## Density of Granular Material by Modified Sand-Cone Method for Thin Layers

### 1. Scope:

This test is for determining in-place density of granular materials that have a total thickness of 3” or less.

### 2. Apparatus:

2.1 Density apparatus consisting of a 6 1/2" diameter sand cone and two 1 gallon jars conforming to the requirements of AASHTO T 191.

2.2 Modified base plate: The modified base plate is the same base plate used in SD 105 with a 10” diameter cone attached to the bottom. The height of the 10” diameter cone is approximately 3”.

2.3 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.01 lb. An additional scale or balance that is readable to the nearest 0.1 gram will be needed for determining the moisture.

2.4 Oven capable of maintaining a temperature of 230° $\pm$ 9°F or other equipment according to SD 108.

2.5 1/10$^{th}$ cubic foot standard measure.

2.6 Sand: Clean, dry and free flowing. It must not have a variation in bulk density greater than 1%. Sand retained between the #12 and #20, or #12 and #30 sieve sizes is most suitable. To prove suitability, several bulk density determinations must be made, using the same representative sample.

2.7 Sieves: 3/4", #12, and a #20 or #30 sieves conforming to ASTM E11.

2.8 Miscellaneous: Small pick, hammer, chisels, spoons, pans or other suitable containers for drying moisture samples, buckets, plastic bags and paint brush.

### 3. Procedure:

3.1 Calibration of density apparatus

A. Determine the weight of sand required to fill the cone and modified base plate.

Pour the standard sand into the density apparatus through the cone with the valve open until the jar is full. The density apparatus should be gently tapped several times (With palm of hand) during filling to ensure that the maximum amount of sand will be available for the next test. Weigh the full density apparatus and record the weight to the nearest 0.01 lb.

Place the 10” cone of the modified base plate on a clean, level, plane surface (Such as a tabletop). Invert the density apparatus and seat the cone into the recess of the modified base plate. Open the valve to allow the sand to fill the cone and modified base plate. Avoid jarring or vibrating the density apparatus while the sand is flowing.

Close the valve and weigh the density apparatus and remaining sand. Subtract this weight from the weight of the density apparatus full of sand. The difference is the weight of the sand to the nearest 0.01 lb. required to fill the cone and modified base plate. Use DOT–87 worksheet to record weights. An average of three such tests will be used to determine the weight of sand in the cone and modified base plate. Replace the sand removed in the cone and modified base plate weight determination and close the valve.

B. Determine the bulk density of the sand.

(1) Determine the weight of sand to fill the cone.

Pour the standard sand into the density apparatus through the cone with the valve open until the jar is full. The density apparatus should be gently tapped several times (With palm of hand) during filling to ensure that the maximum amount of sand will be available for the next test. Weigh the full density apparatus and record the weight to the nearest 0.01 lb.

Invert the density apparatus and place the cone on a clean, level, plane surface (Such as a tabletop). Open the valve to allow the sand to fill the cone. Avoid jarring or vibrating the density apparatus while the sand is flowing.

Close the valve and weigh the density apparatus and remaining sand. Subtract this weight from the weight of the density apparatus full of sand. The difference is the weight of the sand to the nearest 0.01 lb. required to fill the cone. Use DOT–87 worksheet to record weights. An average of three such tests will be used to determine the weight of sand in the cone. Replace the sand removed in the cone weight determination and close the valve.

(2) Determine the weight of sand to fill the cone and standard measure.

Weigh the full density apparatus and record the weight to the nearest 0.01 lb. Center the density apparatus with the cone down and resting on the rim of the standard measure. Open the valve to allow the sand to fill the measure and cone. Avoid

jarring or vibrating the density apparatus while the sand is flowing.

Close the valve and weigh the density apparatus and remaining sand. Subtract this weight from the weight of the density apparatus full of sand. The difference is the weight of the sand to the nearest 0.01 lb. required to fill the cone and standard measure. Use DOT–87 worksheet to record weights. An average of three such tests will be used to determine the weight of the sand in the cone and standard measure. Replace the sand removed in the cone weight and standard measure determination and close the valve.

