WSDOT FOP for AASHTO T 176[1]

Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test

1. Scope

1.1 This test is intended to serve as a rapid field test to show the relative proportions of fine dust or claylike material in soils or graded aggregates.

1.2 The following applies to all specified limits in this standard: For the purpose of determining conformance with these specifications, an observed value or a calculated value shall be rounded off "to the nearest unit" in the last right-hand place of figures used in expressing the limiting value, in accordance with E 29, Using Significant Digits in Test Data to Determine Conformance With Specifications.

1.3 The values stated in English units are to be regarded as the standard.

1.4 Refer to R 16 for regulatory information for chemicals.

2. Reference Document

2.1 AASHTO Standards

M 92 – Wire-Cloth Sieves for Testing Purposes

M 231 – Weighing Devices Used in the Testing of Materials

2.2 ASTM Standards

E 29 – Using Significant Digits in Test Data to Determine Conformance With Specifications

2.3 WSDOT Standards

T2 – FOP for Sampling of Aggregates

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

3. Significance and Use

3.1 This test method is used to determine the proportion of detrimental fines in the portion passing the 4.75-mm (No. 4) sieve of soils or graded aggregates.

4. Apparatus

4.1 A graduated plastic cylinder, rubber stopper, irrigator tube, weighted foot assembly, and siphon assembly, all conforming to their respective specifications and dimensions shown in Figure 1. Fit the siphon assembly to a 1 gal (4L) bottle of working calcium chloride solution (see Section 4.9) placed on a shelf 36 ± 1 in (915 ± 25 mm) above the work surface. In lieu of the specified 1 gal (4L) bottle, a glass or plastic vat having a larger capacity may be used provided the liquid level of the working solution is maintained between 36 and 46 inches (915 and 1170 mm) above the work surface.

[1]This FOP is based on AASHTO T 176-08 and has been modified per WSDOT standards. To view the redline modifications, contact the WSDOT Quality Systems Manager at 360-709-5412.

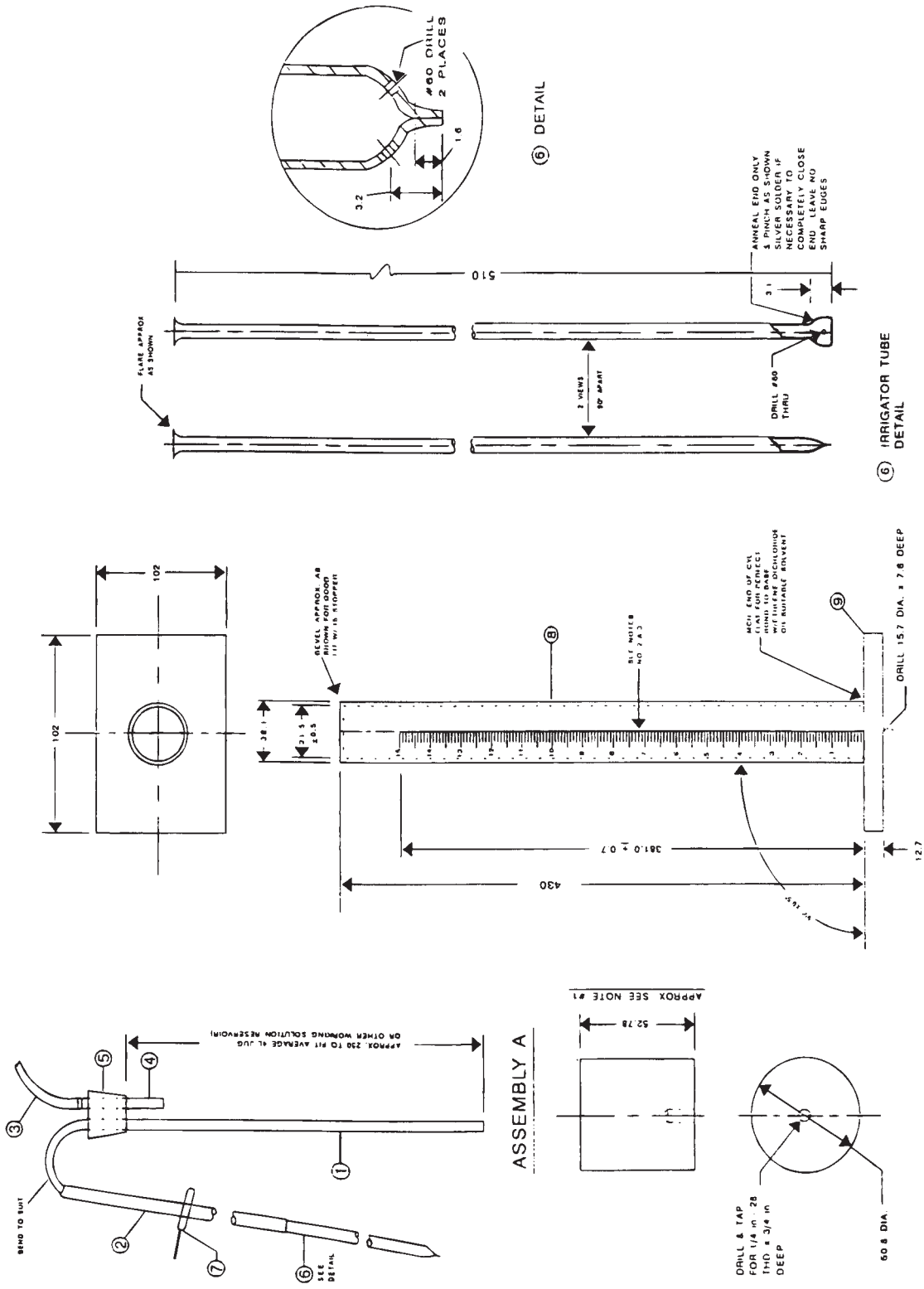
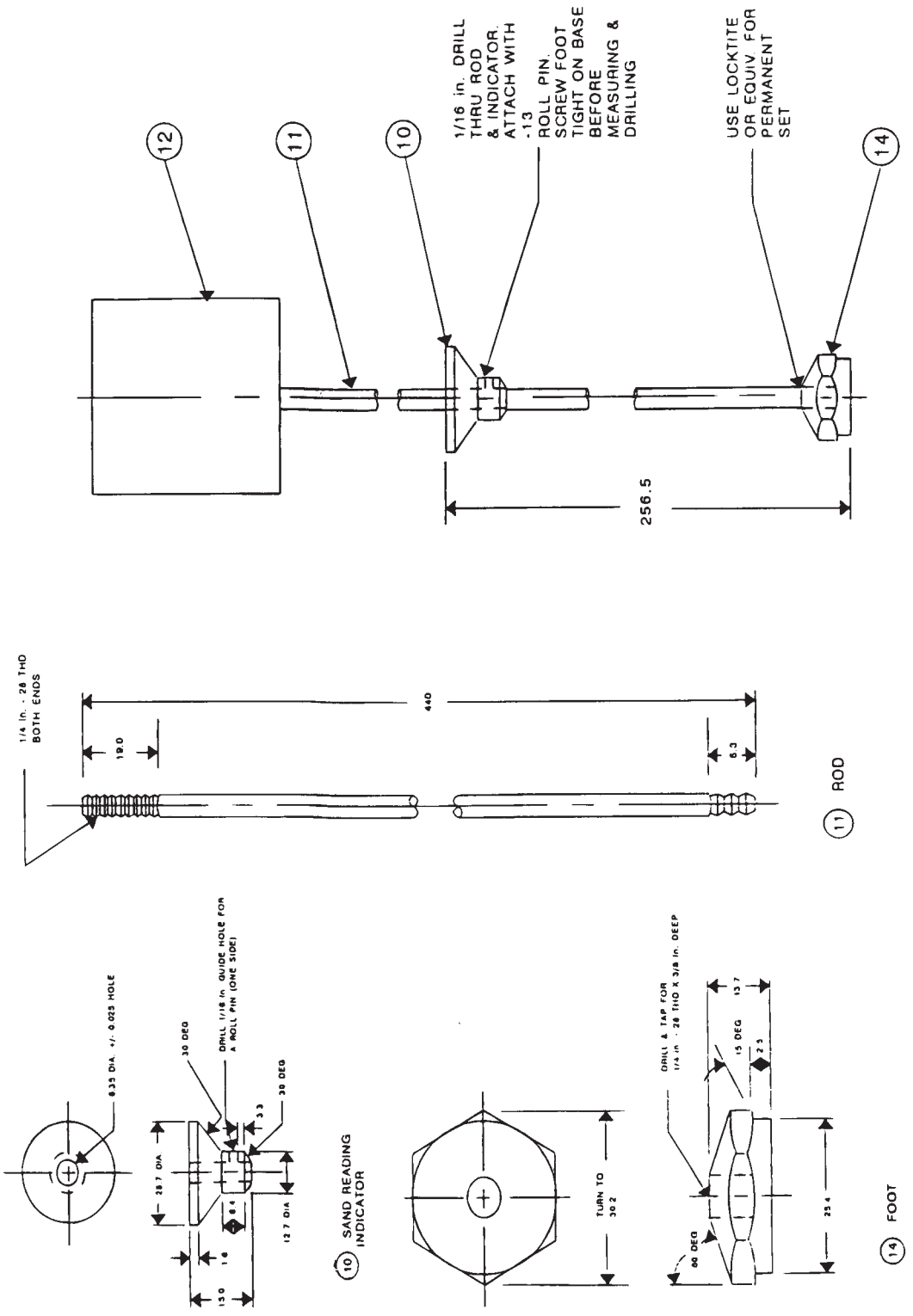


FIGURE 1 Sand Equivalent Apparatus



Note: all dimensions are shown in mm unless otherwise indicated.

FIGURE 1 Sand Equivalent Apparatus (continued)

List of Material					
Assembly	**No. Reg.**	**Description**	**Stock size**	**Material**	**Heat Treatment**
A	**Siphon Assembly**				
	1	Siphon Tube	6.4 dia. × 400		
	2	Siphon Hose	4.6 I.D. × 1220		
	3	Blow Hose	4.8 I.D. × 50.8		
	4	Blow Tube	6.4 dia × 50.8		
	5	Two-Hole Stopper	No. 6		
	6	Irrigator Tube	6.4 O.D. 0.89 Wall × 500 Stainless Steel Tube, Type 316		
	7	Clamp	Pinchcock, Day, BKH No. 21730 or Equiv.		
B	**Graduate Assembly**				
	8	Tube	38.1 Od. × 430	Trans. Acrylic Plastic	
	9	Base	12.7 × 102 × 102	Trans. Acrylic Plastic	
C	**Weighted Foot Assembly**				
	10	Sand Reading Indicator	6.4 dia. × 14.9	Nylon 101 Type 66 Annealed	
	11	Rod	6.4 dia. × 438.2	Brass	
	12	Weight	50.8 dia. × 52.78	C.R. SH.	
	13	Roll Pin	0.16 dia. × 12.7	Steel	
	14	Foot	0.16 dia. × 13.7	Brass	
	15	Solid Stopper	No. 7	Rubber	

Notes

1. "C" Weighted Foot Assembly to Weigh 1000 ± 5g.
2. Graduations of graduate to be 2.54 mm apart and every tenth mark to be numerically designated as shown. Every fifth line should be approximately 9.5 mm long. All other lines should be approximately 5.5 mm long. Depth to be 0.4 mm. Width to be 0.8 mm across the top.
3. Accuracy of scale to be ± 0.25 mm. Error at any point on scale to be ± 0.75 mm of true distance to zero.
4. Glass or stainless steel may be substituted as a material type for the copper siphon and blow tubing.

Sand Equivalent Apparatus
Figure 1

Note 1: An older model of weighted foot assembly has a guide cap that fits over the upper end of the graduated cylinder and centers the rod in the cylinder, and the foot of the assembly has a conical upper surface and three centering screws to center it loosely in the cylinder. The older model does not have the same reading indicator affixed to the rod (Figure 1), but a slot in the centering screws of the weighted foot is used to indicate the sand reading. Apparatus with the sand reading indicator (Figure 2) is preferred for testing clayey materials.

