2}{S_1} \times 100$$

Where:

- S_1 = average tensile strength of dry subset, and
 S_2 = average tensile strength of conditioned subset.

H. TESTING

1. Determine concurrently the indirect tensile strength of dry and conditioned specimens at $25 \pm 0.5^{\circ}\text{C}$.
2. Remove the specimen from the $25 \pm 0.5^{\circ}\text{C}$ water bath and immediately place between the two bearing plates in the testing machine. Care must be taken so that the load will be applied along the diameter of

3. The high and low tensile strength values for each subset shall not be used for the purposes of final TSR calculation.

J. SAFETY AND HEALTH

Prior to handling, testing or disposing of any waste materials, testers are required to read: Part A (Section 5.0), Part B (Sections: 5.0, 6.0 and 10.0) and Part C (Section 1.0) of Caltrans Laboratory Safety Manual. Users of this method do so at their own risk.

REFERENCES:

California Test 125, 304, 309
AASHTO Designations: T 166, T 167,
T 245, T 269
ASTM Designations: D 3549

End of Text
(California Test 371 contains 6 pages)

RESISTANCE OF COMPACTED BITUMINOUS MIXTURE TO MOISTURE DAMAGE

Project:	
Plant:	Mix:
Additive:	Dosage %:
Date Tested:	Tester:
Sample ID	
Diameter, mm	D
Thickness, mm	t
Dry Mass in Air, g	A
S.S.D. Mass, g	B
Mass in Water, g	C
Volume (B-C), cc	E
Bulk Sp. Gr. (A/E)	F
Max Sp. Gr.	G
% Air Voids [100(G-F)/G]	H
Volume Air Voids (H*E/100), cc	I
Load (Dry), N	P
Saturation	
Absolute Pressure: Hg @ Manometer	
Absolute Pressure: Hg @ Pump	
Time, Minutes	
Moisture Conditioned, One Freeze Thaw Cycle	
S.S.D. Mass, g	B'
Mass in Water, g	C'
Volume (B'-C'), cc	E'
Volume Absorbed Water (B'-A), cc	J'
% Saturation (100*J/I)	S'
% Swell [100(E-E)/E]	W'
Load (Wet), N	P'
Dry Strength (2000*P/π*t*D), kPa	S _{id}
Wet Strength (2000*P'/π*t'D), kPa	S _w
Visual Moisture Damage (N,L,M,H)	
Aggregate Break Damage (N,L,M,H)	

Final Tensile Strength Values

	Dry (S _{id}) ²	Wet (S _w) ²
1		
2		
3		
4		
Avg	S ₁	S ₂

Initial Tensile Strength Values

	Dry (S _{id}) ¹	Wet (S _w) ¹
1		
2		
3		
4		
5		
6		

Tensile Strength Ratio S₂/S₁*100= %

Conversions:
PSI to kPa, Multiply psi by 6.895
lb_r to N, Multiply lb_r by 4.448

¹ The high and low tensile strength values from each "Initial Tensile Strength Values" sub-set shall not be used for the purposes of the "Tensile Strength Average".
² The remaining four tensile strength values from each sub-set shall be used for the final tensile strength values.

Figure 1