Washington State Department of Transportation

Publications Transmittal

Transmittal Number	Date
PT 12-015	January 2012
Publication Title / Publication Number: *Materials Manual* M 46-01.11	
Originating Organization: Materials Laboratory, Engineering and Regional Operations	

Remarks and Instructions

The complete manual, revision packages, and individual chapters can be accessed at www.wsdot.wa.gov/publications/manuals/m46-01.htm.

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For updating printed manuals, page numbers indicating portions of the manual that are to be removed and replaced are shown below.

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Approved By

Signature

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Materials Manual

M 46-01.11

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Engineering and Regional Operations
Materials Laboratory

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WSDOT Test Method T 606

Method of Test for Compaction Control of Granular Materials

1. Scope

   This test method is used to establish the theoretical maximum density of granular materials and non-granular materials with more than 30 percent by weight of the original specimen is retained on the No. 4 Sieve or more than 30 percent by weight of the original specimen is retained on the ¾″ sieve.

2. Reference Documents

   2.1 AASHTO Standards

   T 99 – Moisture-Density Relations of Soils Using a 5.5-lb (2.5-kg) Rammer and a 12-in. (305-mm) Drop (Method A only)

   M 92 – Standard Specification for Wire-Cloth Sieves for Testing Purposes

   M 231 – Standard Specification for Weighing Devices Used in the Testing of Materials

   2.2 WSDOT Standards

   T 2 – FOP for AASHTO Standard Practice for Sampling Aggregates

   T 248 – FOP for AASHTO Reducing Samples of Aggregate to Testing Size

   T 255 – FOP for AASHTO Total Moisture Content of Aggregate by Drying

3. Definitions

   3.1 Fine Aggregate Portion-Material passing the No. 4 Sieve

3.2 Coarse Aggregate Portion- Material retained on the No. 4 Sieve

4. Significance and Use

   This test method consists of three separate tests which present a method for establishing the proper theoretical maximum density values to be used for controlling the compaction of granular materials. In general, this test method is applicable to granular materials having 30 to 70 percent of the material passing the No. 4 (4.75 mm) sieve. These methods account for variations of maximum obtainable density of a given material for a given compactive effort, due to fluctuations in gradation.

5. Apparatus

   5.1 A vibratory spring-loaded compactor. Information on where to obtain this equipment will be provided by the State Materials Laboratory.

   5.2 Standard mold and base with a piston to fit inside the mold with a maximum 1/16 inch clearance between piston and mold.

5.3 A ½ ft^3 mold with a piston to fit inside mold having a maximum 1/16 inch clearance between piston and mold.

5.3.1 The molds and pistons will be constructed of metal of such dimensions as to remain rigid and inflexible under test conditions.

5.4 Spacer blocks of varying heights compatible with the compactor and pistons

5.5 Measuring device, accurate and readable to 0.01 inch with a minimum 6 inch length

5.6 Pycnometer calibrated at the test temperature having a capacity of at least 1 quart (100 ml). Metal pycnometers may not be used to determine the specific gravity of the fine particles.

5.7 One vacuum pump or aspirator (pressure not to exceed 100 mm mercury).

5.8 One balance accurate to 0.1 g.

5.9 3 inch (75 mm) and a No. 4 (4.75 mm) sieve conforming to AASHTO M 92 requirements.

5.10 Balance or scale: capacity sufficient for the principle sample mass, readable to 0.1 percent or 0.1 g and meeting the requirements of AASHTO M 231.

5.11 A 5.5 lb (2.5 kg) metal rammer conforming to the requirements of AASHTO T 99.

5.12 Tamping rod of straight steel, 5/8 inch (16 mm) in diameter and approximately 24 inch (400 mm) long having at least one end rounded to a hemispherical tip.

5.13 Graduated cylinder, 1000 ml capacity, readable to 5 ml.

5.14 A stopwatch or timer readable to 1 second.

6. Selection of T 606 Test and Procedure

To select the proper method for determining the maximum density of the Fine Aggregate portion of the sample, refer to the "Fine Aggregate Split of Original Sample" section of Table 1.

To select the proper procedure in Test 2 for determining the maximum density of the Coarse Aggregate portion of the sample, refer to the "Coarse Aggregate Split of Original Sample" section of Table 1.

Test Selection Table 1

Fine Aggregate Split of Original Sample	
Soil Type	**Test Method**
Sandy, Non-plastic, permeable soils or non-cohesive soils.	T606 Test 1
Silt, some plasticity, low permeability	T 99 Method A
Sandy/silt, some plasticity, permeable	T606 Test1/T99 Method A (use highest results)
Coarse Aggregate Slit of Original Sample	
No more than 15 percent of the coarse aggregate split exceeds ¾ in	T606 Test 2 Procedure 1
15 percent or more of the coarse aggregate split is greater than ¾ in. (19 mm), but does not exceed 3 in. (76 mm)	T606 Test 2 Procedure 2

7. Sampling Material

   7.1 Sample the material in accordance with WSDOT FOP for AASHTO T 2.

   7.2 Native soils within the contract limits to be used for embankment construction and/or backfill material do not require sampling by a qualified tester.

   7.3 For material that requires gradation testing such as but not limited to manufactured aggregates and gravel borrow, sampling shall be performed by a qualified testers.

8. Sample Preparation

   8.1 Prepare the field sample by splitting out a representative portion in accordance with WSDOT FOP for AASHTO T 248.

   8.2 Dry the compaction sample to constant mass in accordance with WSDOT FOP for AASHTO T 255.

   8.3 Scalp the plus 75mm (3 inch) material from the compaction sample and discard, if not required for other tests. Separate the remainder of the compaction sample into coarse [minus 3 inch (75mm) to No. 4 (4.75mm)] and fine [minus No. 4 (4.75mm)] aggregate portions.

   8.4 The quantity of material necessary to complete tests on both fractions is:

      8.4.1 Fine aggregate, minimum of 3 portions approximately 13 lb (6 kg) each.

   8.5 Coarse aggregate:

      8.5.1 For material containing 15 percent or less of ¾ inch (19 mm) material, a portion of the minus ¾ inch (19.0mm) aggregate of approximately 13 lbs (6 kg).

      8.5.2 For material containing more than 15 percent plus ¾ in (19.0 mm) aggregate, a portion of 40 to 45 lb (18 to 20 kg).

9. Procedure

9.1 Test No. 1- Compaction Test of the Fine Fraction (No. 4 minus material)

9.1.1 Assemble the small mold and determine its mass, along with the piston, to the nearest 0.01 lb (5g). Record this as the Mass of Mold Assembly.

9.1.2 Using one of the fine aggregate portions, add an amount of water estimated to produce a saturated sample when compacted and mix thoroughly.

Note 1: When the material is at its saturation point, free water (a drop or two) will show at the base of the mold at about the 500 lb (227 kg) load of the first compression run. The ideal saturation point would be a bead of water around the base of the mold at the end of the 10-minute compaction run. Most materials will yield the highest density at that moisture content. Some materials may continue to gain density at higher moisture contents; however, this is due to the washing out of fines, which will alter the character of the sample. Therefore, if severe washing-out or pumping of fines occurs (as evidenced by dirty water flooding off of the base or pumped on top of the piston), the sample is beyond the saturation point, will be discarded and a lower moisture content tried for the saturation point.

9.1.3 Set the piston aside and place the sample in the mold in three approximately equal layers. Consolidate each lift by 25 strokes of the tamping rod followed by 25 blows of the manual rammer. The surface of the top lift should be finished as level as possible.

9.1.4 Place the piston on top of the sample and mount the mold on the jack platform in the compactor. Spacers between the load spring and piston must be used to adjust the elevation of the mold so the hammers strike the mold in the center of the lift area. Elevate the mold until the loading head seats on top of the piston. Apply an initial seating load of approximately 100 lbs on the sample.

9.1.5 Start the compactor hammers and, by elevating the jack, begin the loading procedure. The load is applied as follows:

Load Application Rate	
Load	Time
0 to 500 lb	1 minute
500 lb to 1000 lb	30 sec
1000 lb to 2000 lb	30 sec

9.1.6 Upon reaching the 2000 lb load at the end of the 2-minute cycle, stop the hammers, release the load on the jack, and return to zero pressure.

9.1.7 Repeat Steps 9.1.4 through 9.1.6 four additional times. After the last run, remove the mold from the compactor.

9.1.8 Measure the height of the compacted sample to the nearest 0.01 in (0.1 mm). Record as the Depth.

9.1.9 Determine the mass of the specimen in the mold to the nearest 0.01 lb (5g). Record this as:

Mass of Mold + Sample

9.1.10 Remove the specimen from the mold and determine the moisture content in accordance with WSDOT FOP for AASHTO T 255.

9.1.11 Vertically slice through the center of the specimen, take a representative specimen (at least 1.1 lbs (500 g)) of the materials from one of the cut faces (using the entire specimen is acceptable), weigh immediately, and dry in accordance with AASHTO T 255 to determine the moisture content, and record the results.