Apparatus
Figure 2

4.2 A tinned measure, having a capacity of 3 oz (85 ± 5 mL), approximately 2.25 in (57 mm) in diameter.

4.3 A balance with sufficient capacity, readable to 0.1 percent of the sample mass, or better, and conforming to the requirements of M 231.

4.4 A wide-mouth funnel approximately 4 in (100 mm) in diameter at the mouth.

4.5 A clock or watch reading in minutes and seconds.

4.6 A mechanical shaker having a throw of 8.00 ± 0.04 in (203.2 ± 1.0 mm) and operating at 175 ± 2 cycles per minute (2.92 ± 0.03 Hz) (Note 2). Prior to use, fasten the mechanical sand equivalent shaker securely to a firm and level mount.

Note 2: The mechanical shaker shall be used when performing referee sand equivalent determinations.

4.7 A manually operated shaker capable of producing an oscillating motion at the rate of 100 complete cycles in 45 ± 5 seconds, with a hand-assisted half stroke length of 5.0 ± 0.2 in (127 ± 5 mm). The shaker shall be fastened securely to a firm and level mount by bolts or clamps.

4.8 Stock Solution

4.8.1 Prepare a calcium chloride stock solution

Ingredients: 454 g (1.0 lb) of technical grade Anhydrous Calcium Chloride
2050 g (4.515 lb) of USP Glycerin

Calcium chloride stock solution: Dissolve the 454 g (1.0 lb) of calcium chloride in 1.89 L (1/2 gal) of distilled water. Cool and filter it through ready pleated rapid filtering paper. Add the 2050 g (4.515 lb) of glycerin to the filtered solution, mix well and dilute to 3.78 L (1 gal).

Note 3: The stock solution can be stored provided the time of storage is not sufficient to promote the growth of fungi.

4.9 Working calcium chloride solution: Prepare the working calcium chloride solution by diluting one measuring tin full 3 oz. (85 ± 5 mL), or from a graduated cylinder of the stock calcium chloride solution to 1 gal (3.8 L) with water. Use distilled or demineralized water for the normal preparation of the working solution. Record the date the working solution was made on the gallon container. Working solutions more than 30 days old shall be discarded.

4.10 A straightedge or spatula, suitable for striking off the excess soil from the tin measure.

4.11 A thermostatically controlled drying oven.

4.12 Quartering or splitting cloth, approximately 2 ft. square, nonabsorbent material such as plastic or oil cloth.

4.13 A No. 4 (4.75-mm) sieve conforming to the requirements of M 92.

4.14 Optional Handle for Irrigation Tube – A 25 mm diameter wooden dowel to aid in pushing the irrigation tube into firm materials. See Figure 1, Assembly B.

5. Temperature Control

5.1 The temperature of the working solution should be maintained at 67–77°F (22 ± 3°C) during the performance of this test. If field conditions preclude the maintenance of the temperature range, frequent reference samples should be submitted to a laboratory where proper temperature control is possible. It is also possible to establish temperature correction curves for each material being tested where proper temperature control is not possible. However, no general correction curve should be utilized for several materials even within a narrow range of sand equivalent values. Samples which meet the minimums and equivalent requirement at a working solution temperature below the recommended range need not be subject to reference testing.

6. Sampling

6.1 Obtain a sample of the material to be tested in accordance with WSDOT FOP for AASHTO T 2.

6.2 Reduce the sample in accordance with WSDOT FOP for AASHTO T 248.

6.3 Sieve the sample over No. 4 (4.75 mm) sieve using a mechanical shaker. (Make sure all large clumps of material are broken up before placing sieves in the mechanical shaker.)

6.3.1 Shake the sample in the mechanical shaker for a minimum of 10 minutes or for the minimum verified shaking time, whichever is greater.

6.3.2 The material shall be at Saturated Surface Dry (Saturated Surface Dry is defined herein as no visible free moisture, but material may still appear damp) or drier prior to sieving.

6.3.2.1 If the "as received" sample requires drying to achieve the required SSD or dryer condition prior to initial sieving, either air dry it or dry it in a thermostatically controlled oven at a temperature not to exceed 350°F.

6.3.3 Sieves may be nested above the No. 4 (4.75 mm) to prevent overloading, as defined in Table 1 of WSDOT FOP for WAQTC/AASHTO T 27/T 11, or the sample may be sieved in increments.

