

ALDOT-259-97
OPEN-GRADED ASPHALT CONCRETE FRICTION COURSE DESIGN METHOD

1. Scope

- 1.1. This is the laboratory procedure approved by the Department of Transportation for designing open-graded asphalt concrete friction courses containing a fiber stabilizer.

2. Referenced Documents

- 2.1. Alabama Department of Transportation Specifications for Highway Construction
- 2.2. AASHTO T 209, Maximum Specific Gravity of Bituminous Paving Mixtures
- 2.3. ALDOT-361, Resistance of Compacted Bituminous Mixture to Moisture Induced Damage
- 2.4. ALDOT-384, Mix Design Procedure for Superpave Level I
- 2.5. ALDOT-386, Determination of Drain Down Characteristics in Uncompacted Bituminous Mixtures

3. Test Procedure

- 3.1. Check the coarse and fine aggregate along with the mineral filler for specification compliance. Test for gradation, absorption, bulk dry specific gravity, and apparent specific gravity.
- 3.2. Separate from the combined aggregate blend, material passing the 3/8 in. (9.5 mm) sieve and retained on the No. 4 (4.75 mm) sieve. (This is usually the predominate aggregate portion of the blend.) Quarter out 105 grams (± 2 grams) of this aggregate and dry in an oven at $230 \pm 9^\circ\text{F}$ ($110 \pm 5^\circ\text{C}$) to a constant mass. Then allow the sample to cool to room temperature.
- 3.3. Place approximately 100 grams of the a sample into a metal funnel measuring 4.5 in. (115 mm) in height, with a top diameter of 3.5 in. (90 mm) and a bottom diameter of $\frac{1}{2}$ in. (15 mm). Cover the bottom orifice with wire mesh from a No. 10 (2.00 mm) sieve. Immerse the funnel containing the sample into a container filled with S.A.E. No. 10 lubricating oil until the aggregate is completely covered. If the aggregate has less than 2 percent absorption, let it soak for five minutes. If the aggregate has an absorption greater than 2 percent, let it soak for 30 minutes.
- 3.4. Let the funnel and its contents drain for approximately two minutes at room temperature. Then place in an oven at $140 \pm 5^\circ\text{F}$ ($60 \pm 3^\circ\text{C}$) and let it drain an additional 15 minutes. Empty contents of the funnel into a tarred pan and let cool to room temperature. Record the mass of the sample to the nearest 0.1 gram.

3.5. Calculate the percent oil retained (POR) in the surface of the aggregate using the following equation:

$$\text{POR} = \text{Gsa} / 2.65 * (\text{B}-\text{A}) / \text{A} * 100$$

Where:

Gsa = apparent specific gravity of sample aggregate

A = dry weight of sample (paragraph 3.3)

B = coated weight of sample (paragraph 3.4)

3.6. If the aggregate has less than 2 percent absorption move to paragraph 3.10.

3.7. If the aggregate has more than 2 percent absorption, go on to paragraph 3.8.

3.8. If the aggregate has more than 2 percent absorption, after completing paragraph 3.4, pour the aggregate onto a clean absorptive cloth and obtain a saturated surface dry condition.

3.9. Obtain the mass of the S. S. D. sample, to the nearest 0.1 gram, and calculate the percent oil absorbed (POA) using the following equation:

$$\text{POA} = (\text{SSD} - \text{A}) / \text{A} * 100$$

Where:

SSD = saturated surface dry mass (paragraph 3.8)

A = dry weight of sample (paragraph 3.3)

3.10. Determine the percent free oil (PFO) using the following equation:

$$\text{PFO} = \text{POR} - \text{POA}$$

Where:

POA = percent oil absorbed (paragraph 3.8)

POR = percent oil retained (paragraph 3.5)

3.11. For aggregate with less than 2 percent absorption, calculate the surface constant value using the following equation:

$$\text{SC} = 0.1 + 0.4 * \text{POR}$$

- 3.12. For aggregate with more than 2 percent absorption, calculate the surface constant value using the following equation:

$$SC = 0.1 + 0.4 * PFO$$

- 3.13. For aggregate with less than 2 percent absorption the asphalt content, percent binder (Pb), is computed using the following equation:

$$Pb = (2 * SC + 4) * 2.65 / Gsa$$

- 3.14. For aggregate with more than 2 percent absorption the effective asphalt content, percent binder effective (Pbe), is computed using the following equation:

$$Pbe = (2 * SC + 4) * 2.65 / Gsa$$

- 3.15. Complete section 4 and 5 of this procedure, then prepare at least one batch using at least 0.2 percent mineral fiber, (size based upon nominal maximum aggregate size from AASHTO T 209, Maximum Specific Gravity of Bituminous Paving Mixtures), of this gradation. Estimate the amount of asphalt binder that will be absorbed (ALDOT-384 contains an equation to help with this estimate). Mix and age this batch according to ALDOT-384 using an asphalt content equal to or slightly higher than the sum of the effective and (estimated) absorbed asphalt content. Run the AASHTO T 209 test on the sample and use the equations in ALDOT-384 to calculate the percent of binder that is actually absorbed (Pba). The total amount of asphalt cement needed for aggregates with more than 2 percent absorption is calculated by the following equation:

$$Pb = Pbe + Pba$$

4. Void Capacity of Coarse Aggregate

- 4.1. Determine the unit weight (unit mass) of the coarse aggregate fraction of the proposed gradation by either of the following methods.

4.1.1. Apparatus

4.1.1.1. Compaction Mold: A solid wall metal cylinder, approximately 6 in. (150 mm) nominal diameter, with a detachable metal base plate. A detachable metal guide-reference bar as shown in figure 2 is required for the first method.

4.1.1.2. Timer: A stopwatch or equivalent timing device accurate to \pm one second per two minutes. A circuit breaker connected to the clock is allowed.

4.1.1.3. Dial Indicator (or other measuring device): Indicator shall be accurate to a least 0.001in. (0.025 mm) with a range of at least 3 in. (75 mm).

4.1.1.4. Vibratory Compactor, First Method:

- 4.1.1.4.1. Rammer: A portable electromagnetic vibrating rammer as shown in figure 3, having a frequency of 3,600 cycles per minute. The rammer shall have a tamper and extension as shown in figure 4.
- 4.1.1.4.2. Wooden Base: A plywood disc approximately 15 in. (380 mm) in diameter, 2 in. (50 mm) thick, with a cushion (rubber hose) attached to the bottom. This base shall be constructed so that it can be firmly attached to the base plate of the compaction mold.
- 4.1.1.5. Vibratory Compactor, Second Method:
- 4.1.1.5.1. Vibrating Table: A vibratory table capable of inducing vibratory compaction at 3,600 cycles per minute with an amplitude of 0.013 ± 0.002 in. (0.33 ± 0.05 mm) (i.e. Soiltest CN-166).
- 4.1.1.5.2. Confining Load: A circular steel disc with a mass of approximately 27 kg and a diameter $2/16$ to $3/16$ in. (3 to 4 mm) smaller than the compaction mold (i.e. Soiltest CN-167).
- 4.2. Quarter out a sample from the coarse aggregate of the proposed blend. The sample size shall be approximately 2,270 grams. For light weight aggregate (bulk specific gravity less than 2.0), reduce the sample size to 1,590 grams.
- Note:** Most light weight aggregate will be crushed when subject to field compaction and will not make a suitable open graded mix.
- 4.3. Tare the compaction mold and place the sample into the mold. Record the sample mass to the nearest gram.
- 4.4. First Method:
- 4.4.1. Place the tamper foot on the sample. Place the guide/reference bar over the shaft of the tamper foot and secure the bar to the mold with the thumb screws.
- 4.4.2. Place the vibratory rammer on the shaft of the tamper foot and vibrate for 15 seconds. During vibration exert just enough pressure on the rammer to maintain contact between the sample and the tamper foot.
- 4.4.3. Remove the vibratory rammer from the shaft of the tamper foot and brush any fines from the top of the tamper foot.
- 4.4.4. Measure the thickness (t) of the compacted material to the nearest 0.01 in. (1/4 millimeter).
- 4.5. Second Method:
- 4.5.1. Place the surcharge base plate on the sample and place the sample onto the vibrating table.

- 4.5.2. Lower the confining load onto the base plate and vibrate the assembly for two minutes.
- 4.5.3. Remove the confining load and brush any fines from the top of the surcharge base plate. Measure the thickness (t) of the compacted material to the nearest 0.01 in. (1/4 millimeter).
- 4.6. Calculations:
- 4.6.1. Calculate the vibrated unit weight lbs. per cubic ft. as follows:

$$M_v = m * 6912 / (t * d^2 * 3.1416)$$

Where:

M_v = vibrated unit weight in pcf
 m = mass of sample in pounds
 d = diameter of compaction mold in inches
 t = thickness of sample in inches

- 4.6.2. Calculate the void capacity of the sample, percent based on volume, as follows:

$$VCA = (1 - M_v / M_c) * 100$$

Where:

M_c = bulk dry solid unit weight of coarse aggregate in pcf
VCA = void capacity of coarse aggregate as a percent of total volume

5. Optimum Content Of Fine Aggregate

- 5.1. Calculate the unit weight of the asphalt binder in pounds per cubic yard as follows:

$$M_b = G_b * 62.4 \text{ pcf}$$

Where:

G_b = specific gravity of binder (approximately 1.03)
 M_b = unit weight of binder

- 5.2. Calculate the optimum fine aggregate content, by mass of total aggregate, as follows:

$$P_f = ([VCA - V_a] - [P_b * M_v / M_b]) / ([\{VCA - V_a\} / 100] + M_v / M_f)$$

Where:

P_f = percent of fine aggregate by mass of total aggregate
VCA = void capacity of coarse aggregate
 V_a = design air voids (15 to 20 percent)
 P_b = percent binder (for aggregates with more than 2 percent absorption use P_{be} ,

effective binder content)

Mv = vibrated unit weight in pounds per cubic yard

Mb = unit weight of binder

Mf = bulk dry solid unit weight of fine aggregate

- 5.3. Compare the optimum fine aggregate content (Pf) at both 15 and 20 percent design air voids to the amount passing the No. 8 (2.36 mm) sieve of the job mix formula (JMF). If the JMF is outside the optimum range by more than 1 percent recompute the proportions of coarse and fine aggregates to meet the optimum fine aggregate content. If this changes the coarse aggregate portion of the JMF by more than 5 percent the design procedure shall be repeated.
- 5.4. After completing sections 4 and 5, prepare at least one batch to determine the maximum specific gravity of the bituminous paving mixture. Add at least 0.2 per-cent fiber to the aggregate and mix thoroughly before adding the liquid asphalt binder. The size of sample should be based upon the nominal maximum aggregate size from AASHTO T 209. Estimate the amount of asphalt binder that will be absorbed. (Use the equation found in ALDOT-384 to help with this estimation.) Mix and age this batch according to ALDOT-384 using an asphalt content equal to or slightly higher than the sum of the effective and estimated absorbed asphalt con-tent. Determine the maximum specific gravity of the bituminous paving mixture in accordance with AASHTO T 209. Use the equation in ALDOT-384 to calculate the percent of binder that is actually absorbed (Pba).

$$P_b = P_{be} + P_{ba}$$

6. Drain Down

- 6.1. In general, the mixing temperature is the temperature where the liquid asphalt binder has a viscosity of 170 ± 20 cSt; however, when the liquid asphalt binder contains polymer the mixing temperature may be different, so the manufacturer's recommendation and guidelines should be followed to determine mixing temperature.
- 6.2. Prepare a sample and test it by ALDOT-386, Determination of Drain Down Characteristics in Uncompacted Bituminous Mixtures, using the mixing temperature as the anticipated plant production temperature. If the drain down exceeds 0.3 per-cent when the temperature is 27°F (15°C) higher than the anticipated plant production temperature then the O.G.F.C. shall be redesigned with a higher fiber content. Include the amount of drain down in the mix design report.

