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METHOD OF TEST FOR SPECIFIC GRAVITY OF SOILS

A. SCOPE

This test method describes the procedure for the determination of the specific gravity of soils by means of a pycnometer. This method is only used for the testing of soil particles passing the No. 4 sieve.

When the soil contains particles retained on the No. 4 sieve, the method outlined in accordance with California Test 206 should be followed. This test method provides a procedure for determining the specific gravity of composite soil containing particles both larger and smaller than the No. 4 sieve.

B. REFERENCES

California Test 206 – Specific Gravity and Absorption of Coarse Aggregate
California Test 226 – Determination of Moisture Content by Oven Drying
AASHTO T 88 – Particle Size Analysis of Soils
AASHTO T 100 – Specific Gravity of Soils

C. APPARATUS

1. Pycnometer: one of the following:

   a. Volumetric flask having a capacity of 500 mL.

   b. Volumetric flask having a capacity of 100 mL.

   c. A stoppered bottle having a capacity of 50 mL. The bottle stopper must be of the same material as the bottle, be capable of being easily inserted to a fixed depth in the neck of the bottle, and have a small hole through its center to permit the emission of air and surplus water.

   NOTE: The use of either the volumetric flasks or the stoppered bottle is a matter of individual preference but, in general, a flask should be used when a larger sample than can be used in the stoppered bottle is needed due to maximum grain size of the sample.

2. Balance: either a scale or balance sensitive to 0.01 g for use with the 100 mL and 500 mL volumetric flasks, or a scale or balance sensitive to 0.001 g for use with the 50 mL stoppered bottle.

3. Thermometer: sensitive to 1˚F.

D. CONTROL

The temperature of the pycnometer contents at the two weighings must be 20˚C ± 5˚C, and these temperatures designated at T_i and T_x must not differ by more than 5˚C.

Alternate: If it is desired to perform the test at temperatures outside the above specified range, corrections for differences in temperature must be applied as provided in AASHTO T 100.

E. CALIBRATION OF PYCNOMETER

Clean and dry the pycnometer. Determine and record the mass in grams. Fill the pycnometer with distilled water having a temperature of 110˚C ± 5˚C. Determine and record the weight in grams, W_a, of the pycnometer and water. Insert the thermometer in the water and read and record the temperature, T_i, to the nearest whole degree C.

NOTE: Kerosene is a better wetting agent than water for most soils and may be used in place of distilled water for *oven-dried* samples.

From the mass W_a determined at the observed temperature T_i, a table of values of mass W_a must be prepared for a series of temperatures that are likely to prevail when masses W_b are determined later.

These values of W_a must be calculated as follows:

$$W_a(at\ T_x) = \frac{\text{density of water at } T_x}{\text{density of water at } Ti} \times \left(W_a\ (at\ T_i) - W_f\right) + W_f$$

Where: W_a = mass of pycnometer and water, in grams
W_f = mass of pycnometer, in grams
T_i = observed temperature of water, in degrees C
T_x = any other desired temperature, in degrees C

NOTE: This method provides a procedure that is most convenient for laboratories making many determinations with the same pycnometer. It is equally applicable to a single determination. Bringing the pycnometer and contents to some designated temperature when weights W_a and W_b are taken, requires considerable time. It is much more convenient to prepare a table of weights W_a for various temperatures likely to prevail when weights W_b are taken. It is important that weights W_a and W_b be based on water at the same temperature. Values for the relative density of water at temperatures from 18°C to 30°C are given in Table 1.

TABLE 1

Relative Density of Water and Conversion Factor *K* for Various Temperatures

Temperature °C	Relative Density of Water	Correction Factor K
18	0.9986244	1.0004
19	0.9984347	1.0002
20	0.9982343	1.0000
21	0.9980233	0.9998
22	0.9978019	0.9996
23	0.9975702	0.9993
24	0.9973286	0.9991
25	0.9970770	0.9989
26	0.9968156	0.9986
27	0.9965451	0.9983
28	0.9962652	0.9980
29	0.9959761	0.9977
30	0.9956780	0.9974

F. SAMPLE PREPARATION

1. The soil to be used in the specific gravity test may contain its natural moisture or be oven-dried. The weight of the test sample on an oven-dry basis must be at least: 125 g when the 500 mL flask is to be used, 25 g when the 100 mL flask is to be used, and 10 g when the 50 mL stoppered bottle is to be used.

2. Samples containing natural moisture:

   a. When the sample contains its natural moisture, determine the weight of the soil, W_o, on an oven-dry basis at the end of the test by evaporating the water from the sample in accordance with California Test 226 at 110°C ± 5°F.

      NOTE: Drying of certain soils at 110°C may bring about loss of moisture of composition or hydration, and in such cases, drying must be done, if desired, in reduced air pressure and at a lower temperature.

   b. Using the mechanically operated stirring apparatus specified in AASHTO T 88, disperse samples of clay soils containing their natural moisture content in distilled water before placing in the flask.

3. Oven-dried samples: When an oven-dried sample is to be used, dry the sample for at least 12 hr, or to constant weight in accordance with California Test 226, in an oven maintained at 110°C ± 5°C. However, a lower temperature may be permitted for certain soils as explained in Step 2. Cool the sample in a desiccator and determine the weight upon removal from the desiccator. Soak the sample for at least 12 hr in distilled water.

G. PROCEDURE

1. Place the sample in the pycnometer taking care not to lose any of the soil in case the oven-dry weight has been determined. Add distilled water to the flask until it is about ¾ full or to the stoppered bottle until it is about ½ full.

2. Remove entrapped air by either of the following methods:

   a. Subject the contents to a partial vacuum (air pressure not exceeding 100 mm of mercury).

   b. Gently boil the contents for at least 10 min while occasionally rolling the pycnometer to assist in the removal of air.

   Subjecting the contents to reduced air pressure may be done either by connecting the pycnometer directly to an aspirator or vacuum pump, or by use of a bell jar.

   NOTE: Some soils boil violently when subjected to reduced air pressure. It will be necessary in those cases to reduce the air pressure at a slower rate or to use a larger flask.

3. Cool samples that are heated to approximately 20˚C.

4. After the air has been removed, fill the pycnometer with distilled water and bring the temperature of the total contents to 20˚C ± 5˚C and within 5˚C of temperature T_i by use of a water bath or other suitable means.

   Clean and dry the outside of the pycnometer with a clean, dry cloth. Determine and record the weight in grams of the pycnometer and contents, W_b, and the temperature in degree C, T_x, of the contents.

5. If the test was performed on a sample which contained its natural moisture, determine the dry weight of the material by evaporating off the water in accordance with California Test 226 in an oven maintained at 110°C ± 5°C, or at a lower temperature as explained under Section F-2, until the material reaches a constant mass. Cool the sample to room temperature, determine the weight in grams. Record the weight, W_o.

H. CALCULATIONS

1. Calculate the specific gravity of the soil as follows:

$$\text{Specific gravity} = \frac{W_o}{W_o + W_a - W_b}$$

Where:
- W_o = Oven-dry weight, in grams
- W_a = Weight of pycnometer filled with water at temperature T_i, in grams
- W_b = Weight of pycnometer filled with water and soil at temperature T_x, in grams

2. To obtain the specific gravity of soils that contain particles retained on the No. 4 sieve, separate the sample on the No. 4 sieve and determine the *apparent* specific gravity of the retained No. 4 sieve portion in accordance with California Test 206. Determine the specific gravity of the passing No. 4 portion by the method herein described. The specific gravity value for the soil is determined as the weighted average of the two values as follows:

$$\text{Specific gravity of soil} = \frac{(P_f \times G_f) + (P_c \times G_c)}{100}$$

Where:
- P_f = Percent of passing No. 4 sieve fraction by oven-dry weight
- P_c = Percent of retained No. 4 sieve fraction by oven-dry weight
- G_f = Specific gravity of the passing No. 4 sieve fraction
- G_c = Specific gravity of the retained No. 4 sieve fraction

3. Unless otherwise required, base reported specific gravity values reported on water at 20°C. Calculate the value based on water at 20°C from the value based on water at the observed temperature T_x, as follows:

$$\frac{\text{Specific Gravity, } T_x}{20°\,C} = K \times \frac{\text{Specific Gravity, } T_x}{T_x}$$

Where: K = a number found by dividing the relative density of water at temperature T_x by the relative density of water at 20°C. Values for a range of temperatures are given in Table 1.

I. HEALTH AND SAFETY

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

Caltrans Laboratory Safety Manual is available at:

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

End of Text
(California Test 209 contains 5 pages)