6.3.4 Break up any remaining clumps of fine-grained material and clean the fines from particles retained above the No. 4 (4.75 mm) sieve. Pass this material over the No. 4 (4.75 mm) sieve and include the material that passes in the total material passing the No. 4 (4.75 mm) sieve.

6.4 Split or quarter the material passing the No. 4 (4.75 mm), in accordance with WSDOT FOP for AASHTO T 248, to yield approximately 1,000 g to 1,500 g of material. Use extreme care to obtain a truly representative portion of the original sample (Note 4).

Note 4: Experiments show that as the amount of material being reduced by splitting or quartering is decreased, the accuracy of providing representative portions is decreased. It is imperative that the sample be split or quartered carefully. When it appears necessary, dampen the material before splitting or quartering to avoid segregation or loss of fines.

7. Sample Preparation

7.1 Prepare two test samples by the following method:

7.1.1 The sample must be in the proper moisture condition to achieve reliable results. Condition is determined by tightly squeezing a small portion of the thoroughly mixed sample in the palm of the hand. If the cast that is formed permits careful handling without breaking, the correct moisture range has been obtained. If the material is too dry, the cast will crumble and it will be necessary to add water and remix and retest until the material forms a cast. If the material shows any free water, it is too wet to test and must be drained and air-dried, mixing it frequently to ensure uniformity. This overly wet material will form a good cast when checked initially, so the drying process should continue until a squeeze check on the drying material gives a cast which is more fragile and delicate to handle than the original.

Place the sample on the splitting cloth and mix by alternately lifting each corner of the cloth and pulling it over the sample toward the diagonally opposite corner, causing the material to be rolled. When the material appears homogeneous, finish the mixing with the sample in a pile near the center of the cloth.

7.1.2 Fill the 3 oz (85 mL) tin measure by pushing it through the base of the pile while exerting pressure with the hand against the pile on the side opposite the measure. As the tin is moved though the pile, hold enough pressure with the hand to cause the material to fill the tin to overflowing. Press firmly with the palm of the hand, compacting the material and allowing the maximum amount to be placed in the tin. Strike off the tin measure level full with a spatula or straightedge. For the second determination, remix the sample and fill the tin again.

Dry the test sample in an oven in accordance with FOP for AASHTO T 255. The oven temperature shall not exceed 350°F (177°C). Cool to room temperature before testing. It is acceptable to place the test sample in a larger container to aid drying.

8. Procedure

8.1 Start the siphon by forcing air into the top of the solution bottle through the bent copper, glass, or stainless steel blow tube while the pinch clamp is open. The apparatus is now ready for use.

8.2 Siphon 4.0 ± 0.1 in (101.6 ± 2.5 mm) of working calcium chloride solution into the plastic cylinder. Pour the prepared test sample into the plastic cylinder using the funnel to avoid spillage (see Figure 3). Tap the bottom of the cylinder sharply on the heel of the hand several times to release air bubbles and to promote thorough wetting of the sample.

Tapping Bottom of Cylinder
Figure 3

8.3 Allow the wetted sample to stand undisturbed for 10 ± 1 minute. At the end of the 10-minute soaking period, stopper the cylinder, then loosen the material from the bottom by partially inverting the cylinder and shaking it simultaneously.

8.4 After loosening the material from the bottom of the cylinder, shake the cylinder and contents by any one of the following methods:

8.4.1 Mechanical Shaker Method – Place the stoppered cylinder in the mechanical sand equivalent shaker, set the timer, and allow the machine to shake the cylinder and contents for 45 ± 1 second.

8.4.2 Manual Shaker Method – Secure the stoppered cylinder in the three spring clamps on the carriage of the hand-operated sand equivalent shaker and reset the stroke counter to zero. Stand directly in front of the shaker and force the pointer to the stroke limit marker painted on the backboard by applying an abrupt horizontal thrust to the upper portion of the right hand spring steel strap. Then remove the hand from the strap and allow the spring action of the straps to move the carriage and cylinder in the opposite direction without assistance or hindrance. Apply enough force to the right-hand spring steel strap during the thrust portion of each stroke to move the pointer to the stroke limit marker by pushing against the strap with the ends of the fingers to maintain a smooth oscillating motion. The center of the stroke limit marker is positioned to provide the proper stroke length and its width provides the maximum allowable limits of variation. The proper shaking action is accomplished only when the tip of the point reverses direction within the marker limits. Proper shaking action can best be maintained by using only the forearm and wrist action to propel the shaker. Continue the shaking action for 100 strokes.

