ATT-13/22, FORMING MARSHALL SPECIMENS, Field Method

1.0 SCOPE

This method covers the procedures for preparation, forming and compacting field formed 102mm (4") diameter by 64mm (2.5") high Marshall specimens.

2.0 EQUIPMENT

Marshall Hammer	Marshall Molds (2)	Marshall Mold Holder
Tare Pans (for heating agg.)	Grocer Scoop	Mixing Bowls
Mixing Spoons	Thermometers	Large Mixing Pan

Spatula (for rodding mix)
Marking Crayons (for identifying test specimens)
Table Fan (for cooling compacted specimens)

Compaction Block – the compaction block shall consist of an **8" x 8" wooden post capped by a 12" x 12" x 1" steel plate**. The wooden post shall be oak, pine, or other wood having an average dry weight of 42-48 lb/ft^3. **The wooden post shall be secured by four angle brackets to a solid concrete slab (or concrete block)**. The steel cap shall be firmly fastened to the wooden post. The compaction block assembly shall be installed so that the post is plumb, the steel plate level, and the entire assembly is free from movement during the compaction process.

electronic balance - capable of reading to 0.1 g and having an accuracy of at least 0.01% of the sample mass, e.g. for a 2000 g sample weight, the balance must be accurate to 0.2 g. The balance must be operated and calibrated as per manufacturer's recommendations.

Oven – capable of maintaining a temperature of 135 ± 5^{o}C for heating aggregates, asphalt, marshall molds, mixing tools and containers, asphalt mixes, and other equipment, to the required mixing and compaction temperatures.

Thermometers – amored, glass, or dial-type with metal stem, 50^{o}C to 230^{o}C, for determining the temperature of aggregates, asphalt and asphalt mixtures.

Paper Discs – a paper disc with a diameter of 101.6 mm (4 in.) for use as a bond breaker during compaction in the mold.

Gloves – for handling hot equipment.

Hot Plate – for heating the Marshall hammer and a sand bath (container filled with heated sand to keep rods, trowels and scoops sufficiently hot).

Wide Mouth Funnel – for filling the Marshall mold with asphalt mix.

Extrusion Jack – for extruding compacted specimens from the Marshall mold.

ASTM D6926 shall be referenced for Marshall Compaction Hammer, Compaction Mold, Compaction Pedestal (wood post capped with a steel plate), and other associated test specification requirements.

3.0 PROCEDURE

3.1 Equipment Preparation

1. Install the concrete block, post and steel plate.

2. Before sampling the asphalt mix, place the two Marshall molds, grocer scoop, funnel and spatula in the oven (pre-heated to the compaction viscosity temperature of the asphalt cement being used).

   NOTE: If the equipment is not heated, it will cool the mix, mix will stick to the tools, and the density of the compacted specimen may be affected.

3.2 Forming the Marshall Specimens

1. Obtain a sample of representative asphalt mix as directed in ATT-37, SAMPLING MIXES.

2. Pour the contents of the sampled mix into the large heated mixing pan and use a heated grocer scoop to thoroughly mix it.

3. Perform a visual inspection on the mix as directed in ATT-51, VISUAL INSPECTION, Asphalt Concrete Paving Mixtures, and record pertinent data in the compaction data sheet.

4. Weigh two 1200 gram samples of mix into two tared tare pans. Two Marshall specimens are formed from each loose mix sample (1A & 1B, 2A & 2B, 3A & 3B, 4A & 4B, 5A & 5B).

5. Insert a thermometer into each tare pan containing the mix, and then place the tare pans into the oven and heat to the required compaction temperature.

   The compaction viscosity temperature is the temperature to which asphalt cement must be heated to produce a viscosity of 280 mm^2/s (millimetres squared per second) and at which the mix for the Marshall specimen must be compacted.

   The Asphalt Mix Design for the project includes the mixing temperature and compaction temperature of the asphalt mix specimens for the asphalt supplier and grade of asphalt cement used in the mix.

6. If the mix is too cold, place the mix in the oven and re-heat it, or if the mix is too hot, air cool it, until the mix is within $\pm 2^oC$ of the compaction viscosity temperature.

7. Once the mix is at, or slightly above, the compacting temperature, remove one heated mold assembly, and the heated funnel and spatula from the oven.

8. Assemble the mold and place it between the mold holder guide bolts on the steel plate.

9. Place a paper disc in the bottom of the mold, then put the heated wide-mouth funnel on top of the mold.

10. Pour all of the mix from the tare pan into the mold in one batch to avoid segregation. Ensure that no material is lost.

    If the sample is being segregated when dumped into the mold, use the scoop to place the sample in the mold instead.

11. Remove the funnel, and then use the heated spatula to rod the mix vigorously 15 times around the perimeter of the mold, then 10 times over the interior. This will result in a smoother specimen and eliminate any bridging of the rock.

    NOTE: If the mix is coarse, excessive rodding over the interior will tend to segregate the sample and not be effective.

