



WSDOT Standard Operating Procedure SOP 615

Determination of the % Compaction for Embankment & Untreated Surfacing Materials using the Nuclear Moisture-Density Gauge

1. SCOPE

This procedure covers the procedures for determining the in-place density, moisture content, gradation analysis, oversize correction, and determination of maximum density of compacted soils and untreated surfacing materials using a nuclear density device in the direct transmission mode.

2. REFERENCES

- a. WSDOT FOP for AASHTO T 99 for Method of Test for Moisture-Density Relations of Soils
- b. WSDOT FOP for AASHTO T 180 for Method of Test for Moisture-Density Relations of Soils
- c. WSDOT FOP for AASHTO T 224 for Correction for Coarse Particles in Soil Compaction Test
- d. WSDOT FOP for AASHTO T 255 for Total Moisture Content of Aggregate by Drying
- e. WSDOT FOP for AASHTO T 272 for Family of Curves — One Point Method
- f. WSDOT FOP for AASHTO T 310 for In-Place Densities and Moisture Content of Soils and Soil-Aggregate by Nuclear Methods (Shallow Depth)
- g. WSDOT T 606 Method of Test for Compaction Control of Granular Materials

3. TEST LOCATION

When selecting a test location, the tester shall visually select a site where the least compactive effort has been applied. Select a test location where the gauge will be at least 6 in. (150 mm) away from any vertical mass. If closer than 24 in. (600 mm) to a vertical mass, such as in a trench, follow gauge manufacturer correction procedures.

Note: When retesting is required due to a failing test; retest within a 10 foot radius of the original station and offset.

4. NUCLEAR DENSITY TEST

Determine the dry density and moisture content of soils and untreated surfacing materials using the nuclear moisture-density gauge in accordance with WSDOT FOP for AASHTO T 310, and record on DOT Form 350-074 “Field Density Test”

5. OVERSIZE DETERMINATION

a. WSDOT FOP AASHTO T 99 and WSDOT T 606

A sample weighing a minimum of 9 lbs. will be taken from beneath the gauge. Care shall be taken to select material that is truly representative of where the moisture density gauge determined the dry density and moisture content.

There are two methods for determining the amount of material retained on the No. 4 sieve:

Method 1

1. Dry the sample to SSD conditions, (i.e. dried until no visible free moisture is present, material may still appear damp). Allow the sample to cool sufficiently and record mass to the nearest 0.1 percent of the total mass or better.
2. Shake sample by hand over the No. 4 (4.75 mm) sieve. Limit the quantity of material on the sieve so that all particles have the opportunity to reach the sieve openings a number of times during the sieving operation. The mass retained on the No. 4 (4.75 mm) sieve at the completion of the sieving operation shall not exceed 800 grams, 1.8 pounds, for a 12" sieve, or 340 grams, 0.75 pounds; for a 8" sieve.
3. Remove and weigh the material on the No. 4 (4.75 mm) sieve to the nearest 0.1% of the total mass or better and record.

Method 2

This method is only recommended for crushed surfacing materials, materials with high clay content or other granular materials that are at or near the optimum moisture content for compaction.

1. Determine the mass of the sample to the nearest 0.1% of the total mass or better and record.
2. Charge the material in a suitable container with water, agitate the material to suspend the fines, then slowly decant and screen the material over a verified No. 4 (4.75 mm) sieve. Repeat as necessary to remove as much of the No. 4 (4.75 mm) minus material as possible. DO NOT overload the sieve.
3. Place the washed sample retained on the No. 4 (4.75 mm) sieve into a tared container. Blot the material to a SSD condition (i.e. no visible free moisture present, material may still appear damp) during this step.
4. Weigh the mass of the material on the No. 4 (4.75 mm) sieve to the nearest 0.1% of the total mass or better and record.

b. WSDOT FOP AASHTO T 180

Follow the either Method 1 or Method 2 in 5 a. with the following exception; sieve the material over a $\frac{3}{4}$ in (19.0 mm) sieve rather than a No. 4 (4.75 mm)sieve.

- c. Calculate the percent retained and the percent passing the sieve used to the nearest percent and record on DOT Form 350-074 by the following formula:

$$\% \text{ of oversized particles of sieve used} = 100 \times \frac{\text{Mass retained on sieve used}}{\text{Initial Mass}}$$

Note: "Sieve used" is defined as No. 4 sieve for T 99 and the $\frac{3}{4}$ " sieve for T 180.

6. CORRECTION OF OPTIMUM MOISTURE CONTENT

- a. Obtain the moisture content of the fine particles and oversize particles of the material used during compaction from the Moisture Density Gauge.
- b. Obtain the approximate Optimum Moisture Content for material from the appropriate density curve.
- c. Calculate the corrected optimum moisture content:

Corrected Optimum moisture content for WSDOT FOP for AASHTO T 99:

$$\begin{aligned} \text{Corrected Optimum Moisture} = \\ ((\text{Optimum Moisture of material passing No. 4}) (\% \text{ Passing No. 4}))/100 \end{aligned}$$

Corrected Optimum moisture content for WSDOT FOP for AASHTO T 180:

$$\begin{aligned} \text{Corrected Optimum Moisture} = \\ ((\text{Opt. Moisture of material passing } \frac{3}{4} \text{ in. sieve}) (\% \text{ Passing } \frac{3}{4} \text{ in. sieve}))/100 \end{aligned}$$

Corrected Optimum moisture content for WSDOT T 606:

$$\begin{aligned} \text{Corrected Optimum Moisture} = \\ ((\text{Optimum Moisture of material passing No. 4}) (\% \text{ Passing No. 4})) + \\ ((\text{Optimum Moisture of material retained No. 4}) (\% \text{ Retained No. 4}))/100 \end{aligned}$$

- d. Record the Optimum Moisture Content and Corrected Optimum Moisture Content on DOT Form 350-074.

