EFFECT OF WATER ON STRENGTH OF COMPACTED, TREATED AND UNTREATED BITUMINOUS MIXTURES (IMMERSION COMPRESSION TEST)

(A Modification of AASHTO Designation T 167 and ASTM D 1075)

1. SCOPE

1.1 This method covers measurement of the loss of strength resulting from the effect of water on compacted bituminous mixtures. A numerical index of retained strength is obtained by comparing the compressive strength of freshly molded and cured specimens with the compressive strength of duplicate specimens that have been immersed in water under prescribed conditions. Provisions are also given for testing specimens which have been treated with a mineral admixture. With some modifications this procedure may be used in testing recycled bituminous mixtures or emulsion mixes.

1.2 This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. REFERENCED DOCUMENTS

2.1

ARIZ 415	Bulk Specific Gravity and Bulk Density of Compacted Bituminous Mixtures
ARIZ 815	Marshall Mix Design Method for Asphaltic Concrete

2.2

AASHTO M 231	Weighing Devices Used in the Testing of Materials
AASHTO T 167	Compressive Strength of Hot Mix Asphalt
AASHTO T 316	Viscosity Determination of Asphalt Binder Using Rotational Viscometer

2.3	ASTM D 1075	Effect of Water on Compressive Strength of Compacted Bituminous Mixtures
	ASTM D 2493	Standard Viscosity-Temperature Chart for Asphalt

3. APPARATUS

3.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

3.2 Molds and Plungers – Molds and plungers conforming to the requirements of AASHTO T 167.

3.3 Support Bars – Steel bars to hold the mold cylinder one inch above the baseplate during molding operation.

3.4 Testing Machine – A testing machine conforming to the requirements of AASHTO T 167.

3.5 Ovens – A minimum of two ovens that are controllable to within ± 5 °F of any temperature specified in this method.

3.6 Hot Plate – A small controllable hot plate shall be provided under the mixing bowl to maintain the mix at the desired temperature during mixing.

3.7 Hot Water Bath – An automatically controlled water bath of sufficient size to permit total immersion of the test specimens. It shall have a perforated false bottom or be equipped with a shelf. Either one shall support the specimens at least 1 inch above the bottom of the bath. The bath and shelf or false bottom shall be either lined with or constructed of a non-reactive material. It shall provide accurate and uniform control of a temperature of 140 ± 2 °F.

3.8 Water Bath – A separate water bath conforming to Section 3.7 above and which provides accurate and uniform control for bringing immersed specimens to a temperature of 77 ± 2 °F for the compression test.

Note: The water used in both of the above baths shall be distilled water. Only one set of specimens shall be in the 140 °F bath at a time. The 140 °F bath shall be emptied, cleaned, and refilled with fresh distilled water for each set of specimens. The 77 °F water bath shall be drained and cleaned on a regular basis.

3.9 Air Bath – An automatically controlled air bath for storing the specimens at 77 ± 2 °F.

3.10 Balance – A balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.1 gram.

3.11 Mixer – A commercial grade mixer conforming to the requirements of AASHTO T 167.

3.12 Miscellaneous Equipment – A flexible spatula for scraping the mixing bowl and a stiff spatula, approximately 1" wide and 8" long, for spading the mix in the mold. A supply of transfer plates approximately 5" x 5" made of glass or non-reactive material for transferring the molded specimens.

4. PREPARING AGGREGATE-MINERAL ADMIXTURE SAMPLES

4.1 Based on the stockpile composite aggregate gradation, the aggregate samples needed for the immersion compression (IMC) test are prepared as follows.

4.2 Dry the mineral aggregate from each individual stockpile at a temperature not exceeding any temperature restrictions in Section 5. Drying shall be performed until no further weight loss is obtained from continued drying.

4.3 Representative samples of aggregate material which are retained on the individual No. 8 and larger sieve sizes and the Minus No. 8 Material from each stockpile are used to prepare the samples for mix design testing.

4.4 Weigh up three 3400 gram samples of mineral aggregate plus the required percent of mineral admixture, by dry weight of the aggregate, to yield three sets of two IMC specimens.

