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METHOD OF TEST FOR SAND EQUIVALENT

A. SCOPE

This test method provides the procedure for measuring the relative proportions of detrimental fine dust or clay-like material in soil or fine aggregates.

B. REFERENCES

California Test 201 – Soil and Aggregate Sample Preparation
California Test 226 – Moisture Content of Soils and Aggregates by Oven Drying
California Test 227 – Evaluating Cleanness of Coarse Aggregate

C. APPARATUS

1. Sand Equivalent Test Apparatus: a graduated plastic cylinder, rubber stopper, irrigator tube, weighted foot assembly, and siphon assembly, all conforming to the specifications and dimensions shown in Figure 1. A glass or plastic container with cover, having a minimum capacity of 1 gal, and fitted with the siphon assembly or a discharge tube near the bottom, must be used to dispense the working solution. The container must be placed on a shelf or suspended above the work area in such a manner that the level of the solution is maintained between 36 and 46 in. above the work surface (Figure 2).
2. Mechanical Sand Equivalent Shaker (Figure 3): a mechanical device designed to hold the sand equivalent (SE) graduated plastic cylinder in a horizontal position while subjecting it to a reciprocating motion parallel to its length. The motion must be provided through a “scotch-yoke” mechanism, which provides a stroke length of 8 in. \pm 0.05 in. The device must operate at a speed of 175 cycles per minute (cpm) \pm 2 cpm. Prior to use, the shaker must be fastened securely to a firm and level mount.
3. (Alternate) Manually-Operated Sand Equivalent Shaker (Figure 7).
 - a. A manually actuated device designed to hold a graduated plastic cylinder in a horizontal position while subjecting it to a reciprocating motion parallel to its length. The device consists of a carriage mounted on top of two spring steel straps. Motion is provided by pushing the carriage in one direction and allowing the spring action of the straps to move it in the opposite direction. The shaker may be held stable by hand, but it is recommended that it be fastened securely to a firm and level mount if a large number of tests are to be run.
 - b. A manually actuated device capable of producing an oscillating motion at the rate of 100 complete cycles in 45 s \pm 5 s, with a hand-assisted half stroke length of 5.0 in. \pm 0.2 in. The shaker must be fastened securely to a firm and level mount by bolts or clamps if a large number of tests are to be made.

4. Workbench or Table: a flat, level surface that must be free of vibration.
5. Measuring Tin: a 3 oz. tin of approximately 2¼ in. diameter having a capacity of 85 mL ± 5 mL.
6. Funnel: a wide-mouth funnel suitable for directing the test specimen into the plastic cylinder.
7. Rubber Stopper: a stopper to fit the plastic cylinder.
8. Oven: an oven or other suitable thermostatically controlled heating device capable of maintaining a uniform temperature of 230°F ± 9°F.
9. Timer: a clock or watch reading in minutes and seconds.

D. MATERIALS

1. Stock calcium chloride solution.
 - a. “Sand Equivalent Stock Solution” may be purchased and used in accordance with manufacturer’s guidelines, or
 - b. “Sand Equivalent Stock Solution” may be prepared from the following:
 - 454 g technical grade anhydrous calcium chloride
 - 2050 g (1640 mL) glycerin (95 %)Dissolve the calcium chloride in ½ gal of distilled or deionized water. Cool the solution to room temperature; then filter it through Whatman No. 2V or equivalent filter paper. Add the glycerin to the filtered solution, mix well, and dilute to 1 gal with distilled or deionized water.
2. Working calcium chloride solution.
 - a. Prepare the working solution by diluting 85 mL ± 5 mL of stock solution with distilled or deionized water to obtain 1 gal of solution. Thoroughly mix the working solution.
 - b. Working solution that is more than 2 weeks old must be discarded. Working solution mix date and discard date must be posted in the SE work area.
 - c. Mixing and storage containers must be thoroughly rinsed prior to mixing a fresh batch of solution.
 - d. Fresh solution must not be added to old solution regardless of age.
3. Use distilled or deionized water for the performance of this test, including the preparation of the working solution.

E. CONTROL

1. Maintain the temperature of the working solution at $72^{\circ}\text{F} \pm 5^{\circ}\text{F}$ during the performance of this test. If this is impractical, it is necessary to establish temperature correction factors for each material being tested.

