



# Standard Test Procedures Manual

Section: ASPHALT MIXES

Subject: PREPARATION OF MARSHALL  
COMPACTION SPECIMENS

## 1. SCOPE

### 1.1. Description of Test

The method described is used to prepare standard Marshall Mix Design specimens containing asphalt cement and aggregate up to 25 mm maximum size. Nominal size of the specimens is 101.7 mm diameter by 63.5 mm in thickness.

### 1.2. Application of Test

The test may be used to prepare Marshall Mix Design specimens for the purposes of mix design, research activities, quality control testing, quality assurance testing and product acceptance testing.

### 1.3. Units of Measure

No units of measure are specified. All references to units of dimension, weight or volume will be metric.

## 2. APPARATUS AND MATERIALS

### 2.1. Equipment Required

#### 2.1.1. Specimen Mold Assembly

Mold cylinders with an inside diameter of 101.7 mm and a height of 76.2 mm, base plates, and extension collars shall conform to the details shown in Figure 1 of the most recently approved ASTM D1559 -Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures using Marshall Apparatus. Three mold cylinders are recommended.

#### 2.1.2. Specimen Extractor

A steel disc with a diameter not less than 100 mm and a minimum thickness of 13 mm for extracting the compacted specimen from the mold collar by applying a slow gradual force (hydraulic jack) to the face of the specimen. A frame is also required to place the mold in so that the specimen can be extracted.

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COMPACTION SPECIMENS**2.1.3. Compaction Hammer**

The compaction hammer as shown in ASTM D1559, Figure 2, will have a flat circular tamping face and a 4 536 g sliding weight with a free fall of 457.2 mm. Two compaction hammers are recommended.

**2.1.4. Compaction Pedestal**

The compaction pedestal will consist of a 203.2 by 203.2 by 457.2 mm wooden post capped with a 304.8 by 304.8 by 25.4 mm steel plate. The wooden post will be oak, pine or other wood having an average dry weight of 0.67 to 0.77 g/cm<sup>3</sup>. The wooden post will be secured by four angle brackets to a solid concrete slab. The wood post will be imbedded approximately 10-15 mm into a cylindrical concrete block with minimum dimensions of 400 mm in diameter and 200 mm in height. The steel cap will be firmly fastened to the post. The pedestal assembly will be installed so that the post is plumb and the cap is level.

**2.1.5. Specimen Mold Holder**

The mold holder will be mounted on the compaction pedestal so as to center the compaction mold over the centre of the post. It will hold the compaction mold, collar and base plate securely in position during compaction of the specimen.

**2.1.6. Ovens or Hot Plates**

Ovens or hot plates will be provided for heating aggregates, asphalt, specimen molds, compaction hammers and other equipment to the required mixing and compaction temperatures. Heating units will be thermostatically controlled so as to maintain the required temperature within 3° C. Suitable shields, should be used on the surfaces of the hot plates to minimize localized overheating.

**2.1.7. Scale**

A scale is required to weigh materials up to 3 000 g. The scale will be capable of weighing to 0.1 g.

**2.1.8. Miscellaneous Equipment**

Pans, pails, mixing bowls, scoop, spatula, trowels and thermometers. Electric thermometers with digital read out are recommended. Gloves for handling hot materials and equipment. Marking crayons for identifying specimens.

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## 2.2. Materials Required

### 2.2.1. Marshall Mix Designs

The preparation of specimens for Marshall Mix Designs requires representative samples of the aggregates to be used. The samples will be approximately 1200 g in size and shall be combined to the desired gradation.

Samples of the asphalt cement which is the specified grade to be used in the field and from the asphalt manufacturer who will supply the asphalt.

### 2.2.2. Field Mix Specimens

Select approximately 3600 g of a representative sample of asphalt mix as described in STP 103 - SAMPLING ASPHALT MIXES.

Split the sample into three 1200 g portions for the preparation of three Marshall specimens. Samples will be split using a method which will ensure that all three samples are representative of the original 3600 g sample. If the correlation between the density of three briquettes meets acceptable requirements for precision, the Engineer may approve the use of an average of two briquettes instead of three.

## 3. PROCEDURE

### 3.1. Equipment Preparation

Thoroughly clean the specimen mold assembly and the face of the compaction hammer and heat them to a temperature between 90° C and 145° C. Assemble the mold, mold base and collar on the compaction base. Place two filter papers on the bottom of the mold in preparation for placing the asphalt mix in the assembled mold.

It is desirable to heat the mold assembly and the face of the compaction hammer to the same temperature for all specimens. In a field testing situation, the equipment may have to be heated to the upper end of the specified range if ambient temperatures are cool.

The compaction pedestal shall be set on a solid foundation. In field situations, the compaction base will be firmly seated on a 150 mm thick base of compacted bituminous mix placed in an excavation constructed for this purpose. Care must be taken to ensure that the plate that the mold assembly sits on is level and that the compaction pedestal does not bounce or wobble during the compaction process.

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### 3.2. Sample Preparation

#### 3.2.1. Marshall Mix Design

Prepare representative samples of the field aggregates by following the procedure below:

- (a) Dry the aggregate in an oven for approximately eighteen hours at 105° C to 110° C. Separate the aggregate into the individual specified sieve sizes by dry sieving. The sieve sizes will be established by the specified aggregate type.
- (b) Recombine individual aggregate fractions in correct proportions to obtain the average stockpile gradation which is determined during the crushing of the aggregate. Proportioning will be for approximately 1200 g specimens.
- (c) Combine trial percentages of each size, then run a wet sieve and compare the result to the stockpile average. Adjust the proportions of each size and repeat the procedure until the desired gradation is achieved. Use the final percentages of each size to produce Marshall specimens.

If fillers or blenders are to be used in the mix, actual samples of field fillers/blenders must be used.

Place the asphalt cement in an oven for approximately two hours for pre-heating. The temperature of the asphalt cement should not exceed 110° C during the pre-heating.

### 3.3. Test Procedure

#### 3.3.1. Marshall Mix Design

Weigh into separate pans for each test specimen the amount of each aggregate size fraction required to produce a batch that will result in a compacted specimen  $63.5 \pm 1.3$  mm in height. Usually 1200 g of aggregate is required.

Place the pans on the hot plate or in the oven and heat to a temperature not exceeding the mixing temperatures specified in Table 1 by more than approximately 28° C.

Remove one pan at a time from the oven and place on a hot plate. Form a crater in the dry blended aggregate and weigh the pre-heated required amount of asphalt

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cement into the mixture. Mix the aggregate and asphalt thoroughly, maintaining the required mixing temperature. Continue mixing until all particles are well coated.

Remove pan and mix from the hot plate and continue mixing until the mix cools to the required compaction temperature. This is the temperature which results in an asphalt viscosity of 280 cst. The required temperatures are shown in Table 1.

TABLE 1 - MIXING AND COMPACTION TEMPERATURES

Asphalt Cement (Grade)	Mixing Temp. (° C)	Compaction Temp. (° C)
150-200A	143 ± 2	133 ± 2
200-300A	138 ± 2	126 ± 2
300-400A	128 ± 2	122 ± 2
400-500A	120 ± 2	116 ± 2
200-300B	134 ± 2	126 ± 2
300-400B	128 ± 2	122 ± 2

Proceed with specimen preparation as described in 3.3.3 Compaction Procedure.

### 3.3.2. Field Mix Specimens

Collect samples as described in 2.2.2. Adjust the temperature of the mix for each specimen to the required compaction temperature as specified in Table 1.

### 3.3.3. Compaction Procedure

Place the entire batch in a previously prepared mold assembly, 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 mix immediately prior to compaction shall be within the limits of the specified compaction temperature.

Place two filter papers on the surface of the mix and replace the mold collar. Place the mold assembly on the compaction pedestal in the mold holder and unless otherwise specified, apply 50 blows with the compaction hammer. During compaction the operator will hold the axis of the compaction hammer by hand as nearly perpendicular to the base of the mold assembly as possible. Remove the base plate and collar and reverse and reassemble the mold. Apply the same number of compaction blows to the face of the reversed specimen.

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When compaction is completed, extrude the sample from the compaction mold. Carefully transfer the specimen to a smooth, flat surface and allow it to cool to ambient temperature before testing.

The specimen should be extruded using a hydraulic jacking device to provide a gentle and constant pressure. Using hammers or other methods of impact loading to remove specimens from the mold is not acceptable. Mixtures that lack sufficient cohesion to retain the required cylindrical shape on removal from the mold immediately after compaction should be cooled in the mold in air until sufficient cohesion has developed to result in the proper cylindrical shape.

Marshall briquettes which will be tested for stability and flow characteristics will be allowed to stand at room temperature overnight before any testing is conducted on them.

The compacted specimen should be between 62.2 and 64.8 mm high. If the specimens are outside this range, adjust the amount of asphalt mix in subsequent tests.

## 4. RESULTS AND CALCULATIONS

### 4.1. Collection of Test Results

Marshall specimens will be appropriately marked using a wax crayon as soon as they are removed from the compaction mold. Specimen height will also be measured and recorded for future reference.

## 5. CALIBRATIONS, CORRECTIONS, REPEATABILITY

### 5.1. Equipment Calibration

The method described in this Standard Test Procedure does not include mechanical mixing and compaction apparatus. If a laboratory wishes to use equipment or methods other than those described herein must ensure that specimens prepared using different methods are equal in every respect to those manufactured by this specification.

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For Quality Assurance samples which have been allowed to cool, a correlation must be established in the field lab for specimens prepared using fresh hot asphalt mix to those prepared from asphalt mix which has been allowed to cool to ambient temperature and then reheated to the specified compaction temperature.

Quality assurance check samples prepared in a checking lab should then correlate with the reheated field samples.

## 5.2. Sources of Error

Compaction pedestal sitting on a soft, spongy or flexible foundation.

Compaction pedestal not set so compaction surface is level.

Hammer face and mold assembly not properly heated before compaction.

Asphalt mix at wrong compaction temperature. This may be a particular problem in cool weather when mold assembly and mix cools very quickly outdoors.

Incorrectly calibrated thermometers.

Marshall compaction hammers with incorrect free fall, or hammer weight.

Segregation of the mix during mixing or placement in the mold assembly.

Operator not giving the hammer the full required drop on each stroke or bouncing the hammer by hitting the top of the hammer handle on the upstroke or catching the hammer before it impacts all of its energy at the bottom of the stroke.

Not holding the hammer perpendicular to the compaction pedestal.

## 5.3. Precision

The allowable difference of the density of Marshall specimens prepared using the method will be:

Marshall Mix Designs: The results from two labs will not differ by more than 15 kg/m<sup>3</sup>.

Field Mix Specimens: The results from two labs will not differ by more than 20 kg/m<sup>3</sup>.

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## 6. ADDITIONAL INFORMATION

### 6.1. References

ASTM D1559 - Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus.

### 6.2. Safety

Use extreme caution when lifting and dropping the Marshall hammer. Avoid injury by being careful not to trap fingers under the falling compaction hammer. This most often occurs when the hand is brought down too quickly after releasing the weight at the top of the stroke.

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## APPROVAL SHEET

New  Revision  Date of Previous Document 91-01-16  
Effective Date: 92-03-05

Description of Revision (Reason for Revision):

- Recommendations and suggestions have been written into the test procedure
- Description of compaction pedestal has been updated to describe new compaction pedestals.

Review/Implementation Process:

Reviewed by the Lab Supervisors Committee

Other Manuals/Policies Affected:

Nil

Follow Up/Training Required:

Nil

Comments/Concerns/Implications (Budget/Environment/Stakeholders):

Prepared and Recommended by D. MacLeod 92-03-05  
Quality Control Engineer Date

Approval Recommended by R.A. Widger 92-03-18  
Director, Geotechnical & Materials Br. Date

Approved by D.G. Metz 92-03-19  
Executive Director, Engineering Division Date

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Update Mailed - -