T 176

PLASTIC FINES IN GRADED AGGREGATES AND SOILS BY THE USE OF THE SAND EQUIVALENT TEST

FOP FOR AASHTO

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Significance

02 Excessive amounts of fine dust or clay-like materials – materials smaller than the No. 200 sieve – may cause problems in aggregate and soils. For example, road base with a high fine content may not drain freely. Trapped moisture will freeze and thaw during winter months, causing damage to the road.

Scope

This procedure covers the determination of plastic fines in accordance with AASHTO T 176. It serves as a rapid test to show the relative proportion of fine dust or clay-like materials in fine aggregates (FA) and soils.

Apparatus

03 See AASHTO T 176 for a detailed listing of sand equivalent apparatus. Note that the siphon tube and blow tube may be glass or stainless steel as well as copper.

Apparatus

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- Graduated plastic cylinder.
- Rubber stopper.
- Irrigator tube.
- Weighted foot assembly having a mass of 1000 ±5 g. There are two models of the weighted foot assembly. The older model has a guide cap that fits over the upper end of the graduated cylinder and centers the rod in the cylinder. It is read using a slot in the centering screws. The newer model has a sand reading indicator 10 in. above this point and is preferred for testing clay-like materials.
- Siphon assembly: The siphon assembly will be fitted to a 1 gal bottle of working calcium chloride solution placed on a shelf 36 ±1 in. above the work surface.
- Measuring can having a capacity of 3 fl. oz.

- Funnel with a wide-mouth for transferring sample into graduated cylinder.
- Quartering cloth – 2 ft square nonabsorbent cloth, such as plastic or oilcloth.
- Mechanical splitter – see FOP for AASHTO T 248.
- Strike off bar – A straight edge or spatula.
- Clock or watch reading in minutes and seconds.
- Manually operated sand equivalent shaker capable of producing an oscillating motion at a rate of 100 complete cycles in 45 ±5 seconds, with a hand assisted half stroke length of ±0.2 in. It may be held stable by hand during the shaking operation. It is recommended that this shaker be fastened securely to a firm and level mount, by bolts or clamps, if a large number of determinations are to be made.
- Mechanical shaker – See AASHTO T 176 for equipment and procedure.
- Oven capable of maintaining a temperature of 230 ±9°F.
- Thermometer – Calibrated liquid-in-glass or electronic digital type designed for total immersion and accurate to 0.2°F.

Materials

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- Stock calcium chloride solution: Obtain commercially prepared calcium chloride stock solution meeting AASHTO requirements.

Working calcium chloride solution: Dilute one 3 oz. measuring can of stock calcium chloride solution to 1 gal with distilled or demineralized water

Note 1: Mix the working solution thoroughly. Add the 3 oz. of stock solution to a clean empty 1 gal. jug. Add approximately 1 qt. of water and agitate vigorously for 2 to 3 minutes. Add the remainder of the water in approximately 1 qt. increments repeating the agitation process.

Note 2: Tap water may be used if it is proven not to be detrimental to the test and if it is allowed by the agency.

Note 3: The shelf life of the working solution is approximately 30 days. Working solutions more than 30 days old shall be discarded.

Control

06 The temperature of the working solution should be maintained at 72 ±5°F during the performance of the test. If field conditions preclude the maintenance of the temperature range, reference samples should be submitted to the Central/Regional Laboratory, as required by the agency, where proper temperature control is possible. Samples that meet the minimum sand equivalent requirement at a working solution temperature outside of the temperature range need not be subject to reference testing.

Sample Preparation

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1. Obtain the sample in accordance with FOP for AASHTO T 2 and reduce in accordance with FOP for AASHTO T 248.
2. Prepare sand equivalent test samples from the material passing the No. 4 sieve. If the material is in clods, break it up and rescreen it over a No. 4 sieve. All fines shall be cleaned from particles retained on the No. 4 sieve and included with the material passing that sieve.
3. Split or quarter 1000 to 1500 g of material from the portion passing the No. 4 sieve. Use extreme care to obtain a truly representative portion of the original sample.

08 ***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 reduced. 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.

Note 5: All tests including Reference Tests will be performed utilizing Alternative Method No. 2 as described in AASHTO T 176 unless specifications call for oven dry samples.

09 4. The sample must have the proper moisture

content to achieve reliable results. This 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 content has been obtained.

Note 6: Clean sands having little No. 200 such as sand for Portland Cement Concrete (PCC) may not form a cast.

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. When the moisture content is altered to provide the required cast, the altered sample should be placed in a pan, covered with a lid or with a damp cloth that does not touch the material, and allowed to stand for a minimum of 15 minutes. Samples that have been sieved without being air-dried and still retain enough natural moisture are exempted from this requirement.

If the material shows any free water, it is too wet to test and must be drained and air dried. Mix frequently to ensure uniformity. This drying process should continue until squeezing provides the required cast.

Mixing

5. Place the sample on the quartering cloth and mix by alternately lifting each corner of the cloth and pulling it over the sample toward the diagonally opposite corner, being careful to keep the top of the cloth parallel to the bottom, thus 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.

Filling measuring can

Tapping bottom of cylinder

Mechanical Shaker

6. Fill the measuring can by pushing it through the base of the pile while exerting pressure with the hand against the pile on the side opposite the measuring can. As the can is moved through 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 place the maximum amount in the can. Strike off the can level full with the straight edge or spatula.
7. When required, repeat steps (5) and (6) to obtain additional samples.

Procedure

1. Start the siphon by forcing air into the top of the solution bottle through the tube while the pinch clamp is open.
2. Siphon 4 ±0.1 in. of working calcium chloride solution into the plastic cylinder. Pour the prepared test sample from the measuring can into the plastic cylinder using the funnel to avoid spilling. 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.
3. Allow the wetted sample to stand undisturbed for 10 ±1 minutes. At the end of the 10-minute period, stopper the cylinder and loosen the material from the bottom by simultaneously partially inverting and shaking the cylinder.
4. After loosening the material from the bottom of the cylinder, shake the cylinder and contents by any one of the following methods:
   a. Mechanical Method – Place the stoppered cylinder in the mechanical shaker, set the timer, and allow the machine to shake the cylinder and contents for 45 ±1 seconds.

Caution: Agencies may require additional operator qualifications for the next two methods.

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Manually-operated shaker

b. Manually-operated Shaker Method – Secure the stoppered cylinder in the three spring clamps on the carriage of the manually-operated sand equivalent shaker and set 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 strap.

   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.

   Proper shaking action is accomplished when the tip of the pointer 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 shaking for 100 strokes.

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Hand shaking

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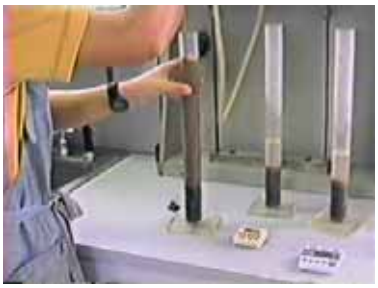
c. Hand Method – Hold the cylinder in a horizontal position and shake it vigorously in a horizontal linear motion from end to end. Shake the cylinder 90 cycles in approximately 30 seconds using a throw of 9 ±1 in. A cycle is defined as a complete back and forth motion. To properly shake the cylinder at this speed, it will be necessary for the operator to shake with the forearms only, relaxing the body and shoulders.

5. Set the cylinder upright on the work table and remove the stopper.

6. 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. Work the irrigator tube to the bottom of the cylinder as quickly as possible, since it becomes more difficult to do this as the washing proceeds. This flushes the fine material into suspension above the coarser sand particles.

24 Continue to apply a stabbing and twisting action while flushing the fines upward until the cylinder is filled to the 15 in. mark. Then raise the irrigator slowly without shutting off the flow so that the liquid level is maintained at about 15 in. while the irrigator is being withdrawn. Regulate the flow just before the irrigator is entirely withdrawn and adjust the final level to 15 in.



Irrigation

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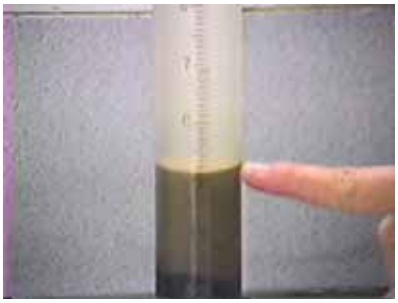
Note 7: Occasionally the holes in the tip of the irrigator tube may become clogged by a particle of sand. If the obstruction cannot be freed by any other method, use a pin or other sharp object to force it out (such as a tooth pick), using extreme care not to enlarge the size of the opening. Also, keep the tip sharp as an aid to penetrating the sample.

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

Note 8: Any vibration or movement of the cylinder during this time will interfere with the normal settling rate of the suspended clay and will cause an erroneous result.

8. Clay and Sand Readings

28 a. 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.



Clay reading

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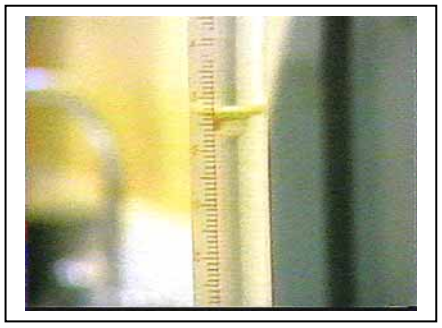
Note 9: If no clear line of demarcation has formed at the end of the 20-minute sedimentation period, allow the sample to stand undisturbed until a clay reading can be obtained, then immediately read and record the level of the top of the clay suspension and the total sedimentation time. If the total sedimentation time exceeds 30 minutes, rerun the test using three individual samples of the same material.

Read and record the clay column height of the sample requiring the shortest sedimentation period only. Once a sedimentation time has been established, subsequent tests will be run using that time. The time will be recorded along with the test results on all reports.



Sand reading

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b. After the clay reading has been taken, place the weighted foot assembly over the cylinder and gently lower the assembly until it comes to rest on the sand. Do not allow the indicator to hit the mouth of the cylinder as the assembly is being lowered. Subtract 10 in. from the level indicated by the extreme top edge of the indicator and record this value as the sand reading.

c. If clay or sand readings fall between 0.1 in. graduations, record the level of the higher graduation as the reading. For example, a clay reading that appears to be 7.95 would be recorded as 8.0; a sand reading that appears to be 3.22 would be recorded as 3.3.

d. If two Sand Equivalent (SE) samples are run on the same material and the second varies by more than ±4, based on the first cylinder results, additional tests shall be run.

e. If three or more Sand Equivalent (SE) samples are run on the same material, average the results. If an individual result varies by more than ±4, based on the average result, additional tests shall be run.

Calculations

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1. Calculate the SE to the nearest 0.1 using the following formula:

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

For Example: Sand Reading = 3.3 and Clay Reading = 8.0

$$SE = \frac{3.3}{8.0} \times 100 = 41.25 \text{ or } 41.3$$

Note 10: This example reflects the use of equipment made with English units. At this time, equipment made with metric units is not available.

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2. Report the SE as the next higher whole number. In the example above, the 41.3 would be reported as 42. An SE of 41.0 would be reported as 41.

3. In determining the average of the two samples, raise each calculated SE value to the next higher whole number before averaging. For example, calculated values of 41.3 and 42.8 would be reported as 42 and 43, respectively.

   Then average the two values: 35

$$\frac{42+43}{2} = 42.5$$

   If the average value is not a whole number, raise it to the next higher whole number – in this case: 43.

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Report

- Results shall be reported on standard forms approved for use by the agency.
- Report results to the whole number.
- Sedimentation time if over 20 minutes.

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Tips!