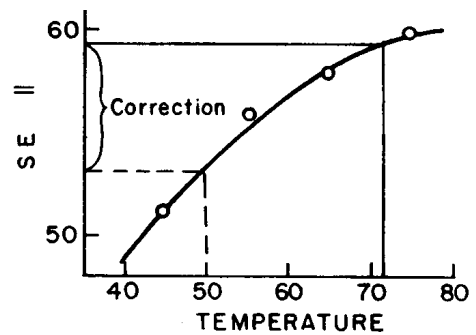
Results for individual specimens that meet the minimum SE specification when the temperature of the working solution is below $72^{\circ}\text{F} \pm 5^{\circ}\text{F}$ do not require correction provided they do not reduce the moving average results below specified minimums.

2. Establish correction factors by the following procedures:
 - a. Prepare a minimum of 12 test specimens in accordance with Section F of this test procedure.
 - b. Perform tests in groups of 3, using working solution at different temperatures. Prepare working solutions near the upper and lower expected temperature range and in approximately 10°F increments. The temperature of the working solution used with at least 1 group must be $72^{\circ}\text{F} \pm 5^{\circ}\text{F}$.
 - c. Establish a correction curve by plotting the temperature of the working solution against the average test value at that temperature.

This correction curve may be used to determine the correction to be applied in order to obtain a test value corrected to 72°F .

Example:

Test Value	Temperature Range of Solution			
	45°F	55°F	65°F	75°F
1	52	55	57	59
2	50	55	58	60
3	51	58	59	60
Average	51	56	58	60



The result of a test performed on the material of this example when the temperature of the solution was 50°F would have to be corrected by +6 points to obtain a test value equivalent to that at 72°F .

F. PREPARATION OF TEST SPECIMENS

1. Prepare 1000 to 1500 g specimens from the passing No. 4 sieve portion of the material to be tested after it has been processed in accordance with California Test 201.
 - a. When testing aggregate samples containing reclaimed asphalt pavement, the oven drying temperature must not exceed 100°F .

- b. Aggregates for use in Sacked Concrete Slope Protection must be prepared in accordance with California Test 227. Because a cleanness test is to be performed on the coarse aggregate portion of this material, do not remove the fines from the material retained on the No. 4 sieve.
2. Split or quarter the passing No. 4 sieve material to provide a test specimen that fills the measuring tin to level full.

NOTE: The accuracy of splitting or quartering representative portions of a material decreases as the sample size is reduced. To minimize the effects of adjusting the size of the relatively small SE sample, the following procedure should be followed:

- Determine the exact amount required to provide 4 test specimens by dipping 4 measuring tins full of the material and determining either the combined volume or weight. When filling the measuring tin, tap the bottom edge of the tin with a hard object or on a hard surface to consolidate the material. Fill each measure to slightly rounded above the brim and then strike off to level full using a straightedge. After determining the combined amount, return the material to the sample.
 - Carefully split or quarter the predetermined amount of material necessary to provide 4 test specimens.
 - Split or quarter the premeasured material to obtain a test specimen. Two successive splits will provide specimens of the proper size. Do not make adjustments to the specimen size by adding or removing material at this time.
3. Dry the prepared test specimen to constant weight at $230^{\circ}\text{F} \pm 9^{\circ}\text{F}$ in accordance with California Test 226, and cool to room temperature.
 - a. When testing aggregate samples containing reclaimed asphalt pavement, the oven drying temperature must not exceed 100°F .
 - b. Aggregates, which are sampled immediately after being dried in an asphalt plant dryer may be tested without additional drying provided they are not exposed to dampness prior to testing. Aggregates that are not tested on the same day they are sampled must be oven-dried in accordance with California Test 226 prior to testing unless they have been stored in moisture-proof containers.
 - c. As a timesaving expedient in routine work, it is permissible to test materials in an air-dried condition. Air-dried material, which does not meet minimum requirements, must be retested in an oven-dried condition in accordance with California Test 226 and the results of the oven-dried sample will control.

G. TEST PROCEDURE

1. Read and record the temperature of the working solution.

- a. When the working solution is being stored in a temperature-controlled work area where the room temperature remains constant within $\pm 5^{\circ}\text{F}$ over a 24 hr period, the average room temperature may be recorded in lieu of the solution temperature.
2. Fill the plastic cylinder to 4 in. \pm 0.1 in. with working solution.
3. Pour the prepared test specimen from the measuring tin into the plastic cylinder (Figure 4).
 - a. Use the funnel to avoid spillage.
 - b. Release air bubbles and promote thorough wetting by bumping the base of the plastic cylinder against a firm object while the test specimen is being poured into the plastic cylinder or by tapping the plastic cylinder sharply on the heel of the hand several times after the test specimen has been poured in.
 - c. Allow the wetted material to stand undisturbed for 10 min \pm 1 min.
4. Following the 10 min wetting period, agitate the test specimen to break up clay lumps and remove coatings.
 - a. At the end of the 10 min wetting period, stopper the plastic cylinder, then loosen the material from the bottom by shaking the plastic cylinder while holding it in a partially inverted position. Shake the plastic cylinder just enough to loosen the material. Excessive agitation may affect the test results.
 - b. Secure the plastic cylinder in one of the specified shakers and agitate for 45 s \pm 1 s. according to (1) or (2) below:
 - (1) Mechanical Shaker Method
Set the timer and allow the machine to operate for 45 s \pm 1 s.
 - (2) Manually-Operated Shaker Method
 - (a) Set the stroke counter to zero.
 - (b) Stand directly in front of the shaker and place the right hand against the upper portion of the right hand spring steel strap (Figure 8).
 - (c) Use the fingers and wrist to apply enough force to push the carriage to the left until the pointer lines up with the stroke limit marker painted on the backboard.
 - (d) Allow the spring action of the straps to move the carriage in the opposite direction without assistance or hindrance to complete the cycle.

- (e) Once the shaker is in motion, maintain a smooth oscillating motion by gently applying pressure to the right hand strap during the thrust portion of each cycle.
 - (f) The center of the stroke limit marker is positioned to provide the proper stroke length and its width indicates the maximum allowable limits of variation. Proper shaking action is accomplished only when the tip of the pointer reverses direction within the marker limits.
 - (g) Continue the shaking action for 100 strokes.
 - c. At the end of the shaking period remove the plastic cylinder from the shaker and set it upright on the workbench.
- NOTE: If a dispute arises over results when the manually-operated shaker method has been used, the mechanical shaker method will be used for dispute resolution.
- 5. Irrigate the test specimen with working solution to flush the clay-size particles from the sand.
 - a. Insert the irrigator tube in the plastic cylinder, start the flow of working solution, and rinse the material from the side of the plastic cylinder as the irrigator is lowered.
 - b. With the plastic cylinder remaining in an upright position and the solution flowing from the tip of the irrigator, apply a twisting action to the irrigator and force it to the bottom of the plastic cylinder (Figure 5). The flow of solution will flush the clay-size particles upward and into suspension. Withdraw the irrigator from the sample as necessary to change position and again force it to the bottom. The most effective technique for penetrating the sample with the irrigator is to hold the irrigator between the palms of both hands and rotate it by rubbing the hands back and forth while applying a downward pressure.
 - c. Continue twisting and forcing the irrigator to the bottom of the plastic cylinder until the fines have been flushed from all areas of the sample. Rotate the plastic cylinder with each penetration of the irrigator and visually inspect the test specimen for pockets of fine material.
 - d. When the solution reaches the 15 in. mark on the plastic cylinder, slowly withdraw the irrigator without shutting off the flow so that the liquid level is maintained at about 15 in. Regulate the flow just before the irrigator is entirely withdrawn and adjust the final level to 15 in.
 - 6. Place the plastic cylinder on a workbench or table free of vibration and allow the plastic cylinder and contents to stand undisturbed for 20 min \pm 15 s from the time the irrigation is completed.
 - 7. Determine the "clay reading."
 - a. At the end of the 20 min period, read and record the level of the top of the sediment column. This is the clay reading (Figure 6).

- b. When the clay reading falls between 0.1 in. graduations, record the level of the higher graduation.
 - c. If a clearly defined line of demarcation does not form between the sediment and the liquid above it in the specified 20 min period, allow the plastic cylinder to stand undisturbed until the clear line of demarcation does form. Then immediately read and record the time and height of the column.
 - d. If the liquid immediately above the line of demarcation is still darkly clouded at the end of 20 min, and the demarcation line, although distinct, appears to be in the sediment column itself, read and record the level of this line at the end of the specified 20 min period.
8. Determine the “sand reading.”
- a. After the clay reading has been taken, gently lower the weighted foot assembly into the plastic cylinder until it comes to rest on the sand. Do not allow the sand reading indicator to hit the mouth of the plastic cylinder as the assembly is being lowered.
 - b. As the weighted foot assembly comes to rest on the sand, tip the assembly toward the graduation on the plastic cylinder so that the position of the sand reading indicator is visible. Take care not to press down on the assembly.
 - c. Read the level of the top edge of the indicator (Figure 6).
 - d. Subtract 10 in. from the observed reading. This is the sand reading.
 - e. When the sand reading falls between 0.1 in. graduations, record the level of the higher graduation.

H. CALCULATIONS AND REPORTING

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

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

2. If the calculated SE is not a whole number, report it as the next higher whole number.

I. PRECAUTIONS

1. Perform the test in a location free of vibration, because vibrations may cause the suspended material to settle at a faster rate than normal.
2. Occasionally a fungus growth may develop in the working solution. This fungus can easily be seen as a slimy substance in the solution or as a mold growing on the inside of the container.

When this occurs, discard the remaining solution, and clean the growth from the container and from the inside of the flexible tubing and irrigator by the following procedure:

- a. Prepare a cleaning solvent by diluting sodium hypochlorite (household bleach or equivalent) with an equal quantity of water.
 - b. Fill the solution container with the prepared cleaning solvent. Allow about a liter of the cleaning solvent to flow through the siphon assembly, and irrigator tube; then place the pinch clamp on the end of the tubing to cut off the flow of solvent and to hold the solvent in the tube. Refill the container, and allow it to stand overnight.
 - c. After soaking, allow the cleaning solvent to flow out through the siphon assembly and irrigator tube.
 - d. Remove the siphon assembly from the solution container, and rinse both with clear water. The irrigator tube and siphon assembly can be rinsed easily by attaching a hose between the tip of the irrigator tube and water faucet and backwashing fresh water through the tube.
3. At the beginning of each test, visually observe the flow of solution from the irrigator to ensure proper discharge. If the solution is discharged from any point other than the drilled holes, replace the irrigator. If the drilled holes become clogged, remove the obstruction by any method that does not damage the irrigator or change the size or shape of the hole. Dislodging an obstruction with a sharp object should be done only as a last resort and with extreme care.

J. HEALTH AND SAFETY

It is the responsibility of the user of this test method to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. Prior to handling, testing or disposing of any materials, testers must be knowledgeable about safe laboratory practices, hazards and exposure, chemical procurement and storage, and personal protective apparel and equipment.

Caltrans Laboratory Safety Manual is available at:

http://www.dot.ca.gov/hq/esc/ctms/pdf/lab_safety_manual.pdf

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FIGURE 2. Sand Equivalent Test Apparatus Excluding Shaker

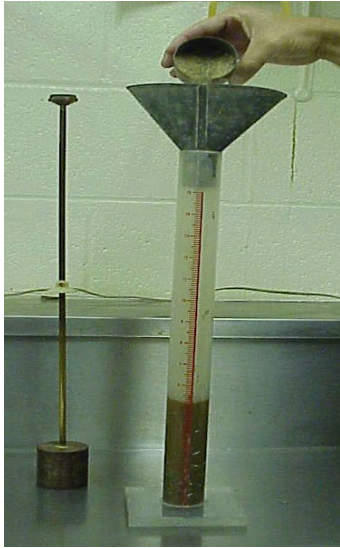
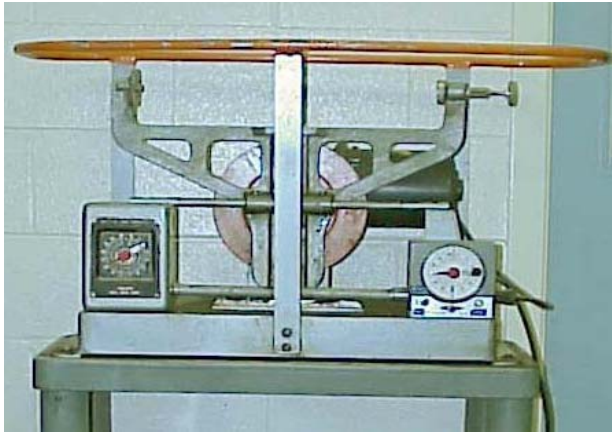