(3) Determine bulk density of sand.

Subtract the average weight of the sand in the cone from the average weight of the sand in the cone and standard measure. Multiply the result by the factor on the standard measure. The results will be the bulk density of the sand in pounds per cubic foot. Use DOT–87 worksheet to record the results.

**NOTE: Vibration of the sand during any sand weight-volume determination may increase the bulk density of the sand and decrease the accuracy of the determination. After the sand is calibrated it should be stored in a reasonably airtight container to prevent changes in bulk density caused by a change in moisture content.**

**The calibration of the density apparatus and modified base plate must be done following its use for 5 density tests or each time un-calibrated sand is added to the sand jar. Ensure that the sand has been thoroughly mixed, or the sand comes from the same bag when using two jars.**

3.2 Density of in-place material.

A. Prepare the surface of the location to be tested so that it is a level plane. Seat the 10” cone of the modified base plate on the plane surface, ensuring that the edge of the cone makes contact with the plane surface. Mark the outline of the cone to check for movement during the test.

B. Dig the test hole inside of the cone mark, being very careful to avoid disturbing the soil that will bound the hole. Soils that are essentially granular require extreme care. Place all loosened soil in a container, being careful to avoid losing any material or moisture.

C. After completion of the hole, screen the material over a 3/4“screen. Return – 3/4" material to the container.

D. Place the cone of the modified base plate inside of the cone mark. Seat the density apparatus in the recess of the modified base plate. Open the valve and release sufficient sand to cover the bottom of the hole, shut off the flow of sand and remove the density apparatus. Carefully place the rock retained on the 3/4" sieve in a single layer on the sand. If a large quantity of rock is retained on the 3/4" sieve, place a layer of sand between the layers of rock. Reseat the density apparatus and fill the hole until the sand is just below the modified base plate.

E. Remove the partially filled jar and remove the cone. Place the sand cone on the full jar. Reseat the density apparatus, open the valve and after the sand has stopped flowing, close the valve. Avoid jarring or vibrating the density apparatus while the sand is flowing. Weigh the density apparatus with the remaining sand and the partial jar to the nearest 0.01 lb.

F. Weigh the material that was removed from the test hole to the nearest 0.01 lb.

G. Mix the material thoroughly and secure a representative sample for moisture determination.

H. Weigh the material to the nearest 0.1 gram and dry it to a constant weight as per SD 108.

I. Use the suggested minimum test hole volumes and the minimum weight of the moisture content samples shown in table 1.

Suggested Minimum Test Hole Volumes and Minimum Moisture Content Samples Based on Maximum Size of Particle

| *Nominal Maximum Particle Size Sieve | Minimum Test Hole Volume $ft^3$ | Minimum Moisture Content Sample Grams |
|---|---|---|
| ½" | 0.0500 | 500 |
| ¾" | 0.0650 | 500 |
| 1" | 0.0750 | 500 |
| 2" | 0.1000 | 500 |

*Nominal maximum size particle is denoted by the smallest sieve opening listed above, through which 90% or more of the material will pass.

For particle size not listed above, use the next larger minimum sample size.

**NOTE: The volume of the test hole will be computed to the nearest 0.0001 $ft^3$ on the DOT-41.**

3.3 Standard density determination (1-point)

A. Sample the material from or adjacent to the test hole. Perform the standard density as per SD 104, method 4.

**4. Report:**

4.1 Calculations

A. The procedure for calculating the in-place density, standard density, and moisture content are shown on a DOT-41. (Figure 1 & 1A)

B. The maximum dry density from the family of curves established by the 1-point determination is used to compute the percent of standard obtained for the test.

4.2 Report

A. Report the moisture content to the nearest 0.1 percentage point.

B. Report the wet and dry densities for the in-place and standard test, to the nearest 0.1 lb./ft$^3$.

C. Report the percent of standard density obtained to the nearest whole percentage point.

**5. References**:

AASHTO T 191
ASTM E11
SD 104
SD 105
SD 108
DOT-41
DOT-87

**Sample ID** 2205193
**File No.**

## Density Report

DOT - 41
6-21

County: Aurora, Ziebach | PCN/PROJECT: B015 PH 0066(00)15
Station: 243+00 | Dist From CL: 11' R | Width (Gravel): 52.50
Depth: ____ (from top of Subgrade or Pipe) | Field #: abc123
Tested By: Tester, One | Checked By: Tester, Two | Date: 06/21/2021

WORK AREA REPRESENTED (Circle what applies)

EMBANKMENT — STA. TO STA. ____ (per half mile, for each roadbed)
Zone 1 (0-1 ft.) Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 5 ft.

BRIDGE END EMBANKMENT — STA. TO STA. ____
1 per zone within plan limits | 3 equal zones when backwall is less than 7ft. | 4 equal zones when backwall is greater than 7ft.
Zone 1 Zone 2 Zone 3 Zone 4 Zone 5

BERM — STA. TO STA. ____ (100 ft. from Bridge End)
Zone 1 (0-1 ft.) Zone 2 (1-3 ft.) Zone 3 (3-5 ft.) Zone 4 (5 ft. to bottom) 1 per 3 ft.

PIPE
CROSS: 24" or smaller — undercut — (1/2 way up) — (0-2 ft. Above)
STORM: 30" to 72" — undercut — (Lower 1/2) — (Upper 1/2) — (0-2 ft. Above)
INTERSECTION: 72" or more — undercut — (Bottom 1/3) — (Middle 1/3) — (Top 1/3) — (0-2 ft. Above)
After Minimum for size pipe installation ☐ 1 per 3 ft of backfill beginning at 2' above top of pipe

SUBBASE — STA. TO STA. ____ LIFT ____

BASE COURSE — STA. TO STA. 200+00 to 252+80 LIFT 3 of 3

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**Standard Density**

| Curve Type | Curve Used | | Maximum Density | Optimum Moisture | | Granular Material 4-Point Range | SPECIFICATION | 97% |
|---|---|---|---|---|---|---|---|---|
| Ohio | d | U. | 133.0 | 8.7 | % | 128.1 - 134.1 | % Obtained 100X(G/U) | 97% |

### Balloon Method

| | |
|---|---|
| B. Wt. Undried Matl. from Hole | |
| C. Volumeter Reading in Hole | |
| D. Initial Volumeter Reading | |
| E. Volume of Test Hole (C-D) | |
| F. Wet Density (B/E) | |
| G. Dry Density F/(100+M{Field}) x 100 | |

### Sand Method

| | | |
|---|---|---|
| A. Std. Sand PCF | | 96.4 |
| B. Wt. Undried Matl. from Hole | | 11.37 |
| C. Initial Wt. Sand | | 30.90 |
| D. Final Wt. Sand Plus Cone Sand | 10.69<br>12.37 | 23.06 |
| E. Volume of Test Hole (C-D)/A | | 0.0813 |
| F. Wet Density (B/E) | | 139.9 |
| G. Dry Density F/(100+M{Field}) x 100 | | 128.6 |

### Nuclear Method

Meter No. ____
Test Mode ____
F. Wet Density from Gauge ____ +/-Corr. * ____ = ____
G. Dry Density F/(100+M{Field}) x 100 ____

### 1-Point Density Determination

| | | 1-Point |
|---|---|---|
| O. Weight of Mold & Specimen | 25.64 | |
| P. Weight of Mold | 14.95 | 523.1 |
| Q. Wet Wt. of Molded Specimen (O-P) | 10.69 | 484.3 |
| R. Factor of Mold No. 2-36 Used in Test | 13.29 | 38.8 |
| S. Wet Density (QxR) | 142.1 | 484.3 |
| T. Dry Density S/(100+M [1-PT])x100 | 131.6 | 8.0 |