7. % COMPACTION DETERMINATION BASED ON WSDOT FOP AASHTO T 99

- a. This process is applicable to silty materials with less than 30 percent retained on the No. 4 (4.75 mm) sieve. WSDOT FOP AASHTO Test Method T-99 and WSDOT FOP for AASHTO T-272 are used to determine the maximum density of the material passing the No. 4 (4.75 mm) sieve. Record the maximum density on DOT Form 350-074 line "Maximum Density"
- b. Using the appropriate computer-generated chart, determine the corrected theoretical maximum density, based on the percent retained on the No. 4 (4.75 mm) sieve. This value should be entered on DOT Form 350-074 line "Corrected Maximum Density". When less than 5% is retained on the No. 4 (4.75 mm) sieve, no correction is necessary.
- c. Percent Compaction is calculated by the following formula and entered on DOT Form 350-074:

$$\% \text{ Compaction (kg/m}^3) = \frac{\text{Dry Density lbs./ft.}^3 \text{ (kg/m}^3) \times 100}{\text{Corrected Maximum Dry Density lbs/ft}^3 \text{ (kg/m}^3)}$$

8. % COMPACTION DETERMINATION BASED ON WSDOT FOP AASHTO T 180
- a. This process is applicable to materials with 30 percent or more retained on the No. 4 (4.75 mm) sieve and less than 30 percent retained on the $\frac{3}{4}$ in (19.0mm) sieve. WSDOT FOP AASHTO T 180 is used to determine the maximum density of the material passing the $\frac{3}{4}$ in (19.0 mm) sieve. Record the maximum density on DOT Form 350-074 line “Maximum Density”.
 - b. Using the appropriate computer-generated chart, determine the corrected theoretical maximum density, based on the percent retained on the $\frac{3}{4}$ in. sieve (19.0 mm) sieve. This value should be entered on DOT Form 350-074 line “Corrected Maximum Density”. When 5% or less is retained on the $\frac{3}{4}$ in (19.0 mm) sieve, no correction is necessary.
 - c. Percent Compaction is calculated by the following formula and entered on DOT Form 350-074.

$$\% \text{ Compaction (kg/m}^3\text{)} = \frac{\text{Dry Density lbs./ft.}^3 \text{ (kg/m}^3\text{)} \times 100}{\text{Corrected Maximum Dry Density lbs/ft}^3 \text{ (kg/m}^3\text{)}}$$

9. % COMPACTION DETERMINATION BASED ON WSDOT TEST METHOD T 606.
- a. This process is applicable to granular, free-draining materials and to materials with 30 percent or more retained on the No. 4 (4.75 mm) sieve. Test Method 606 requires specialized equipment and is run only by the Region or State Materials Laboratory.
 - b. Using the appropriate computer-generated chart, determine the maximum density, based on the percent passing the No. 4 (4.75 mm) sieve. This value should be entered on DOT Form 350-074 on line “Maximum Density”.
 - c. Percent of compaction is then calculated by the formula and entered on DOT Form 350-074:

$$\% \text{ Compaction} = \frac{\text{Dry Density lbs./ft.}^3 \text{ (kg/m}^3\text{)} \times 100}{\text{Maximum Dry Density lbs/ft}^3 \text{ (kg/m}^3\text{)}}$$

10. REPORT

Report compaction data of DOT Form 350-074, “Field Density Test” and on DOT Form 351-015 “Daily Compaction Test, or other report approved by the State Materials Engineer.

Report percent compaction to the nearest whole number.

Performance Exam Checklist

WSDOT Standard Operating Procedure SOP 615 Determination of the % Compaction for Embankment & Untreated Surfacing Materials using the Nuclear Moisture-Density Gauge

Participant Name _____ Exam Date _____

- | Procedure Element | Yes | No |
|--|--------------------------|--------------------------|
| 1. The tester has a copy of the current procedure on hand? | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present? | <input type="checkbox"/> | <input type="checkbox"/> |

Gradation Analysis

- | | | |
|---|--------------------------|--------------------------|
| 1. Percent of oversize material identified? | <input type="checkbox"/> | <input type="checkbox"/> |
| 2. Sample Dried to a SSD condition (dried until no visible free moisture present) and mass recorded? | <input type="checkbox"/> | <input type="checkbox"/> |
| 3. Sample allowed to cool sufficiently prior to sieving? | <input type="checkbox"/> | <input type="checkbox"/> |
| 4. Sample was shaken by hand through the appropriate sieve for T 99 or T 180 for a sufficient period of time? | <input type="checkbox"/> | <input type="checkbox"/> |
| 5. Recorded mass of material retained on the sieve used? | <input type="checkbox"/> | <input type="checkbox"/> |
| 6. Calculated and recorded percent of material retained and passing for the sieve used? | <input type="checkbox"/> | <input type="checkbox"/> |

Correction for Coarse Particles

- | | | |
|--|--------------------------|--------------------------|
| 7. Used the appropriate computer-generated chart to determine the maximum density? | <input type="checkbox"/> | <input type="checkbox"/> |
| 8. All calculations performed correctly? | <input type="checkbox"/> | <input type="checkbox"/> |

First attempt: Pass Fail Second attempt: Pass Fail

Signature of Examiner _____

Comments: