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METHODS OF TEST FOR SOILS

PART III DETERMINATION OF SPECIFIC GRAVITY

Section 1 Fine Grained Soils

(First Revision)

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(*Continued on page* 2)

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(*Continued on page* 8)

Indian Standard

METHODS OF TEST FOR SOILS

PART III DETERMINATION OF SPECIFIC GRAVITY

Section 1 Fine Grained Soils

(First Revision)

0. FOREWORD

0.1 This Indian Standard (Part III/Sec 1) (First Revision) was adopted by the Indian Standards Institution on 3 October 1980, after the draft finalized by the Soil and Rock Mechanics Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 With a view to establishing uniform procedures for the determination of different characteristics of soils and also for facilitating a comparative study of the results, the Indian Standards Institution is bringing out a series of standards on methods of test for soils (IS : 2720). This standard (Part III) deals with the method of test for determination of specific gravity of soils which finds application in finding out the degree of saturation and unit weight of moist soils. The unit weights are needed in pressure, settlement and stability problems in soil engineering. This standard was published in the year 1964. In view of the further work done in this field in this, as well as in other countries, the revision has been prepared so as to give the latest method of test which has separate provision for fine grained and coarse soils. The revision is being prepared in two sections : Section 1, dealing with the method for fine grained soil which is a basically laboratory method and Section 2 for fine, medium and coarse grained soils which is field method.

0.3 In reporting the result of a test or analysis made in accordance with this standard, if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

*Rules for rounding off numerical values (*revised*).

1. SCOPE

1.1 This standard (Part III/Sec 1) lays down the methods of test for the determination of the specific gravity of soil particle of fine grained soils (*see* Note).

NOTE — The method may also be used for medium and coarse grained soils if the coarse particles are grained to pass 4·75-mm IS sieve before using.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definition of terms given in IS : 2809-1972* shall apply.

3. APPARATUS

3.1 The following apparatus is required:

a) Two density bottles (pyknometers) of approximately 50 ml capacity with stoppers.

b) A water-bath maintained at a constant temperature to within ± 0·2°C. (If standard density bottles are used this constant temperature is 27°C.)

c) A vacuum desiccator (a convenient size is one about 200 mm to 250 mm in diameter).

d) A desiccator (a convenient size is one about 200 mm to 250 mm in diameter) containing anhydrous silica gel.

e) A thermostatically controlled drying oven, capable of maintaining a temperature of 105 to 110°C.

f) A balance readable and accurate to 0·001 g.

g) A source of vacuum, such as a good filter pump or a vacuum pump.

h) A spatula (a convenient size is one having a blade 150 mm long and 3 mm wide; the blade has to be small enough to go through the neck of the density bottle), or a piece of glass rod about 150 mm long and 3 mm diameter.

j) A wash bottle, preferably made of plastics, containing air-free distilled water (*see* Note).

k) A sample divider of the multiple slot type (riffle box) with 7 mm width of opening.

m) A length of rubber tubing to fit the vacuum pump and the desiccator.

NOTE — Obtain the air-free distilled water for at least 30 minute in a container that can be sealed from the atmosphere during cooling. Take care to see that the container is strong enough to resist the reduction in pressure inside it during cooling.

*Glossary of terms and symbols relating to soil engineering (*first revision*).

4. PROCEDURE

4.1 The complete density bottle with stopper, shall be dried at 105 to 110°C, cooled in the desiccator and weighed to the nearest 0·001 g (m_1) (*see* Note 1).

4.2 The 50 g sample obtained as described in the procedure for the preparation of disturbed samples for testing (*see* **1.5**) shall if necessary be ground to pass a 2-mm IS test sieve. A 5 to 10 g subsample shall be obtained by riffling, and oven dried at 105 to 110°C (*see* Note 2). This sample shall be transferred to the density bottle direct from the desiccator in which it has been cooled. The bottle and contents together with the stopper shall be weighed to the nearest 0·001 g (m_2).

4.3 Sufficient air-free distilled water (*see* Note 3) shall be added so that the soil in the bottle is just covered. The bottle containing the soil and liquid, but without the stopper, shall be placed in the vacuum desiccator, which shall then be evacuated gradually. The pressure shall be reduced to about 20 mmHg. When using a water pump, because of variation in mains pressure, care shall be taken to ensure that the required vacuum is maintained. Care shall be taken during this operation to see that the air trapped in the soil does not bubble too violently, so as to prevent small drops of the suspension being lost through the mouth of the bottle. The bottle shall be allowed to remain in the desiccator for at least 1 hour until no further loss of air is apparent.

4.4 The vacuum shall be released and the lid of the desiccator removed. The soil in the bottle shall be stirred carefully with the spatula, or the bottle vibrated. Before removing the spatula from the bottle the particles of soil adhering to the blade shall be washed off with a few drops of air-free liquid. The lid of the desiccator shall then be replaced and the desiccator evacuated again.

4.5 The procedure outlined in **4.3** and **4.4** shall be repeated until no more air is evolved from the soil (*see* Note 4).

4.5.1 Alternately, the entrapped air can be removed by getting heating the pyknometer placed on a water-bath or sand-bath.

4.6 The bottle and contents shall then be removed from the desiccator and further air-free liquid added until the bottle is full. The stopper shall then be inserted. The stoppered bottle shall be immersed up to the neck in the constant-temperature bath for approximately 1 hour or until it has attained the constant temperature of the bath (*see* Note 5).

If there is an apparent decrease in volume of the liquid the stopper shall be removed and further liquid added to fill the bottle and the stopper replaced. The bottle shall then be returned to the bath and sufficient time shall be allowed to elapse after this operation to ensure that the

bottle and its contents again attain the constant temperature of the bath. If the bottle is still not completely full this process shall be repeated.

4.7 The stoppered bottle shall then be taken out of the bath, wiped dry and the whole weighed to the nearest 0·001 g (m_3).

4.8 The bottle shall then be cleaned out and filled completely with air-free liquid, the stopper inserted and then the whole immersed in the constant temperature bath for 1 hour or until it has attained the constant temperature of the bath. If there is an apparent decrease in the volume of the liquid, the stopper shall be removed and further liquid added to fill the bottle and the stopper replaced. The stoppered bottle shall then be returned to the batch and sufficient time shall be allowed to elapse after this operation to ensure that the bottle and its contents again attain the constant temperature. If the bottle is still not completely full this process shall be repeated. The bottle shall then be taken out of the bath, wiped dry and the whole weighed to the nearest 0·001 g (m_4) (*see* Note 6).

4.9 Two determinations of the specific gravity of the same soils sample shall be made (*see* Notes 7 and 8).

NOTE 1 — *Standard Density Bottles* — If a density bottle is used then in order to avoid distortion it should not be dried by placing it in an oven. It may be dried by rinsing with acetone or an alcohol-ether mixture and then blowing warm air through it.

NOTE 2 — Oven drying of the soil has been specified for convenience. If there is any reason to believe that this will change the specific gravity due to loss of water of hydration the soil should be dried at not more than 80°C. This fact should be reported.

NOTE 3 — *Alternative Liquids for Specific Gravity Determination* — With certain soils, for example those containing soluble salts, kerosene (paraffin oil) or white spirit may be preferred. If one of these is used, record the fact and carry out a separate experiment to determine the specific gravity of the liquid at the room temperature of the test. The equation for the specific gravity of the soil particles, G, given in **5.1** then becomes:

$$G = \frac{G_L (m_2 - m_1)}{(m_4 - m_1) - (m_3 - m_2)}$$

where

G_L = specific gravity of the liquid used, at the constant temperature;

m_1 = mass of density bottle in g;

m_2 = mass of bottle and dry soil in g;

m_3 = mass of bottle, soil and liquid in g; and

m_4 = mass of bottle when full of liquid only in g.

NOTE 4 — Experience has shown that the largest source of error in the test is due to the difficulty in ensuring the complete removal of air from the sample. To obtain reliable results the soil should be left under vacuum for several hours, preferably overnight. Shaking the bottle in hand once or twice interuppting the vacuum gives quicker results.

NOTE 5 — If a constant temperature room or cabinet is available then this procedure need not be carried out in a water-bath.

NOTE 6 — If method given in **4.8** is used to find the volume of the density bottle then the test may be carried out at any temperature provided it is constant throughout the test.

NOTE 7 — Many soils have a substantial proportion of heavier or lighter particles. Such soils will give erratic values for the specific gravity even with the greatest care in testing and a number of repeated tests may be needed to obtain a good average value.

NOTE 8 — Clean quartz and flint sands generally have a specific gravity close to 2·65; low values would suggest the presence of organic matter.

5. CALCULATION

5.1 The specific gravity of the soil particles G shall be measured at room temperature If water has been used as the air-free liquid, then the following equation shall be used:

$$G = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)}$$

where

m_1 = mass of density bottle in g;

m_2 = mass of bottle and dry soil in g;

m_3 = mass of bottle, soil and water in g; and

m_4 = mass of bottle when full of water only in g.

If some other air-free liquid has been used reference should be made to Note 3.

5.2 The specific gravity shall be calculated at 27°C. If the room temperature is different than 27°C, the following correction shall be done:

$$G' = K\,G$$

where

G' = Corrected specific gravity at 27°C, and

$$K = \frac{\text{Relative density of water at room temperature}}{\text{Relative density of water at 27°C.}}$$

6. REPORTING OF RESULTS

6.1 The average of the values obtained shall be taken as the specific gravity of the soil particles and shall be reported to the nearest 0·01. If the two results differ by more than 0·03 the tests shall be repeated.

(*Continued from page* 2)

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