OCW 2020

FUNDAMENTALS OF GEOTECHNICAL ENGINEERING

ASSIGNMENTS

LESSON 2
BASIC CHARACTERISTICS OF SOILS AND ROCKS

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EXERCISE 1

Using the definitions of the basic properties of soils, verify the following relationships:

1. $\mathbf{n = \frac{e}{1+e}}$
2. $\gamma_d = \frac{\gamma_S}{1+e}$
3. $\gamma_{sat} = \gamma_d + n \cdot \gamma_w$
4. $\gamma = \gamma_d \cdot (1+w)$
5. $S_r = \frac{w}{e} \cdot \frac{\gamma_S}{\gamma_w}$

EXERCISE 2

A sample of soil of mass 27.35 g has a volume of 14.25 cm^3. After oven drying, its mass was reduced to 22.94 g. The specific gravity of soil solids was found to be 2.7.

Calculate:

1. Unit weight of soil solids.
2. Unit weight of the sample.
3. Unit weight of the oven-dried sample.
4. Porosity and void ratio.
5. Saturated and effective unit weights.
6. Water content and degree of saturation.

Answers:

1) γ_S = 26.46 kN/m³; 2) γ = 18.81 kN/m³; 3) γ_d = 15.78 kN/m³; 4) n = 0.404; e = 0.677

4) γ_{sat} = 19.73 kN/m³; γ' = 9.93 kN/m³; 5) w = 19.2 %; S_r = 76.6 %

EXERCISE 3

A dry soil sample is uniformly mixed with 16.2 % of water. Then, it is compacted in a cylindrical container. The volume of the compacted sample is 0.987 litres and its mass 1605 g.

If the specific gravity of soil solids is 2.6, determine:

1. Unit weight of the compacted sample.
2. Unit weight of the dry soil sample.
3. Porosity and void ratio.
4. Saturated unit weight.
5. Degree of saturation.

Answers:

1) γ = 15.94 kN/m^3; 2) γ_d = 13.71 kN/m^3; 3) n = 0.462; e = 0.858; 4) γ_{sat} = 18.24 kN/m^3

5) S_r = 49.1 %

EXERCISE 4

A dry soil sample is uniformly mixed with 10.5 % of water. The specific gravity of soil solids was found to be 2.7.

This mixture is put into a cylindrical container 150 mm in diameter and 125 mm long and then it is compacted up to air volume in soil is 5 % of total volume.

Considering that the mixture has completely filled the container, determine:

1. Mass of the dry soil sample.
2. Unit weight of the compacted dry soil.
3. Void ratio of the compacted soil.
4. After performing different tests, it has been obtained that the dry soil, in the most compacted state, shows a void ratio e_{min} = 0.317, and in the loosest state e_{max} = 0.507. Determine the density index of the compacted soil.

Answers:

1) M_S = 4414.43 g; 2) γ_{dcomp} = 19.58 kN/m^3; 3) e_{comp} = 0.351; 4) I_D = 79.84 %

EXERCISE 5

An undisturbed cubic sample 250 mm long has been taken from a construction site after performing a test pit. The sample was completely covered with a 5 mm paraffin layer to preserve their properties. The mass of this block was 34.60 kg. Calculate:

1. Unit weight of soil.

Then, after removing the paraffin from one face, two samples were extracted. The first one was 38 mm in diameter and 60 mm long. Completely dried, the soil dry mass was 130.63 g. Determine:

2. Unit weight of the dried soil sample.
3. Water content of the soil.

Finally, the second sample was used to determine the specific gravity of soil solids, which was found to be 2.75. Determine:

4. Porosity.
5. Degree of saturation.
6. If the soil is saturated, calculate the unit weight of soil.

Additional information: Density of paraffin, $\rho_p = 0.9$ g/cm^3

Answers:

1) γ = 20.60 kN/m^3; 2) γ_d = 18.81 kN/m^3; 3) w = 9.5 %; 4) n = 0.302; 5) S_r = 60.4 %

6) γ_{sat} = 21.77 kN/m^3

EXERCISE 6

A dry soil sample completely fills a cylindrical mold 60 mm in diameter and 150 mm height. Soil mass is 950 g.

If the voids of the soil are filled with mercury, what would the soil mass be?

Additional data: Specific gravity of soil solids, $G_S = 2.55$

Density of mercury, $\rho_{Hg} = 13.6$ g/cm^3

Answer: M = 1651.35 g

EXERCISE 7

A soil sample has the following data:

- Specific gravity of soil solids = 2.69
- Void ratio = 0.46

Calculate:

1. Porosity.
2. Unit weight if the soil sample is dry.
3. Unit weight if the soil simple is saturated.
4. Is it possible to determine its bulk unit weight? Explain your answer.

Answers: 1) n = 0.313; 2) γ_d = 18.11 kN/m^3; 3) γ_{sat} = 21.18 kN/m^3

EXERCISE 8

A soil sample has the following data:

- Bulk unit weight: 18.91 kN/m^3
- Dry unit weight: 17.74 kN/m^3
- Water content: 15.2 %

But the technician in charge of the laboratory considers that there is something incorrect in these data, so he/she goes to the warehouse, takes another sample of the soil, which was preserved completely dried, and obtains the following data:

- Mass: 60.67 g
- Volume: 33.52 cm^3
- Specific gravity of soil solids: 2.68

Using these data, determine what could be the correct values of γ, γ_d and w. Also, calculate e and n.

Answers:

1) γ_d = 17.74 kN/m^3; 2) e = 0.481; 3) n = 0.325

EXERCISE 9

Soil compaction is a necessary step in road construction. It can be achieved by different means – by tamping action, by kneading action, by vibrating, or by impact - and the main goal is to move solid particles to fill part of the existing air volume. In this way, the total volume of the soil is reduced and, consequently, its density increases.

A certain soil has the following data:

- Bulk unit weight: 17.22 kN/m^3
- Water content: w = 10 %
- Specific gravity of soil solids: 2.67

In this initial state, calculate:

1. Dry unit weight.
2. Porosity and void ratio.
3. Degree of saturation.

If a compaction process is performed on this soil,

4. Find a relationship between γ_d, γ_S, γ_w, w and S_r.
5. Calculate the maximum dry unit weight, γ_{dmax}, and the corresponding degree of saturation.
6. Calculate the new values of porosity and void ratio.
7. Find the bulk unit weight of the compacted soil.

Answers:

1) γ_d = 15.65 kN/m^3; 2) n = 0.402; e = 0.672; 3) S_r = 39.7 %; 4) $\gamma_d = \dfrac{\gamma_S}{1 + \dfrac{w}{S_r} \cdot \dfrac{\gamma_S}{\gamma_w}}$

5) S_r = 100 %; γ_{dmax} = 20.65 kN/m^3; 6) n_{comp} = 0.211; e_{comp} = 0.267; 7) γ_{comp} = 22.72 kN/m^3

EXERCISE 10

A slake durability test has been conducted on some fragments of a certain rock mass. Those fragments were placed in a drum, weighed and dried in an oven. The overall mass was 2527.3 g. After completing two cycles of 10 minutes (NLT-251/91 standard), the drum and retained rock fragments were dried in the oven and then weighed. The mass was found to be 2408.1 g. If the drum weighed 2 kg, determine the durability of the rock mass according to the following table:

Durability	% retained after 1st cycle	% retained after 2nd cycle
Very high	99	98
High	98 – 99	95 – 98
Medium high	95 – 98	85 – 95
Medium	85 – 95	60 – 85
Low	60 – 85	30 -60
Very low	60	30

Answer: Medium durability.

EXERCISE 11

It is required to determine the effective porosity of a rock according to the UNE-EN 1936:2007 standard, wherein that rock is immersed in water. The following data have been obtained from the test:

- Volume of the rock sample: 1266.1 cm^3
- Mass of the dried rock sample: 3255.7 g
- Mass of the rock sample after submerging in water: 3498.3 g

Calculate the effective porosity.

Answer: n_e = 0.192