# EXPERIMENT 3

# SPECIFIC GRAVITY DETERMINATION

## Purpose:

This lab is performed to determine the specific gravity of soil by using a pycnometer. Specific gravity is the ratio of the mass of unit volume of soil at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature.

## The Theoretical Part:

The specific gravity of a given material is defined as the ratio of the weight of a given volume of the material to the weight of an equal volume of distilled water. In soil mechanics, the specific gravity of soil solids (which is often referred to as the specific gravity of soil) is an important parameter for calculation of the weight-volume relationship. Thus specific gravity, G" is defined as

$$G_s = \frac{\text{unit weight (or density) of soil solids only}}{\text{unit weight (or density) or water}}$$

**Or**

$$G_s = \frac{W_s / V_s}{\rho_2} = \frac{W_s}{V_s \rho_w}$$

where : $W_s$ = mass of soil solids (g)

$V_s$ = volume of soil solids (cm3)

$P_w$ = density of water (g/cm3 )

## Equipment And Tools:

1. Volumetric flask (500 ml)
2. Thermometer graduated in O.soC division scale
3. Balance sensitive up to 0.01 g
4. Distilled water
5. Bunsen bumer and a stand (and/or vacuum pump or aspirator)
6. Evaporating dishes
7. Spatula
8. Plastic squeeze bottle
9. Drying oven


**Figure. 3-1** Equipment and tools for Specific Gravity test

## Procedure:

1. Clean the volumetric flask well and dry it.

2. Carefully fill the flask with de-aired, distilled water up to the 500 ml mark (bottom of the meniscus should be at the 500 ml mark).

3. Determine the mass of the flask and the water filled to the 500 ml mark *(Wi)'*

4. Insert the thermometer into the flask with the water and determine the temperature of the water $T = T1$°C.

5. Put *approximately* 100 grams of air dry soil into an evaporating dish.

6. If the soil is cohesive, add water (de-aired and distilled) to the soil and mix it to the form of a smooth paste. Keep it soaked for about one-half to one hour in the evaporating dish. *(Note:* This step is not necessary for granular, i.e., non cohesive, soils.)

7. Transfer the soil (if granular) or the soil paste (if cohesive) into the volumetric flask.

8. Add distilled water to the volumetric flask containing the soil (or the soil paste) to make it about two-thirds full.

9. Remove the air from the soil-water mixture. This can be done by:

a. Gently boiling the flask containing the soil-water mixture for about 15 to 20 minutes. Accompany the boiling with continuous agitation of the flask. (If too much heat is applied, the soil may boil over.) Or

b. Apply vacuum by a vacuum pump or aspirator until all of the entrapped air is out.

This is an *extremely important step.* Most ofthe errors in the results of this test are due to *entrapped air which is not removed.*

10. Bring the temperature of the soil-water mixture in the volumetric flask down to room

temperature, i.e., *Ti* DC-see Step 4. (This temperature of the water is at room temperature.)

11. Add de-aired, distilled water to the volumetric flask until the bottom of the meniscus touches the 500 m1 mark. Also dry the outside of the flask and the inside of the neck above. the meniscus.

12. Determine the combined mass of the bottle plus soil plus water *(W2).*

13. Just as a precaution, check the temperature of the soil and water in the flask to see if It is *T1* ± 1°C or not.

14. Pour the soil and water into an evaporating dish. Use a plastic squeeze bottle and wash the inside of the flask. Make sure that no soil is left inside.

15. Put the evaporating dish in a oven to dry to a constant weight.

16. Determine the mass of the dry soil in the evaporating dish *(W,)*.

## Calculation:

Calculate the specific gravity

$$G_s = \frac{\text{mass of soil, } W_s}{\text{mass of equal volume of soil}}$$

Where:

mass of soil = *Ws*

mass of equal volume of water, *W w* = (WI + *Ws)* - *W2*

So

$$G_{s(\text{at } T_1 °\text{C})} = \frac{W_s}{W_w}$$

Specific gravity is generally reported on the value of the density of water at 20°C. So

$$G_{s(\text{at }20^\circ\text{c})} = G_{s(\text{at }T_1{}^\circ\text{C})}\left[\frac{\rho_{w(\text{at }T_1{}^\circ\text{C})}}{\rho_{w(\text{at }20^\circ\text{C})}}\right]$$
$$= G_{s(\text{at }T_1{}^\circ\text{C})}\,A$$

$$\text{where } A = \frac{\rho_{w(\text{at }T_1{}^\circ\text{C})}}{\rho_{w(\text{at }T_{20}{}^\circ\text{C})}}$$

$\rho_w$ = density of water.

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| Temperature ($T_1$°C) | $A$ | Temperature ($T_1$°C) | $A$ |
|---|---|---|---|
| 16 | 1.0007 | 24 | 0.9991 |
| 17 | 1.0006 | 25 | 0.9988 |
| 18 | 1.0004 | 26 | 0.9986 |
| 19 | 1.0002 | 27 | 0.9983 |
| 20 | 1.0000 | 28 | 0.9980 |
| 21 | 0.9998 | 29 | 0.9977 |
| 22 | 0.9996 | 30 | 0.9974 |
| 23 | 0.9993 | | |

The values of $A$ are given in **Table 3-1**

## Standard Results:

| Soil Type | Range of $G_s$ |
|---|---|
| Sand | 2.63–2.67 |
| Silts | 2.65–2.7 |
| Clay and silty clay | 2.67–2.9 |
| Organic soil | less than 2 |

**Table 3-2**. General Ranges of Gs for Various Soils

Standard Reference:

ASTM D 854-00 – Standard Test for Specific Gravity of Soil Solid.

## Discussion and Conclusions:

- Typical Values of Gs for Various Soils are shown in **Table 3-2.**