FIGURE 4. Pouring the Sample

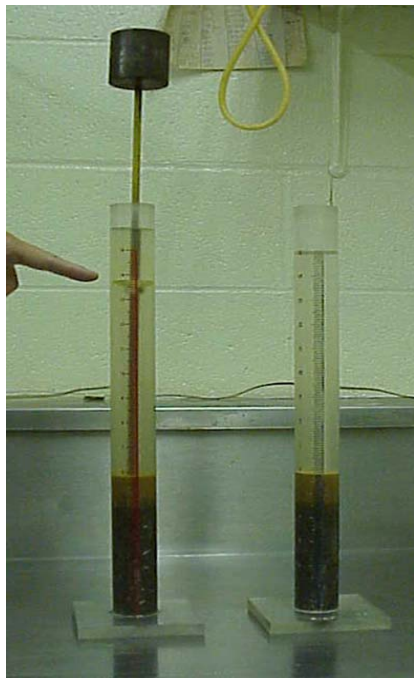


FIGURE 6. Sand Reading (Left) Clay Reading (Right)

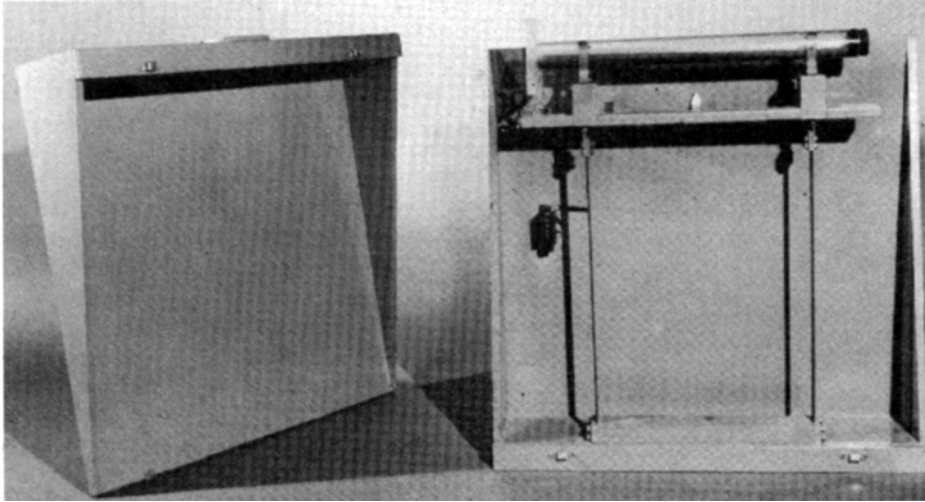


FIGURE 7. Manually Operated Sand Equivalent Shaker

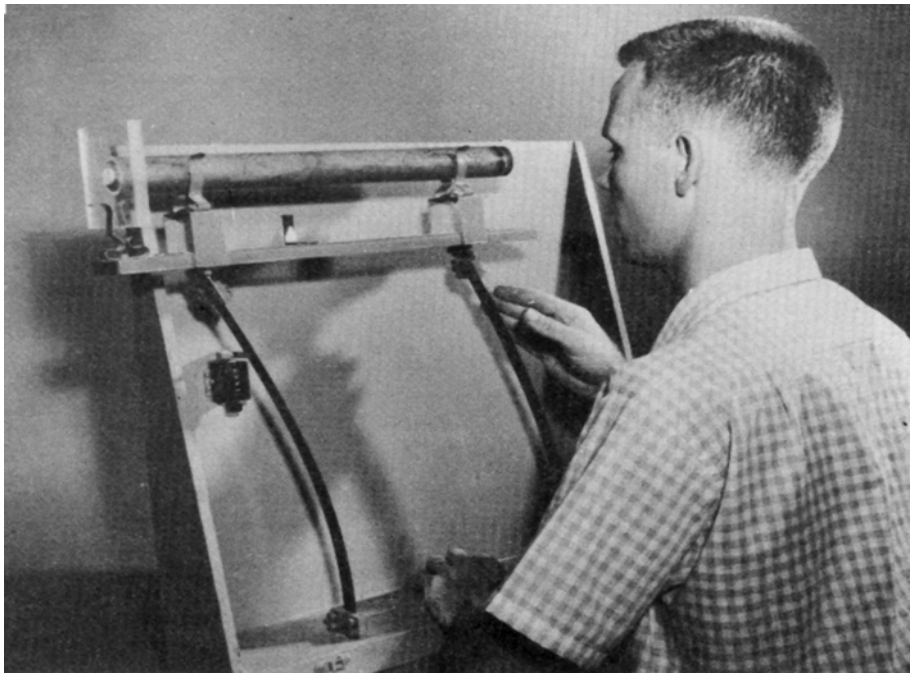


FIGURE 8. Operating a Manual Sand Equivalent Shaker