Manually-Operated Shaker
Figure 4

8.5 Following the shaking operation, set the cylinder upright on the work table and remove the stopper.

8.6 Irrigation Procedure – Insert the irrigator tube in the cylinder and rinse material from the cylinder walls as the irrigator is lowered. Force the irrigator through the material to the bottom of the cylinder by applying a gentle stabbing and twisting action while the working solution flows from the irrigator tip. This flushes the fine material into suspension above the coarser sand particles (see Figure 5). Continue to apply the stabbing and twisting action while flushing the fines upward until the cylinder is filled to the 15 in (381 mm) mark. Then raise the irrigator slowly without shutting off the flow so that the liquid level is maintained at about 15 in (381 mm) while the irrigator is being withdrawn. Regulate the flow just before the irrigator is entirely withdrawn and adjust the final level to 15 in (381 mm). Final level as judged by the bottom of the meniscus shall be between the top two gradations on the tube but shall not be above the 15 in (381 mm) level.

Irrigation
Figure 5

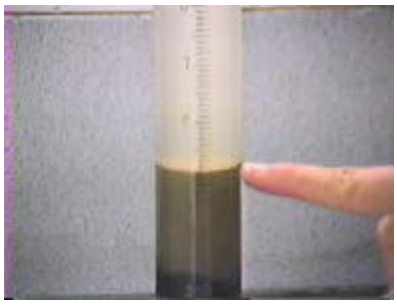
Note 5: For certain soils, particularly on crushed materials, the stabbing action may not be possible. For these materials, the irrigation technique is as follows: Continue to apply a twisting action as the irrigation tube is slowly withdrawn. As the tube is withdrawn, it is essential that as many fines as possible flushed upward until the cylinder is filled to the 15 in (381 mm) mark.

8.7 Allow the cylinder and contents to stand undisturbed for 20 minutes ± 15 seconds. Start the timing immediately after withdrawing the irrigator tube

8.8 At the end of the 20 minute sedimentation period, read and record the level of the top of the clay suspension. This is referred to as the "clay reading." If no clear line of demarcation has formed at the end of the specified 20 minute sedimentation period, allow the sample to stand undisturbed until a clear reading can be obtained, then immediately read and record the level of the top of the clay suspension and the total sedimentation time. If the total sedimentation time exceeds 30 minutes, it will be rejected.

8.9 After the clay reading has been taken, the "sand reading" shall be obtained by one of the following methods:

8.9.1 When using the weighted foot assembly having the sand indictor on the rod of the assembly, place the assembly over the cylinder and gently lower the assembly toward the sand. Do not allow the indicator to hit the mouth of the cylinder as the assembly is being lowered. As the weighted foot comes to rest on the sand, tip the assembly toward the graduations on the cylinder until the indicator touches the inside of the cylinder. Subtract 10 in (254 mm) from the level indicated by the extreme top edge of the indicator and record this value as the "sand reading" (see Figure 6).



Clay Reading
Figure 6

8.9.2 If an older model weighted foot assembly having centering screws is used, keep one of the centering screws in contact with the cylinder wall near the graduations so that it can be seen at all times while the assembly is being lowered. When the weighted foot has come to rest on the sand, read the level of the centering screw and record this value as the "sand reading."

8.10 If clay or sand readings fall between 0.1 in (2.5 mm) graduations, record the level of the higher graduation as the reading. For example, a clay reading of 7.95 would be recorded as 8.0, and a sand reading of 3.22 would be recorded as 3.3.

9. Calculations

9.1 Calculate the sand equivalent (SE) to the nearest 0.1 using the following formula:

$$SE = \frac{\text{Sand Reading} \times 100}{\text{Clay Reading}}$$

9.2 If the calculated sand equivalent is not a whole number, report it as the next higher whole number, as in the following example:

$$SE = \frac{3.3 \times 100}{8} = 41.25$$

which is reported as 42.