12. Smooth the surface of the mix to a slightly rounded shape.

13. Place the grocer scoop, funnel and spatula back into the heated oven.

14. Check the temperature of the mix, then refer to step 6. When the temperature of the mix in the mold reaches the compaction temperature, place a paper disk on top of the mix.

15. Compact the mix carefully with the Marshall hammer for the proper amount of blows as specified in the mix design, e.g., 50 blows or 75 blows.

    During the compaction process, hold the axis of the tamper as perpendicular as possible to the steel plate. No mechanical device of any kind shall be used to hold the tamper in the above described position. For safety purposes, the teri-cord gloves (or other heat resistant gloves) should be worn while operating the tamper.

16. After compacting the first side, reverse the mold to compact the bottom face of the asphalt mix. Remove the base plate and collar, then reverse and reassemble the mold assembly. Apply the same number of compaction blows to the face of the reversed specimen.

17. After compaction, take the mold off the base and remove the paper discs from the top and bottom. **Mark the specimens on the last side compacted with a colored grease pencil. As an example, mark them with the Lot number 5-A or 5-B.** Set the mold on a level surface, base plate downward and allow the specimen to cool until it is hard enough to be removed from the mold without distortion. For faster cooling, an air fan may be used.

18. For each series of tests, form a second Marshall specimen by repeating steps 7 to 17.

3.3 Extruding the Marshall Specimens

1. If an extruder is available, proceed to step 2 below.
   ***IF AN EXTRUDER IS NOT AVAILABLE*, remove each specimen from the mold as follows:**

   a) set the mold collar on the steel plate;

   b) set the mold on top of the collar;

   c) place the compaction hammer vertically over the mold so that the tamper foot rests on the specimen;

   d) slide the hammer weight upwards on the hammer and then firmly pound it against the tamping foot;

   e) repeat step (d) until the specimen begins to move from the mold;

   f) decrease the force of the blows so that the sample gently slides out, and is not disturbed.

2. ***IF AN EXTRUDER IS AVAILABLE*, remove each specimen from the mold in the following manner:**

   a) center the extruder's circular base plate on the jack;

   b) center the mold in the extruder's base plate;

   c) jack the assembly up until the top of the mold is just about touching the top plate;

   d) line up the inside circumference of the top of the mold with the hole on the top plate;

   e) jack the specimen up through the hole, keeping the specimen as perpendicular as possible so that the specimen is not distorted.

3. Place the extruded marshall specimen, sitting on its flat side, on a smooth, level surface.

3.4 Processing the Marshall Specimens

1. For each specimen, perform ATT-32, VISUAL INSPECTION, Asphalt Concrete Formed Specimens.

2. Determine the dry density of each specimen using ATT-7, DENSITY Immersion Method, Saturated Surface Dry Asphalt Concrete Specimens (or ATT-6 for Waxed Specimens), and ATT-15, Part V, MOISTURE CONTENT, Oven Method, Asphalt Concrete Mixes.

3. Determine the asphalt content of the test series Marshall specimens as follows:

   a) If performing quality control testing, determine the asphalt content of the test series mix using ATT-74, Part I, Ignition Asphalt Content, Ignition Method. For this test, use the mix remaining in the large mixing pan from step 2 of Section 3.2.

   b) If performing quality assurance testing, determine the average corrected extraction asphalt content of the cores taken for the lot.

4. Use the average dry density of the two Marshall specimens compacted for the test series and the asphalt content determined in step 3 above to determine the test series Marshall Airvoid contents as directed in ATT-36, Void Calculations (or by Gmm to determine Airvoids).

5. Use the average dry density of the Marshall specimens (or Gmm) compacted for the lot as a comparison for core road densities that fall within that lot. The procedure for determining segment and lot percent compaction is described in ATT-67, %Compaction, ACP.

6. If performing quality control testing and a nuclear asphalt gauge is available, adjustments to the plant's asphalt setting may be made if required until the field Marshall's air void content is within ±0.5% of the design air void content. Those adjustments are described in ATT-32, Visual Inspection of Marshalls.

4.0 Installation of Compaction Post and Block

The interaction of the hammer, pedestal, and supporting foundation is critical.
ATT-13, FORMING MARSHALL SPECIMENS, Field Method (ASTM D6926)

EQUIPMENT:

Concrete Block (nominal size of 18" x 18" x 9" (457.2mm x 228.6mm)),
Wood Post (203mm x 203mm) (8" x 8"),
Steel Top Plate (305mm x 305mm x 25mm) (12" x 12" x 1"),
Crushed Aggregate (12.5mm – 25mm),
Sand, for levelling
Wood Shims.

INSTALLATION:

1. Check the concrete block and wood post for structural integrity.
   Ensure that both of the wood post ends are flush and square.
   It it rocks, then sand down the high spots, on both ends, until the top plate and concrete block is solid on the post.

2. If possible, position the lab so the ground drains away from where the block will be located. Avoid positioning the mobile lab where nearby building drain spouts and drainage courses are located. Water draining under the lab can severely saturate the ground under the compaction post, and may cause marshall densities to gradually decrease.

