Method of Test for Density and Air Voids of Asphalt Concrete by the Marshall Method

1. Scope:

This test is to determine the density and air void level of asphalt concrete mixtures.

2. Apparatus:

2.1 Slant foot (1° bevel) rotating base Marshall mechanical compaction machine mounted on a wooden pedestal secured to a concrete slab.

2.2 Compaction hammer conforming to AASHTO T 245.

2.3 Compaction molds conforming to AASHTO T 245.

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. The scale or balance shall be equipped with a suitable suspension apparatus and holder to permit weighing the sample while suspended from the center of the scale pan of the weighing device.

2.5 Thermometers, dial type, armored glass, or digital with a range of 50° to 400°F with a sensitivity of 5° F.

2.6 Thermometer sensitive to 0.5°F and readable to 1°F.

2.7 Miscellaneous. Insulated gloves, small trowel, filter paper discs, pails, shovel, pans, scoop or spoon, fuel oil, and rags.

2.8 Electric hot plate or roaster oven.

2.9 Water bath with an overflow outlet for maintaining a constant water level. An aquarium heater will suffice to control the temperature of the water bath at 77° ± 2°F. The water bath must be large enough to allow the suspension apparatus holder to be covered with water at all times. The sample and suspension apparatus must be completely covered with water during weighing. The wire suspending the suspension apparatus shall be the smallest practical size to minimize any possible effects of a variable immersed length.

2.10 A mechanical convection oven with a minimum chamber volume of 5.0 cubic feet capable of heating to 350°F.

3. Procedure:

3.1 Sampling uncompacted mix.

A. Material for the Marshall determinations shall be obtained from the same sample as obtained in SD 312.

B. Take approximately 70 to 80 lbs. of hot mix for the laboratory density determination - 110 to 120 lbs. when IA testing is required.

C. Transport the sample in a pail or box that is insulated or protected to help retain heat.

D. Place the sample in a clean pan where there will be neither loss of material nor the addition of foreign matter. Place the pan and material in an oven maintained at or slightly above the required compaction temperature.

3.2 Laboratory density determination.

A. Preheat 3 molds, a flat bottom scoop, and a trowel or spatula in an oven or on a hot plate to the established mix compaction temperature recommended on the job mix formula. Preheat the tamping face of the hammer to 200° to 300° F on a hot plate. On non QC/QA projects compact the mix at the delivery temperature to the road ± 10°F.

B. Obtain by quartering or by using a heated flat bottom scoop a representative sample, from the same pan of material used in SD 312 Section 3.3 B. The material placed in the mold shall make a Marshall specimen with a compacted height of 2 1/2" ± 1/8". Once the amount of material needed to make a compacted specimen the required height is established, material can be weighed into the compaction molds that have a paper disc in the bottom of the mold and placed in an oven. Monitor the temperature of the hot mix so that compacting will take place when the mix is at the established mix design compaction temperature recommended on the job mix formula. Thermometers should be calibrated and checked often to insure accurate temperature measurements.

C. Once the hot mix in the mold has reached the correct temperature, remove from the oven, rod 25 times (15 around the perimeter and 10 in the center) with the small trowel or spatula. After rodding, round off the top surface of the mixture. Measure and record the temperature of the mix in the mold.

D. Place a paper disc on the top of the mix in the mold and place the mold on the base of the mechanical compactor under the mold holder. Place the face of the hammer inside the mold and apply 50 blows, unless otherwise specified in the plans. Invert the mold and apply 50 blows or the number of blows specified in the plans to the opposite end of the specimen. After compaction, the base plate shall be removed and the paper discs discarded.

E. Repeat the procedure listed in paragraphs B., C., and D. above for the second and third specimens.

F. Cool the specimens in air. A fan may be used to aid in the cooling of the specimens. After a specimen has cooled enough to touch with the bare hand, remove it from the forming mold.

G. After removal, number each specimen and set aside. Avoid fracturing or deforming the specimens when handling. Rest specimens on a smooth, level surface until ready for testing. The height of each specimen shall be 2 1/2" ± 1/8".

If the Marshall specimen doesn't compact to a height of 2 1/2" ± 1/8", use the following equation to correct the amount of material to be used:

A = Actual weight of the specimen

$$\frac{(2.5 \times A)}{B}$$

B = Actual height of the specimen

H. After the specimen has cooled to room temperature, measure the height at four locations. Record the average height of the specimen to the nearest 1/16".

I. Weigh the specimen in air and record the weight to the nearest 0.1 gram.

J. Suspend the specimen in a water bath at 77° ± 2° F for 3 to 3.5 minutes. Record the immersed weight to the nearest 0.1 gram. Maintain a constant level of water in the water bath at the overflow outlet through the entire test procedure.

K. Immediately after weighing under water, blot the specimen dry with a damp terry cloth towel and record the saturated surface dry weight to the nearest 0.1 gram.

L. Repeat H., I., J., and K. for the other two specimens.

NOTE: Cores and pucks shall be weighed individually.

4. Report:

4.1 Calculate the Marshall bulk specific gravity of the laboratory specimens in the following manner.

$$\text{Marshall bulk specific gravity} = \frac{A}{C - B}$$

A = Weight of sample in air.

B = Weight of the sample suspended in water.

C = Weight of saturated surface dry sample in air.

F = Marshall bulk specific gravity

4.2 Report the Marshall bulk specific gravity to the nearest 0.001 on the DOT-48

NOTE: Use all three of the specimens provided the difference between the high and low specimen does not exceed 0.020. When any specimen varies by more than 0.020 from any of the other specimens, that specimen will not be used in the calculations and will be discarded. If the remaining two specimens are within 0.010 of each other, use their average for the Marshall density data. If they are not, discard the specimens and obtain a new set of Marshall specimens.

4.3 Calculate the percent of air voids in the following manner:

$$\%\text{ air voids} = \frac{(G - F)}{G} \times 100$$

G = Theoretical maximum specific gravity from SD 312.

F = Marshall bulk specific gravity.

H = % air voids.

4.4 Report the percent air voids to the nearest 0.1 on the DOT-48.

5. References:

AASHTO T 245
SD 312
DOT-48

MOISTURE SENSITIVITY REPORT - BITUMINOUS SURFACING

DOT - 48
3-19

FILE NUMBER ______________

PROJECT	P 3079(00)219	DESIGN LEVEL	I Q2	
PCN	5415	DESIGN AIR VOIDS	4.0	
COUNTY	Harding	DESIGN AC CONTENT	6.0	
DATE	09/27/2019			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	> 80
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 19

SATURATED 3 MIN. 19 "HG AVERAGE AIR VOIDS OF SAT. SUBSET 6.96

		1	2	3	4	5	6	7	8	9	10
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

		1	2	3	4	5	6	7	8	9	10
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				950		1035
DRY STRENGTH ((2P) / tDπ)	Std	69.5	76.5				75.9			78.0	
WET STRENGTH ((2P") / t"Dπ)	Stm			61.0	63.5				58.4		61.9
VISUAL MOISTURE DAMAGE											
CRACK / BREAK DAMAGE											

$\pi = 3.1416$

TENSILE STRENGTH RATIO $\frac{\text{Average Wet Strength (psi)}}{\text{Average Dry Strength (psi)}} = \frac{\text{Stm1 + Stm2 + ... + Stmn}}{\text{Std1 + Std2 + ... + Stdn}} = \frac{61.2}{75.0} \times 100 = $ 81.6

Figure 1