Method of Test for Density and Air Voids of Asphalt Concrete by the Gyratory Method

1. Scope:

This test is to determine the density and air void level of asphalt concrete mix by using the gyratory compactor.

2. Apparatus:

2.1 Gyratory compactor conforming to the requirements of AASHTO T 312.

2.2 Gyratory molds & plates conforming to the requirements of AASHTO T 312.

2.3 Thermometers, dial type, armored glass, or digital with a range of 50° to 400°F with a sensitivity of 5°F.

2.4 Thermometer sensitive to 0.5°F and readable to 1°F.

2.5 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure, accurate and readable to the nearest 0.1 gram. The scale or balance shall be equipped with a suitable suspension apparatus and holder to permit weighing the sample while suspended from the center of the scale pan of the weighing device.

2.6 Mechanical convection oven with a minimum chamber volume of 5.0 cubic feet capable of heating to 350°F.

2.7 Flat bottom metal pan, flat bottom scoop, containers, large mixing spoon or small trowel, large spatula, gloves, paper disks, WD 40 lubricant, and grease.

2.8 Water Bath with an overflow outlet for maintaining a constant water level. An aquarium heater will suffice to control the temperature of the water bath at 77° ± 2°F. The water bath must be large enough to allow the suspension apparatus holder to be covered with water at all times. The sample and suspension apparatus must be completely covered with water during weighing. The wire suspension apparatus shall be the smallest practical size to minimize any possible effect of a variable immersed length.

3. Procedure:

3.1 Sampling uncompacted mix.

A. Material for the gyratory testing shall be obtained from the same sample as will be used for SD 312 but a larger sample must be obtained.

B. Take approximately 160 to 180 lbs. of hot mix for the laboratory density determination, 240 to 260 lbs. when IA testing is required.

C. Transport the sample in a pail or box that is insulated or protected to help retain heat.

D. Place the hot mix in a clean pan where there will be neither loss of material nor the addition of foreign matter. Place the pan and material in an oven maintained at or slightly above the required compaction temperature.

3.2 Gyratory machine preparation.

NOTE: Before operating the gyratory, it's important to make sure that it's ready for operation. The steps below need to be completed prior to operating the Pine Brovold portable (AFGB1A) gyratory. Other gyratory compactors can be used and must be operated according to the manufacturer's recommendations.

A. Make sure the gyratory compactor has been calibrated to an internal angle of (1.16 ± 0.02°) or if using a Pine RAM calibration device, calibrated to a cold internal angle of (1.19 ± 0.03°) and the calibration records are available. SD DOT machines are calibrated by the SD DOT Central Lab.

B. Make sure that the gyratory is properly lubricated. There are a number of spots that require a regular application of grease, including:

a. The ring at the top of the cylinder which controls the angle of the gyration. This should be done prior to running a set of three gyratories.

b. The ram head on the top of the gyratory. Grease the outer portion of the ram head prior to running a set of three gyratories. This head causes the cylinder to gyrate.

c. The ram pressure head at the bottom of the cylinder. This is the head that pushes up the plate. This should get a coating of grease prior to running every gyratory, before the mold is put in place.

d. Once the material is loaded and leveled, put in the paper disk and top plate and grease the top of the plate. This is to be done on every gyratory.

e. The spherical bearing that contacts the bottom of the mold. The spherical bearing is located below the ram pressure plate. The best way to lubricate it is to use a brush with grease. This should be done once every three gyratories.

C. The gyratory mold needs to be cleaned inside and out with WD 40 at the end of each day to avoid HMA buildup. This is easiest when the molds are hot.

D. Turn the machine on and wait for it to run through the startup routine.

E. Make sure all the "Set Points" on the machine are correct. This is done by going into the "Setup" program on the machine. Most of these, like the dwell and the pressure, are constant and shouldn't require adjustment. However, the number of gyrations will need to be changed when switching from the design gyration number to the maximum gyration number. This is done in the "Set Gyrations" category at the top of the "Setup" page. The gyrations are specified in the plans and shown on the mix design DOT-64 form. To change any of the settings, using the arrow keys scroll the cursor down to the desired attribute. Type in the number you want and press ↵ "Enter".

F. Make sure that all pertinent points are lubricated (See gyratory machine preparation, step B)

3.3 Laboratory density determination.

A. Preheat molds, a flat bottom scoop and a trowel or spatula in an oven to the established mix compaction temperature recommended on the job mix formula (JMF) from the DOT 64 mix design form.

B. Obtain by quartering or by using a heated flat bottom scoop a representative sample from the pan of material used in SD 312 Section 3.3 B. The material placed in the mold shall make a specimen 4.5 ± 0.2 inches high and 6 inches in diameter (Approximately 4500-4800 grams of material) and be compacted at established mix design compaction temperature on the JMF.

If the gyratory specimen doesn't compact to a height of 115 mm ± 5 mm use the following equation to correct the amount of material to put in the mold.

A = Actual weight of the specimen (grams)

(115 X A) ÷ B

B = Actual height of the specimen

C. Heat the hot mix so that compaction takes place when the mix is at the established mix design compaction temperature recommended on the JMF. Thermometers shall be calibrated and checked often to insure accurate temperature measurements.

D. Once the hot mix, tools and mold has reached the correct temperature recommended on the JMF prepare to make a specimen.

E. Apply grease to bottom ram head. Place a cylinder plate in the bottom of the mold with the beveled end toward the bottom that is heated to compaction temp prior to being placed in the gyratory machine. Put a paper disk in on top of the plate.

F. Place the mold into the gyratory compactor using the tongs, lowering it into the compactor until it reaches bottom, and then rotate the mold clockwise until it stops. Put the funnel on the top of the mold, and load the mold with HMA mix in one lift (Usually about 4500-4700 grams of mix), which should only be loaded at the proper mix compaction temperature. Remove funnel, lightly level out the mix with spatula and put paper disk on top. Do not pack the mix. The temperature should be within ± 5° of the mix design compaction temperature shown on the DOT-64 JMF.

G. Place the plate on top of mix, with the beveled edge away from the mix, grease the top of the plate and swing the gyratory head on top of the cylinder and lower the head into place. Lock the gyratory head onto the machine using the three levers.

H. Press “Run” on the machine to get into the “Run Mode”, and then press “Start”, which will begin the process. As the gyratory is running, keep an eye on the gyrations, pressure, and angle. The gyrations are as specified in the Special Provision or plan notes. The pressure should be 600 ± 18 kPa. If the angle goes out (External angle range from calibration) make sure the molds are clean on the outside and the mold and material is at the correct compaction temperature. Call the Central Materials Lab on a SDDOT gyratory before making any adjustments to the machine angle.

I. Once the specified number of gyrations is complete and the ram head returned to its original position, then loosen the three levers on the side of the machine, lift the gyratory head and swing it out of the way.

J. Place the funnel on the top of the machine, press “Unload” twice, and as the gyratory breaks free of the mold, remove the funnel quickly to prevent injury to the gyratory specimen.

K. Once the specimen is completely extruded, remove the top paper disk and carefully remove the specimen from the machine, inverting it before you set it down to allow removal of the bottom paper disk. Set the specimen in front of a fan to cool on a smooth flat surface and cool to room temperature.

L. Press the “Main Menu” button, and then press “Result”. This will bring up a menu with “Select”, “Print”, and “Send”. Press “Print”, and the machine will ask you if you want to “Print Report” - “Yes”. Press “Enter” to print.

M. Once the gyratory is unloaded and results printed, grease the machine as needed and ready it for the next test.

N. Make sure to label the gyratory correctly and label the printout sheet the same way.

O. After the specimens have cooled to room temperature, begin bulk specific gravity procedure as outlined below in the report section.

P. Make sure the required number of gyratory specimens has been made.

* For more detailed instructions or to solve any problems that might arise, contact the Central Materials lab (605 773-6994) if problem is not resolved.

4. Report:

Calculations to be completed on the DOT-86:

- G_{mm} - The maximum specific gravity will be determined according to SD 312 to the nearest 0.001 gram.

- ***Put in the plant settings values until the actual cutoff values are obtained.

- % binder P_b - Binder content calculation value determined on DOT-89 to the nearest 0.1 percent.

  If it is a RAP (Recycled asphalt pavement) mix, values off of the job mix formula (JMF) on DOT 64 are needed (Just below the gradation chart):

  Estimated total binder by weight of total mix - Virgin binder recommended by weight of total mix = RAP binder content

  The obtained RAP binder content needs to be added to the binder content that was determined on the DOT 89 form to take into account the oil that is being added to the mix by the RAP and recorded to the nearest 0.1 percent.

- G_{sb} – Aggregate Composite G_{sb}, found on the DOT-64 mix design JMF reported to the nearest 0.001 gram.

- Binder G_b – Designated on the oil tickets from the supplier reported to the nearest 0.001 gram.

- Dust (- #200) – On the gradation DOT-69 form total/ combined - #200 or from the (Acc % passing #200 sieve rounded) column if a + #4 sample was not washed reported to the nearest 0.1 percent.

- Lime – Lime content determination from the DOT 33Q reported to the nearest 0.01 percent.

- Add the dust and the lime together and report to the nearest 0.1 percent.

- Obtain the number of gyrations needed for the type of mix design from gyratory QC/QA Special Provision or project plan notes (Field gyration values will be shown on the DOT-64 mix design form).

Complete the following calculations in order as follows:

1. Effective specific gravity of the mineral aggregate ($G_{se)}$.

$$Gse = \frac{100 - Pb}{\frac{100}{Gmm} - \frac{Pb}{Gb}}$$

(Report to nearest 0.001)

2. Percent asphalt absorption ($P_{ba)}$.

$$Pba = 100 \times \left[\frac{Gse - Gsb}{Gse \times Gsb} \right] \times Gb$$

(Report to nearest 0.01 %)

3. Percent effecting asphalt content ($P_{be)}$.

$$Pbe = Pb - \frac{Pba \times Ps}{100}$$

(Report to nearest 0.1 %)

4. Bulk specific gravity measured ($G_{mb\ meas.}$) – Gyratory specimen G_{mb} weights determined using SD 313 procedure:

Weight in air, weight in water, SSD weight.

$$Gmb\ (measured) = \frac{Weight\ in\ Air}{SSD\ Weight - Weight\ in\ Water}$$

(Report to nearest 0.001)

5. Bulk specific gravity calculated (G_{mb}).

$$Gmb\ x = \frac{Gmb\ (measured) \times height\ (measured)}{height\ x}$$

Gmb x = calculation for Gmb bulk specific gravity of compacted mix at any given gyration point in the compaction process when x is number of gyrations such as at Nini or Ndes

6. Make sure that the Rice specific gravity (G_{mm}) testing is completed using SD 312. Average the two Rice G_{mm} values together that were obtained and record to the nearest 0.001 gram.

7. Calculate average $G_{mb.}$

Get the average of both N_{ini} G_{mb} (N_{des}) calculated values.
Get the average of both N_{des} G_{mb} measured values.
Get the one N_{max} G_{mb} measured value.
(Report all to nearest 0.001 gram)

8. % of Rice specific gravity (G_{mm}).

$$\% \text{ of Gmm} = \frac{\text{Gmb}}{\text{Gmm}} \times 100$$

(Report to nearest 0.1 %)

9. % air voids.

$$Va = \left(\frac{\text{Gmm} - \text{Gmb}}{\text{Gmm}} \right) \times 100$$

(Report to the nearest 0.1 %)

10. % VMA – Voids in mineral aggregate.

$$VMA = 100 - \frac{\text{Gmb} \times \text{Ps}}{\text{Gsb}}$$

(Report to the nearest 0.1 %)

11. % VFA – Voids filled with asphalt.

$$VFA = \left(\frac{\text{VMA} - \text{Va}}{\text{VMA}} \right) \times 100$$

(Report to the nearest %)

12. Dust to binder ratio.

$$\text{Dust to binder ratio} = \frac{(\% \text{ - \#200 material} + \% \text{ hydrated lime})}{\text{Pbe}}$$

(Report to the nearest 0.1)

Do not forget to compare calculated values with the QC/QA specification requirements.

5. References

AASHTO R 35
AASHTO T 312
ANSI B46.1 (Note 2)
SD 312
SD 313
DOT-33Q
DOT-64
DOT-69
DOT-89

Sample ID 2224267 **File No.**

Gyratory Specific Gravity

DOT - 86
9-14

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015
Field # QC01QA01 Date Sampled 08/05/2015 Date Tested 08/05/2015
Sampled By Tester, One Tested By Tester, One Checked By Tester, Two
Material Type Class Q2 Hot Mixed Asphalt Concrete Ticket # 15729
Source Lift 1 of 1
Lot No. 1 Sublot No. 1

Mix Temp 270 Offset 6 ESAL's Q2
Daily Ton 483.83 Total Ton 2632.46 Oil Type PG 64-28

			No. of gyrations		
% binder Pb	5.1	N initial	6	Gse	2.681
Gsb	2.636	N design	50	Pba	0.66
binder Gb	1.032	N max	75	Pbe	4.5
dust (-#200)	4.9				
lime	0.49				
dust (-#200) + lime	5.4				

	Spec. A (Ndes)		Spec. B (Ndes)		Spec. M (Nmax)		
	@ N ini	@ N des	@ N ini	@ N des	@ N ini	@ N des	@ N max
a) Height, mm	123.60	113.40	123.90	113.90			
b) Weight in air		4705.1		4708.3			
c) Weight in water		2729.6		2729.0			
d). SSD weight		4707.9		4710.9			
e) Bulk SpGr meas b /(d - c)		2.378		2.376			
f) Bulk SpGr calc (Gmb)	2.182		2.184				

	Gmm #1	Gmm #2
Weight of sample in air	1,522.0	1,524.9
Weight of canister + water	1376.4	1376.4
Weight of canister + water + sample	2284.1	2286.2
Temperature of the water	77F (25.0C)	77F (25.0C)
Water correction factor	1.0000	1.0000
Rice SpGr (Gmm)	2.478	2.479

Average Maximum SpGr (Gmm) 2.479

	N initial	N design	N maximum
Average Gmb	2.183	2.377	
% of Rice SpGr (Gmm)	88.1	95.9	

% Air Voids(Va)	4.1	% VMA	14.4	% VFA	72	Dust to binder ratio	1.2

Figure 1