COMPACTION AND TESTING OF BITUMINOUS MIXTURES UTILIZING 152.4 mm (SIX INCH) MARSHALL APPARATUS

(A Modification of ASTM D 5581)

SCOPE

1. (a) This method covers the procedure for compacting and testing bituminous mixtures utilizing 152.4 mm (six inch) Marshall apparatus.

(b) This procedure is used for bituminous mixtures with a mix design gradation target of less than 85% passing the 19.0 mm (3/4 inch) sieve.

(c) This test method may involve hazardous material, operations, or 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 any regulatory limitations prior to use.

(d) 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.

(e) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) Compaction Mold Assembly [152.4 mm (six inch) diameter] - Cylindrical mold, baseplate, and extension collar; constructed of steel and conforming to the requirements of Figure 1. (Three compaction mold assemblies are normally utilized.)

(b) Specimen Extruding Device - Extrusion jack or press for extruding specimens from molds.

(c) Compaction Hammer.

1) A mechanical compaction hammer having a flat, circular tamping face with a nominal diameter of 149.4 mm (5-7/8 inches), and a 10.21 ± 0.01 kg (22.50 ± 0.02 pound) sliding weight with a free fall of 457.2 ± 2.5 mm (18.0 ± 0.1 inches).

2) For calibration purposes, the density of a 152.4 mm (six inch) diameter specimen of a 19 mm (3/4") AC mix compacted with the 152.4 mm (six inch) mechanical hammer utilizing approximately 112 blows per side shall not vary by more than 16.0 kg/m^3 (1.0 lb./cu. ft.) from the density of a 101.6 mm (four inch) diameter specimen of the same mix compacted with a compaction hammer meeting the requirements of Arizona Test Method 410. The number of blows may be varied from 112 in order to obtain calibration. If changes or adjustments to the compaction hammer or pedestal are made, a recalibration may be warranted.

(d) Compaction pedestal - The compaction pedestal shall consist of a 203.2 mm by 203.2 mm by 457.2 mm (8" x 8" x 18") wooden post capped with a 304.8 mm by 304.8 mm by 25.4 mm (12" x 12" x1") steel plate. The steel cap shall be firmly fastened to the post. The wooden post shall have a dry weight of 673 to 769 kg/m^3 (42 to 48 lbs./cu. ft.) and shall rest squarely on, and be firmly secured to, a solid concrete slab. The pedestal assembly shall be installed so that the post is plumb and the cap is level.

(e) Specimen Mold Holder - Mounted on the compaction pedestal so as to center the compaction mold over the center of the post. It shall hold the compaction mold, collar, and base plate securely in position during compaction of specimen.

(f) Oven for heating bituminous mixtures and specimen mold assemblies at required temperature.

(g) Hot plate for heating compaction hammer, spoon, and spatula.

(h) A flat spatula with blade approximately 25 mm (1 inch) wide and at least 150 mm (6 inches) long, stiff enough to penetrate the entire bituminous mixture.

(i) Thermometers for determining temperatures of bituminous mixtures. Armored glass thermometers or dial-type with metal stem with a range of 10 to 200 °C (50 to 400 °F) are recommended. Thermometers shall have increments of not greater than 2.8 °C (5 °F).

(j) A balance or scale 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 or scale utilized shall be at least one gram.

(k) Large spoon for placing mixtures in specimen molds.

(l) If Marshall stability and flow are to be determined, the following additional apparatus is required:

1) Breaking head consisting of upper and lower cylindrical segments or test heads. The lower segment shall be mounted on a base having two perpendicular guide rods or posts extending upward. Guide sleeves in the upper segment shall be in such a position as to direct the two segments together without appreciable binding or loose motion the guide rods. When a 152.4 ± 3.1 mm (6.000 ± 0.120 inch) diameter by 100 mm (4 inch) thick metal block is placed between the two segments, the breaking head shall conform to the requirements of Figure 2.

2) Water bath of sufficient depth to provide for the complete immersion of specimens and thermostatically controlled so as to maintain the bath at 60 ± 1 °C (140° ± 1.8 °F). The tank shall have a perforated false bottom or be equipped with a shelf for supporting specimens 50.8 mm (2 inches) above the bottom of the bath.

3) Marshall stability and flow testing apparatus, with operating instruction manual. The apparatus shall be capable of applying a load with a constant rate of travel of 50.8 ± 2.5 mm (2.0 ± 0.1 inches) per minute.

4) Height gauge capable of measuring the height of specimens to the nearest 0.1 mm (0.001 inch).

PROCEDURE

3 (a) A set of three 4000 gram (approximate) representative samples of bituminous mixture shall be obtained. The weight utilized will be such that compacted specimens for Marshall stability and flow testing meet the height requirement of 88.9 to 101.6 mm (3.500 to 4.000 inches).

(b) Before placing in the mold, the mixture and a mold assembly (baseplate, mold and collar) shall be at approximately 143 °C (290 °F). The face of the compaction hammer shall be thoroughly cleaned and heated on a hot plate set at approximately 143 °C (290 °F). The temperature of the laboratory during compaction of the specimens shall be between 20 and 30 °C (68 and 86 °F).

(c) Place a 152.4 mm (6 inch) paper disc in the bottom of the mold before the mixture is introduced. Place approximately one-half of the batch in the mold with a heated spoon. Spade the mixture vigorously, penetrating the entire mixture, with the heated spatula 15 times around perimeter and 10 times over the interior. Place the second half of the batch in the mold and repeat the spading procedure. Smooth the surface of the mix to a slightly rounded shape.

(d) Unless otherwise indicated on the mix design, the compaction temperature range (except for recycle mixes and bituminous mixtures containing asphalt-rubber) shall be as shown in Table 1 below for the specified type of bituminous material. For asphalt-rubber mixes, the compaction temperature range shall be 163 ± 6 °C (325 ± 10 °F). For recycle mixes, the compaction temperature range shall be 141 ± 6 °C (285 ± 10 °F).

TABLE 1

Bituminous Material	Compaction Temperature Range
AC 10, AC 20	138 ± 6 °C (280 ± 10 °F)
AC 30, AC 40	141 ± 6 °C (285 ± 10 °F)
PG 58-XX, PG 64-XX	138 ± 6 °C (280 ± 10 °F)
PG 70-XX, PG 76-XX	141 ± 6 °C (285 ± 10 °F)
Polymer Modified Asphalts	143 ± 6 °C (290 ± 10 °F)

(e) If necessary, the mixture and mold shall be returned to an oven at the required temperature for the minimum time necessary to achieve the required compaction temperature.

(f) Place a 152.4 mm (six inch) paper disc on top of material, place the mold assembly on the compaction pedestal in the mold holder, and apply the calibrated number of blows (approximately 112) with the mechanical compaction hammer. Compaction shall be performed at a minimum rate of 40 blows per minute. The compaction hammer shall apply only one blow with each fall, that is, there shall not be a rebound impact. Remove the base plate and collar, and reverse and reassemble the mold. Apply the calibrated number of compaction blows to the face of the reversed specimen.

(g) Remove collar, baseplate, and paper discs, and allow specimen to cool. Cooling may be accomplished at room temperature, in a 25 °C (77 °F) air bath, or if more rapid cooling is desired the mold and specimen may be placed in front of a fan until cool.

(h) Extrude the specimen from the mold. Care shall be taken in extruding the specimen from the mold, so as not to develop tensile stresses in the specimen or tear the sides of the specimen.

SPECIMEN TESTING

4. Specimens prepared as above shall be tested by some or all of the following procedures, as applicable due to testing requirements and availability of apparatus.

(a) If Marshall stability and flow are to be determined, measure height of specimens to the nearest 0.1 mm (0.001 inch). Prior to measurement of height, excess material shall be brushed from the edges of the specimens. Compacted specimens shall be 88.9 to 101.6 mm (3.500 to 4.000 inches) in height. If this criteria is not met, the entire set of specimens shall be discarded and a new set prepared after necessary adjustments in sample weight have been made.

(b) Determine the specific gravity of the specimens in accordance with Arizona Test Method 415, Method A. (Assume specimen is at constant weight after cooling.)

(c) Determine the bulk density of each of the specimens, by multiplying the respective specific gravity by 998 kg/m^3 (62.3 lbs./cu. ft.). Record the individual bulk densities to the nearest 1 kg/m^3 (0.1 lb./cu. ft.). The densities of the three specimens shall not differ by more than 48 kg/m^3 (3.0 lbs./cu. ft.). If this density

requirement is not met, the entire set of specimens shall be discarded and a new set of specimens prepared.

(d) Determine the average specific gravity of the specimens and record to the nearest 0.001. Calculate the average bulk density of the specimens, by multiplying the average specific gravity by 998 kg/m^3 (62.3 lbs./cu. ft.). Record the average bulk density to the nearest 1 kg/m^3 (0.1 lb./cu. ft.).

(e) If the stability and flow are to be determined, the steps in paragraphs (f) through (l) below are followed, utilizing apparatus in accordance with the operating instructions for that apparatus.

(f) Bring the specimens to 60 ± 1 °C (140° ± 1.8 °F) by immersing in the water bath 45 to 60 minutes. Prior to testing, it shall be assured that the inside of the test heads are clean, and that the guide rods are clean and lubricated so that the upper test head slides freely over them.

(g) The breaking head temperature shall be maintained between 21 to 38 °C (70 to 100 °F), using a water bath when required. Remove the specimen from the water bath, quickly towel dry specimen and place in the lower segment of the breaking head. Place the upper segment of the breaking head on the specimen, and place the complete assembly in position on the testing machine.

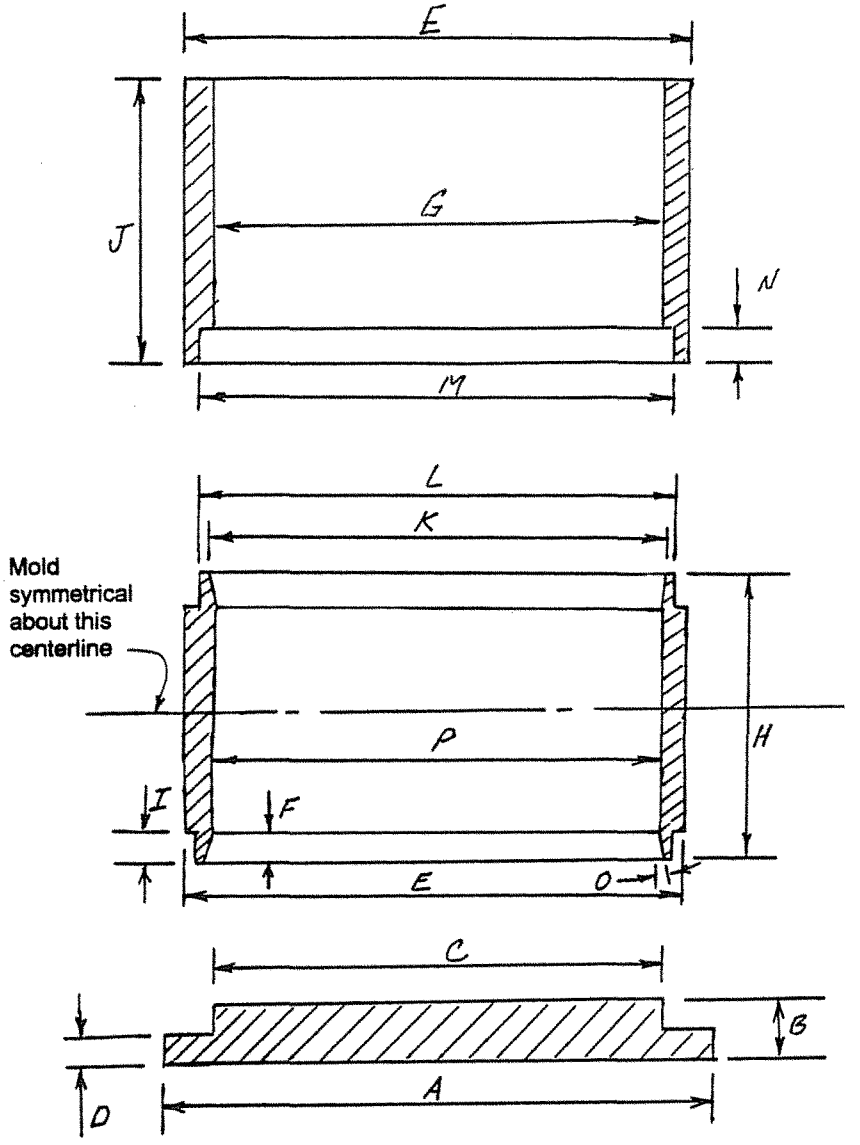
(h) Apply the load to the specimen with a constant rate of 50.8 ± 2.5 mm (2.0 ± 0.1 inches) per minute until the maximum load is reached and the load decreases. The maximum load is defined as the last point in the load/time curve before the load decreases. The elapsed time for the test from removal of the test specimen from water bath to maximum load determination shall not exceed 30 seconds.

(i) Record the stability of each specimen to the nearest 50 newtons (10 pounds force), and the flow to the nearest 0.1 mm (0.01 inch).

(j) Correct the stability obtained for each specimen, for the height of the specimen, by the table in Figure 3. Record the corrected stability to the nearest 50 newtons (10 pounds force).

(k) Determine and record the average corrected stability to the nearest 50 newtons (10 pounds force), and the average flow to the nearest 0.1 mm (0.01 inch).

(l) The average stability shall be corrected to correspond to a 101.6 mm (four inch) specimen by dividing the average test result by 2.0.

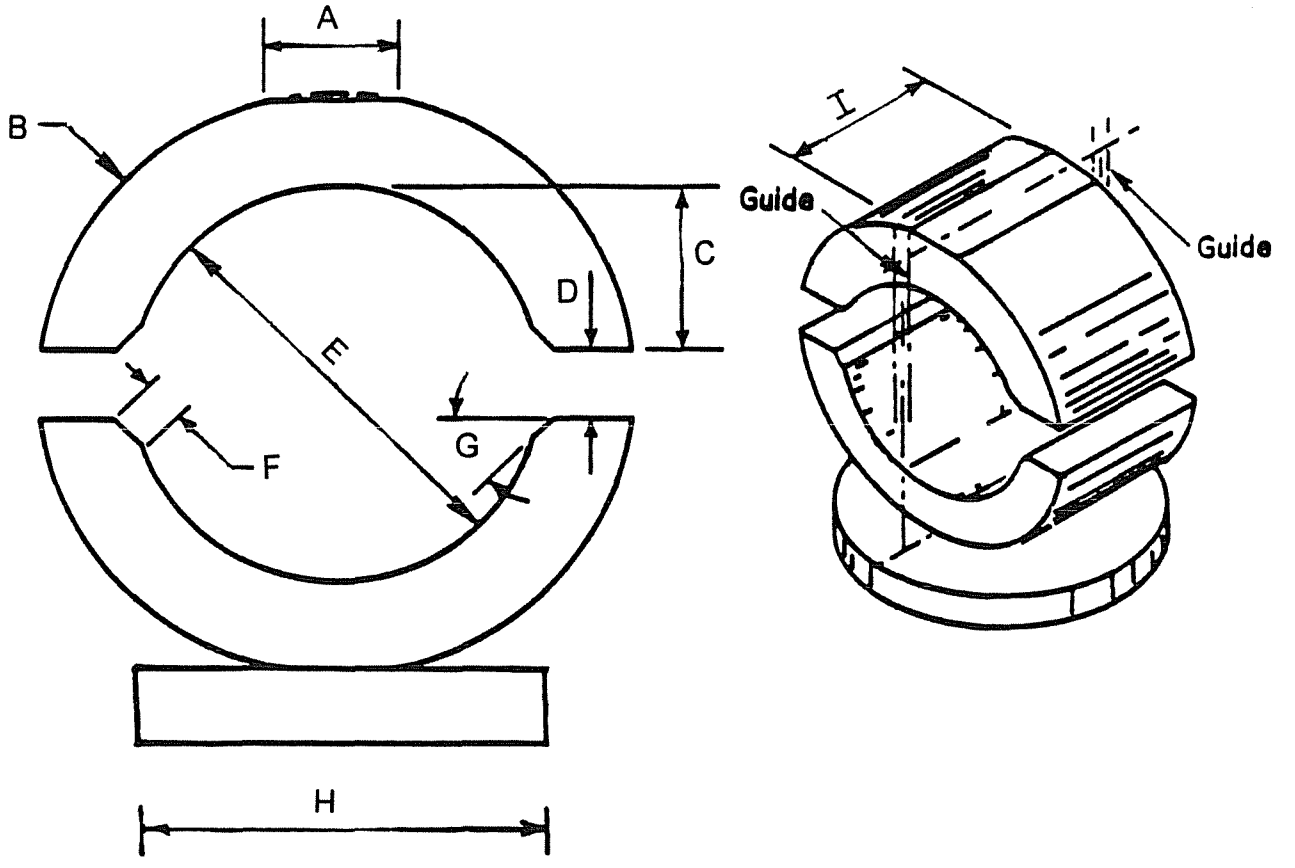


A	171.5 mm (6-3/4 in.)	H	114.3 mm (4-1/2 in.)
B	12.7 mm (1/2 in.)	I	6.4 mm (1/4 in.)
C	151.6 mm (5-31/32 in.)	J	82.6 mm (3-1/4 in.)
D	6.4 mm (1/4 in.)	K	155.6 mm (6-1/8 in.)
E	165.1 mm (6-1/2 in.)	L	159.1 mm (6-17/64 in.)
F	6.4 mm (1/4 in.)	M	159.6 mm (6-9/32 in.)
G	155.6 mm (6-1/8 in.)	N	7.1 mm (9/32 in.)
O	14°		
P	152.2 to 152.6 mm (5.992 to 6.008 in.)		

All dimensions are nominal, except where tolerances are indicated.

152.4 mm (Six Inch) Compaction Mold, Extension Collar, and Baseplate

FIGURE 1



A	50 mm (2 in.)
B	22 mm (0.87 in.) minimum
C	66.7 ± 1.3 mm (2.625 ± 0.050 in.)
D	19.0 ± 0.5 mm (0.750 ± 0.020 in.)
E	152.4 ± 3.1 mm (6.000 ± 0.120 in.)
F	13.5 ± 0.3 mm (0.53 ± 0.01 in.)
G	45°
H	152.4 (6 in.) nominal
I	108 mm (4.25 in.)

Breaking Head

FIGURE 2

STABILITY CORRELATION RATIOS*
For 152.4 mm (6 inch) Diameter Specimens

Height of Specimen (millimeters)	Height of Specimen (inches)	Correlation Ratio
88.9 - 89.1	3.500 - 3.511	1.12
89.2 - 89.6	3.512 - 3.532	1.11
89.7 - 90.2	3.533 - 3.553	1.10
90.3 - 90.7	3.554 - 3.574	1.09
90.8 - 91.2	3.575 - 3.594	1.08
91.3 - 91.7	3.595 - 3.615	1.07
91.8 - 92.3	3.616 - 3.636	1.06
92.4 - 92.8	3.637 - 3.657	1.05
92.9 - 93.3	3.658 - 3.678	1.04
93.4 - 93.9	3.679 - 3.699	1.03
94.0 - 94.4	3.700 - 3.719	1.02
94.5 - 94.9	3.720 - 3.739	1.01
95.0 - 95.5	3.740 - 3.760	1.00
95.6 - 96.0	3.761 - 3.782	0.99
96.1 - 96.5	3.783 - 3.803	0.98
96.6 - 97.2	3.804 - 3.831	0.97
97.3 - 97.9	3.832 - 3.858	0.96
98.0 - 98.6	3.859 - 3.886	0.95
98.7 - 99.2	3.887 - 3.907	0.94
99.3 - 99.7	3.908 - 3.928	0.93
99.8 - 100.4	3.929 - 3.956	0.92
100.5 - 101.1	3.957 - 3.983	0.91
101.2 - 101.6	3.984 - 4.000	0.90

* The measured stability of a specimen multiplied by the correlation ratio for the height of the specimen equals the corrected stability for a 95.25 mm (3-1/2 inch) specimen.

FIGURE 3