Note: Generally the weight of mineral aggregate will provide specimens of acceptable heights, but adjustments may be necessary in some cases. Use the following equation below to adjust the weight of aggregate as necessary to conform to specimen height requirements of 4.000 ± 0.100 inches for IMC specimens.

$$\begin{pmatrix}\text{Adjusted Weight}\\ \text{of Aggregate}\end{pmatrix} = \frac{\begin{pmatrix}\text{Combined Bulk OD}\\ \text{Agg. Specific Gravity}\end{pmatrix}}{2.650} \text{ X } (3400 \text{ grams})$$

4.5 The aggregate-mineral admixture samples shall be dried to constant weight within ± 5 °F of the laboratory mixing temperature and shall be at this temperature at the time of mixing with the asphalt binder. If necessary, a small amount of proportioned Minus No. 8 aggregate make-up material shall be added to bring samples to the desired weight.

5. LABORATORY MIXING TEMPERATURES AND BATCHING PROCEDURE

5.1 The rotational viscosity of the asphalt binder at 275 °F and 350 °F shall be determined in accordance with AASHTO T 316, and a viscosity-temperature curve developed in accordance with ASTM D 2493.

5.2 The laboratory mixing temperature range is defined as the range of temperatures where the un-aged asphalt binder has a rotational viscosity of 0.17 ± 0.02 Pascal·seconds. The actual laboratory mixing temperature used is normally selected at or near the mid-point of the range.

5.3 Alternatively, the viscosity-temperature curve may be found in the mix design report. For PG asphalt binders that have a maximum laboratory mixing temperature exceeding 325 °F or for modified asphalt binder, refer to the binder manufacturer to establish appropriate mixing temperature ranges. In no case shall the mixing temperature exceed 350 °F.

Note: When IMC testing is performed with Warm Mix Asphalt (WMA) technology, testing shall be performed with and without the WMA technology. The test results, both with and without the WMA technology, shall meet the minimum requirements of the specifications.

The WMA technology must be added to the mix before testing in accordance with the WMA technology manufacturer's recommendations. The WMA technology shall be added at the rate anticipated to be used in the production of the asphaltic concrete.

The mixing temperature for the laboratory prepared samples shall be per the WMA technology manufacturer's recommendations, but shall not exceed the maximum anticipated mixing temperature during field production. In making laboratory mixing temperature recommendations, the WMA technology manufacturer should consider the mixing temperature based on the viscosity-temperature curve for the asphalt which has been modified with the WMA technology as well as the minimum mixing temperature required for adequate coating.

5.4 Before each batch of asphaltic concrete is mixed, the asphalt binder shall be heated in a loosely covered container in a forced draft oven for approximately 2 hours or as necessary to bring the asphalt binder to within ± 5 °F of the laboratory mixing temperature. (Avoid prolonged heating of the binder.)

5.5 Calculate the weight of asphalt binder to be used as determined by the following equation:

$$\left[\begin{array}{c}\text{Weight of}\\ \text{Asphalt Binder}\end{array}\right] = \left[\frac{\left(\begin{array}{c}\text{Weight of Aggregate and}\\ \text{Mineral Admixture}\end{array}\right)}{100 - \left(\begin{array}{c}\text{Percent of}\\ \text{Asphalt Binder}\end{array}\right)}\right] X \left[\begin{array}{c}\text{Percent of}\\ \text{Asphalt Binder}\end{array}\right]$$

Percent of asphalt binder is based on the mix design asphalt binder content.

5.6 Preheat the mixing bowl and whip to within ± 5 °F of the laboratory mixing temperature. The aggregate-mineral admixture blend and the appropriate amount of asphalt binder shall be mechanically mixed together for 90 to 120 seconds within ± 5 °F of the required laboratory mixing temperature. After mechanical mixing, hand mixing shall be used as necessary to produce a well-coated homogeneous mixture.

5.7 Immediately after mixing, place the hot material on a tarp or a sheet of heavy paper large enough to manipulate the sample. Thoroughly scrape the bowl and whip and add this material to the sample. In a rolling motion, thoroughly mix the material. Leave the mound in a circular shape after rolling is completed. Spread the material into a circular mass. Spreading may be accomplished either by leveling the mound of material with a concrete trowel or hand float; or by placing a straightedge of sufficient length to span the final diameter of the circular mass over the center of the material and rotating it until the desired

height is obtained. Whichever method is utilized, the operator shall assure that the material is evenly distributed with as little segregation as possible. The thickness of the circular mass shall not exceed 3 inches. The circular mass shall be cut into 4 equal pie-shaped segments. Take opposite segments for each individual sample and use the entire batch.

6. MOLDING AND CURING TEST SPECIMENS

6.1 Place the mixtures in an oven maintained at 255 ± 5 °F for 2 hours ± 10 minutes. A mold and bottom plunger for each mixture shall also be heated to 255 ± 5 °F.

Note: For mixtures with WMA technology, the samples shall be at a compaction temperature of 255 ± 5 °F, unless an alternative compaction temperature is recommended by the WMA technology manufacturer and approved by the Engineer.

For WMA water foaming processes, if laboratory water foaming equipment is not available, the specimens for IMC testing may be fabricated from plant produced mix. The specimens shall be tested as described above except the specimens shall be compacted without allowing the mixture to cool after the sample is obtained. Reheating, aging, or curing will not be allowed.

6.2 Remove the bottom plunger and mold cylinder from the oven, and place the mold assembly on the baseplate (bottom plunger in place with the mold cylinder supported on the two steel bars). Place the paper disc on the bottom plunger to prevent material from adhering to the plunger. Place 1/2 of the mixture into the molding cylinder and spade the mixture vigorously with a heated, flat, metal spatula with a blade approximately 1" wide and 8" long, stiff enough to penetrate an entire layer of material, 15 times around the edge of the mold and 10 times at random into the mixture, penetrating the mixture to the bottom of the mold. Place the remaining half of the mixture into the mold and repeat the spading process, penetrating into the first lift of the mixture. The top of the mixture should be slightly rounded to aid in firm seating of the upper plunger.

6.3 Place a paper disc and then the upper plunger (which has been preheated) on the sample and compress the mixture under an initial load of 150 psi, to set it against the sides of the mold. Remove the support bars and permit full double-plunger action. Apply the load to the mixture at a rate of 0.2 inches per minute until a load of 2750 psi is reached. Hold the load at 2750 psi for 2 minutes.

Note: A load of 2750 psi will generally produce specimens that meet the criteria specified for air voids in Section 7. The loading may be varied, if necessary, to a minimum of 2000 psi. However, in all cases the requirements for air voids must be met. Record the load at which the specimens are prepared.

6.4 Remove the specimen from the mold. During and after extrusion from the mold, take care to maintain the specimen's shape and prevent tensile stresses in the specimen. Place the specimen on a transfer plate.

Note: The specimen may be allowed to cool for a maximum of 10 minutes before removal from the mold.

6.5 Place the specimen and plate in an oven at 140 ± 5 °F.

6.6 Repeat Sections 6.2 through 6.5 for the other mixtures.

6.7 Cure the specimens for 18 ± 0.5 hours at 140 ± 5 °F.

7. BULK DENSITY DETERMINATION

7.1 After removal from the 140 °F oven, allow the specimens to cool on the plate to room temperature.

Note: Cooling may be accomplished in a 77 °F air bath or if more rapid cooling is desired the specimen may be placed in front of a fan until cooled to room temperature.

7.2 Determine and record the bulk density in accordance with ARIZ 415 (Method A) and record the height of each specimen to the nearest 0.001 inches.

Note: The bulk densities between specimens shall not differ by more than 2.5 lbs/cu ft. If this criterion is not met the entire set of specimens shall be discarded and a new set prepared.

Note: The mixture shall be compacted to 7.0 +/- 1.0 percent air voids based on the mix design maximum specific gravity. The standard molding load of 2750 psi may be increased or decreased to achieve a target air voids.

7.3 Sort the six specimens into two groups of three specimens each, so that the average bulk density of the specimens in group 1 is essentially the same as for group 2. Test the specimens in group 1 as specified in Section 8. Test the specimens in group 2 as specified in Section 9.

8. DETERMINATION OF DRY STRENGTH

8.1 Bring the test specimens to testing temperature by storing in an air bath maintained at 77 ± 2 °F for 4 to 5 hours.

8.2 Remove each specimen from the air bath and test each specimen in axial compression without lateral support at a uniform rate of vertical deformation of 0.2 inches per minute. Record the load failure point for each specimen and the average load failure point. Determine the dry strength by converting the average load failure point to pounds per square inch.

Note: At least two of the individual load failure points shall be within ± 10% of the average load failure point for the three specimens. If this criterion is not met the entire set of 6 specimens shall be discarded and a new set prepared. If only two of the three specimens meet this criterion, a new average load failure point is determined using the two values.

9. DETERMINATION OF WET STRENGTH

9.1 Immerse the test specimens in a water bath maintained at 140 ± 2 °F, at least 1 inch below the top of the water, on a transfer plate, for 24 ± 0.5 hours.

9.2 Transfer the specimens to a 77 ± 2 °F water bath for 2 hours keeping them on the plates and making sure all specimens are totally immersed.

9.3 Remove each specimen from the water bath and test each specimen in axial compression without lateral support at a uniform rate of vertical deformation of 0.2 inches per minute. Record the load failure point for each specimen and the average load failure point. Determine the wet strength by converting the average load failure point to pounds per square inch.

Note: At least two of the individual load failure points shall be within ± 10% of the average load failure point for the three specimens. If

this criterion is not met the entire set of 6 specimens shall be discarded and a new set prepared. If only two of the three specimens meet this criterion, a new average load failure point is determined using the two values.

10. CALCULATIONS

10.1 The index of retained strength shall be expressed as the percentage of "dry strength" of the specimens. It shall be calculated as follows:

$$\left(\begin{array}{c}\text{Index of}\\ \text{Retained Strength}\end{array}\right) = \frac{\left(\begin{array}{c}\text{Wet Strength}\\ \text{of Specimens}\end{array}\right)}{\left(\begin{array}{c}\text{Dry Strength}\\ \text{of Specimens}\end{array}\right)} \text{ X } (100)$$

10.2 The index of retained strength shall be reported to the nearest whole percent.

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ARIZ 802 Workcard

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GRADE OF ASPHALT: PG 70-22 % ASPHALT: 4.6 ADMIXTURE: 1% LIME

DENSITY DETERMINATION OF DRY IMC SPECIMENS:

SPEC. #	HEIGHT	SSD WT.	H_20 WT.	AIR WT.	SP. GR.	DENSITY	AVERAGE SP. GR.	AVG. IMC DENSITY
1	3.988	1830.8	1017.5	1823.4	2.242	139.7	2.242	139.7
2	3.988	1827.3	1015.2	1819.5	2.240	139.6		
3	3.986	1828.6	1015.2	1821.5	2.239	139.5		
4	3.981	1829.5	1016.8	1820.6	2.240	139.6		
5	3.988	1833.6	1020.5	1824.7	2.244	139.8		
6	3.991	1837.1	1024.3	1826.9	2.248	140.0		

MIX DESIGN MAXIMUM DENSITY = 150.5

$$\% \text{ AIR VOIDS} = 1-\left(\frac{\text{AVG IMC DENSITY}}{\text{MIX DESIGN MAX DENSITY}}\right) \times 100 = 1-\left(\frac{139.7}{150.5}\right) \times 100 = 7.2\%$$

LOAD: ☑ 2750 psi ☐ Other: _____ psi

COMPRESSIVE STRENGTH OF DRY SPECIMENS:

SPEC. #	LOAD FAILURE POINT	AVG. LOAD FAILURE POINT	PSI
3	4170	4260	338.9
4	4280		
6	4330		

COMPRESIVE STRENGTH OF WET SPECIMENS:

SPEC. #	LOAD FAILURE POINT	AVG. LOAD FAILURE POINT	PSI
1	3610	3780	300.7
2	3840		
5	3890		

$$\text{INDEX OF RETAINED STRENGTH} = \frac{\text{PSI (WET)}}{\text{PSI (DRY)}} \times 100 = \left(\frac{300.7}{338.9}\right) = 89\%$$

FIGURE 1