DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
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METHOD OF TEST FOR SAND EQUIVALENT

CAUTION: Prior to handling test materials, performing equipment setups, and/or conducting this method, testers are required to read "**SAFETY AND HEALTH**" in Section I of this method. It is the responsibility of the user of this method to consult and use departmental safety and health practices and determine the applicability of regulatory limitations before any testing is performed.

A. SCOPE

The sand equivalent test provides a measure of the relative proportions of detrimental fine dust or clay-like material in soil or fine aggregates.

B. APPARATUS

The following equipment is required to perform this test. Detailed descriptions and specifications are included as necessary to assure standardization. Items bearing an Office of Purchasing and Warehousing (OPW) catalog number are available to California state agencies from the Department of Transportation, Office of Purchasing and Warehousing. Detailed plans are available for these items bearing a Transportation Laboratory (TL) drawing number.

1. Sand Equivalent Test Apparatus (Figure 1).

   a. A graduated plastic cylinder, rubber stopper, irrigator tube, weighted foot assembly, and siphon assembly, all conforming to the specifications and dimensions shown in TL drawing number C 218 (Figure 3). A glass or plastic container with cover, having a minimum capacity of one gallon, and fitted with the siphon assembly or a discharge tube near the bottom, shall be used to dispense the working calcium chloride solution. The container shall 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 inches above the work surface.

2. Mechanical Sand Equivalent Shaker (Figure 2).

   a. A mechanical device designed to hold a graduated plastic cylinder in a horizontal position while subjecting it to a reciprocating motion parallel to its length.

      The motion shall be provided through a "scotch-yoke" mechanism, which provides a stroke length of 8 ± 0.05 inches. The device shall operate at a speed of 175 ± 2 complete cycles per minute. Prior to use, the shaker shall be fastened securely to a firm and level mount.

   b. TL drawing number D-256.

3. (Alternate) Manually-Operated Sand Equivalent Shaker (Figure 4).

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 shall consist of a carriage mounted on top of two spring steel straps. Motion shall be 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.

4. Measuring tin: A 3 oz. tin approximately 2¼ inches in diameter having a capacity of 85 ± 5 mL.

5. Rubber stopper: A stopper to fit the plastic cylinder.

6. Funnel: A wide-mouth funnel suitable for directing the test specimen into the plastic cylinder.

7. Oven: A drying oven set to operate at 230˚ ± 9˚F.

8. Timer: A clock or watch reading in minutes and seconds.

C. MATERIALS

1. Stock calcium chloride solution.

   a. "Sand Equivalent Stock Solution" OPW catalog number 6810-0090-3.

   b. May be prepared from the following:

      454 g (1 lb.) technical grade anhydrous calcium chloride.

      2050 g (1640 mL) USP glycerin (95 %)

      Dissolve the calcium chloride in ½ gallon 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 gallon with distilled or deionized water.

2. Working calcium chloride solution.

   a. Prepare the working calcium chloride solution by diluting 85 ± 5 mL of stock solution with water to obtain 1 gallon of solution. Thoroughly mix the solution.

   b. Working solution, which is more than two weeks old, shall be discarded.

   c. The mixing and storage container(s) shall be thoroughly rinsed prior to mixing a fresh batch of solution.

   d. Fresh solution shall not be added to old solution regardless of age.

3. Water.

   Use distilled or deionized water for the normal performance of this test, including the preparation of the working calcium chloride solution. If it is determined, however, that the local tap water is of such quality that it does not affect the test results, it is permissible to use it in lieu of distilled or deionized water.

D. CONTROL

1. The temperature of the working solution should be maintained at 72˚ ± 5˚F during the performance of this test. If this is impractical, it will be necessary to establish temperature correction factors for each material being tested. Establish correction factors by the following procedures:

a. Prepare a minimum of 12 test specimens in accordance with Section E of this test procedure.

b. Perform tests in groups of three, using working solution at different temperatures. Prepare solutions near the upper and lower expected temperature range and at approximately 10˚F increments through the range should be used. The temperature of the solution used with at least one group must be 72˚ ± 5˚F.

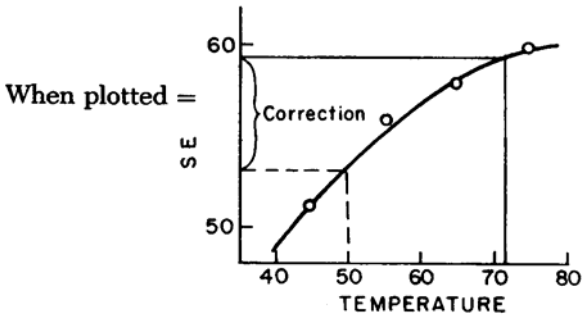
c. Establish a correction curve by plotting the temperature of the solution against the average test value at that temperature.

d. This correction curve may be used to determine the correction that must be applied to obtain a test value corrected to 72˚F.

e. Results for individual specimens which meet the minimum sand equivalent specification when the temperature of the working solution is below the recommended range do not require correction provided they do not reduce the moving average results below specified minimums.

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



A test performed on this material when the temperature of the solution was 50˚F would have to be corrected by +6 points.

2. The workbench or table shall be a flat level surface and shall be free of vibrations.

E. PREPARATION OF TEST SPECIMENS

1. Prepare sand equivalent test specimens from the passing No. 4 sieve portion of the material to be tested after it has been processed according to the procedures prescribed in California Test 201, except that reclaimed aggregate containing traces of asphalt or asphalt concrete shall not be oven dried at temperatures greater than 100˚F.

   a. Aggregates for use in Sacked Concrete Slope Protection shall be prepared as prescribed in California Test 227. Since 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 which fills the 85 mL measuring tin to level full. 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 sand equivalent test sample, the following procedure should be followed:

a. Determine the exact amount required to provide four test specimens by dipping four measuring tins full of the material and determining either the combined volume or mass. 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.

b. Carefully split or quarter the predetermined amount of material necessary to provide four test specimens.

c. Split or quarter the premeasured material to obtain a test specimen. Two successive splits will provide a specimen 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 mass at 230˚ ± 9˚F and cool to room temperature.

   a. When testing reclaimed aggregates containing traces of asphalt or asphalt concrete, the oven-drying temperature shall not exceed 100˚F.

   b. Aggregates, which are sampled immediately after being dried in an asphalt plant drier 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 shall be oven-dried 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, shall be retested in an oven-dried condition and the results of the oven-dried sample will control.

F. TEST PROCEDURE

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

   a. In a temperature-controlled work area where the room temperature remains constant within ± 5°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 ± 0.1 inches with working calcium chloride solution.

3. Pour the prepared test specimen into the plastic cylinder (see Figure 5).

   a. Use the funnel to avoid spillage.

   b. Release air bubbles and promote thorough wetting by bumping the base of the cylinder against a firm object while the test specimen is being poured into the cylinder or by tapping the 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 ± 1 min.

4. Immediately 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 soaking period, stopper the cylinder, then loosen the material from the bottom by shaking the cylinder while holding it in a partially inverted position. Shake the cylinder just enough to loosen the material. Excessive agitation may affect the test results.

b. Secure the cylinder in one of the specified shakers and agitate according to (1) or (2) below:

(1) Mechanical Shaker Method

(a) Set the timer and allow the machine to operate for 45 ± 1 s.

(2) Manual 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 (see Figure 6).

(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 cylinder from the shaker, and set it upright on the workbench.

5. Immediately irrigate the test specimen with working calcium chloride solution to flush the clay-size particles from the sand.

a. Insert the irrigator tube in the cylinder, start the flow of working calcium chloride solution, and rinse the material from the side of the cylinder as the irrigator is lowered.

b. With the 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 cylinder (see Figure 7). 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 test 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 cylinder until the fines have been flushed from all areas of the sample. Rotate the 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 inch mark in the cylinder, slowly withdraw the irrigator without shutting off the flow so that the liquid level is maintained at about 15 inches. Regulate the flow just before the irrigator is entirely withdrawn and adjust the final level to 15 inches.

6. Immediately place the cylinder on a workbench or table free of vibrations, and allow the cylinder and contents to stand undisturbed for 20 min ± 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 (see Figure 8).
b. When the clay reading falls between 0.1 inch 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 cylinder to stand undisturbed until the clear line of demarcation does form. Then immediately read and record the time and height of the column. If tap water was used, retest an untested portion of the sample using distilled or deionized water.

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. If tap water was used, retest an untested portion of the sample using distilled or deionized water.

8. Determine the "sand reading."

a. After the clay reading has been taken, gently lower the weighted foot assembly into the cylinder until it comes to rest on the sand. Do not allow the sand reading indicator to hit the mouth of the 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 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 (see Figure 8).

d. Subtract 10 inches from the observed reading. This is the sand reading.
e. When the sand reading falls between 0.1 inch graduations, record the level of the higher graduation.

G. CALCULATIONS AND REPORTING

1. Calculate the sand equivalent to the nearest 0.1 using the following formula:

SE = (Sand reading/Clay reading) x 100

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

H. PRECAUTIONS

1. Perform the test in a location free of vibrations, because vibrations may cause the suspended material to settle at a greater rate than normal.

2. Do not expose the plastic cylinders to direct sunlight any more than is necessary.

3. Occasionally a fungus growth may develop in the working calcium chloride 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.

4. 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, immediately 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.

I. SAFETY AND HEALTH

Soils and aggregates may contain bacteria and/or organisms, which can be harmful to one's health. The wearing of dust masks and protective gloves when handling materials is advised.

The use of heat resistant gloves/mitts or potholders to remove samples from the ovens is required.

When preparing stock solution, protective eyewear, an approved respirator, protective gloves, and apron shall be worn.

The requirements listed for preparing stock solution should be considered for use when mixing working solution and performing the Sand Equivalent test.

Prior to handling, testing or disposing of any materials, testers are required to read Caltrans Laboratory Safety Manual: Part A, Section 5.0, Hazards and Employee Exposure; Part B, Sections: 5.0, Safe Laboratory Practices; 6.0, Chemical Procurement Distribution and Storage; and 10.0, Personal Protective Apparel and Equipment; and Part C, Section 1.0; Safe Laboratory Practices. Users of this method do so at their own risk.

REFERENCES:
California Tests 201 and 227

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(California Test 217 contains 11 Pages)

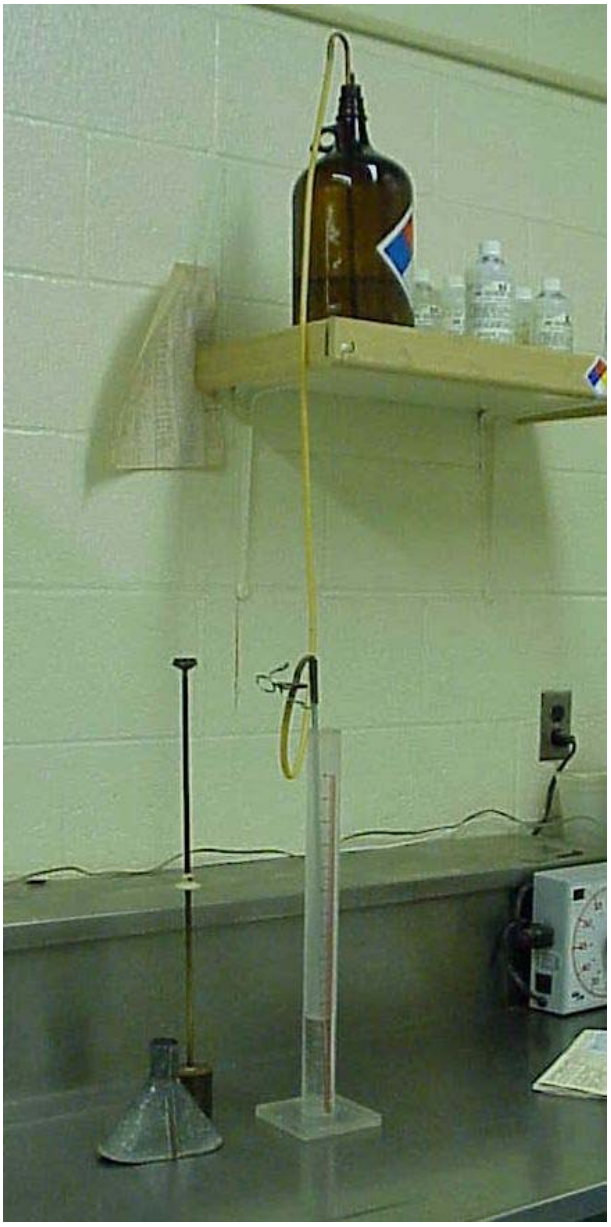

FIGURE 1

Sand Equivalent Test Apparatus
Excluding Shaker

FIGURE 2

Mechanical Sand Equivalent Shaker

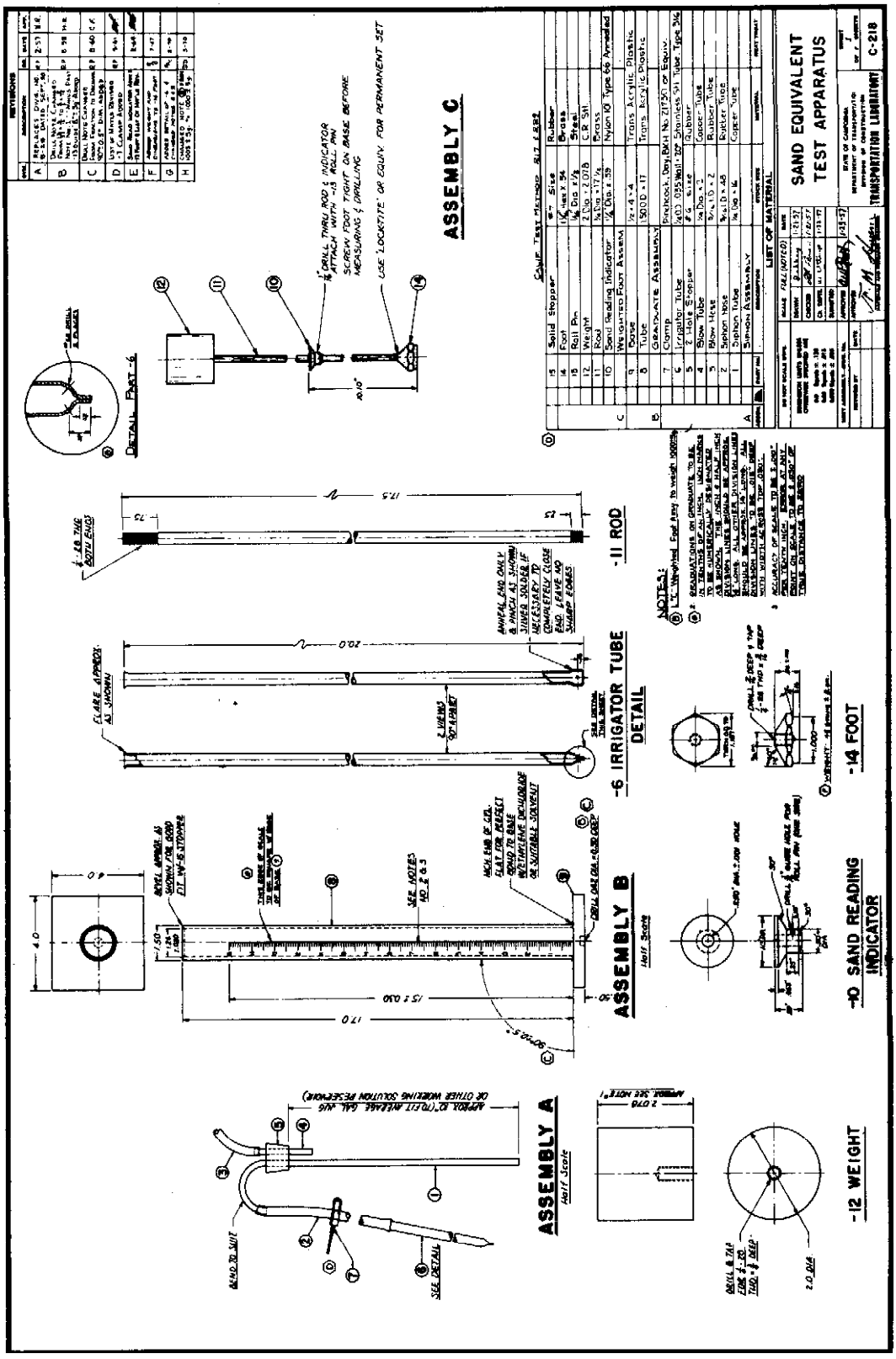
SAND EQUIVALENT TEST APPARATUS
TRANSPORTATION LABORATORY
C-218
ASSEMBLY C
DETAIL PART -6
-11 ROD
-6 IRRIGATOR TUBE DETAIL
ASSEMBLY B
Half Scale
-14 FOOT
-10 SAND READING INDICATOR
ASSEMBLY A
Half Scale
-12 WEIGHT
LIST OF MATERIAL
NOTES:

FIGURE 3

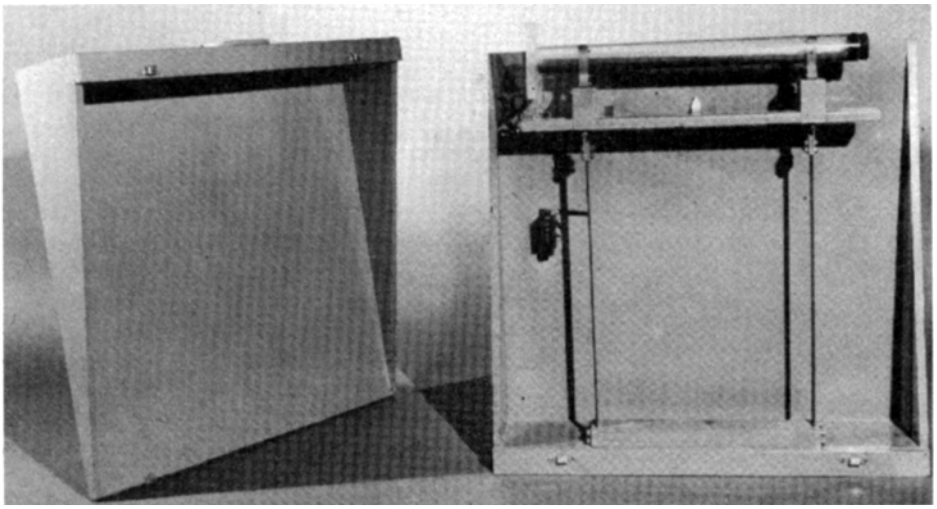

FIGURE 4

Manually Operated Sand Equivalent Shaker
(Idaho Shaker)

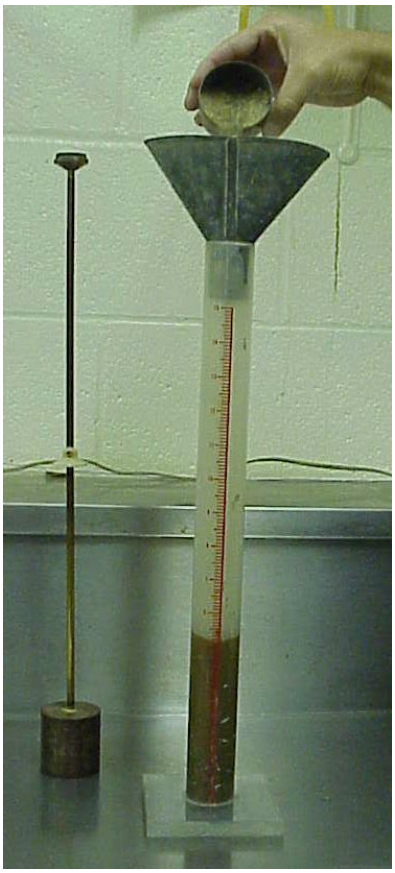

FIGURE 5

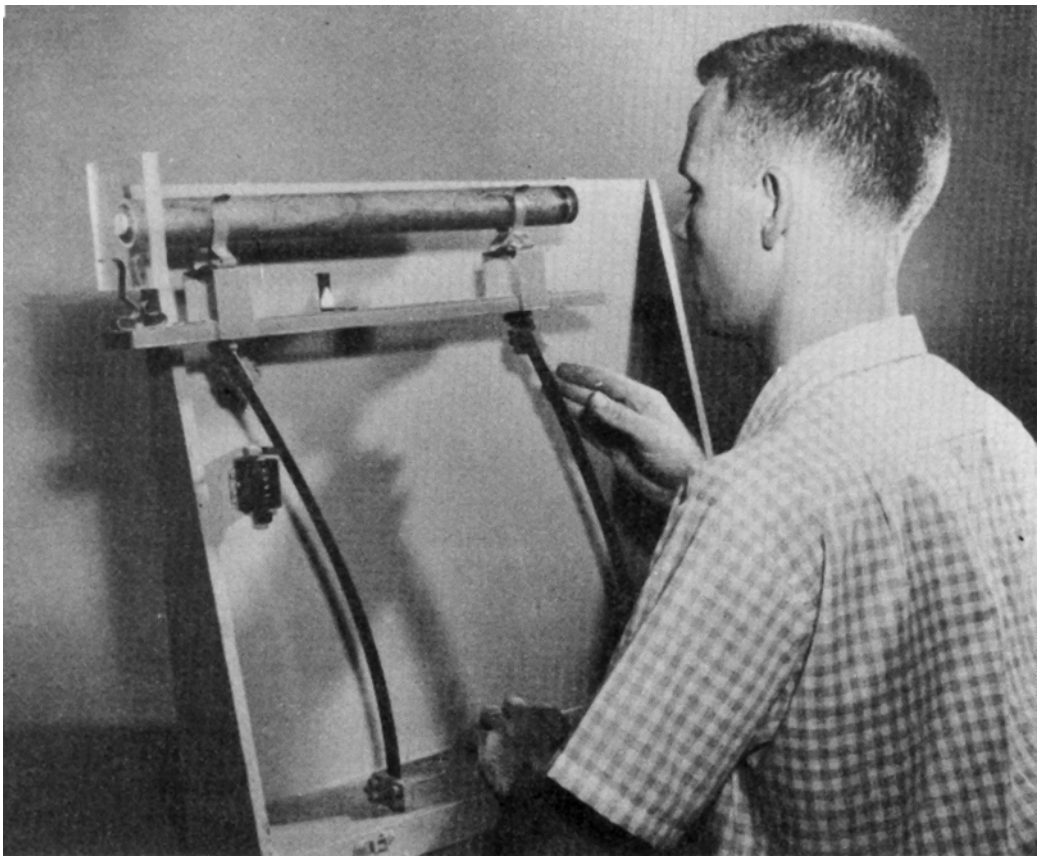

FIGURE 6

FIGURE 7

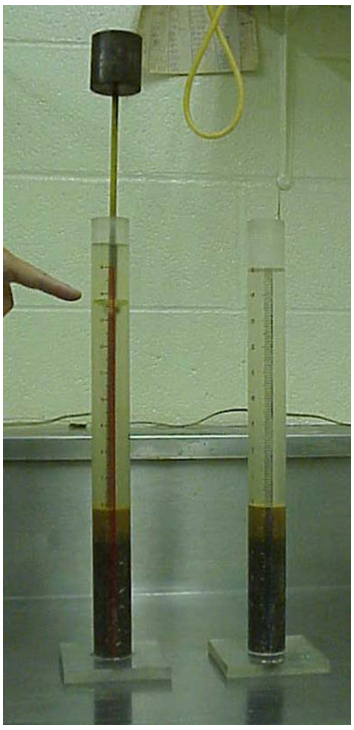

FIGURE 8