### Moisture Determination

| | Field |
|---|---|
| H. Wt. of Wet Matl. and Container | 829.9 |
| I. Wt. of Dry Matl. and Container | 762.7 |
| J. Wt. of Moisture (H-I) | 67.2 |
| K. Wt. of Container | |
| L. Wt. of Dry Matl. (I-K) | 762.7 |
| M. Percent Moisture (Jx100)/L | 8.8 |

### Rock Determination

A. Total Sample Weight ____
B. Weight of Material Retained on 3/4" Sieve ____
C. Percent Retained On 3/4" Sieve (Bx100)/A ____

* Correction from DOT-39. If there is no correction or, if the correction has been applied to the meter show "NA".

Figure 1

Sample ID 2225660

# Calibration of Sand Cone and Base Plate and Determination of Sand Bulk Density SD 105 and SD 110

DOT-87
3-19



PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015

Calibrated by: Tester, One Date: 04/29/2019

## SAND CONE AND BASE PLATE: SD 105

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| A. Initial weight of sand, cone, and jar. | (1) | | (2) | | (3) | | 0.01 lb (1g) |
| B. Final weight of sand, cone, and jar. | (1) | | (2) | | (3) | | 0.01 lb (1g) |
| C. Weight of sand in cone and base plate. (A - B) | (1) | | (2) | | (3) | | 0.01 lb (1g) |
| D. Average weight of sand in cone and base plate. | | | | | | | 0.01 lb (1g) |

## SAND CONE AND MODIFIED BASE PLATE: SD 110

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| E. Initial weight of sand, cone, and jar. | (1) | 16.07 | (2) | 16.07 | (3) | 16.07 | 0.01 lb (1g) |
| F. Final weight of sand, cone, and jar. | (1) | 3.70 | (2) | 3.70 | (3) | 3.71 | 0.01 lb (1g) |
| G.Weight of sand in cone and modified base plate. (E - F) | (1) | 12.37 | (2) | 12.37 | (3) | 12.36 | 0.01 lb (1g) |
| H. Average weight of sand in cone and modified base plate. | | | | 12.37 | | | 0.01 lb (1g) |

## SAND BULK DENSITY

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| I. Initial weight of sand, cone, and jar. | (1) | 15.98 | (2) | 12.66 | (3) | 9.35 | 0.01 lb (1g) |
| J. Final weight of sand, cone, and jar. | (1) | 12.66 | (2) | 9.35 | (3) | 6.03 | 0.01 lb (1g) |
| K. Weight of sand in cone. (I - J) | (1) | 3.32 | (2) | 3.31 | (3) | 3.32 | 0.01 lb (1g) |
| L. Average weight of sand in cone. | | | | 3.32 | | | 0.01 lb (1g) |
| M. Initial weight of sand, cone, and jar. | (1) | 15.98 | (2) | 15.98 | (3) | 15.98 | 0.01 lb (1g) |
| N. Final weight of sand, cone, and jar. | (1) | 3.03 | (2) | 3.04 | (3) | 3.03 | 0.01 lb (1g) |
| O. Weight of sand in cone and measure. (M - N) | (1) | 12.95 | (2) | 12.94 | (3) | 12.95 | 0.01 lb (1g) |
| P. Average weight of sand in cone and measure. | | | | 12.95 | | | 0.01 lb (1g) |
| Q. Average weight of sand in measure. (P - L) | | | | 9.63 | | | 0.01 lb (1g) |
| R. Factor of Measure No. P-1881 | | | | 10.01 | | | |
| Sand Bulk Density (Q x R) = | | | | 96.4 | | | 0.1 lb/ft $^3$ (1 kg/m $^3$) |

Comments

Figure 2