3. To prepare the concrete block base, centre the base location under the lab floor posthole, then excavate all topsoil and organics until solid ground is reached. Fill in the excavation with moist crushed aggregate up to about 3 cm above ground level, then pack the aggregate. Fill in the voids in the crushed aggregate with a thin layer of moist sand and gravel. ***THIS IS AN IMPORTANT STEP WHICH IS SOMETIMES OVERLOOKED.***

4. Position the concrete block centered under the lab floor posthole by directly placing it on the prepared gravel base. Set the block by twisting it in the sand so that the block doesn't rock. Check the concrete block for levelness and if it is not level, remove the block and adjust the sand. The wood post is to be centered in the floor hole and not leaning against any of the sides of the hole.

5. Before placing the wooden post into the concrete block brush out the post insert cavity in the block. Fasten the top plate to the post with screws, and place the post in the block. The post is to be free in the floor hole and not leaning against any of the side of the hole. Ensure the steel top plate if flush with the post. Check the steel top plate for levelness, and if not level, remove the post and adjust the block.

6. Set the block further by lifting and pounding the post up and down in the block about 10 times. Secure the wood post in the block by tightening the L brackets against all four sides of the wood post. Secure the wood post in the floor hole by wedging shims in against the four side of the post by hand. Check again that the steel top plate is level and flush with the post, then secure it to the wood post with screws.

COMPACTION:

1. Ensure that the compaction hammers have been calibrated.

2. Ensure that the asphalt mix is at the compaction viscosity temperature (± 2°C) before compaction. Consistent marshall densities depend on the consistency of sample weights, consistency of compaction temperatures, and by allowing the hammer to double-bounce during the compaction process.

3. Variations in compacted density may even occur when a given mix is compacted with different compaction hammers.

4. To avoid segregating the mix, quickly pour the heated loose mix through a heated funnel into the compaction mold.

5. Keeping the compaction hammer foot war, by keeping it on a hot plate, or on a heated sand bath, in-between marshall compactions, will prevent heat loss from the asphalt mix during compaction.

6. For mechanical compactors, it is necessary to establish the mechanical equivalency correction factor for the equipment, as compared to the control density achieved using the manual compaction process. ***This correction factor should be established for each mix design.***

DENSITY PROBLEMS:

9 out of 10 low marshall density problems encountered are due to either:

Not excavating all topsoil and organics from under the concrete block.

Ensure that the aggregate base under the concrete block is above the ground level, as this assists in keeping water from infiltrating under the concrete block.

Water draining under the lab and soaking the ground under the compaction post, from either the lab sink drain or a nearby building eaves trough downspout, will give a cushioning effect during compaction, causing marshall densities to gradually get lower and lower. Ensure that your sink drain has a long hose attached to keep the water draining well away from under the lab.

Compaction Post ends which are not flush or square.

Not securing the compaction post to the concrete block, or steel top plate.

Not establishing a correction factor for the automatic compactor, for each mix type used.

5.0 HINTS AND PRECAUTIONS

1. Ensure that the mix is at the compaction viscosity temperature (± 2°C) before tamping. Consistent marshall densities depend on the consistency of sample weights, consistent compaction temperatures, and by allowing the hammer to double-bounce during the compaction process.

2. Gloves should be worn when using and handling the Marshall hammer. This piece of equipment is capable of inflicting severe injury to the hands and fingers. Use caution when lifting and dropping the Marshall hammer weight. Avoid injury by taking special care not to trap fingers under the falling compaction hammer. This may happen when the operators hand is brought down too quickly after releasing the weight at the top of the stroke.

3. Ensure that the Marshall specimens are cooled before removing from the mold. Specimens may distort if removed while hot, resulting in erroneous densities. Incorrect Marshall densities will result in incorrect air voids content and percent compaction.

4. For mobile labs, ensure that the 1" steel top plate is secured to the top of the wood compaction post, and the post goes through a hole in the lab trailer floor, and is then secured to a large concrete block, which sits on a well compacted gravel base underneath the mobile lab. For main labs, the base under the compaction block is bolted to a concrete floor. If the compaction pedestal is sitting on a soft, spongy or flexible base, then the marshall densities will be affected (lower than mix design).

5. Keep the compaction hammer foot warm, by keeping it on a hot plate, or on a heated sand bath, in-between marshall compactions, to prevent heat loss from the asphalt mix.

6. Ensure that the compaction hammers have been calibrated.

7. Allow the hammer foot to completely stop before catching it and lifting it up for the next drop. ***The foot should be allowed to double bounce on the marshall puck so that it imparts all of its energy at the bottom of the stroke.***

8. Ensure that the thermometers are calibrated.

9. Ensure that the compaction pedestal is level.

10. Thoroughly clean the compaction mold assembly and the face of the compaction hammer before, and after, each use.

11. It is recommended that two compaction hammers be available in case one is damaged during the project.

NOTE: Automatic marshall compactors may be used when properly correlated with the manual hammer, by determining the number of blows necessary for the automatic compactor to produce the same marshall density as that produced by the specified number of blows from the mix design with a calibrated manual hammer.
A correction factor will be required for each different mix design.