9.1.12 Calculate and record the dry density of fine fraction.

9.2 Test No. 2 – Compaction Test of the Coarse Fraction:

9.2.1 Procedure 1 – Minus ¾ in (19 mm) aggregates

9.2.1.1 Determine the mass of the coarse aggregate to the nearest 0.01 lb (5g).

9.2.1.2 Add 2.5 percent moisture to the sample, mix thoroughly

9.2.1.3 Place in 0.1 ft^3 (0.0028 m^3) mold in approximately three equal lifts. Compact each lift with 25 blows of the tamping rod (omit hammering). Avoid the loss of any material during placement.

9.2.1.4 Follow steps 9.1.4 through 9.1.6.

9.2.1.5 Calculate and record the dry density of coarse fraction.

9.2.2 Procedure 2 – Plus ¾ in (19 mm) aggregates

9.2.2.1 Determine the mass of the coarse aggregate to the nearest 0.01 lb (5g) or better.

9.2.2.2 Divide the sample into five representative and approximately equal portions.

9.2.2.3 Place one of the portions into the ½ ft^3 (0.014 m^3) mold.

9.2.2.4 Level the surface by hand and consolidate the layer with 25 strokes of the tamping rod, using the rounded end. Distribute the strokes evenly over the entire cross section of the material rodding full depth, if possible, without hitting the bottom too hard.

9.2.2.5 Repeat this procedure for the other four lifts, penetrating, if possible, into the lower layer. Avoid the loss of any material during this operation.

9.2.2.6 Position the piston on the sample, mount the mold in the compactor and follow the procedure described in steps 9.1.4 through 9.1.6

9.2.2.7 Calculate and record the dry density of coarse fraction.

9.3 Test No. 3 – Specific Gravity Determination for Maximum Density Test

9.3.1 Material

9.3.1.1 Fine fraction U.S. No. 4 (4.75 mm) minus 1.1 lbs. (500 g) minimum

9.3.1.2 Coarse fraction U.S. No. 4 (4.75 mm) plus 2.2 lbs. (1,000 g) minimum.

9.3.2 Procedure

9.3.2.1 Place dry materials, either fine or coarse fraction, in pycnometer, add water.

9.3.2.2 Put pycnometer jar top in place and connect to vacuum apparatus.

9.3.2.3 Apply vacuum for at a minimum of 20 minutes until air is removed from sample. Slight agitation of the jar every 2 to 5 minutes will aid the de-airing process. If the material boils too vigorously, reduce the vacuum.

9.3.2.4 Remove vacuum apparatus, fill pycnometer with water, dry outside of jar carefully and weigh.

9.3.2.5 Water temperature during test should be maintained as close to 68° ± 1°F (20° ± 0.5°C) as possible.

Calculations

10. Determine the dry density of each of the fine aggregate points as follows

10.1 Calculate Specific Gravity as follows:

$$\text{Sp. Gr.} = \frac{a}{a/(a+b-c)}$$

Where:

a = Weight of dry material, grams
b = Weight of pycnometer + water, grams
c = Weight of pycnometer + material + water, grams

10.2 Calculate the wet sample weight:

$$e = c - d$$

Where:

e = Wet sample weight, g
c = mold and sample weight
d = Tare of mold assembly

10.3 Calculate the wet density by:

$$g = \frac{e \times b}{f}$$

Where:

g = wet density, lb/ft^3
e = wet sample weight
b = mold constant, in/ft^3
f = height of sample, in (height constant-depth)

10.4 Calculate the dry density of each of the fine fraction specimens as follows:

$$h = \frac{g}{1 + n}$$

Where:

h = dry density, lb/ft^3
g = wet density, lb/ft^3
n = moisture content, expressed as a decimal

11. Reports

11.1 Enter information into the WSDOT Materials Testing System (MATS) or other form approved in writing by the State Materials Engineer to obtain the theoretical maximum density curve.

Performance Exam Checklist

Method of Test for Compaction Control of Granular Materials
WSDOT Test Method T 606

Participant Name _____ Exam Date _____

Procedure Element	Yes	No
1. The tester has a copy of the current procedure on hand?	❒	❒
2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?	❒	❒
Fine Fraction — 100% Passing the US No. 4 (4.75 mm) Sieve		
Specimen Preparation		
1. Has the specimen been oven-dried?	❒	❒
2. Has the specimen been separated on the US No. 4 (4.75 mm) sieve?	❒	❒
3. Is the specimen weight approximately 13 lbs?	❒	❒
Procedure		
1. Is specimen saturated when compacted?	❒	❒
2. Has specimen been placed in three layers, rodded 25 and tamped 25 times, each layer?	❒	❒
3. Is the hammer blow approximately a 12 inch free fall to prevent severe displacement of the specimen?	❒	❒
4. The specimen is as level as possible?	❒	❒
5. Has piston been placed on top of the specimen?	❒	❒
6. Has the mold been mounted on the jack in the compactor?	❒	❒
7. Has the mold been elevated until the load-spring retainer sits on top of the piston?	❒	❒
8. Has the initial load been set at 100 pounds?	❒	❒
9. Is the loading rate applied as specified in the test procedure?	❒	❒
10. Has the hammer been stopped, jack released, and pressure returned to zero when 2,000 pounds pressure was reached?	❒	❒
11. Steps 7 through 10 repeated four additional times?	❒	❒
12. Is free water present at the base of the mold within 1½ minutes of the start of the first compression run?	❒	❒
13. The mold removed from the compactor?	❒	❒
14. Has the height of the specimen been determined?	❒	❒

Procedure Element	Yes	No
15. Has specimen been weighed?	❒	❒
16. Has specimen been removed from mold and a representative portion immediately weighted and the moisture percentage determined?	❒	❒
17. Moisture content, dry density determined and entered on the testing sheet?	❒	❒
18. Theoretical maximum density determined by testing fresh specimens, as necessary, at different moisture contents and entered on the testing sheets?	❒	❒

Aggregate Size: No. 4 to ¾ in (19 mm)

Specimen Preparation

1. Has the specimen been oven-dried?	❒	❒
2. Has the specimen been separated on the US No. 4 (4.75 mm) sieve?	❒	❒
3. Does more than 85 percent of the material pass the ¾ in (19 mm) sieve?	❒	❒

Procedure

1. Weight and record specimen weight?	❒	❒
2. Has the specimen been dampened to 2½ percent and placed in a 0.1 ft^3 mold and placed in three lifts?	❒	❒
3. The specimen is tamped lightly to archive a level surface?	❒	❒
4. Piston placed on top of specimen and mold mounted on jack in compactor?	❒	❒
5. Mold elevated until the load-spring retainer sits on top of the piston?	❒	❒
6. Initial load of 100 lbs set prior to starting machine?	❒	❒
7. Is the load rate applied as specified in the test procedure?	❒	❒
8. Hammers stopped, jack released, and pressure returned to 100 pounds when 2,000 pound load has been reached?	❒	❒
9. Steps 5 and 6 repeated four additional times?	❒	❒
10. The mold removed from the compactor and the height measured?	❒	❒
11. Dry density calculated and entered on the testing sheets?	❒	❒

Aggregate Size: No. 4 to 3 in.

Specimen Preparation

1. Has the specimen been oven-dried?	❒	❒
2. Has the specimen been separated on the US No. 4 (4.75 mm) sieve?	❒	❒
3. Is the specimen weight approximately 45 lbs?	❒	❒
4. Does the specimen contain 15 percent or more ¾ + material?	❒	❒
5. Has material greater than 3 in (76 mm) been removed?	❒	❒
6. Specimen separated into five approximately equal parts?	❒	❒

Procedure Element	**Yes**	**No**
Procedure		
1. Specimen place in the mold in five separate lifts?	❒	❒
2. The specimen is as level as possible?	❒	❒
3. After each lift, mold placed in compactor and compacted according to test procedure?	❒	❒
4. After compacting final lift, specimen removed from compactor and volume determined?	❒	❒
5. Dry density determined calculated and entered onto testing sheet?	❒	❒
Specific Gravity Determination for Theoretical Maximum Density Test		
Specimen Preparation		
1. Has the specimen been oven-dried?	❒	❒
2. Has the specimen been separated on the US No. 4 (4.75 mm) sieve?	❒	❒
3. Weight of fine fraction approximately 500g?	❒	❒
4. Weight of coarse fraction approximately 1000g?	❒	❒
Procedure		
1. Material placed in pycnometer and water at 68°F added?	❒	❒
2. Vacuum applied for at least 20 minutes?	❒	❒
3. Container and contents agitated manually by shaking at intervals of about 2 to 5 minutes?	❒	❒
4. Pycnometer filled with water at 68°F?	❒	❒
5. Pycnometer dried, weighted, and recorded on testing sheet?	❒	❒
6. Specific Gravity calculated and entered onto testing sheet?	❒	❒

First Attempt: Pass ❒ Fail ❒ Second Attempt: Pass ❒ Fail ❒

Signature of Examiner _____

Comments: