Moisture Sensitivity of Compacted Asphalt Concrete Paving Mixtures

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1. Scope:

This test method covers the procedure for preparing and testing asphalt concrete specimens for the effect of water on the tensile strength of the paving mixture.

2. Apparatus:

2.1 Marshall slant foot rotating base compaction hammer.

2.2 Vacuum container, preferably a metal container and vacuum pump or water aspirator including a manometer or vacuum gauge.

2.3 Water bath at 140° ± 2°F and a water bath at 77° ± 2°F.

2.4 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram.

2.5 Loading jack or mechanical testing machine with a vertical motion rate of 2” per minute.

2.6 Steel loading strips with a concave surface having a radius of curvature equal to the nominal radius of the test specimen. The strips shall be 0.5” wide for 4” specimens and have a length that exceeds the thickness of the specimens.

2.7 Calipers capable of measuring to the nearest 0.01".

3. Procedure:

3.1 Preparation of laboratory specimens.

A. At least 8 specimens are prepared as described in the South Dakota Mix Design Procedure. When adding a dry powder additive such as lime to the material, use the same procedure to add lime as will be used in the field. If adding a liquid anti-stripping to the asphalt binder, add the required quantity of liquid anti-strip to the asphalt binder, mix with a mechanical mixing device for at least 3 minutes.

Maintain the asphalt binder at the mixing temperature until it is used. Two samples of the minimum size specified in SD 312 are to be prepared to determine the theoretical maximum specific gravity of the uncompacted mix.

B. After mixing, the samples are put in a covered container in an oven at the compaction temperature for 2 hours prior to compaction.

C. The specimens shall be compacted to an air void level of 7% ± 1% by adjusting the number of Marshall blows.

D. Cool the specimens until the mold can be handled without gloves and extract from the molds. Allow the specimens to set overnight and then proceed with the test procedure.

3.2 Preparation of field samples.

A. Obtain a random sample of mix from behind the paver screed.

B. Stabilize the mix at the compaction temperature for 1 hour in the lab.

C. Compact at least 8 specimens to 7% ± 1% air void level using SD 313 test procedures.

D. Cool the specimens to room temperature and extract from the molds. Allow the specimens to set overnight and then proceed with the test procedure.

3.3 Preparation of core test specimens.

A. Select the core locations by using a random number table. Obtain at least 8 cores for testing. Separate the core lifts by use of a cutoff saw.

B. When determining the dry weight, make sure no moisture is remaining in the core.

3.4 Procedure for determining subsets.

A. Determine the theoretical maximum specific gravity of the mixture by using SD 312.

B. Determine specimen thickness to the nearest .01” by using calipers to measure the thickness at four quarter point locations on the specimen.

C. Determine the bulk specific gravity of the specimens by using SD 313. Record the dry weight, the submersed weight, and the saturated surface dry weight on a DOT-48. The SSD weight minus the submersed weight is the volume of the specimen in cubic centimeters.

D. Calculate the air voids as shown in SD 313. (The theoretical maximum specific gravity minus the specimen bulk specific gravity divided by the theoretical maximum specific gravity times 100 will be the percent of air voids.) Record the air voids to the nearest 0.01 percent.

E. Sort specimens into two subsets of at least three specimens each, so that the average air voids of the two subsets are approximately equal.

The 2 extra samples can be used to determine the correct amount of vacuum needed in the saturation procedure.

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

3.5 Procedure for subset to be saturated. (Laboratory, field, or core specimens)

A. Partially saturate the subset to be moisture conditioned with room temperature distilled water using a vacuum container and a vacuum gauge or manometer to control the level of vacuum applied. Put one of the specimens in a vacuum container for 3 to 5 minutes with a specific level of vacuum applied such as 10" of Hg. After the vacuum saturation, place in 77° ± 2°F water for 3 to 3.5 minutes and then determine the submerged weight and the saturated surface dry weight of the partially saturated specimen. Determine the volume of water absorbed by subtracting the air dry mass of the specimen in 3.4 C. from the saturated surface dry mass obtained above. Continue to place in the vacuum container and reapply a higher level of vacuum until the specimen is saturated to the level required by this test procedure. If the level of saturation exceeds the upper limit allowed, the specimen is damaged and must be discarded.

B. If the average air voids of the subset to be saturated is 6.5% or less, saturate to a level of 70% to 80%. If the average air voids of the subset is between 6.6% and 7.4%, saturate to a level of 55% to 80%. If the average air voids of the subset is 7.5% or more, saturate to a level of 55% to 65%. One of the extra samples may be used to determine the correct amount of vacuum to apply to get the required level of saturation.

Remember, if the specimen is saturated to a level exceeding the upper limit, the specimen is damaged and must be discarded. The level of saturation is determined by dividing the volume of the absorbed water in 3.5 A. above by the volume of air voids in 3.4 D. and expressing as a percentage.

C. Moisture condition the partially saturated specimens by soaking in distilled water at 140° ± 2°F for 24 hours.

After the 24 hour period, remove the specimens and place them in a 77° ± 2°F water bath for one hour.

D. After one hour, measure the height of the moisture conditioned specimens to the nearest .01" and determine the saturated surface dry weight, the submersed weight and the difference which is the volume of the saturated specimen. Return the specimens to the 77° ± 2°F water bath until ready to determine the tensile strength.

E. Determine the water absorption and the degree of saturation. A degree of saturation exceeding 80% is acceptable at this stage in the testing procedure.

F. Determine the swell of the partially saturated subset by dividing the change in specimen volumes from 3.5 A. and 3.4 C. by the specimen volume in 3.4 C. Determine the swell of the moisture conditioned specimens by dividing the change in specimen volumes from 3.5 E. and 3.4 C. by the specimen volume in 3.4 C.

3.6 Procedure for subset to be tested dry.

A. Adjust the temperature of the dry subset by soaking in a water bath for 20 minutes at 77° ± 2°F.

3.7 Procedure for determining the tensile strength.

A. Determine the tensile strength at 77° ± 2°F of both subsets.

B. Place a specimen in the loading strip apparatus and position the loading strips so that they are parallel and centered on the vertical diametral plane. Apply a diametral load at 2" per minute until the maximum load is reached, and record the maximum load on a DOT-48.

C. Continue loading until the specimen fractures. Break open the specimen and visually estimate the degree of moisture damage, if any.

D. Record observations on the degree of broken or cracked aggregate.

4. Report:

4.1 Calculate the tensile strength (S) as follows:

S = Tensile strength, psi

P = Maximum load, pounds

t = Specimen height immediately before tensile strength test, .01 inches

D = Specimen diameter, .01 inches

π = 3.1416

$$S = \frac{(2 \times P)}{(\pi \times t \times D)}$$

TSR = Tensile strength ratio, percent

Stm = Average tensile strength of the moisture conditioned subset, psi

Std = Average tensile strength of the dry subset, psi

$$TSR = \frac{Stm}{Std} \times 100$$

4.2 Record the test data on a DOT-48. Weights shall be recorded to the nearest 0.1 gram. Bulk specific gravity and maximum specific gravity shall be recorded to the nearest thousandth. Load shall be recorded to the nearest pound.

4.3 Volume and percentage calculations shall be reported to the nearest 0.01.

4.4 Tensile strength shall be calculated to the nearest 0.1 and the TSR reported to the nearest whole number.

5. References:

AASHTO T 245
ASTM D4867
SD 312
SD 313
SD 316
DOT-48
SD Mix Design Procedures

MOISTURE SENSITIVITY REPORT - BITUMINOUS SURFACING **DOT - 48**
FILE NUMBER _____ **9-14**

PROJECT	P 3079(00)219		DESIGN LEVEL	Q LVT	
PCN	5415		DESIGN AIR VOIDS	2.9	
COUNTY	Harding		DESIGN AC CONTENT	6.0	
DATE	09/27/2014				Spec.'s
ASPHALT BINDER	Cenex PG 58-28		AVERAGE AIR VOIDS	6.72	6-8
ADDITIVE & DOSAGE	0.75 percent hydrated lime		AVERAGE SATURATION LEVEL	65.0	55-80
METHOD OF ADDING	dry to aggregate with 3% H_2O		TENSILE STRENGTH RATIO	82	> 60
COMPACTION BLOWS	13 blows per side				

SPECIMEN NUMBER		1	2	3	4	5	6	7	8	9	10
DIAMETER (.01 in.)	D	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
THICKNESS (.01 in.)	t	2.53	2.57	2.61	2.57	2.57	2.59	2.56	2.58	2.59	2.66
DRY MASS IN AIR (0.1 g)	A	1169.4	1154.7	1177.4	1173.9	1163.5	1167.5	1181.4	1168.0	1175.8	1200.7
MASS IN WATER (0.1 g)	B	650.5	641.5	650.0	654.5	648.5	642.8	663.9	648.1	652.3	662.4
SSD MASS (0.1 g)	C	1170.6	1157.3	1179.1	1175.7	1164.9	1169.4	1182.6	1169.5	1177.7	1201.9
VOLUME (C - B)	E	520.1	515.8	529.1	521.2	516.4	526.6	518.7	521.4	525.4	539.5
BULK SP. GR. (A / E)	F	2.248	2.239	2.225	2.252	2.253	2.217	2.278	2.240	2.238	2.226
THEO. MAX. SP. GR.	G	2.403	2.403	2.403	2.403	2.403	2.403	2.403	2.403	2.403	2.403
% AIR VOIDS ((G-F)/G)x100	H	6.45	6.82	7.41	6.28	6.24	7.74	5.20	6.78	6.87	7.37
VOLUME AIR VOIDS (HE)/100	I	33.55	35.18	39.21	32.73	32.22	40.76	26.97	35.35	36.09	39.76
LOAD (LB.)	P	1105	1235				1235			1270	
										AVERAGE AIR VOIDS OF DRY SUBSET	6.97
SATURATED		3	MIN.	19	"HG					AVERAGE AIR VOIDS OF SAT. SUBSET	6.96
MASS IN WATER (0.1 g)	B'			674.0	672.7				670.2		687.1
SSD MASS (0.1 g)	C'			1203.6	1194.0				1191.6		1226.6
VOLUME (C' - B')	E'			529.6	521.3				521.4		539.5
VOL. ABS. WATER (C' - A)	J'			26.2	20.1				23.6		25.9
% SATURATION (J'/ I) x 100				66.8	61.4				66.8		65.1
% SWELL ((E' -E) / E) x 100				0.09	0.02				0.00		0.00

CONDITIONED 24 HOURS IN 140 DEGREE F WATER

THICKNESS (.01 in.)	t"			2.61	2.58				2.59		2.66
MASS IN WATER (0.1 g)	B"			681.9	680.1				678.2		695.5
SSD MASS (0.1 g)	C"			1217.4	1205.8				1206.3		1242.6
VOLUME (C" - B")	E"			535.5	525.7				528.1		547.1
VOL. ABS. WATER (C" - A)	J"			40.0	31.9				38.3		41.9
% SATURATION (J" / I) x 100				102.0	97.5				108.4		105.4
% SWELL((E" - E) / E) x 100				1.21	0.86				1.29		1.41
LOAD (LB.)	P"			1000	1030				940		1035
DRY STRENGTH ((2P) / tDπ)	Std	69.5	76.5				75.9			78.0	
WET STRENGTH((2P") / t"Dπ)	Stm			61.0	63.5				57.8		61.9
VISUAL MOISTURE DAMAGE											
CRACK / BREAK DAMAGE											

π = 3.1416

TENSILE STRENGTH RATIO $\frac{\text{Average Wet Strength (psi)}}{\text{Average Dry Strength (psi)}}$ $\frac{\text{Stm1+ Stm2 + ...+ Stmn}}{\text{Std1 + Std2 + ... + Stdn}} = \frac{61.1}{75.0} \times 100 =$ **81.5**

Figure 1