9.3 Average the whole number values determined as described above. If the average of these values is not a whole number, raise it to the next higher whole number, as in the following example:

Calculated SE values: 41.2, 40.9

After raising each to the next higher whole number, they become: 42, 41

The average of these values is then determined:

$$\frac{42 + 41}{2} = 41.5$$

which is reported as 42.

If the two results from the same SE sample vary by more than 8 points, the test shall be invalid and a new test completed.

9.3.1 Since the average value is not a whole number, it is raised to the next higher whole number and the reported averages and equivalent value is reported as 42.

10. Report

10.1 Report the results using one or more of the following:

- Materials Testing System (MATS)
- DOT Form 350-161, 422-022, 422-022A, or 422-022B
- Form approved in writing by the State Materials Engineer

Performance Exam Checklist

Plastic Fines in Graded Aggregates and Soils by the Use of the Sand Equivalent Test FOP for AASHTO T 176

Participant Name _____ Exam Date _____

Procedure Element	Yes	No
Preparation		
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?		
3. Sample passed through No. 4 (4.75 mm) sieve?		
4. Material in clods broken up and re-screened?		
5. No fines lost?		
6. Temperature of working solution 72 ± 5°F (22 ± 3°C)?		
7. Working calcium chloride solution 36 ± 1 in (915 mm ± 25 mm) above the work surface?		
8. 4 ± 0.1 in (101.6 ± 2.5 mm) working calcium chloride solution siphoned into cylinder?		
9. Working solution dated?		
Sample Preparation		
1. If necessary, sample sprayed with water to prevent loss of fines?		
2. Material checked for moisture condition by tightly squeezing small portion in palm of hand and forming a cast?		
3. Sample at proper water content?		
a. If too dry (cast crumbles easily), water added and remixed?		
b. If too wet (shows free water), sample drained, air dried and mixed frequently?		
4. Sample placed on splitting cloth and mixed by alternately lifting each corner of the cloth and pulling it over the sample toward diagonally opposite corner, causing material to be rolled?		
5. Is material thoroughly mixed?		
6. When material appears to be homogeneous, mixing finished with sample in a pile near center of cloth?		
7. Fill the 85 mL tin by pushing through base of pile with other hand on opposite side of pile?		
8. Material fills tin to overflowing?		
9. Material compacted into tin with palm of hand?		
10. Tin struck off level full with spatula or straightedge?		
11. Test sample dried in an oven at the correct temperature?		
12. Sample cooled to room temperature		

Procedure

1. Prepared sample funneled into cylinder with no loss of fines?
2. Bottom of cylinder tapped sharply on heel of hand several times to release air bubbles?
3. Wetted sample allowed to stand undisturbed for 10 min ± 1 min?
4. Cylinder stoppered and material loosened from bottom by shaking?
5. Properly performed shaking method?
   - Mechanical Shaker Method
   - Manual Shaker Method
6. Following shaking, cylinder set vertical on work surface and stopper removed?
7. Irrigator tube inserted in cylinder and material rinsed from cylinder walls as irrigator is lowered?
8. Irrigator tube forced through material to bottom of cylinder by gently stabbing and twisting action?
9. Stabbing and twisting motion applied until cylinder filled to 15 in (381 mm) mark?
10. Liquid raised and maintained at 15 in (381 mm) mark while irrigator is being withdrawn?
11. No clear solution at top of column?
12. Contents let stand 20 minutes ± 15 seconds?
13. Timing started immediately after withdrawal of irrigator?
14. No vibration or disturbance of the sample?
15. Readings taken at 20 minutes or up to 30 minutes, when a definite line appears?
16. Weighted foot assembly lowered into cylinder without hitting mouth of cylinder?
17. Calculations made to 0.1 and reported to the next higher whole number?
18. SE is based on the average results of two samples?
19. If the two SE values vary by more than 8 points, additional tests run?
20. All calculations performed correctly?

First Attempt: Pass Fail Second Attempt: Pass Fail

Signature of Examiner _____

Comments: