

METHOD OF TEST FOR ABRASIVE MEDIA EVALUATION

SCOPE: This test is used to determine the relative degree to which blasting abrasives breakdown during a specific blasting operation. Use is made of Test Methods No. Calif. 201-D, 202-G, 208-B, and ASTM D-422-63.

PROCEDURE

A. Apparatus

1. One abrasive blasting pot (Figure 3 and Sheet 1) Coned bottom sloping 40° from the horizontal.
1-1/4" I. D. plumbing and hose Ball valve shutoffs.
Fixed size abrasive feed orifices - 16/32" diameter to 26/32" diameter openings in 1/32" increments.
2. Air Compressor - 315 CFM
3. One blasting chamber as shown in attached Figures 1 and 2, and detailed on sheets A-1 to A-4 inclusive.
4. One CFSD-X-6 Venturi Style Nozzle.
5. Two each 50' long three-quarter inch I.D. water supply hoses.
6. Balances or scales accurate to .01 percent of the test sample weight.
7. Stop Watch.
8. Sieves - Woven wire cloth sieves of No. 4, 8, 10, 12, 16, 20, 25, 30, 40, 50, 70, 100, and 200 designations with square openings conforming to AASHTO Designation: M92.
9. Riffle Splitters - Two required, one with chutes 2 to 2-1/2 in. wide, one with chutes approximately 3/8-inch wide.
10. Sample Containers - Various sized metal containers, some of which should have the following approximate capacities: 50,000g., 30,000g., 3,500g., 300g., and 100g.
11. Sieve Shaker - Any mechanical sieve shaker may be used which produces the thoroughness of sieving required, i.e., not more than 1 percent by weight of the residue retained on any sieve after mechanical sieving is completed shall pass that sieve during one minute of continuous hand sieving as described under "Sieving Procedure" in Section E of Test Method No. Calif. 202-G.

12. Mechanical Washing Vessel - A flat-bottom, straight-sided cylindrical vessel conforming to the specifications and dimensions shown in Figure 1 of Test Method No. Calif. 202-G.
13. Agitator - An agitator providing the same action as a Tyler portable sieve shaker set to operate at 285 ± 10 complete cycles per minute with a throw of $1\frac{3}{4} \pm \frac{1}{4}$ in. The agitation period for washing the test sample specified in this method is for the Tyler portable sieve shaker. Other types of agitators may be used provided the length of time and other factors are adjusted to produce the same results as those obtained on the Tyler portable sieve shaker.
14. Oven - an oven or other suitable thermostatically controlled heating device capable of maintaining a temperature of 110 ± 1 C (230 ± 1.8 F).
15. Glass beaker - 100 and 250 ml. capacities.
16. Stirring apparatus - A mechanically operated stirring apparatus consisting of an electric motor suitable mounted to turn a vertical shaft at a speed not less than 10,000 revolutions per minute without load, a replaceable stirring paddle made of metal, plastic or hard rubber, and a dispersion cup conforming to one of those shown in ASTM D-422-63.
17. Hydrometer - The hydrometer shall be graduated to read in grams per liter of suspension at a temperature of 68 F. and shall conform to the requirements for hydrometer, Designation 152 H of ASTM D-422-63.
18. Thermometer - A floating glass thermometer, range 0 to 160 F., accurate to 1 F. (0.5 C.).
19. Sedimentation cylinder - A glass cylinder 18 in. in height and $2\frac{1}{4}$ in. in diameter marked for a volume of 1000 ml.
20. Water bath or constant temperature room - A water bath or constant temperature room - A water bath or constant temperature room for maintaining the soil suspension at a constant temperature during the hydrometer analysis. A satisfactory water bath is an insulated tank which maintains the soil suspension at a convenient constant temperature near 68 F. (20 C.) as facilities will permit. In cases where the work is performed in a room at an automatically controlled temperature, the water bath is not necessary and subsequent reference to a constant temperature bath shall be interpreted as meaning either a water bath or a constant temperature room.
21. Timer - A watch or clock with a second hand and capable of timing 24 - hr. periods.

22. Graduated cylinder of 200 ml. or 250 ml. capacity graduated in increments of two or five ml.
23. Flask - Standard LeChatelier flask conforming to the dimensions shown in Figure 1 of Test Method No. California 208-B.
24. Brush - A brush small enough to insert in the cylindrical portion of LeChatelier flask.
25. Impingment plates - 10" x 10" x 3/16" mild steel.
26. Bag filter - 30.5 sq. ft. surface area, material: nine-ounce cotton-sateen.
27. Transparent Polyethylene bags 9" x 15" with cinch ties.
28. Canvas samples sacks 9" x 18".

B. Materials

1. Distilled, demineralized or good quality tap water.
2. Dispersion Agent.
 - a. Prepare the dispersion agent by dissolving 21.6 grams of Sodium Polyphos granules ($\text{Na}_{12}\text{P}_{10}\text{O}_{31}$) in one liter of distilled water at a temperature not exceeding 100 F. It is important that the Sodium Polyphos be completely dissolved. Therefore, mix the solution until none of the undissolved granules are still visible and then allow to stand at least four hours before using.
 - b. Solutions of this salt slowly revert back to orthophosphate form with resultant decrease in dispersive action; therefore, fresh solutions should be prepared frequently. The date of preparation should be marked on the bottle containing the solution, and any solution remaining at 14 days after preparation shall be discarded.
 - c. Sodium Polyphos shall be the "ground grade" of $\text{Na}_{12}\text{P}_{10}\text{O}_{31}$ (Sodium Polyphos)
3. Kerosene (free of water).

C. Preparation of Sample

1. Split out approximately 80,000 grams of abrasive material from the sample in accordance with Test Method No. Calif. 201-D.

2. Dry this material in an oven at $120 \pm 2F$. until a constant weight is obtained.
3. Split the dry material into four representative $18,750 \text{ g} \pm 10\text{g}$ samples and two $500 \pm 50\text{g}$ samples.
4. Seal the six samples in plastic bags.

D. Initial Sample Analysis

1. Perform a separate sieve analysis, in accordance with Test Method No. Calif. 202-G, on each of the two 500 gram samples obtained in Step C-3.
2. If the results of the above sieve analysis vary by more than 4% of the total on any one sieve, recombine and resplit the 80,000 gram sample and repeat the procedure given in step D-1 of this method.

E. Blasting Cabinet Preparation

1. Review sheets A-1 to A-4 inclusive of this test method for delineation of cabinet components and nomenclature.
2. Weigh impingment plate to one-tenth of a gram.
3. Install impingment plate with the unblasted surface facing the nozzle.
4. Start water flow through compressed air cooler using valve (9) shown on sheet A-1
5. Start compressor.
6. Insure there is no moisture or dust inside the chamber by simultaneously vibrating and running compressed air through it with the hopper discharge valves (14) sheet 1 open until no dust is ejected. Turn off air flow using valve (16) at heat exchanger, sheet 1.
7. Install a polyethylene sample bag at each discharge valve (14) using doubled over no. 84 rubber bands ($1/2$ " wide x $3-1/2$ " long).
8. Slip a canvas sample sack over the plastic bag on rear discharge and leave discharge valve wide open.
9. Close front discharge valve.
10. Drain any water which has accumulated in the moisture separator using valve (17) sheet 1.

11. Close moisture separator valve (17).

F. Shooting abrasive

1. Each 18,750 gram sample is shot at one of three different feed rates. This feed rate is varied using fixed size orifices in the abrasive feed at the abrasive pot. The feed rates are approximately 15 to 25% overfeed, standard feed, and 15 to 25% underfeed (Standard feed - 600#/hr.).
2. Using initial sample grading information from section D-2 of this test method enter Table 1, and determine the size of the initial feed orifice. The physical characteristics of every abrasive effects its flow through the orifices. The initial orifice selected should yield a feed rate within the range of 450 to 750 #/hr.

TABLE 1
Initial Orifice Selection Guide

** Orifice Number	Orifice Opening Diam. Inches	* microns
13	20/32"	250-700
14	21/32"	700-1000
15	22/32"	1000-1500
16	23/32"	1500-2000

- * The value in microns which 80% of the sample is smaller than.
- ** For extremely angular or crushed particles select one size larger orifice.

3. Install the selected orifice in (21) of the sandpot.
4. Close abrasive feed valve (25) at bottom of pot.
5. Pour one of the 18,750 gram samples into the abrasive pot and replace the abrasive inlet plug.
6. Close the pressure equalization valve (34) at the pot.
7. Set choke valve (16) on pot fully open.
8. Using air valve (16) at water cooler air outlet, adjust air flow so that approximately 98 psi is obtained at the nozzle, gauge (47) (no abrasive flow condition).
9. Open the pressure equalization valve (34) on the pot.

10. Adjust air pressure to pot vibrator to 30 psi. gauge (38) using valve (34) in vibrator line.
11. Simultaneously turn on abrasive feed (25) and start the stop-watch for timing the shooting interval. Quickly adjust nozzle pressure to 100 psi gauge (47) using main air valve (16) at water condenser.
12. Adjust the front hopper discharge valve (14) so that the flow rate of the shot abrasive into the sample bag does not exceed that being fed from the abrasive pot. This is readily apparent because too great a valve opening will cause the sample bag to fully inflate with air with possible loss of fine particles.
13. Continue monitoring nozzle pressure to maintain 100 psi.
14. Stop the stop-watch upon completion of shooting the abrasive. This is readily apparent by two means:
 - a. The nozzle sound changes to a high pitched whistle.
 - b. The nozzle pressure will immediately rise to approximately 103 psi. and then immediately decline to 98 psi. and remain there.
15. Adjust the pot vibrator pressure to 80-100 psi.
16. Close and open the pot choke valve (16), three times in twenty seconds.
17. Turn off abrasive pot vibrator (34).
18. Close the pressure equalization valve (34) on the pot.
19. Close the choke valve (16) and plug (40) into (39) on the pot.
20. Start vibrators on blasting chamber and set gauge (38) at approximately 80-100 psi. Leave on until step 25 of this section.
21. Open fully the front discharge valve (14).
22. Shake air filter bag and push it back into the abrasive chamber.
23. Using your hand, vigorously shake and beat the air filter bag within the chamber for approximately thirty seconds.
24. When it appears that no further abrasive is flowing into the sample bags, vary the air pressure to the chamber vibrators using vibrator line valve (34), inducing a change in vibration rate and magnitude.

25. When no further abrasive comes out of the hoppers, turn off the chamber vibrators.
26. Remove the two sample bags from the hoppers, combine in a single sample bag and seal until ready to perform the particle analysis.
27. Remove the impingement plate and mark sample number on it.
28. Remove the feed orifice from the abrasive pot.
29. Return to Section E of this test method and repeat all steps except E-1, E-4, E-5, E-6. Then return to step 30 of this section.
30. Knowing the feed rate of the material through the previously selected orifice, select another orifice for the next desired feed rate. Normally a change of one orifice size will increase or decrease the feed rate by approximately 10 to 15 percent when shooting in the desired range.
31. Return to Step 2 of this testing Section F and repeat all steps until three samples have been shot which bracket the 600 #/hour feed rate and fall within the range of 450 to 750 #/hours. The fourth 18,750 gram sample split out in Section C-3 of this test method is available in the event a sample is shot at an incorrect rate.
32. Select the shot abrasive samples which meet the requirements of Step 31 above for particle analysis.

G. Particle Analysis

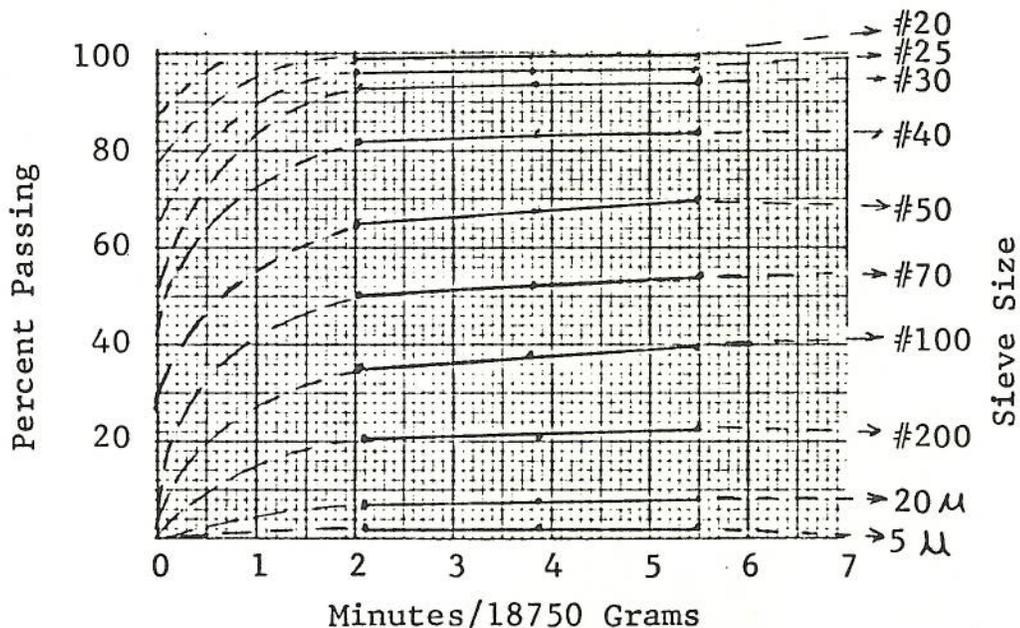
1. Determine the weight of each collected sample.
2. Using the splitters, obtain three 100 ± 5 gram samples and one 250 ± 25 gram sample from each of the three shot 18,750 gram samples.
3. Determine the apparent specific gravity of one of the 100 ± 5 gram samples obtained in G-2 above, in accordance with the procedure given in Test Method No. Calif. 208 B.
4. Using one of the 100 ± 5 grams samples split out in Step G-2, perform a mechanical analysis in accordance with ASTM (D422-63).
 - a. Hydrometer readings for those materials with a specific gravity of 2.6 to 2.7 shall be made at the following approximate times: 4, 8, 16, 30, 60, 120, and 240 minutes. Record the readings to the nearest tenth of a percent and the time of reading to the nearest tenth of a minute.

- b. Hydrometer readings for those materials with a specific gravity greater than 2.7 shall be made at the following approximate times: 3, 6, 12, 30, 60, 120, and 240 minutes. Record the same as in 4a above.
 - c. The sieve analysis should be performed using the following U.S. Standard sieve sizes: No. 4, 8, 10, 12, 16, 20, 25, 30, 40, 50, 70, 100, 200.
5. The remaining 100 ± 5 gram sample split out in step G-2 is to be retained as a back-up in the event of testing error.

H. Reporting

- 1. Plot a grain size accumulation curve for each sample using the values calculated from the hydrometer readings.
- 2. Graph percent passing curves vs shooting time for each sieve size as in Figure 4. Also graph the 20 and 5 micron readings taken from the grain size accumulation curves.

FIGURE 4. GRADATION VS. SHOOTING TIME



3. Report the gradation of the material in percent passing before shooting and also the gradation at the four minute and ten seconds shooting rate selected from the curves as in Figure 4.

I. Precautions

1. Insure that air compressor is not pumping oil, and moisture separator is working properly.
2. Observe the precautions as specified in Test Method No. Calif. 201-D, 202-G, and 208-B.
3. Prior to removing or installing new orifice, tip abrasive pot 45° to minimize the probability of dropping the orifice down the feed pipe. As an additional precaution a cloth may be placed in the feed pipe to prevent the orifice from entering same.
4. Inject WD-40 lubricant or equivalent into the vent holes of each vibrator approximately every two tests. This is done while vibrators are off.
5. Wear ear protection while operating testing unit.

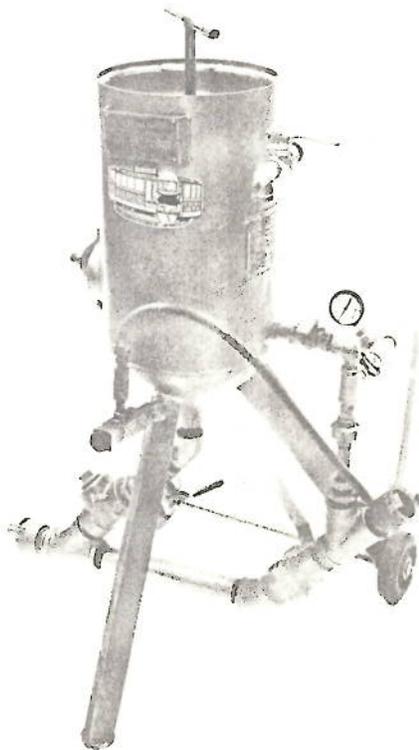


Figure 1. Abrasive Pot



Figure 2. Blasting Chamber

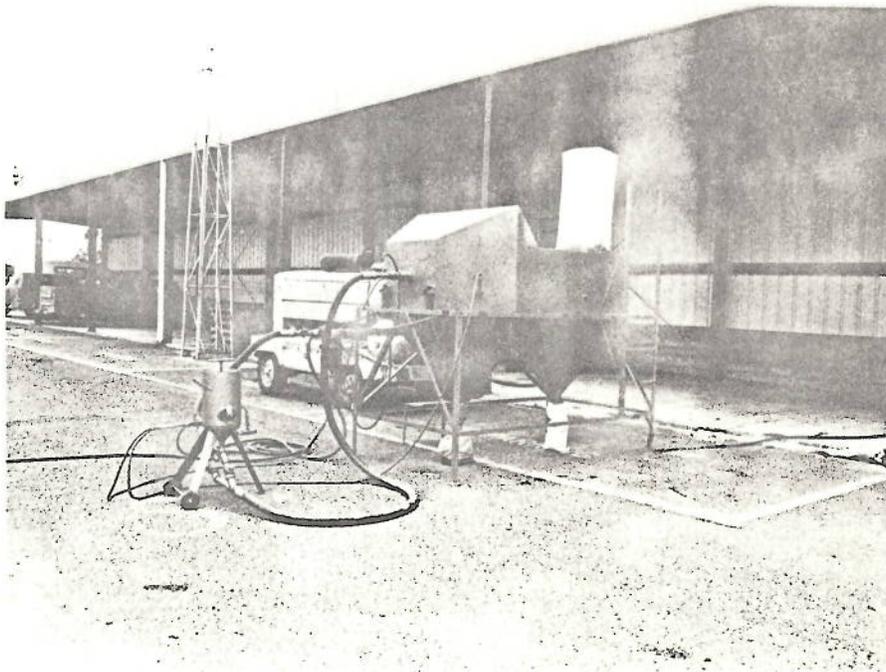
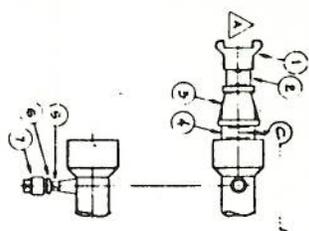


Figure 3. Blasting Chamber

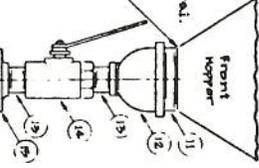
- 1) 1/2" Camco C-1 Connector
- 2) 1/2" Whipple
- 3) 6" x 1/2" Ball Backer
- 4) 1/2" Whipple
- 5) 1/2" x 1/2" Bushing
- 6) 1/2" x 1/2" Pipe Connector - Male
- 7) 1/2" x 1/2" Pipe Connector - Female
- 8) 1/2" Ball Valve
- 9) 1/2" Tee
- 10) 1/2" Tee
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- 12) 1/2" Tee
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SECTION C-C
Scale: 3" = 1'-0"



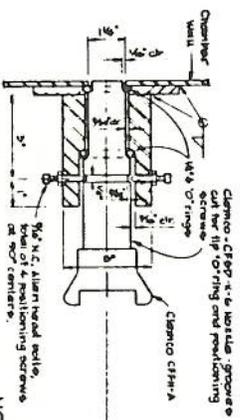
- 1) 1/2" Tee
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- 43) 1/2" Tee
- 44) 1/2" Tee
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- 46) 1/2" Tee
- 47) 1/2" Tee

Note: Hard wear for front hopper shown, hardware for rear hopper finish with inside.

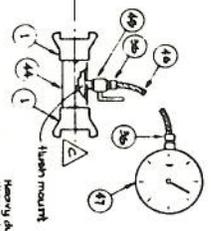


Scale: 3" = 1'-0"

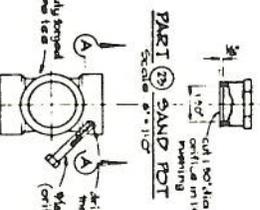
NOZZLE MOUNT
Scale: 3" = 1'-0"



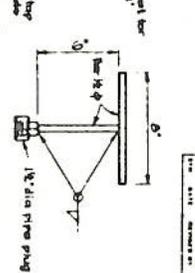
NOZZLE PRESSURE PIPE
Scale: 3" = 1'-0"



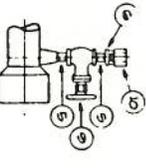
PART (2) SAND POT
Scale: 3" = 1'-0"



POT ABRASIVE PLUG
Scale: 3" = 1'-0"



SECTION B-B
Scale: 3" = 1'-0"



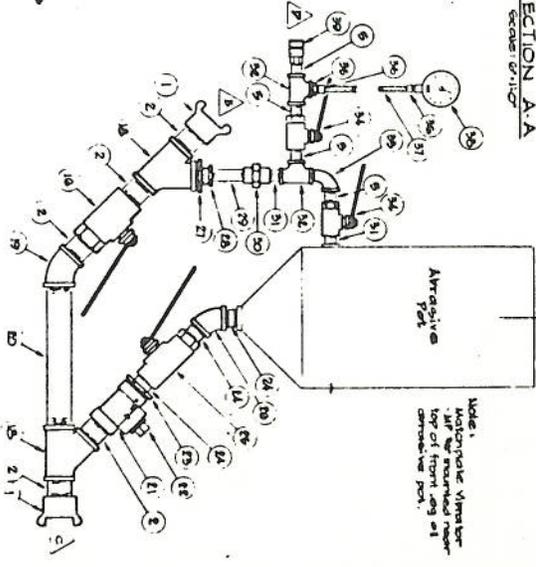
Note: Hole diameter of orifice in increments of 1/64" (1/64" to 5/64") each 1/8" thick, 11 required.



SECTION A-A
Scale: 3" = 1'-0"



Note: Abrasive vibrator shown in front view of abrasive pot.



- Note: 1/2" Tee, Blasting hose with camco CQA-3 quick couplings.
- A) 1-piece, 10' long - Compressor to Air Cooler.
 - B) 1-piece, 5' long - Air Cooler to Abrasive Pot.
 - C) 1-piece, 18' long - Abrasive Pot to Blasting Chamber.
 - D) 1-piece, 4' long - Abrasive Pot to Blasting Chamber.
 - E) 2-piece, 25' long - 1/2" to Multiple Vibrator - 1/2" on Blasting Chamber.

ITEM	DESCRIPTION	QUANTITY	REVISION
1	1/2" Tee	1	
2	1/2" Tee	1	
3	1/2" Tee	1	
4	1/2" Tee	1	
5	1/2" Tee	1	
6	1/2" Tee	1	
7	1/2" Tee	1	
8	1/2" Tee	1	
9	1/2" Tee	1	
10	1/2" Tee	1	
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45	1/2" Tee	1	
46	1/2" Tee	1	
47	1/2" Tee	1	

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California Test 201
1978

METHOD OF SOIL AND AGGREGATE SAMPLE PREPARATION

A. SCOPE

This method describes the processes for preparing untreated aggregate and disturbed soil samples, as received from the field, for the required tests. Separation by screening, weighing, removing soil coatings from coarse aggregate, breaking up clods, and splitting out representative test samples of specified size are described.

B. APPARATUS

1. Sieves. U.S. Standard Sieves conforming to AASHTO Designation: M92. The standard sieve series shall include the following sizes: 3 in. (75 mm), 2½ in. (63 mm), 2 in. (50 mm), 1½ in. (37.5 mm), 1 in. (25 mm), ¾ in. (19 mm), ½ in. (12.5 mm), ¼ in. (9.5 mm), No. 4 (4.75 mm). Other U.S. Standard sieves may be added for special purposes.

2. Sieve Shaker. Any mechanical sieve shaker which accomplishes the thoroughness of sieving specified below:

- a. Not more than 0.5 percent by weight of the total sample shall pass any sieve during 1 minute of hand sieving.
- b. Hand sieving shall be by means of a lateral and vertical motion of the sieve, accompanied by a jarring action, which keeps the sample moving continuously over the surface of the sieve. Do not turn or manipulate particles through the sieve by hand.

3. Crusher. A jaw crusher which can be adjusted to produce material passing the No. 4 sieve. A sledge hammer may be used to reduce oversize particles enough to permit the material to be fed into the crusher.

4. Quartering Canvas or Sample Splitters. If using splitters, a minimum of three riffle-type splitters of different sizes is required. Sample splitters shall have an even number of equal-width chutes, but not less than a total of eight for coarse aggregate and twelve for fine-aggregate, which discharge alternately to each side of the splitter. The minimum width of the individual chutes shall be approximately 50 percent larger than the largest particles in the sample to be split. The splitter shall be equipped with two receptacles to hold the two halves of the sample fol-

lowing splitting. It shall also be equipped with a hopper or straightedged pan which has a width equal to or slightly less than the over-all width of the assembly of chutes by which the sample may be fed at a controlled rate to the chutes. The splitter and accessory equipment shall be so designed that the sample will flow smoothly without restriction or loss of material.

5. Rock cleaning and clod breaking device. A device for removing fines from coarse aggregate particles and for breaking up clods without appreciably reducing the natural individual particle sizes. The following devices may be used on most materials:

- a. Stiff fiber brush,
- b. Mortar and rubber-covered pestle,
- c. Soil pulverizing apparatus consisting of the following:¹

- (1) Containers—Steel drums approximately 11 inches in diameter with positive seal covers. Standard six-gallon paint pails with covers having flowed-in rubber seals and lever-lock fastening devices are adequate.
- (2) Rollers—Rubber covered metal bars approximately 2 inches outside diameter and 1 to 3 inches shorter than the inside length of the container. 1½ inch diameter cold rolled steel bars 13 to 14 inches long and covered with fuel oil hose (U.S. Royal P5196 or equivalent) are satisfactory for use with the six-gallon paint pails.

The exact dimensions of the container and rollers are not critical provided adequate pulverizing can be accomplished without reducing the natural individual particle size.

- (3) Rotating Device—A motor-driven apparatus capable of rotating one or more containers at a rate of approximately 65 rpm.

6. Sample Containers. Various sized metal containers are required some of which should have the following approximate capacities: 30,000 g., 7,000 g., 3,500 g., 300 g. and 100 g.

¹ For details of this soil pulverizing apparatus see Suggested Mechanical Method for Breaking up Soil Aggregations by C. M. Johnson and J. R. Blystone, "Procedures for Testing Soils" ASTM 1958.

C. SAMPLE IDENTIFICATION

Each sample shall be given an identification number which shall be written on suitable cards or tickets. One of these cards or tickets bearing the sample identification number shall accompany each portion of the sample throughout the processing and testing of the material.

D. DRYING OF SAMPLES

1. Dry wet samples sufficiently to permit a complete separation on the No. 4 sieve and to develop a free-flowing condition in the portion passing the No. 4 sieve. Drying may be performed by any means which does not heat the aggregate in excess of 140° F. or cause degradation of the particles. The use of sunlight, ovens or forced drafts of warm air are the most common drying methods.

- a. Drying can be expedited by occasionally stirring the material during the drying process.
- b. Drying may be done at $230^{\circ} \pm 9^{\circ}$ F. when all subsequent tests require or permit drying at this temperature.

E. SEPARATING COARSE AND FINE PORTIONS ON THE NO. 4 SIEVE

1. Follow the sieving instructions in California Test 202 to separate the material on the No. 4 sieve.
2. Separation of the coarse portion into individual coarse size fractions may be done simultaneously with the separation on the No. 4 sieve if desired.
3. Remove coatings from coarse aggregate and break up clods retained on the No. 4 sieve as prescribed in Section F.
4. Combine all of the passing No. 4 sieve material accumulated from the various steps of sieving removing coatings and clod breaking.
5. Retain the passing No. 4 sieve material and each separated coarse size fraction in separate containers.

F. REMOVAL OF COATINGS FROM COARSE AGGREGATES AND BREAKING-UP OF CLODS

1. Hard clods of material with a natural grain size smaller than the No. 4 sieve must be broken-up to pass the No. 4 sieve. Coatings on coarse aggregate particles must also be removed and included with the passing No. 4 sieve material.
2. Any method which does not appreciably reduce the natural individual particle sizes may be used. Three approved methods are described below.
 - a. Mortar and rubber-covered pestle.
 - (1) Place a portion of the retained No. 4 sieve material in the mortar.
 - (2) Use a pushing and twisting motion with the pestle to apply a grinding action to the

material.

- (3) Do not pound the material in such a way as to cause fracturing of aggregate particles.
 - (4) Separate the material on the No. 4 sieve and add the passing No. 4 portion to the fine material previously separated.
 - (5) Repeat this procedure on all portions of the retained No. 4 material until the clods have been broken and the coarse particles appear to be free of coatings.
- b. Soil pulverizing apparatus.
 - (1) Place a minimum of approximately 5 pounds of the retained No. 4 sieve material in the steel drum.
 - (2) Place two or three rollers in the drum with the material and secure the dust-proof cover in place.
 - (3) Position the drum horizontally on the rotating device.
 - (4) Start the device and rotate the drum and its contents as necessary to break-up clay lumps and loosen coatings.

NOTE: When large quantities of fines are generated, the pulverizing process should be interrupted periodically to permit resieving and removal of the portion which will pass the No. 4 sieve. Because of variations in materials, operator judgment is required to determine the number of rollers and the rotation time to be used.

c. Wash method.

- (1) Place the retained No. 4 sieve portion in a suitable container and cover with water.
- (2) Soak for sufficient time to soften the lumps and coatings.
- (3) Hand wash the individual particles and disperse the lumps.
- (4) Remove the cleaned retained No. 4 sieve particles from the wash water and dry to constant weight at $230^{\circ} \pm 9^{\circ}$ F.
- (5) Evaporate the water from the residual material. Do not heat to a temperature greater than $140^{\circ} \pm 9^{\circ}$ F.

G. ADJUSTING GRADING OF SAMPLES

1. When it is necessary to adjust the grading of a sample prior to testing in order to bring the material within a specified grading, the adjustments of scalping, wasting or combining materials should be such that it can be duplicated under field conditions. See California Test 105 for information and instruction on aggregate grading adjustments.
2. When the sample submitted for preliminary tests represents aggregate which will require crush-

ing on the job, crush the oversize aggregate to such a degree that a blend made with the crushed and uncrushed portions will conform to the proposed grading specifications. Perform a coarse sieve separation (California Test 202) on the crushed portion and record the weight on the appropriate work card.

H. SECURING REPRESENTATIVE PORTIONS FOR SPECIFIED TESTS

1. Refer to the respective test methods for grading requirements and quantity of materials needed.

2. Split or quarter the sample into representative portions for the various tests. The use of a sample splitting device is preferred. However, hand quartering is acceptable if carefully performed.

a. Splitting sample with mechanical device.

- (1) Thoroughly mix the sample and spread it evenly across the pan or hopper.
- (2) Open the hopper gate or pour the material from the pan so that the material flows evenly through all of the chutes. Control the rate of discharge as necessary to maintain a continuous flow of material through the chutes.
- (3) Continue to split or combine successive portions until the desired sample size is achieved.

b. Hand quartering of samples weighing over 100 lb.

- (1) Mix and pile the sample on a quartering canvas. Shovel the material into the center to form a cone. Place each shovelful so that the material spills over the cone equally in all directions to mix the sample. Dampen samples which tend to segregate before proceeding with the following steps.
- (2) Flatten the cone with a shovel, spreading the material to a circular layer of uniform thickness.
- (3) Insert a stick or pipe beneath the canvas and under the center of the pile, then lift both ends of the stick, dividing the sample into two equal parts. Remove the stick leaving a fold of canvas between the divided portions.
- (4) Insert the stick under the center of the pile at right angles to the first division and again lift both ends of the stick, dividing the sample into four parts. In lieu of dividing by use of a stick, a shovel may be used to divide the sample into four equal parts.
- (5) Remove two diagonally opposite quarters, being careful to clean the fines from the canvas.

(6) Remix the remaining material by taking alternate shovelfuls from each remaining quarter and placing it in the center so that a cone is formed as before. Repeat the quartering process until the sample is reduced to the desired size.

c. Hand quartering of sample weighing 25 to 100 lb.

(1) Pile the sample on the canvas and mix by alternately lifting each corner of the canvas and pulling it over the sample toward the diagonally opposite corner, causing the material to be rolled. Dampen material which tends to segregate.

(2) Flatten and quarter as specified above.

d. Hand quartering of samples weighing less than 25 lb.

(1) Place the sample on a canvas or a clean sheet of heavy paper. Mix thoroughly with a trowel and form the material into a conical pile. Dampen material which tends to segregate.

(2) Flatten the cone by pressing it down with a trowel.

(3) Divide the material into quarters with the trowel and remove diagonally opposite quarters.

(4) Repeat the above process until the sample is reduced to the desired size.

e. Samples of coarse aggregates which have been separated into basic sizes using the standard coarse sieve series may be obtained by scooping the required amount from each size fraction. Do not scoop or pour out samples of passing No. 4 sieve material or samples of coarse aggregate which has not been separated into basic sizes using the standard coarse sieve series.

3. After the required test samples have been prepared, save the remainder of the submitted sample for possible future check tests.

I. PRECAUTIONS

1. If the Test for Evaluating Cleanness of Coarse Aggregate, California Test 227, is to be performed on the submitted sample, prepare this test sample from the material in an "as received" condition. Samples which have been subjected to any form of cleaning or any sieving action other than that specified in California Test 227 may not be used for determining the cleanness of the aggregate.

2. When possible, attempt to duplicate field conditions when preparing test samples. For example, do not remove coatings from A.C. bin samples when the

material is to be used in fabricating asphalt concrete test specimens.

3. Check sieves frequently for broken or distorted wires. Repair or replace defective sieves.

4. Periodically check splitters for accuracy by taking a dry sample of material which tends to segregate and dividing it into eight or more equal parts by use of the splitter. Then weigh and grade several of the parts and compare.

5. Review the test procedures for which the samples are being prepared frequently to make sure the samples are processed in accordance with these procedures.

J. HAZARDS

Dust, noise, lifting, and the operation of equipment are encountered in sample preparation. It is

not possible to completely eliminate these hazards, but steps should be taken to minimize them as much as possible.

The use of dust collection units and the spraying of work room floors with dust palliatives are very effective methods of reducing dust conditions.

Enclosures built around noisy equipment can eliminate much of the noise. The use of sound deadening material should be utilized when appropriate.

Guards or shields should be provided around dangerously exposed moving parts of machinery. Also, personnel should be instructed in the proper operation of each machine and in proper lifting methods. The use of table-height carts to move materials can eliminate much of the lifting.

REFERENCES

AASHTO Designation: M92
California Test 105, 202, and 227
End of Text (4 pgs) on Calif 201

DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
 Office of Transportation Laboratory
 P. O. Box 19128
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California Test 202
 July 1, 1982

METHOD OF TESTS FOR SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES

A. SCOPE

1. This method, which includes modifications of AASHTO Designations: T11, T27, T30 and T37, specifies the procedures for determining the particle-size distribution of fine and coarse aggregates.

2. Special procedures for testing aggregate from extracted bituminous mixtures, supplemental fine aggregate, glass spheres, and granular quicklime are included in Appendices A, B, C and D, respectively. A procedure for expediting testing and providing an approximate particle-size distribution for processed fine aggregate is included in Appendix E.

B. APPARATUS

1. Balance: A balance or scale reading to 1 gram for samples weighing less than approximately 1000 grams. For samples weighing more than 1000 grams the balance or scale should read to 0.2 percent of the test sample's weight.

2. Sieves: Woven-wire cloth sieves of 3-in., 2½-in., 2-in., 1½-in., 1-in., ¾-in., ½-in., ¼-in., No. 4, No. 8, No. 16, No. 30, No. 50, No. 100, No. 200 designations with square openings conforming to AASHTO Designation: M92.

a. Each sieve shall be inspected visually for bent or distorted wires after each use. Repairs shall be made when the need becomes apparent.

3. Sieve Shaker: Any mechanical sieve-shaking device which accomplishes the same thoroughness of sieving as the hand-sieving procedure described in E.1.a of this method.

a. Refer to Section E.1.b of this method for procedures to verify shaker efficiency.

b. It is essential that the sieve shaker be designed so that its motion includes a bumping or bouncing action sufficient to keep the aggregate particles in motion on the surface of the sieves. The combination sieve shaker-agitator, available through the office of Business Management, is capable of meeting these requirements for fine-sieve analysis when in the sieving mode.

4. Mechanical Washing Vessel: A flat-bottom straight-sided cylindrical vessel conforming to the specifications and dimensions shown in Figure 1.

5. Agitator (figure 2): A mechanical device designed to hold the wash vessel in an upright position while subjecting it to a reciprocating motion at a rate of 285 ± 10 complete cycles per minute. The reciprocating motion shall be produced by means of an eccentric located in the base of the carrier, and the length of the stroke shall be $1.75 \pm .250$ inches. The combination sieve shaker-agitator, available through the Office of Business Management, meets these requirements. Other types of agitators may be used provided the length of time and other factors are adjusted to produce the same results as those obtained using the agitator described above.

6. An oven or other suitable thermostatically controlled heating device capable of maintaining a temperature of $230^\circ \pm 9^\circ\text{F}$ ($110^\circ \pm 5^\circ\text{C}$).

C. MATERIALS

Distilled, demineralized or good-quality tap water shall be used for washing the fine-aggregate test sample.

D. SIZE OF SAMPLE

1. The sample to be tested shall be of sufficient size to assure representation of the material. The exact amount of material required will vary according to the nominal size of the aggregate and the particle-size distribution.

2. Recommended sample weights for processed aggregates, such as sized aggregates for PCC and AC, or composite aggregates such as AB and CTB which are comprised of approximately 40% or more of aggregate retained on the No. 4 sieve, are listed in Table 1.

Table 1

Maximum Nominal Aggregate Size	Recommended Weight of Portion Retained No. 4 Sieve
Over 2½ inches	30,000 grams
2½ inches	25,000 grams
2 inches	20,000 grams
1½ inches	15,000 grams
1 inches	10,000 grams
¾ inches	5,000 grams
½ inches	2,500 grams
¼ inches	1,000 grams

3. Sample size, for materials not adaptable to the recommendations in paragraph 2, should be suffi-

cient to yield the amounts noted below for each coarse-size fraction which makes up 5 percent or more of the total sample.

- a. At least 1000 grams of coarse-size fractions equal to or larger than $\frac{3}{4}$ inch.
 - b. At least 500 grams of coarse-size fractions smaller than $\frac{3}{4}$ inch.
4. Samples containing more than 15 percent passing the No. 4 sieve shall be of sufficient size to yield at least 1000 grams of material passing the No. 4 sieve.

E. SIEVING PROCEDURE

1. Separate the test sample into a series of sizes using such sieves as are necessary to determine compliance with the specifications for the material being tested. Either the hand- or mechanical-sieving method may be used.

- a. Perform the hand method of sieving by means of a lateral and vertical motion of the sieve, accompanied by a jarring action, so as to keep the sample moving continuously over the surface of the sieve. Do not turn or manipulate particles through the sieve by hand. Continue sieving until not more than 0.5 percent by weight of the total sample will pass any sieve during one additional minute of hand sieving.
- b. Mechanical sieving may be used only after it has been demonstrated that the shaker will separate a test sample with the same effectiveness as the hand method.

The effectiveness of the mechanical shaker and the minimum shaking time shall be determined for each shaker by comparison with the hand-sieving method using the procedure described below.

- (1) Obtain a test sample of all-crushed, clean, durable aggregate with a relatively uniform size distribution over the range of sieves to be included.
- (2) Determine the total weight of the test sample and the tare weight of each sieve.
- (3) Separate the sample into its various sieve sizes using the mechanical shaker operated for a trial period.
- (4) At the end of the trial period, determine the amount of material retained on each sieve by weighing the sieves and retained material and subtracting the weight of the sieve.
- (5) Reassemble the sieves in the mechanical shaker, and shake for an additional period of time of not less than 1 minute.
- (6) Determine the amount of material on each sieve as in Step (4).

- (7) Repeat steps (4) through (6) until not more than 0.5 percent by weight of the total sample passes through any of the sieves during the additional shaking time.
 - (8) Sieve each size fraction for one additional minute using the hand-sieving procedure.
 - (9) If more than 0.5 percent by weight of the total sample passes through any sieve during the hand sieving, the mechanical shaker is not performing effectively, and it shall not be used.
 - (10) The required shaking time for the shaker shall be at least 125% of the minimum time required to accomplish the thoroughness of sieving described above. In no case shall the shaking time for any shaker be less than 5 minutes.
- c. When sieving, limit the amount of material retained on the No. 4 and coarser sieves to a single layer of aggregate. If necessary, sieve the test sample in portions; then combine all respective portions retained on the sieves before weighing.
 - d. In no case, when sieving fine aggregate (material passing the No. 4 sieve), shall the material retained on any sieve at the completion of the sieving operation exceed that weight specified in Table 2. To reduce the amount of material retained on a sieve, either use a sieve with openings slightly larger than the overloaded sieve, or split the entire sample into smaller portions prior to sieving, and then combine respective fractions prior to weighing.

TABLE 2
MAXIMUM WEIGHT IN GRAMS OF MATERIAL
ALLOWED ON SIEVE * AT COMPLETION
OF SIEVING OPERATION

Sieve size	Wt. per sq. in.	Total weight for 8" diameter sieve
8	4.0	200
16	3.0	150
30	2.5	125
50	2.0	100
100	1.5	75
200	1.0	50

* For intermediate sieve sizes not listed in this table, the weight specified for the next smaller sieve size shall apply.

F. DETERMINATION OF COARSE-AGGREGATE PARTICLE-SIZE DISTRIBUTION

1. Prepare all materials as prescribed in California Test No. 201. Be sure to clean all coatings from the coarse aggregate and break clods sufficiently to pass the No. 4 sieve.
2. If the coarse-aggregate particles contained in a sample are clean or are coated lightly with fines

which can be removed easily by sieving, it will not be necessary to subject the coarse portion to a cleaning process prior to performing the coarse-sieve separation.

3. Separate the sample on the following sieves: 3-in., 2½-in., 2-in., 1½-in., 1-in., ¾-in., ⅝-in., and No. 4. Other sieves may be added as required to determine compliance with specifications or to reduce the amount of material retained on certain sieves. It is permissible to include the No. 8 sieve with the coarse-sieve separation when it is not necessary to determine the distribution of material finer than the No. 8 sieve.

4. Place each coarse-size fraction in a separate container.

a. When a sample has been divided into two or more portions to facilitate sieving, recombine all portions of the same size.

b. Combine all portions of the material passing the No. 4 sieve obtained from the sample-preparation and sieving phases.

5. Determine the total weight of material retained on each coarse sieve and the total amount of fine material passing the No. 4 sieve. The total weight retained on a given sieve is the sum of the material retained on the sieve plus the material retained on all larger sieves.

a. Accumulate the weight of material retained on each successive sieve beginning with the coarsest size.

b. When it is not necessary to keep the aggregate's size fractions separated, the sized portions may be combined in succession, and the accumulated weights may be determined directly.

G. DETERMINATION OF THE FINE-AGGREGATE PARTICLE-SIZE DISTRIBUTION

1. Split or quarter a fine-aggregate test sample weighing 500 ± 25 grams from the material passing the No. 4 sieve.

a. If there is insufficient material passing the No. 4 sieve to obtain the required 500 ± 25 grams, use all of the material passing the No. 4 sieve for the fine-aggregate test sample.

b. If less than 10 percent of the submitted sample is retained on the No. 30 sieve, it is permissible to reduce the fine-aggregate test sample's weight to approximately 125 grams. Obtain this smaller test sample by carefully splitting the prepared 500-gram portion into four quarters. Do not make any adjustments for weight during this splitting operation.

2. Oven-dry the fine-aggregate test sample to constant weight at a temperature of $230 \pm 9^\circ\text{F}$, and then cool it to room temperature. Weigh and record the weight of oven-dried material as the test sample's weight.

a. Oven-drying the test sample prior to washing may be eliminated provided the moisture content is determined by drying a duplicate sample and the weight is corrected to establish the dry weight of the test sample.

b. When testing reclaimed aggregates containing traces of asphalt or asphalt concrete, the oven-drying temperature shall not exceed 100°F (38°C).

3. Place the fine-aggregate test sample in the mechanical washing vessel, add 1000 ± 5 ml. of water, and clamp the lid in place. Secure the vessel in the mechanical agitator. After ten minutes ± 30 seconds have elapsed from the introduction of the wash water, agitate the vessel and contents for two minutes ± 5 seconds.

4. Following agitation, remove the vessel from the shaker, unclamp the lid, and pour the contents into a No. 200 sieve. Rinse any remaining fines from the vessel into the sieve. Direct water from a flexible hose attached to a faucet onto the sample until the water passing through the sieve comes out clear. It may be necessary to flood clayey or silty samples while it is still in the vessel to prevent clogging the No. 200 sieve. Repeated flooding may be necessary before all of the contents can be poured from the vessel into the sieve.

5. After rinsing, wash the material from the sieve into a drying pan; then place the drying pan in a slanting position until the free water that drains to the lower edge is clear. Pour this water off taking care not to lose any material from the test sample.

6. Oven-dry the washed test sample to constant weight at a temperature of $230 \pm 9^\circ\text{F}$ and cool it to room temperature. Spreading the sample as thin as possible in large, shallow drying pans will decrease the drying time.

a. When testing reclaimed aggregate containing traces of asphalt concrete the oven-drying temperature shall not exceed 100°F (38°C).

7. Separate the sample on the Nos. 8, 16, 30, 50, 100 and 200 sieves. Other sieves may be added as required to determine compliance with specifications or to reduce the amount of material retained on certain sieves.

8. Determine, and record, the weights of material retained on each sieve. The following procedure normally is used for the fine-aggregate test sample.

- a. Weigh the material retained on the coarsest sieve, and record this weight on the appropriate work card. Do not remove the material from the scale or balance.
- b. Add the material retained on the next finer sieve, and record this weight on the appropriate work card. Do not remove the material from the scale or balance.
- c. Continue accumulating weights until the material in the sieve pan is weighed.

H. CALCULATIONS

1. Convert weights to percentages as follows:
 - a. Compute the percentage of material retained on each sieve by the following formula:

$$R = 100W_c/W_t$$

Where: R = Percentage of test sample retained on the sieve.

W_c = Cumulative weight of material retained on the sieve.

W_t = Oven dried weight of test sample prior to washing.

- b. Compute the percentage of material passing each sieve as follows:

$$P = 100 - R$$

Where: P = Percentage of test sample passing the sieve.

R = Percentage of test sample retained on the sieve.

2. If a composite or sized sample has been separated into two or more aggregate size fractions for testing, compute the grading of the entire sample by the following method:

- a. Compute the percentage, by weight, represented by each aggregate-size fraction based on the total weight of sample as received.

Example:

Fraction	Aggregate size		Weight in grams	Percent of total sample
	Pass	Retained		
A.....	1"	No. 4	6,600	68%
B.....	No. 4	0	3,400	34%
Total Sample.....	1"	0	10,000	100%

- b. Then, take each aggregate size in turn, and multiply the percent passing each sieve, as determined by the sieve analysis on the test sample, by the percentage of that aggregate size found to be present in the "as-received" sample.

Example:

Sieve size	Grading of aggregate size fraction "A"		Products of items 1 and 2
	1	2	
1".....	100	66%	66
3/4".....	94	66%	62
3/8".....	24	66%	16
No. 4.....	3	66%	2
8.....	3	66%	2
16.....	3	66%	2
30.....	2	56%	1
50.....	2	66%	1
100.....	1	66%	1
200.....	0	66%	0

- c. Add the products thus obtained on corresponding sieve sizes as shown in the following example. These sums, as shown in the last column of the example, constitute the "as received" grading of the original sample.

Example:

Sieve size	Grading of aggregate size fractions		66%A 34%B	"As received" grading of original sample A + B percent passing
	A	B		
	1" x No. 4 % Passing	No. 4 x 0 % Passing		
1".....	100	100	66 + 34 =	100
3/4".....	94	100	62 + 34 =	96
3/8".....	24	100	16 + 34 =	50
No. 4.....	3	100	2 + 34 =	36
8.....	3	70	2 + 24 =	26
16.....	3	56	2 + 19 =	21
30.....	2	41	1 + 14 =	15
50.....	2	27	1 + 9 =	10
100.....	1	17	1 + 6 =	7
200.....	0	8	0 + 3 =	3

I. PRECAUTIONS

1. Proper care of the sieves is necessary for accurate sieving. Use the following procedure in removing particles stuck in the mesh of the fine sieves:
 - a. No. 4 and No. 8 sieves. Clean by brushing with a brass wire brush. A rounded piece of wood, such as a brush handle, can be used if one hand is placed on the opposite side when pushing against the sieve in order to avoid stretching the sieve out of shape.
 - b. No. 16, No. 30, and No. 50 sieves. Clean by brushing with a brass wire brush.
 - c. No. 100 sieves. Clean by brushing with a stiff, short bristle brush such as a stencil brush.
 - d. No. 200 sieves. Clean only by brushing with a small paint brush. These sieves are damaged easily.
 - e. Do not use a sharp object to push out particles which are stuck in the mesh of the sieves because this will result in enlarging the openings.
2. Examine sieves each day for broken wires, and solder any breaks. Discard any sieve that develops a

break in the main body of the screen. Soldering decreases effective sieving area; therefore, sieves with large breaks or several small breaks should be discarded.

3. Check all sieves from No. 4 through No. 200 biannually with a standard sample of known grading made up from hard, clean aggregate that does not degrade from the sieve-shaking procedure. This is especially useful for checking Nos. 100 and 200 sieves, as small breaks and distortions are missed easily in these fine-mesh sieves.

4. Never sieve hot samples, as hot aggregate will distort the fine meshes of the Nos. 100 and 200 sieves.

5. Take care to avoid loss of material during transfer of sample from wash pot to sieves and also during rinsing.

6. Always run the sieve shaker for the time specified in the mechanical-agitation washing procedure. Aggregate will not be cleaned properly in less than the specified time, and particle-breakdown will result from excessive agitation.

J. REPORTING OF RESULTS

Report the total percentage passing each sieve to the nearest whole number. Calculate percentage on the basis of the oven-dry weight of the test sample prior to washing and/or sieving.

REFERENCES

California Test 201

AASHTO DESIGNATION: M92, T11, T27, T30, T37

End of Text (9 pgs) on Calif. 202

APPENDIX A

SIEVE ANALYSIS OF AGGREGATE FROM EXTRACTED BITUMINOUS MIXTURES

A. SCOPE

This appendix specifies modifications which must be made to the basic California Test 202 when determining the particle-size distribution of aggregate from extracted bituminous mixtures.

B. APPARATUS

Use the apparatus described in the basic test method.

C. MATERIALS

Use a solution consisting of 125 ml denatured alcohol and 875 ml of distilled, demineralized, or good-quality, tap water for washing the test sample.

D. PROCEDURE

1. The sample to be tested by sieve analysis shall be the entire aggregate sample recovered from the asphalt extraction test (California Test 310 or 362).

2. Weigh the oven-dried test sample, and record this weight as the test sample's weight.

3. Place the test sample in the mechanical washing vessel, add the 1000 ml of prepared washing solution, and clamp the lid in place. Secure the vessel in the mechanical agitator. After one minute \pm 10 seconds has elapsed from the introduction of the washing solution, agitate the vessel and contents for two minutes \pm 5 seconds.

4. Following agitation, remove the vessel from the shaker, unclamp the lid, and pour the contents into Nos. 8 and 200 sieves nested together with the No. 8 sieve on top. Rinse any remaining fines from the vessel into the sieves. Direct water from a flexible hose attached to a faucet onto the aggregate until the water passing through the sieves comes out clear.

5. After rinsing, wash the material from the sieves into a drying pan; then place the drying pan in a slanting position until the free water that drains to the lower edge is clear. Pour this water off taking care not to lose any material from the test sample.

6. Oven-dry the washed test sample to constant weight at a temperature of $230^{\circ} \pm 9^{\circ}\text{F}$, and cool it to room temperature. Spreading the material as thin as possible in large, shallow drying pans will decrease the drying time.

7. Perform the sieving, and determine the weight retained on each sieve as prescribed in the basic test method.

E. CALCULATIONS

Determine the grading of the test sample as prescribed in the basic test method.

F. PRECAUTIONS

Observe the precautions listed in the basic test method.

G. REPORTING OF RESULTS

Report as prescribed in the basic test method.

APPENDIX B

SIEVE ANALYSIS OF SUPPLEMENTAL FINE AGGREGATE FOR ASPHALT CONCRETE

A. SCOPE

This appendix specifies modifications which must be made to the basic California Test 202 when determining the particle-size distribution of supplemental fine aggregate.

B. APPARATUS

Use the apparatus described in the basic test method.

C. MATERIALS

Use distilled, demineralized, or good-quality tap water for washing the test sample.

D. PROCEDURE

1. The total weight of material for testing shall be

not less than 500 grams.

2. From the submitted sample, split or quarter a portion weighing 500 ± 25 grams. Without further adjustments for weight, split or quarter the portion in two operations to obtain a test sample weighing approximately 125 grams.

3. Oven-dry the test sample to constant weight at a temperature of $230^{\circ} \pm 9^{\circ}\text{F}$, and cool it to room temperature. Weigh, and record the weight of oven-dried material as the test sample's weight.

4. Place the test sample on the No. 200 sieve, and direct water from a flexible hose attached to a faucet onto the sample until the water passing through the sieve comes out clear.

5. After rinsing, wash the material from the sieve into a drying pan; then place the drying pan in a slanting position until the free water that drains to the lower edge is clear. Pour this water off taking

care not to lose any material from the test sample.

6. Oven-dry the washed test sample to constant weight at a temperature of $230^{\circ} \pm 9^{\circ}\text{F}$, and cool it to room temperature.

7. Perform the sieving using the Nos. 30 and 200 sieves, and determine the weight retained on each sieve as prescribed in the basic test method.

E. CALCULATIONS

1. Determine the sieve analysis as prescribed in

the basic test method.

F. PRECAUTIONS

Observe the precautions listed in the basic test method.

G. REPORTING OF RESULTS

Report the total percentages passing the Nos. 30 and 200 sieves to the nearest whole number.

APPENDIX C

SIEVE ANALYSIS OF GLASS SPHERES

A. SCOPE

This appendix specifies the modifications which must be made to the basic California Test 202 when determining the particle-size distribution of glass spheres (beads) for reflectorizing paint markings on pavements.

B. APPARATUS

Use the apparatus described in the basic test method except that the balance shall read to 0.1 gram.

C. MATERIALS

No special materials are required for this test.

D. SIZE OF SAMPLE

1. Initial samples supplied by the prospective vendor shall weigh approximately 5 pounds.
2. When testing to determine acceptance of shipment, one test sample shall be obtained from each 50-pound container submitted for testing.

E. PROCEDURE

1. Carefully split or quarter a portion of the glass spheres weighing 400 ± 20 grams. Without further adjustments for weight, split or quarter the portion in three operations to obtain a test sample weighing approximately 50 grams.

2. Oven-dry the test sample to constant weight at a temperature of $230^{\circ} \pm 9^{\circ}\text{F}$, and cool it to room temperature. Weigh, and record the weight of oven-dried material as the test weight.

- a. Do not wash glass spheres.

3. Perform the sieving as prescribed in the basic test method.

F. CALCULATIONS

Determine the grading of the test sample as prescribed in the basic test method.

G. PRECAUTIONS

Observe the precautions listed in the basic test method.

H. REPORTING OF RESULTS

Report as prescribed in the basic test method.

APPENDIX D

SIEVE ANALYSIS OF GRANULAR QUICKLIME

A. SCOPE

This appendix specifies modifications which must be made to the basic California Test 202 when determining the particle-size distribution of granular quicklime.

B. APPARATUS

1. Use the apparatus described in the basic test method.
2. An immediate supply of tap water for emer-

gency washing of eyes or skin.

C. MATERIALS

No special materials are required for this test.

D. SIZE OF SAMPLE

The total weight of quicklime submitted for testing shall be not less than 2000 grams.

E. PROCEDURE

1. Carefully split or quarter a portion of the granular quicklime weighing 2000 ± 100 grams. Without

further adjustment for weight, split or quarter the portion in three operations to obtain a test sample weighing approximately 250 grams.

2. Weigh, and record the weight of the test sample.

a. Test the granular quicklime in its "as-received" condition. Do not wash or oven-dry.

3. Perform the sieving, and determine the weight retained on each sieve as prescribed in the basic test method and the following instructions.

a. Use the sieves necessary to determine compliance with the specifications and additional intermediate sieves as needed to prevent overloading.

b. Sieving shall be accomplished by the mechanical-sieving method. The sieving time shall be 10 minutes \pm 30 seconds.

c. Take care that the quicklime particles are not crushed or abraded by excessive handling.

F. CALCULATIONS

Determine the grading of the test sample as prescribed in the basic test method.

G. PRECAUTIONS

Observe the precautions listed in the basic test method and these special precautions.

a. A heat-producing chemical reaction occurs as water combines with quicklime. Burns can result from allowing quicklime to contact the body when it is wet from perspiration or other moisture.

b. If quicklime gets into the eyes, rinse them immediately with a heavy flow of water, and seek medical assistance.

H. REPORTING

Report as prescribed in the basic test method.

APPENDIX E

APPROXIMATE SIEVE ANALYSIS OF PROCESSED FINE AGGREGATE

A. SCOPE

This appendix provides a procedure for expediting testing and determining an approximate particle-size distribution for processed fine aggregates. Washing the test sample is not required; however, the test results must be correlated with tests done according to the basic California Test 202.

B. APPARATUS

Use the apparatus described in the basic test method.

C. MATERIALS

Use the materials described in the basic test method.

D. PROCEDURE

1. Split or quarter a fine-aggregate test sample weighing 500 ± 25 grams from the material passing the No. 4 sieve.

2. Aggregate sampled from a hot bin need not be dried further. Dry aggregate obtained from any other location in a 230°F (110°C) for 15 minutes or in a microwave oven for 5 minutes.

3. Weigh, and record the weight of the test sample.

4. Separate the sample on the Nos. 8, 16, 30, 50, 100

and 200 sieves. Other sieves may be added as required to determine compliance with specifications or to reduce the amount of material retained on certain sieves.

5. Determine, and record the cumulative weight of material retained on each sieve.

a. Weigh the material retained on the coarsest sieve, and record this weight on the appropriate work sheet. Do not remove the material from the balance.

b. Add the material retained on the next finer sieve, and record this weight on the appropriate work sheet. Do not remove the material from the balance.

c. Continue accumulating weights until the material in the pan is weighed.

6. Save the entire test sample.

7. Calculate the percentage of material passing each sieve by following the procedures in Section H of the basic test and using the weight recorded in step 3 above as the total weight of the sample.

8. Retest selected samples for sieve analysis according to the procedure in the basic California Test 202.

a. A sufficient number of samples shall be retested to establish the correlation between the washed and unwashed test samples.

b. Additional retests should be performed whenever there is an indication that the previous correlation is no longer valid.

c. Any material subject to rejection because of excessive material retained on any sieve, by the approximate method, shall be retested.

E. CALCULATIONS

1. Establish a correction factor for each sieve size by dividing the percent passing the sieve after washing by the percent passing the sieve before the sample was washed.

Example:

Sieve Size	Wash Grading % Pass	Unwashed Grading % Pass	% By Wash Without Wash	= Correction Factor
4	100	100	$\frac{100}{100}$	= 1.00
8	71	67	$\frac{71}{67}$	= 1.06
16	56	50	$\frac{56}{50}$	= 1.12
30	25	18	$\frac{25}{18}$	= 1.39
50	10	6	$\frac{10}{6}$	= 1.67
100	5	3	$\frac{5}{3}$	= 1.67
200	3	2	$\frac{3}{2}$	= 1.50

2. Determine the approximate washed sieve analyses of subsequent unwashed samples by multiplying

the percent passing, as determined by the unwashed sample, by the correction factor for each respective sieve.

F. PRECAUTIONS

1. Observe the precautions listed in the basic test method.
2. If the source of material changes, new correction factors shall be established.

G. REPORTING OF RESULTS

Report the total percentages passing each sieve to the nearest whole number. Identify the reported results as being "approximate".

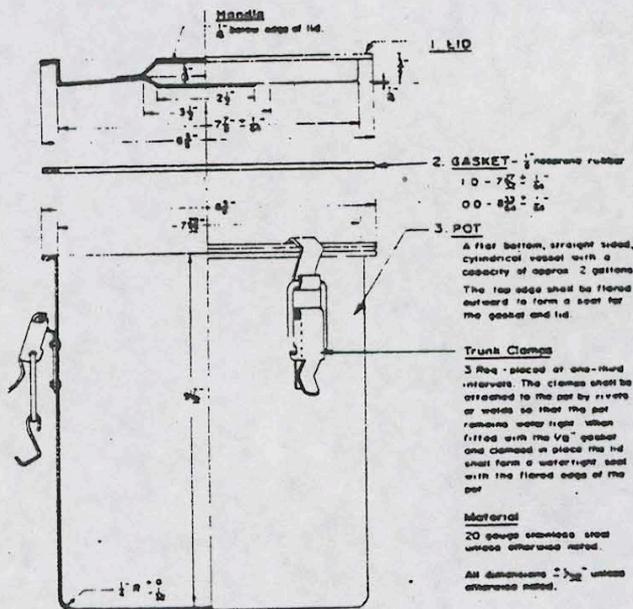


FIGURE 1
MECHANICAL WASHING VESSEL

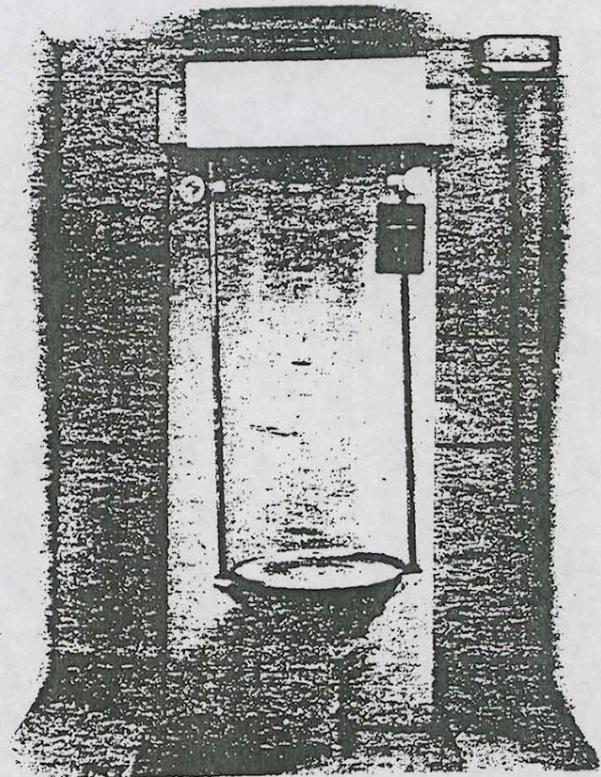


FIGURE 2
STANDARD MECHANICAL AGITATOR

DEPARTMENT OF TRANSPORTATION**DIVISION OF CONSTRUCTION**

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California Test 203

1978

METHOD OF TEST FOR MECHANICAL ANALYSIS OF SOIL**A. SCOPE**

This method, which is a modification of ASSHTO Designation: T88, describes a procedure for the quantitative determination of the distribution of particle sizes in soils.

B. APPARATUS

The apparatus shall consist of the following:

1. Glass beakers: Two sizes, 100 and 250 ml. capacities.
2. Sieves: U.S. Standard Sieve Nos. 4, 8, 10, 16, 30, 50, 100, and 200 conforming to AASHTO Designation: M92 for woven wire cloth sieves.
3. Riffle splitter, with $\frac{3}{8}$ in. width chutes.
4. Balance: A balance sensitive to 0.1 gram.
5. Stirring apparatus: A mechanically operated stirring apparatus consisting of an electric motor suitably mounted to turn a vertical shaft at a speed not less than 10,000 revolutions per minute without load, a replaceable stirring paddle made of metal, plastic or hard rubber, and a dispersion cup conforming to one of those shown in AASHTO Designation: T88.
6. Hydrometer: The hydrometer shall be graduated to read in grams per liter of suspension at a temperature of 68°F. and shall conform to the requirements for hydrometer designation 152 H of AASHTO Designation: T88.
7. Thermometer: A floating glass thermometer, range 0° to 160°F., accurate to 1°F. (0.5°C.).
8. Sedimentation cylinder: A glass cylinder 18 inches in height and 2½ inches in diameter and marked for a volume of 1000 ml.
9. Water bath or constant temperature room: A water bath or constant temperature room for maintaining the soil suspension at a constant temperature during the hydrometer analysis. A satisfactory water bath is an insulated tank which maintains the soil suspension at a convenient constant temperature as near 68°F. (20°C.) as facilities will permit. In cases where the work is performed in a room at an automatically controlled temperature, the water bath is not necessary and subsequent reference to a constant temperature bath shall be interpreted as meaning either water bath or constant temperature room.
10. Timer: A watch or clock with a second hand and capable of timing 24-hr. periods.

11. Graduated cylinder of 200 ml. or 250 ml. capacity.

C. MATERIALS

1. Dispersion Agent

- a. Prepare the dispersion agent by dissolving 21.6 grams of Sodium Polyphos granules ($\text{Na}_{12}\text{P}_{10}\text{O}_{31}$) in one liter of distilled or good quality tap water at a temperature not exceeding 100°F. It is important that the Sodium Polyphos be completely dissolved. Therefore, mix the solution until none of the undissolved granules are still visible and then allow to stand at least four hours before using.

- b. Solutions of this salt slowly revert back to orthophosphate form with resultant decrease in dispersive action; therefore, fresh solutions should be prepared frequently. The date of preparation should be marked on the bottle containing the solution, and any solution remaining at 14 days after preparation shall be discarded.

- c. Sodium Polyphos (granular) is available to District Laboratories from the Office of Business Management. When ordering this chemical from another source, the "ground grade" of $\text{Na}_{12}\text{P}_{10}\text{O}_{31}$ (Sodium Polyphos) should be specified.

2. Water: The water used in this test shall be distilled or good quality tap water.

D. PREPARATION OF SAMPLE

1. Prepare the "as received" soil sample in accordance with California Test 201.

2. Split or quarter the mechanical analysis test sample from the passing No. 4 sieve fraction. The weight of the test sample should vary between 65 g. for silt and clay samples to 115 g. for very sandy samples.

3. At the same time the mechanical analysis test sample is taken, split or quarter a portion weighing approximately 100 g. from the passing No. 4 sieve material for a moisture determination.

Weigh the moisture sample to the nearest 0.1 g., then dry it to constant weight at 221°–230°F., cool to room temperature, reweigh to the nearest 0.1 g. and compute the percent moisture as follows:

Percent moisture

$$= \frac{[(\text{Wet weight} - \text{dry weight}) / \text{Dry weight}] \times 100}{}$$

4. Pour 125 ml. of the dispersion agent into the graduated cylinder.

5. Separate the mechanical analysis test sample on the No. 10 sieve. Place the retained No. 10 sieve material into a 100 ml. beaker and cover it with approximately 50 ml. of the dispersion agent from the graduated cylinder. Place the passing No. 10 sieve material into a 250 ml. beaker and cover it with the balance of the dispersion agent in the graduated cylinder. If all the material passes the No. 10 sieve, place the material into a 250 ml. beaker and cover it with the entire 125 ml. of dispersion agent from the graduated cylinder.

6. Stir the sample until it is thoroughly wetted. Then allow the sample to soak a minimum of 15 hours.

7. At the end of the soaking period, transfer the passing No. 10 sieve material into the mechanical dispersion apparatus cup. Then place the No. 10 sieve over the dispersion cup and pour the material which was originally retained on the No. 10 sieve onto it. Rinse the material still retained on the sieve with water until all particles which will pass the No. 10 sieve are washed into the dispersion cup. After rinsing, transfer the material retained on the No. 10 sieve to the sedimentation cylinder. Exercise care not to use any more water than is necessary when rinsing the retained No. 10 sieve material over the dispersion cup. The cup should not be filled to more than two-thirds nor less than one-half full.

8. Stir the contents of the dispersion cup with the mechanical stirring apparatus for 1 min.

E. TEST PROCEDURE

1. Immediately after dispersion, transfer the water-soil slurry to the sedimentation cylinder. Then add sufficient water, having a temperature within 5°F. of the constant temperature bath, to bring the level to the 1,000-ml. mark.

2. Using the palm of the hand over the open end of the sedimentation cylinder (or a rubber stopper in the open end), mix the contents of the sedimentation cylinder by alternately turning it upside down and right side up approximately 60 times in a period of 1 min. (count the turn upside down and back to right side up as 2 turns). Any material remaining in the bottom of the sedimentation cylinder during the first few turns should be loosened by vigorously shaking the sedimentation cylinder while it is in the inverted position.

3. At the end of the 1-min. mixing process, record

the time, and immediately set the sedimentation cylinder into the constant temperature water bath.

4. Take routine hydrometer readings at the end of 1 hour and 24 hours. Readings at other times may be made as desired.

a. When making a hydrometer reading, carefully and slowly lower the hydrometer into the cylinder about 20 to 25 seconds before the reading is to be taken to assure that it comes to rest before the appointed reading time. Take the reading at the top of the meniscus formed by the suspension around the stem of the hydrometer. As soon as the reading is taken, carefully remove the hydrometer and rinse it clean with water.

b. After each hydrometer reading, determine the temperature of the suspension by inserting a thermometer into the cylinder.

c. Observe the contents of the cylinder after each hydrometer reading to detect flocculations. A sample has flocculated when the suspended particles collect together in small lumps or gels and settle toward the bottom. This results in a clear line of demarcation between the flocculated particles and the liquid above it which may be cloudy to clear. The dispersion agent prescribed in this test procedure is effective in preventing flocculation in most soil samples. However, in those exceptional cases when this dispersion agent is not effective, flocculation will occur and hydrometer readings are not valid. In these cases where the determination of particle size distribution by the hydrometer method is not possible, the particle size distribution by sieve analysis shall be reported along with a notation that the material flocculated during the test.

d. If the 24-hr. reading does not fall on a work day, take readings at 1 hr., 6 hr., and 48 or 72 hr. Correct these readings by applying the composite correction (See Section F) and plot the corrected readings on Figure 1 "Mechanical Analysis Projection Chart". Then draw a smooth curve through these points and determine the 24-hr. reading by interpolation.

5. After taking the final reading, pour the contents of the cylinder onto a No. 200 (74 micron) sieve. Rinse the material retained on the sieve with tap water until the wash water is clear. Transfer the material retained on the sieve to a suitable container, dry it to constant weight in an oven at a temperature of 110°C. (230°F.) and perform a sieve analysis in accordance with "Determination of Particle Size Distribution" in California Test 202.

F. CORRECTIONS

1. Before the percentages of soil remaining in suspension can be calculated as prescribed in Section G, the hydrometer reading must be corrected for the following:

a. *Specific gravity of suspending medium.* Formulas for percentages of soil remaining in suspension, as given in Section G of this test method, are based on the use of distilled or good quality tap water as the suspending medium. A dispersion agent is used in this water, however, and the specific gravity of the resulting liquid is appreciably greater than that of water.

b. *Temperature of the suspending medium.* The soil hydrometer is calibrated to be read at 20°C. (68°F.), and variations from this standard temperature result in inaccurate hydrometer readings. The amount of error increases as the variation from the standard temperature increases.

c. *Apparent hydrometer reading.* Hydrometers are graduated by the manufacturer to be read at the bottom of the meniscus formed by the liquid on the stem. Since it is not possible to secure readings of soil suspensions at the bottom of the meniscus, readings must be taken at the top and a correction applied.

2. A composite correction for the above items (specific gravity of the suspending medium, temperature of the suspending medium and apparent hydrometer reading) may be determined experimentally as follows:

a. Prepare 1000-ml. of the liquid used in this test by diluting 125 ml. of the dispersion agent to the required 1000-ml. with distilled or good quality tap water.

b. Pour this liquid in a sedimentation cylinder and place the cylinder in the constant temperature bath set at one of the bracketing temperatures to be used.

DEPARTMENT OF TRANSPORTATION
TRANSPORTATION LABORATORY
MECHANICAL ANALYSIS PROJECTION CHART

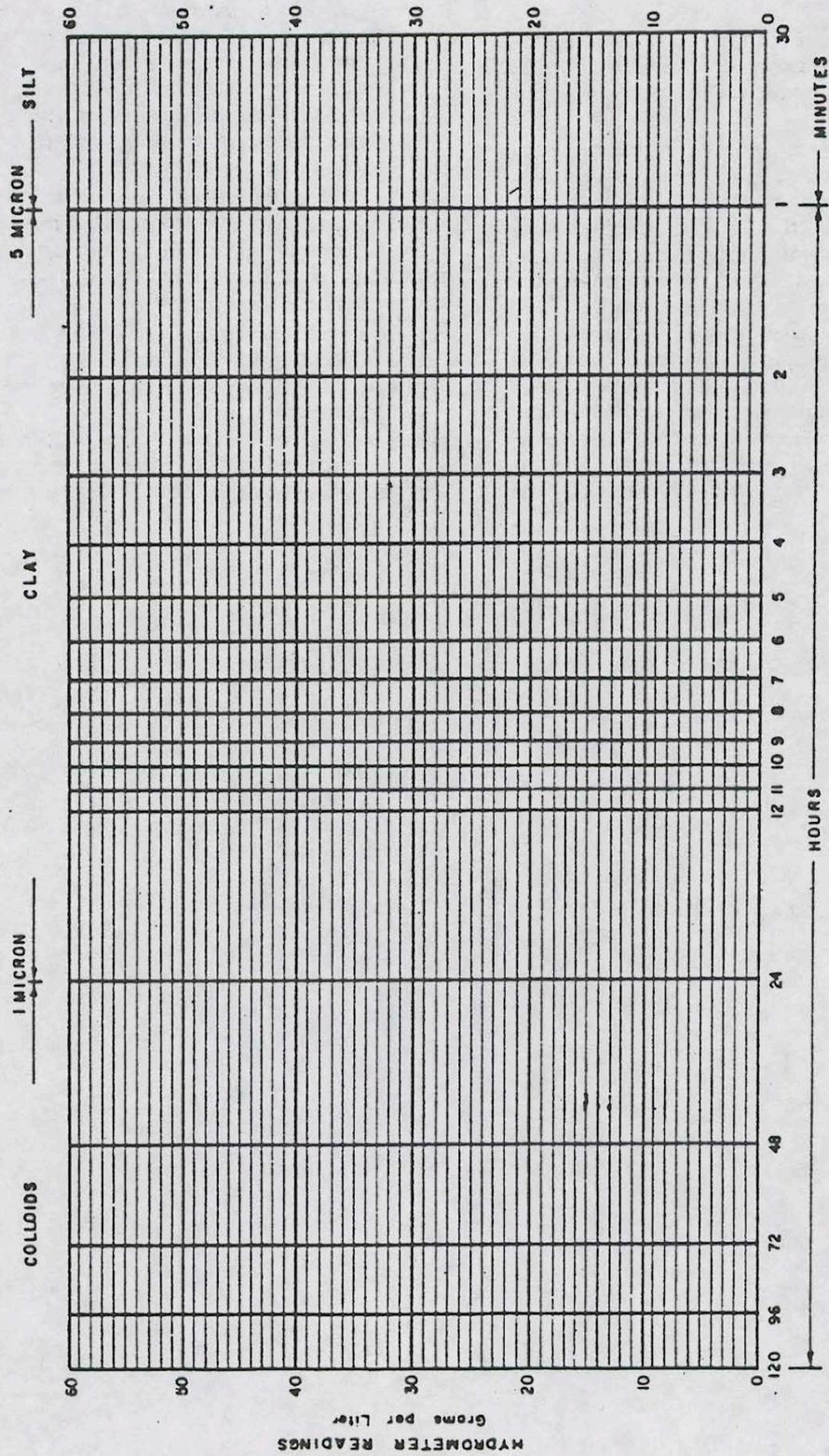


FIGURE 1

FORM T.L.-2041-55

- c. When the temperature of the liquid in the sedimentation cylinder becomes constant, insert the hydrometer and, after the prescribed 20 to 25 second interval allowed for the hydrometer to come to rest, read the hydrometer at the top of the meniscus formed on the stem. The hydrometer reading is the composite correction for this temperature.
- d. Change the constant temperature bath to the second bracketing temperature and repeat the above procedure to obtain the composite correction for this temperature.
- e. Plot these corrections on arithmetic coordinate paper as hydrometer reading vs. temperature. Draw a straight line between the two plotted points to establish the composite corrections for intermediate temperatures.
- f. Since the composite correction for hydrometer readings will be greater than zero in the acceptable range of expected test temperatures, subtract the applicable composite correction from the test hydrometer reading to obtain the corrected hydrometer reading.

G. CALCULATIONS

1. Calculate the oven dry weight of the sample used in the hydrometer test by dividing the wet weight of the sample by the percent moisture plus 100 as shown in the following formula:

$$\text{Oven dry weight} = \frac{\text{Wet weight}}{(\text{Percent moisture} + 100)}$$

2. Calculate the percent of soil in suspension by use of the following formula:

$$P = 100R/W$$

Where:

- P = Percentage of soil remaining in suspension.
 R = Corrected hydrometer reading.

W = Oven dry weight in grams of the sample used in the hydrometer test.

3. The average maximum diameter of soil particles in suspension, corresponding to the most commonly used hydrometer reading time intervals, are listed in Table 1. This table is based on average values calculated by Stokes' Law and shall be used to obtain the maximum particle size in suspension corresponding to the hydrometer reading times.

TABLE 1
AVERAGE MAXIMUM GRAIN
DIAMETER IN SUSPENSION

Sedimentation time	Average maximum grain diameters in suspension in microns
20 sec.	74
40 sec.	53
1 min.	39
2 min.	28
5 min.	18
15 min.	10
30 min.	7
1 hr.	5
2 hr.	3.5
4 hr.	2.5
6 hr.	2
7 hr.	1.7
24 hr.	1

4. Combine the grading of the retained No. 4 sieve Material with the grading of the hydrometer test sample to obtain the "as received" grading in accordance with "Calculations" in California Test 202.

H. REPORTING OF RESULTS

Report the total percentages passing each sieve size and the percentage of material in suspension at the designated sedimentation times to the nearest whole number.

REFERENCES

AASHTO Designation: T88, M92
California Tests 201, 202
End of Text (5 pgs.) on Calif. 203

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California Test 208
 1978

METHOD OF TEST FOR APPARENT SPECIFIC GRAVITY OF FINE AGGREGATES

A. SCOPE

This method of test, which is a modification of AASHTO Designation: T 133, is used for determining the apparent specific gravity of fine aggregates proposed for use in bituminous mixes, cement treated bases and aggregate bases.

B. APPARATUS

1. Flask. The standard LeChatelier flask conforming to the dimensions shown in Figure 1.

2. Weighted collar. A rubber or neoprene covered lead ring having an inside diameter of approximately 2½ inches and of sufficient weight to keep the flask upright in the water-bath.

3. Tank. A constant temperature water bath of sufficient depth to maintain the water level at about the 24 ml. line of the immersed flask. (The tank is not necessary if the test is performed in a constant temperature room.)

4. Balance. A balance having a capacity of 100 g. and sensitive to 0.1 g. or less.

5. Brush. A brush small enough to insert in cylinder portion of LeChatelier flask.

C. MATERIAL

Kerosene¹

D. PROCEDURE

1. Split or quarter a fine aggregate test sample weighing approximately 100 grams.

2. Dry to constant weight at $230^{\circ} \pm 9^{\circ}$ F and cool to room temperature.

3. Fill the LeChatelier flask with kerosene to a level slightly above the zero line.

4. Dry the inside of the flask above the 24-ml. line and insert the stopper.

5. Lower a weighted collar over the stem of the flask and let it rest on the bulb. (The collar is not necessary when the test is performed in a constant temperature room.)

6. Immerse the flask in the constant temperature water bath until the kerosene attains the same temperature as the bath.

¹ Stoddard solvent may be used in lieu of kerosene

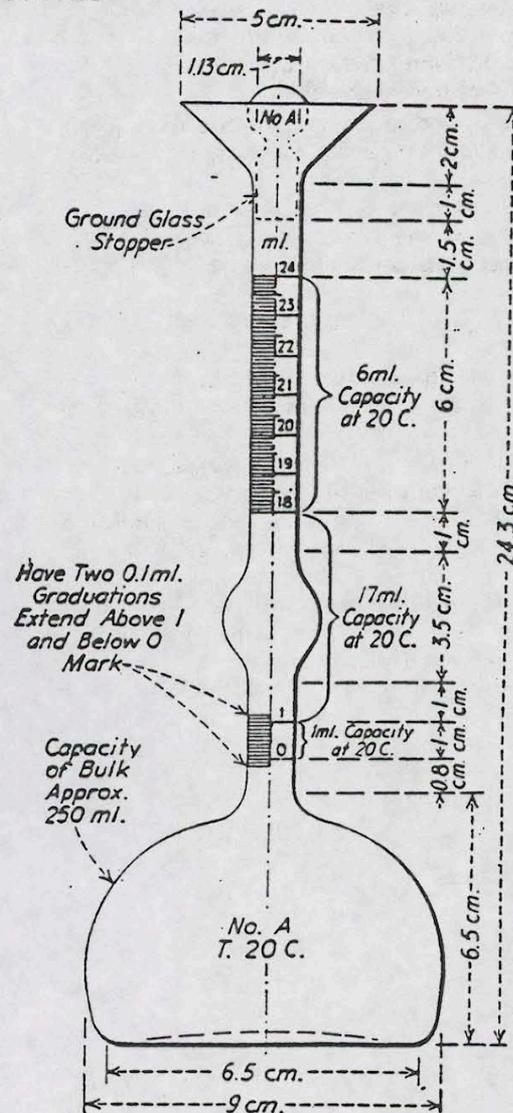


FIGURE 1

LE CHATELIER FLASK FOR SPECIFIC GRAVITY TEST

NOTE: Variations of a few millimeters in such dimensions as total height of flask, diameter of base, etc., are to be expected and will not be considered sufficient cause for rejection.

7. Remove the flask from the bath, remove the collar and dry the outside of the flask.
8. Read and record the temperature of the water bath to the nearest degree F and the level of the kerosene to the nearest 0.1 ml.
9. Weigh the flask and kerosene to the nearest 0.1 gram.
10. Slowly pour a portion of the test sample into the flask until the level of the kerosene is between 19 and 23 ml.
 - a. Gently roll and shake the flask as necessary to cause all the aggregate to fall into the bulb.
 - b. Brush any adhering dust down into the flask below the position of the stopper.
 - c. Insert the stopper in the flask.
11. Remove trapped air by rolling the flask in an inclined position and by gently whirling it in a horizontal circle.
12. If the level of the kerosene falls below the graduated section of the stem, repeat steps 2 and 3 until the kerosene remains at a level within the graduated section.
13. Weigh the flask, kerosene and sample to the nearest 0.1 gram.
14. Place the weighted collar on the flask and immerse the flask in the water bath for a minimum of 4 hours.
15. At the end of the immersion period, remove the flask from the water bath and remove any remaining trapped air by rolling the flask in an inclined position and by gently whirling it in a horizontal circle.
16. Read and record the temperature of the water bath to the nearest degree F and the level of the kerosene to the nearest 0.1 ml.
17. Discard the sample and rinse the flask with kerosene.

E. CALCULATIONS

1. Calculate the test sample weight by subtracting the weight of the flask and kerosene, determined in D-9, from the total weight of the flask, kerosene and test sample, determined in D-13.
2. Calculate the volume of displaced kerosene by subtracting the initial volume reading in D-8 from the final volume reading in D-16.
3. Determine the change in temperature between the initial and final volume readings and correct the volume of displacement as follows:
 - a. For each 1 degree F increase in temperature subtract 0.1 ml. from the calculated displacement.
 - b. For each 1 degree F decrease in temperature add 0.1 ml. to the calculated displacement.
4. Record the volume after the temperature correction as the corrected displacement.
5. Calculate the apparent specific gravity using the formula:

$$\text{Gravity} = \frac{\text{Oven dry sample weight (grams)}}{\text{Corrected displacement (milliliters)}}$$

F. PRECAUTIONS

1. Be sure that the material is free of all air bubbles before the final reading is taken.
2. Since the sample tested is small, care must be taken to insure that it is representative.
3. Be sure to apply temperature corrections properly.
4. Handle the LeChatelier flasks gently. They are fragile.

REFERENCE

AASHTO Designation: T 133
End of Text (2 pgs) on Calif. 208

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California Test 226
 November 1, 1980

METHOD OF DETERMINATION OF MOISTURE CONTENT BY OVEN DRYING

A. SCOPE

This test is used to determine the water content of a material by drying a sample to constant weight at a specified temperature. The water content is expressed as the percentage, by weight, of the dried sample.

B. APPARATUS

1. Weighing device: A balance or scale sensitive to 0.1 percent of the weight of the test sample, and having a capacity equal to, or greater than, the wet weight of the sample to be weighed.

2. Drying device: An oven or other suitable thermostatically controlled heating chamber capable of maintaining a temperature of $230^{\circ} \pm 9^{\circ}\text{F}$ ($110^{\circ} \pm 5^{\circ}\text{C}$).

3. Containers: Any pan or other container, not affected by the drying temperature, suitable for retaining the test sample without loss while permitting the water to evaporate.

- a. A broad shallow pan is normally most suitable for promoting drying.
- b. Containers with moisture-tight covers are required when test samples are not weighed immediately after preparation or after cooling following the drying period.

C. TEST PROCEDURE

1. Prepare a representative portion of the material to be tested. Unless other amounts are specified, the following minimum test sample sizes are suggested.

Material	Minimum Sample Weight
1) Soil	100 grams
2) Fine Aggregate—nominal maximum size of $\frac{3}{8}$ in. or smaller	500 grams
3) Coarse Aggregate—maximum particle size larger than $\frac{3}{8}$ in. sieve.	1000 grams
4) Miscellaneous Materials (straw, chips, etc.)	Sufficient bulk to be representative

a. When testing lightweight, bulky materials, such as straw, hand pack a substantial amount of material into a suitable container having a capacity of approximately one gallon.

2. Determine the weight of the test sample and record this weight as the "wet weight".

- a. The most convenient procedure for weighing

the sample before and after drying is to place it in a tared container where it will remain throughout the test. The container and sample are then weighed and the weight of the container subtracted.

- b. If the test sample is not weighed immediately after preparation, place the moisture-tight cover on the container to prevent evaporation.
3. Dry to constant weight at $230^{\circ} \pm 9^{\circ}\text{F}$ ($110^{\circ} \pm 5^{\circ}\text{C}$).
 - a. To reduce the drying time, break lumps of material into small fragments and spread in a thin layer over the bottom of the containers. Position the containers in the drying device to allow the maximum air circulation and exhaust of the moisture laden air.
 - b. Constant weight has been achieved when less than 0.1 percent of the test sample wet weight is lost during an additional exposure to the drying process. Subsequent drying periods to verify constant weight shall be of a least one hour duration.
 - c. The drying time required to achieve constant weight will vary depending on the type, quantity, and condition of the material. In most cases an overnight (16 hr.) drying period is sufficient. Large clay lumps may require significantly longer drying periods.
 - d. Verification of constant weight will not be necessary for each sample, provided the drying time exceeds the minimum time established for similar materials and conditions in the same drying device.
4. Remove the sample from the drying device and cool to room temperature.
 - a. If the test sample is not weighed immediately after cooling, place the moisture-tight cover on the container to prevent absorption of moisture from the air.
5. Determine the weight of the test sample and record this weight as the "dry weight".

D. CALCULATIONS

1. Determine the moisture content of the test sample as follows:

a. Weight of water in sample = Wet Weight minus

Dry Weight.

$$\text{b. Percent moisture} = \frac{\text{Weight of Water}}{\text{Dry Weight of Sample}} \times 100$$

E. PRECAUTIONS

1. The drying rate of test samples will be affected by the moisture conditions and number of samples in the drying device. When wet samples are placed in the drying device with nearly dry samples, completion of the drying may be retarded.

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