- Make sure you have enough working solution before you start the procedure.
- Be careful when reducing and dampen the material, if necessary, to avoid segregation or loss of fines.
- Make sure both holes in irrigator tube are clear.
- 100 percent crushed material interlocks when inserting the irrigator tube the first time. You must apply a firm, twisting action to lower the irrigator tube in subsequent flushings.
- Do not run equipment that causes vibrations during settling.

REVIEW QUESTIONS

1. Describe the proper way to acquire the SE test sample.

2. After tapping the bottom of the cylinder to release air bubbles, how long should the wetted sample stand?

3. What happens if no clear line of demarcation occurs in 20 minutes? In 30 minutes?

4. Describe how the rounding of numbers in this FOP differs from the standard mathematical approach.

5. How much material passing the No. 4 sieve is required for an SE test?

6. Explain the difference in calculating two cylinder results and three or more cylinder results.

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 _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	**Trial 1**	**Trial 2**
Sample Preparation		
1. Sample passed through No. 4 sieve?	_____	_____
2. Material in clods broken up and re-screened?	_____	_____
3. Split or quarter 1,000 to 1,500g of material passing the No. 4 sieve? NOTE: If necessary, the material may be dampened before splitting to avoid segregation or loss of fines.	_____	_____
4. No fines lost?	_____	_____
5. Working solution dated?	_____	_____
6. Temperature of working solution 72 ±5°F?	_____	_____
7. Working calcium chloride solution (36 ±1in) above the work surface?	_____	_____
8. 4 ± 0.1 in working calcium chloride solution siphoned into cylinder?	_____	_____
9. Material checked for moisture condition by tightly squeezing small portion in palm of hand and forming a cast?	_____	_____
10. Sample at proper water content?		
a. If too dry (cast crumbles easily) water added, re-mixed, covered, and allowed to stand for at least 15 minutes?	_____	_____
b. If too wet (shows free water) sample drained, air dried and mixed frequently?	_____	_____
11. 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?	_____	_____
12. Is material thoroughly mixed?	_____	_____
13. When material appears to be homogeneous, mixing finished with sample in a pile near center of cloth?	_____	_____
14. Fill the 3 oz tin by pushing through base of pile with other hand on opposite side of pile?	_____	_____
15. Material fills tin to overflowing?	_____	_____

OVER

Procedure Element	Trial 1	Trial 2
16. Material compacted into tin with palm of hand?	_____	_____
17. Tin struck off level full with spatula or straightedge?	_____	_____
18. Prepared sample funneled into cylinder with no loss of fines?	_____	_____
19. Bottom of cylinder tapped sharply on heel of hand several times to release air bubbles?	_____	_____
20. Wetted sample allowed to stand undisturbed for 10 min. ±1 min.?	_____	_____
21. Cylinder stoppered and material loosened from bottom by shaking?	_____	_____
22. Stoppered cylinder placed properly in mechanical shaker and cylinder shaken 45 ±1 seconds?	_____	_____
23. Following shaking, cylinder set vertical on work surface and stopper removed?	_____	_____
24. Irrigator tube inserted in cylinder and material rinsed from cylinder walls as irrigator is lowered?	_____	_____
25. Irrigator tube forced through material to bottom of cylinder by gentle stabbing and twisting action?	_____	_____
26. Stabbing and twisting motion applied until cylinder filled to 15 in. mark?	_____	_____
27. Liquid raised and maintained at 15 in. mark while irrigator is being withdrawn?	_____	_____
28. Liquid at the 15 in. mark?	_____	_____
29. Contents let stand 20 minutes ±15 seconds?	_____	_____
30. Timing started immediately after withdrawal of irrigator?	_____	_____
31. No vibration or disturbance of the sample?	_____	_____
32. Readings taken at 20 minutes or up to 30 minutes, when a definite line appears?	_____	_____
33. Clay level correctly read, rounded, and recorded?	_____	_____
34. Weighted foot assembly lowered into cylinder without hitting mouth of cylinder?	_____	_____
35. Sand level correctly read, rounded, and recorded?	_____	_____
36. Calculations performed correctly?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

_____

_____

Examiner Signature _____ WAQTC #:_____