

MODIFIED MARSHALL METHOD FOR SEA BINDER

I. Scope

1.1 This method covers the measurement of the resistance to plastic flow of cylindrical specimens of bituminous paving mixture loaded on the lateral surface by means of the Marshall apparatus. This method is for use with mixtures containing sulphur asphalt and aggregate up to 1-in. (254-mm) maximum size.

Note--Unless otherwise stated in these modifications, references to asphalt and to asphalt cement in the test method shall apply to sulphur extended asphalt.

2. Apparatus

2.1 Specimen Mold Assemblage--Mold cylinders 4 in. (101.6 mm) in diameter by 3 in. (76.2 mm) in height, case plates, and extension collars shall conform to the details shown in Fig. 1. Three mold cylinders are recommended.

2.2 Specimen Extractor, steel, in the form of a disk with a diameter not less than 3.95 in. (100 mm) and $\frac{1}{2}$ in. (13 mm) thick for extracting the compacted specimen from the specimen mold with the use of the mold collar. A suitable bar is required to transfer the load from the ring dynamometer adapter to the extension collar while extracting the specimen.

2.3 Compaction Hammer--The compaction hammer (Fig. 2) shall have a flat, circular tamping face and a 10 lb (4536 g) sliding weight with a free fall of 18 in. (457.2 mm). Two compaction hammers are recommended.

Note 1--The compaction hammer may be equipped with a finger safety guard as shown in Fig. 2.

2.4 Compaction Pedestal--The compaction pedestal shall consist of an 8 by 18-in. (203.2 by 203.2 by 457.2-mm) wooden post capped with a 12 by 12 by 1-in. (304.8 by 304.8 by 25.4-mm) steel plate. The wooden post shall be oak, pine, or other wood having an average dry weight of 42 to 48 lb/ft³ (0.67 to 0.77 g/cm³). The wooden post shall be secured by four angle brackets to a solid concrete slab. The steel cap shall be firmly fastened to the post. The pedestal assembly shall be installed so that the post is plumb and the cap is level.

Note: The method has been modified from ASTM Test Designation D1559-76. Thus all figures referred herein are the same as those in the ASTM test.

2.5 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 the specimen.

2.6 Breaking Head--the breaking head (Fig. 3) shall consist of upper and lower cylindrical segments of test heads having an inside radius 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 on the guide rods.

2.7 Loading Jack--The loading jack (Fig. 4) shall consist of a screw jack mounted in a testing frame and shall produce a uniform vertical movement of 2 in. (50.8 mm)/min. An electric motor may be attached to the jacking mechanism.

Note 2--Instead of the loading jack, a mechanical or hydraulic testing machine may be used provided the rate of movement can be maintained at 2 in. (50.8 mm)/min while the load is applied.

2.8 Ring Dynamometer Assembly--One ring dynamometer (Fig. 4) of 5000-lb (2267 kg) capacity and sensitivity of 10 lb (4.536 kg) up to and 2267 kg shall be equipped with a micrometer dial. The micrometer dial shall be graduated in 0.0001 in. (0.0025 mm). Upper and lower ring dynamometer attachments are required for fastening the ring dynamometer to the testing frame and transmitting the load to the breaking head.

Note 3--Instead of the ring dynamometer assembly, any suitable load-measuring device may be used provided the capacity and sensitivity meet the above requirements.

2.9 Flowmeter--The flowmeter shall consist of a guide sleeve and a gage. The activating pin of the gage shall slide inside the guide sleeve with a slight amount of frictional resistance. The guide sleeve meter gage shall be adjusted to zero when placed in position on the breaking head when each individual test specimen is inserted between the breaking head segments. Graduations of the flowmeter gage shall be in 0.01 in (0.25 mm) division.

Note 4--Instead of the flowmeter, a micrometer dial or stress-strain recorder graduated in 0.001 in. (0.025 mm) may be used to measure flow.

2.10 Ovens or Hot Plates--Ovens or hot plates shall be provided for heating aggregates. Bituminous material, specimen molds, compaction

hammers, and other equipment to the required mixing and molding temperatures. It is recommended that the heating units be thermostatically controlled so as to maintain the required temperature within 5°F (2.8°C). Suitable shields, baffle plates or sand baths shall be used on the surfaces of the hot plates to minimize localized overheating.

2.11 Mixing Apparatus--Mechanical Mixing is recommended. Any type of mechanical mixer may be used provided it can be maintained at the required mixing temperature and will produce a well-coated, homogeneous mixture of the required amount in the allowable time, and further provided that essentially all of the batch can be recovered. A metal pan or bowl of sufficient capacity and hand mixing may also be used.

2.12 Water Bath--The water bath shall be at least 6 in. (152.4 mm) deep and shall be thermostatically controlled so as to maintain the bath at 140 ± 1.8 F (60 ± 1.0 C) or 100 ± 1.8 F (37.8 ± 1 C). The tank shall have a perforated false bottom or be equipped with a shelf for supporting specimens 2 in. (50.8 mm) above the bottom of the bath.

2.13 Air Bath--The air bath for asphalt cut-back mixtures shall be thermostatically controlled and shall maintain the air temperature at 77 F \pm 1.8 F (25 ± 1.0 C).

2.14 Miscellaneous Equipment:

2.14.1 Containers for heating aggregates, flat-bottom metal pans or other suitable containers.

2.14.2 Containers for heating bituminous material, either gilt-type tins, beakers, pouring pots, or saucepans may be used.

2.14.3 Mixing Tool, either a steel trowel (garden type) or spatula, for spreading and hand mixing.

2.14.4 Thermometers for determining temperatures of aggregates, bitumen, and bituminous mixtures. Armoured-glass or dial-type thermometers with metal stems are recommended. A range from 50 to 400 F (9.9 to 204 C), with sensitivity of 5 F (2.8 C) is required.

2.14.5 Thermometers for water and air baths with a range from 68 to 158 F (20 to 70 C) sensitive to 0.4 F (0.2 C).

2.14.6 Balance, 2-kg capacity, sensitive to 0.1 g, for weighing molded specimens.

2.14.7 Balance, 5-kg capacity, sensitive to 0.1 g, for batching mixtures.

- 2.14.8 Gloves for handling hot equipment.
- 2.14.9 Rubber Gloves for removing specimens from water bath.
- 2.14.10 Marking Crayons for identifying specimens.
- 2.14.11 Scoop, flat bottom, for batching aggregates.
- 2.14.12 Spoon, large, for placing the mixture in the specimen molds.

3. Test Specimens

3.1 Number of Specimens--Prepare at least three specimens for each combination of aggregates and bitumen content.

3.2 Preparation of Aggregates--Dry aggregates to constant weight at 221 to 230 F (105 to 110 C) and separate the aggregates by dry-sieving into the desired size fractions. The following size fractions are recommended:

- 1 to 3/4 in. (25.0 to 19.0 mm)
- 3/4 to 3/8 in. (19.0 to 0.9 mm)
- 3/8 in. to No. 4 (9.5 mm to 4.75 mm)
- No.4 to No.8 (4.75 mm to 2.30 mm)
- Passing No.8 (2.30 mm)

3.3 Determination of Mixing and Compacting Temperatures:

3.3.1 The temperature at which the hot asphalt, molten sulphur, and hot aggregate are mixed shall be within a range of 270° to 300° F (132° to 149° C).

3.3.2 The compacting temperature range shall be within a range of 250° to 280° F (121° to 138° C).

3.4 Preparation of Mixtures:

3.4.1 Weigh into a pan the amount of each size fraction required to produce a batch that will result in triplicate compacted specimens 2.5 ± 0.05 in. (63.5 ± 1.27 mm) in height (about 3800 g). Place the pan on the hotplate or in the oven and heat to a temperature not exceeding the mixing temperature established in 3.3 by more than approximately 20° F (7°C). Charge the mixing bowl, which also has been heated to the individual amounts of sulfur and asphalt into a 250-ml stainless steel beaker and heat in the oven at 280° to 300° F (148° to 149° C) for five minutes. Add the sulfur-extended-asphalt mixture to the premixed hot aggregate in the mixing bowl, and mix for a period of 2.0 minutes.

3.5 compaction of Specimens:

3.5.1 Thoroughly clean the specimen mold assembly and the face of the compaction hammer and heat them either in boiling water or on the hot plate to a temperature between 200° and 300° F (93.3 and 148.9) C. place a piece of filter paper or paper toweling cut to size in the bottom

of the mold before the mixture is introduced. Place the entire batch in the mold, spade the mixture vigorously with a heated spatula or trowel 15 times around the perimeter and 10 times over the interior. Remove the collar and smooth the surface of the mix with a trowel to a slightly rounded shape. Temperatures of the mixtures immediately prior to compaction shall be within the limits of the compacting temperature established in 3.3

3.5.2 Replace the collar, place the mold assembly on the compaction pedestal in the mold holder, and unless otherwise specified, apply 50 blows with the compaction hammer with a free fall in 18 in. (457.2 mm). Hold the axis of the compaction hammer perpendicular to the base of the mold assembly during compaction. Remove the base plate and collars, and reverse and reassemble the mold. Apply the same number of compaction blows to the face of the reversed specimen. After compaction, remove the base plate and place the sample extractor on that end of the specimen. Place the assembly with the extension collar up in the testing machine, apply pressure to the collar by means of the load transfer bar and force the specimen into the extension collar. Lift the collar from the specimen. Carefully transfer the specimen to smooth, flat surface and allow it to stand overnight at room temperature. Weigh, measure, and test the specimen.

Note 5--In general, specimens shall be cooled as specified in 3.5.2. When more rapid cooling is desired, table fans may be used. Mixtures that lack sufficient cohesion to result in the required cylindrical shape on removal from the mold immediately after compaction may be cooled in the mold in air until sufficient cohesion has developed to result in the proper cylindrical shape.