7. Resistance to Moisture Damage

- 7.1. At the mixing temperature prepare at least six specimens according to ALDOT-384, using 100 gyrations.
- 7.2. Use the height versus gyration data to estimate each specimen's bulk specific gravity. Separate the specimens into two groups with equal, or as close to equal as possible, bulk specific gravity averages.

- 7.3. Immerse one group in 140°F (60°C) water for 24 hours (as in ALDOT-361). Store the other group in air at room temperature. Place both groups into a 77°F (25 ± 1°C) water bath for a minimum of one hour (both groups must be at the same temperature for testing).
- 7.4. Determine the tensile strength for both groups and calculate the ratio of conditioned at 140°F (60°C) strength to stored at room temperature strength. If this ratio is not 80 percent or higher anti-strip or other additives shall be added until the 80 percent ratio is met when performing this procedure.

8. Reporting

- 8.1. The contractor shall submit to Materials and Tests the job mix formula for review. The contractor shall include all the data this procedure requires including the data required to complete the HMA OGFC Design Work Sheet, included in this procedure.

**HMA OGFC Design
 Work Sheet**

Producer:

Laboratory: F. G. R. 20

Designer:

Project:

Date:

Division:

Job Mix Formula

Aggregate Sources:

<u>Sieve Size</u>	<u>Job Mix</u>	<u>Percent Oil</u>
¾ in. (19.0 mm)	_____	Percent Oil Absorbed:
½ in. (12.5 mm)	_____	
3/8 in. (9.5 mm)	_____	Percent Free Oil:
No. 4 (4.75 mm)	_____	
No. 8 (2.36 mm)	_____	Surface Capacity:
No. 200 (.075 mm)	_____	

Specific Gravity and Unit Weight (mass)

Mv = _____ Mc = _____ VCA = _____
 Va = 15 - 20 %
 Mb = _____ Mf = _____ Pbe = _____ *

Effective
Binder:

Pf = _____ to _____ %

Absorbed
Binder:

Optimum Mixing Temperature

Binder (A.C.) Grade and Source: _____

Percent
Binder (JMF)

Additives (fiber/polymer):

Mixing Temperature Range _____ to _____ °F °C Percent Drain Down = _____ %

Resistance to Moisture Damage

Conditioned Strength = _____

* Percent binder is equal to effective
binder for nonabsorptive aggregates

Unconditioned Strength = _____

Strength Ratio = _____ %

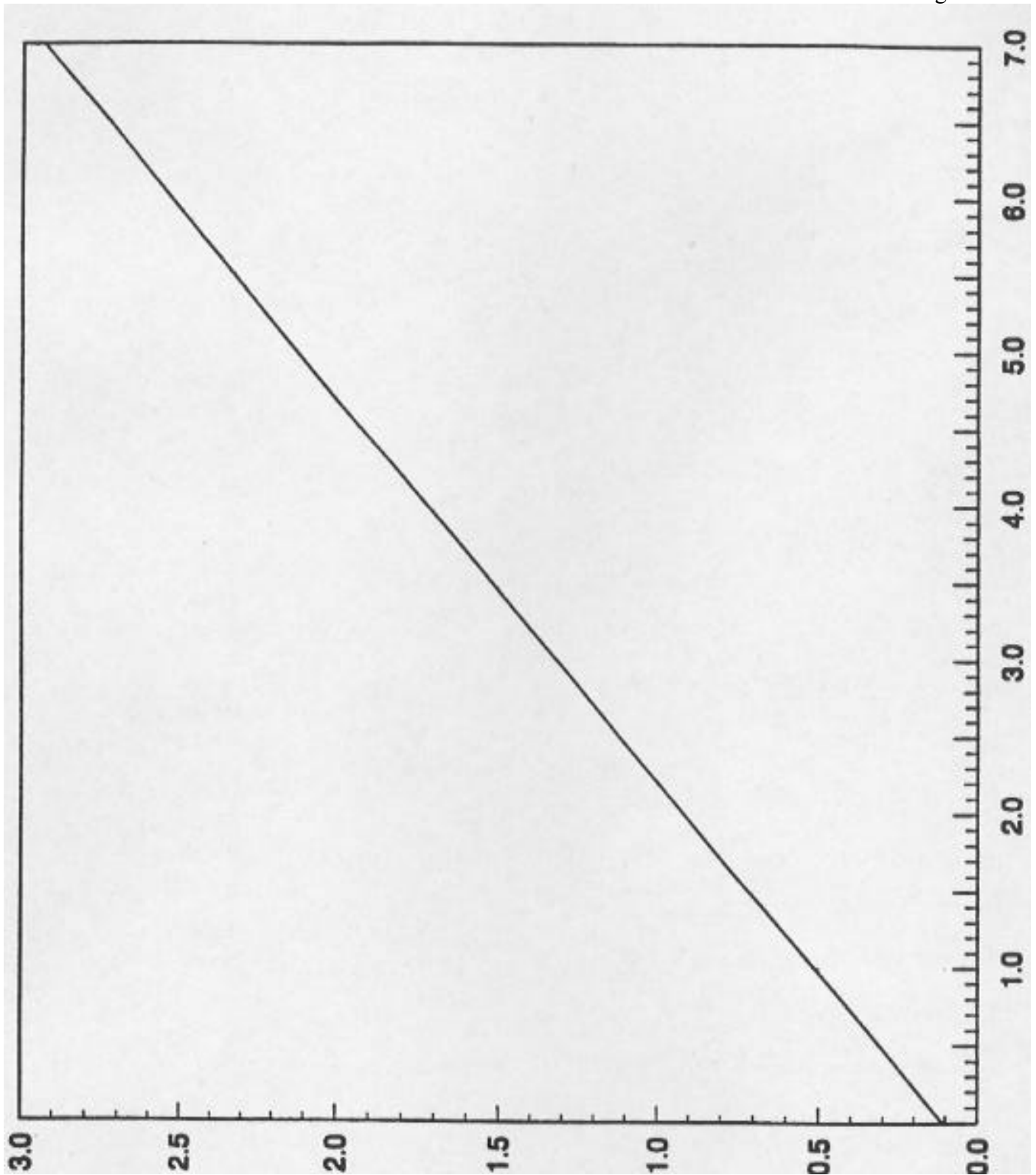


Figure 1 - Surface Constant (SC)

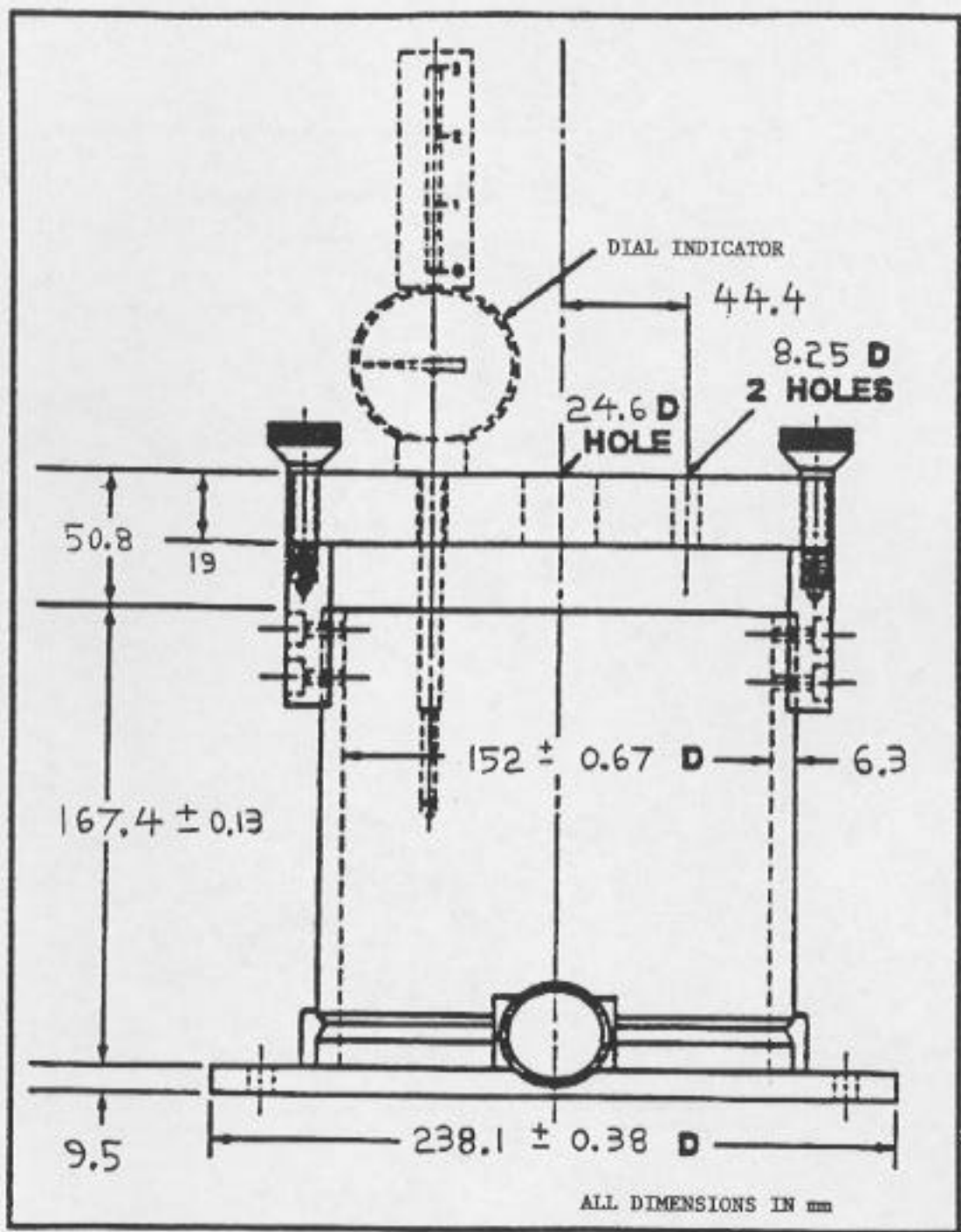


Figure 2 - Compaction Mold

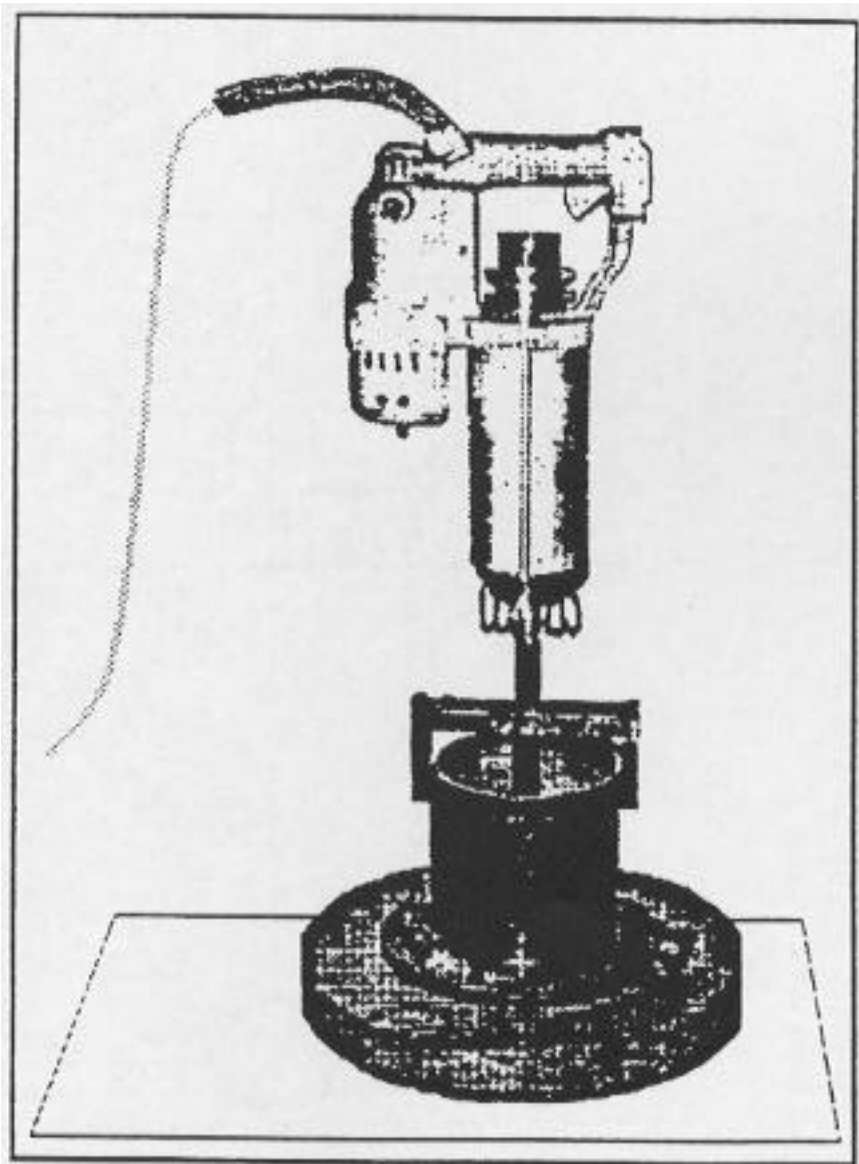


Figure 3 - Vibratory Compaction Assembly

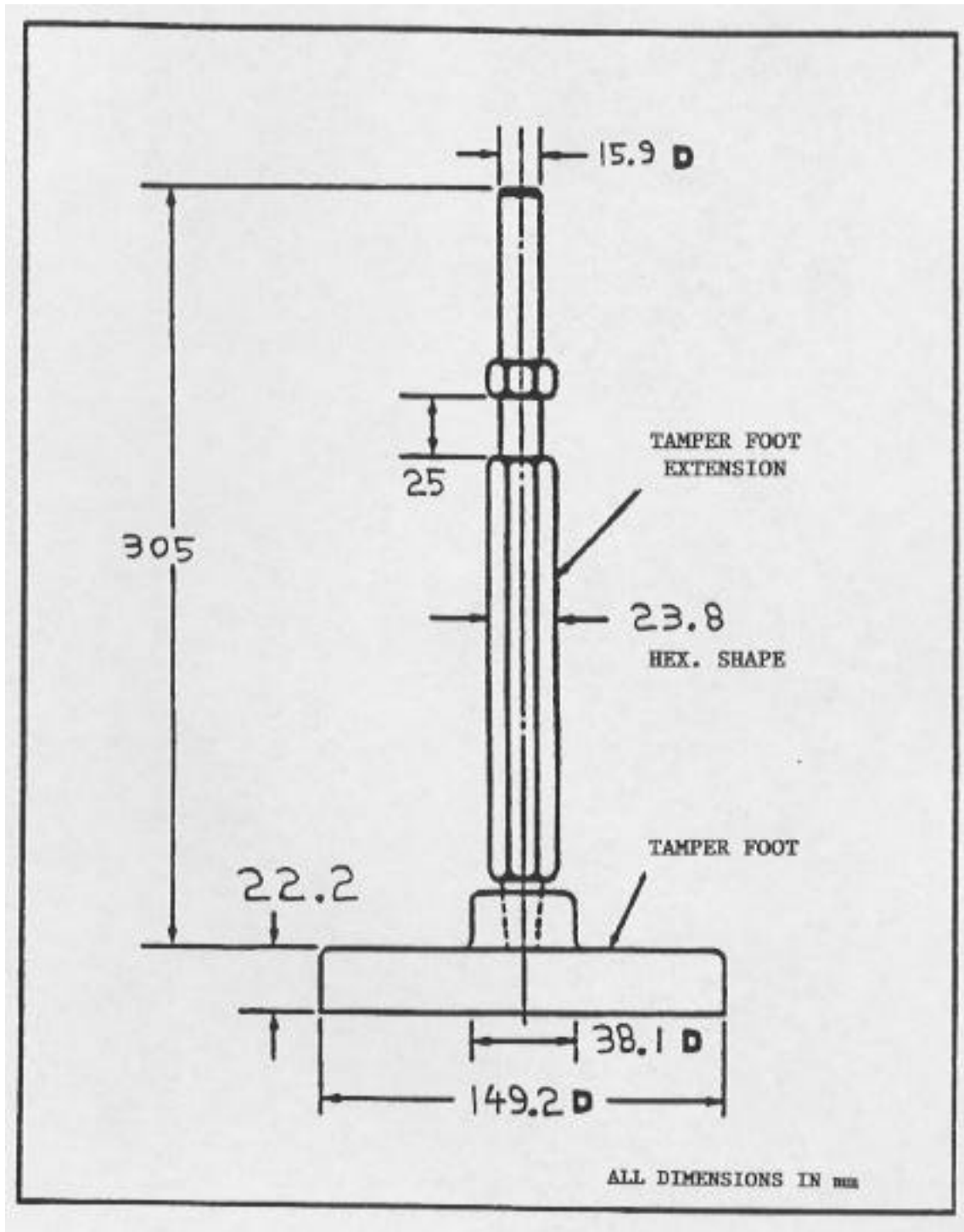
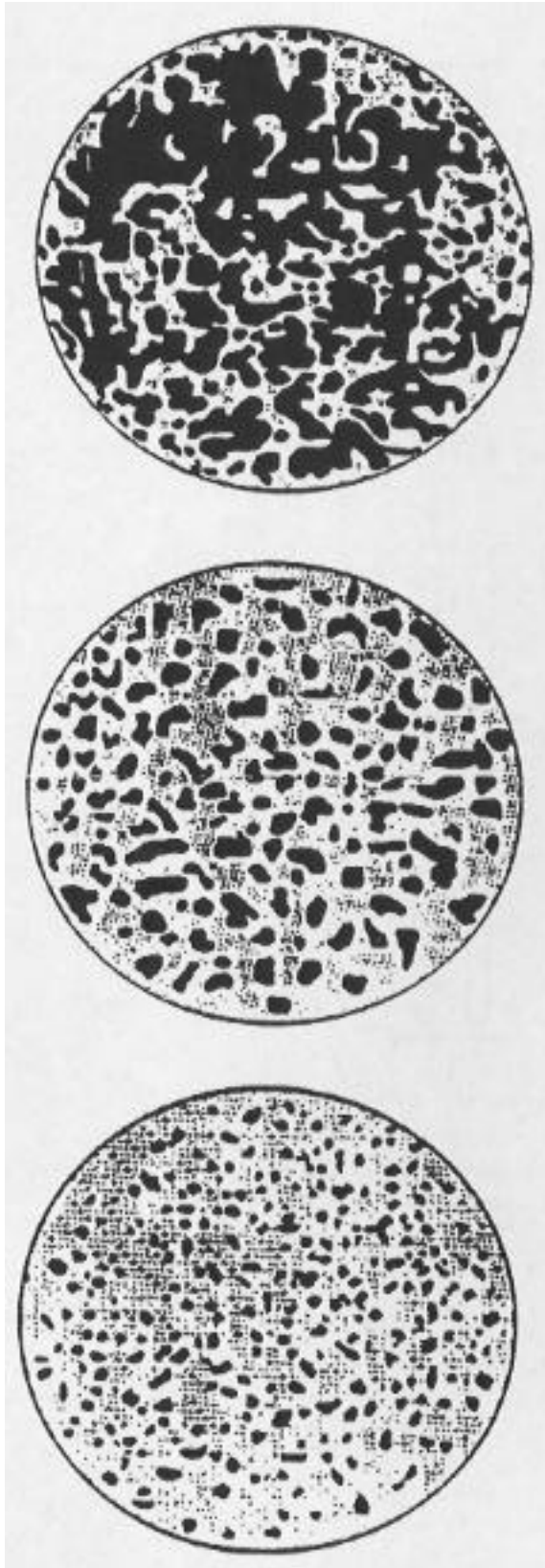


Figure 4 - Tamper Foot



No Drain Down

Increase Mixing Temperature

Desired Drain Down

Optimum Mixing Temperature

Excessive Drain Down

Decrease Mixing Temperature

Figure 5 – Drain Down Characteristics