OCW 2020

FUNDAMENTALS OF GEOTECHNICAL ENGINEERING

ASSIGNMENTS

LESSON 4
STRESSES

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EXERCISE 1

At a planned construction site, a subsurface sampling shows the following strata:

A) From the ground surface to 4 m depth, a gravel stratum with a dry unit weight of 20 kN/m^3 and a specific gravity of soil solids of 2.65.

B) From 4 m to 8 m depth, a clay stratum with a water content of 28 % and a unit weight of soil solids of 26.66 kN/m^3.

C) From 8 m to 10 m depth, a coarse sand with a specific gravity of soil solids of 2.65 and a constant void ratio of 0.38.

The groundwater table is 2 m below the ground surface. Up to that depth, the water content is very low, 5 % approximately, and from the groundwater table there is no capillary rise because the soil is constituted by gravel particles without fines.

Determine:

1. Bulk unit weight of soil in all the strata.
2. Total vertical stress, pore water pressure and effective vertical stress at any point of the ground at 2, 4, 8 and 10 m depth.
3. Effective horizontal stress and total horizontal stress at any point of the ground at 2, 4, 8 and 10 m depth.
4. Plot the distribution of all the stresses with depth.

Additional data: Coefficients of earth pressure at rest, K_0.

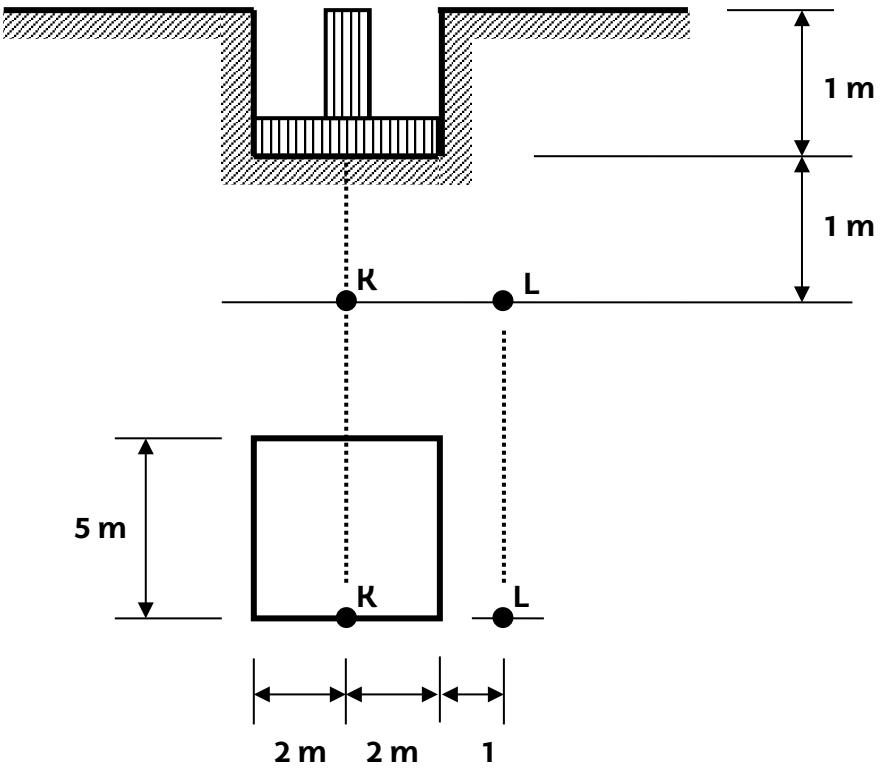
Gravel: $K_0 = 0.55$; Clay: $K_0 = 0.9$; Sand: $K_0 = 0.45$.

Answers: 1) γ_{A1} = 21.0 kN/m^3; γ_{A2} = 22.25 kN/m^3; γ_B = 19.37 kN/m^3; γ_C = 21.52 kN/m^3

2)-3) At 2 m depth: σ_v = 42.0 kN/m^2; u = 0 kN/m^2; σ'_v = 42.0 kN/m^2; σ'_H = 23.1 kN/m^2; σ_H = 23.1 kN/m^2. At 4 m depth: σ_v = 86.5 kN/m^2; u = 19.6 kN/m^2; σ'_v = 66.9 kN/m^2; σ'_H (gravel) = 36.8 kN/m^2; σ'_H (clay) = 60.21 kN/m^2;σ_H (gravel) = 56.4 kN/m^2; σ_H (clay) = 79.81 kN/m^2. At 8 m depth: σ_v = 163.98 kN/m^2; u = 58.8 kN/m^2; σ'_v = 105.18 kN/m^2; σ'_H (clay) = 94.66 kN/m^2; σ'_H (sand) = 47.33 kN/m^2;σ_H (clay) = 153.46 kN/m^2; σ_H (sand) = 106.13 kN/m^2. At 10 m depth: σ_v = 207.02 kN/m^2; u = 78.4 kN/m^2; σ'_v = 128.62 kN/m^2; σ'_H = 57.88 kN/m^2; σ_H = 136.28 kN/m^2.

EXERCISE 2

A 4 m by 5 m rectangular foundation located 1 m below the ground surface (see figure) carries a uniform load q. Calculate the influence coefficient I which is necessary to determine the vertical stress at points K and L.

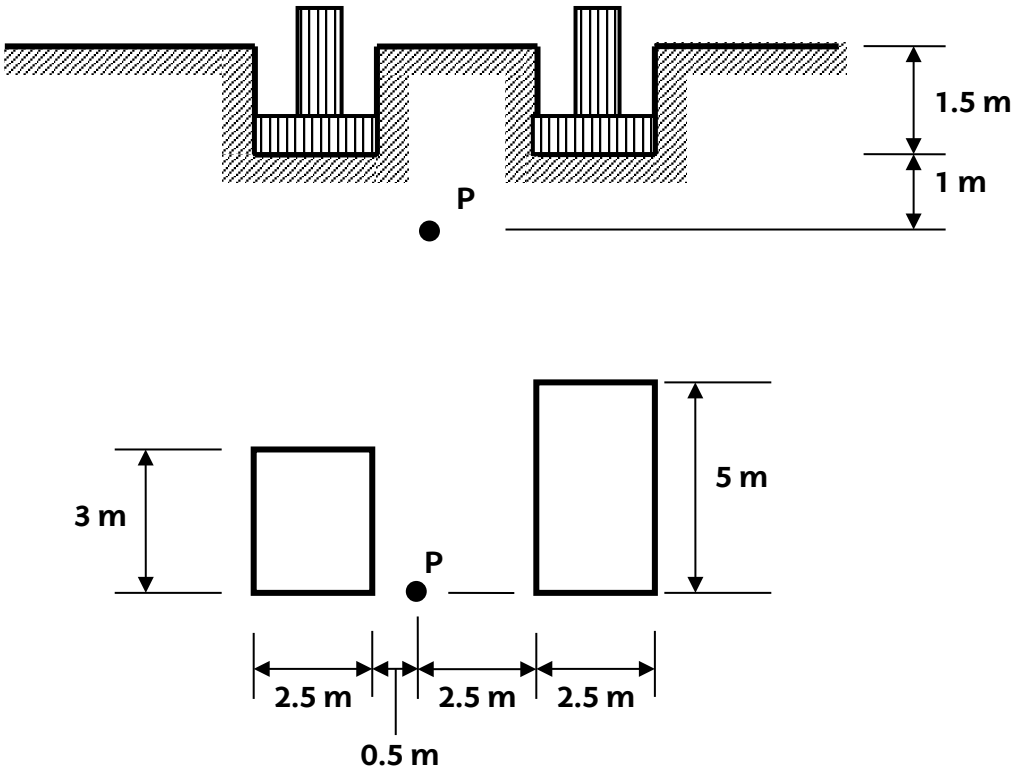


Answers: $I_K = 0.478$; $I_L = 0.045$.

EXERCISE 3

Two footings located 1.5 m below the ground surface (see figure) carry the same uniform load of 110 kN/m^2. Calculate the vertical stress increment at point P, taking into account both footings.

Additional data: unit weight of soil = 20 kN/m^3.

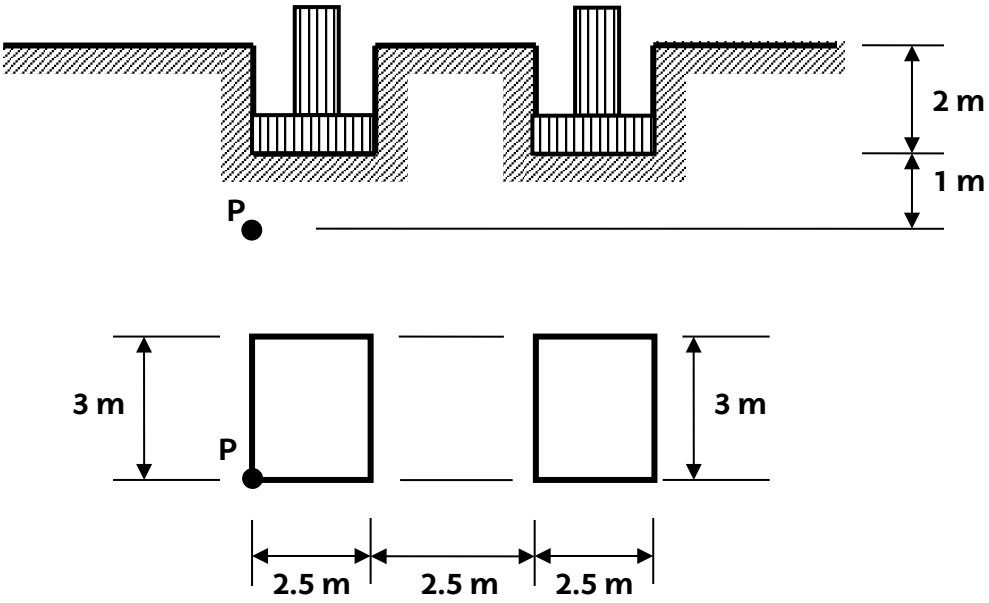


Answer: $\Delta\sigma_v$ = **8.96 kN/m^2**.

EXERCISE 4

Two rectangular footings (see figure) carry the following uniform loads: left footing q_L = 115 kN/m^2; right footing: q_R = 135 kN/m^2. Calculate the vertical stress increment at point P, taking into account both footings.

Additional data: unit weight of soil = 17.5 kN/m^3.

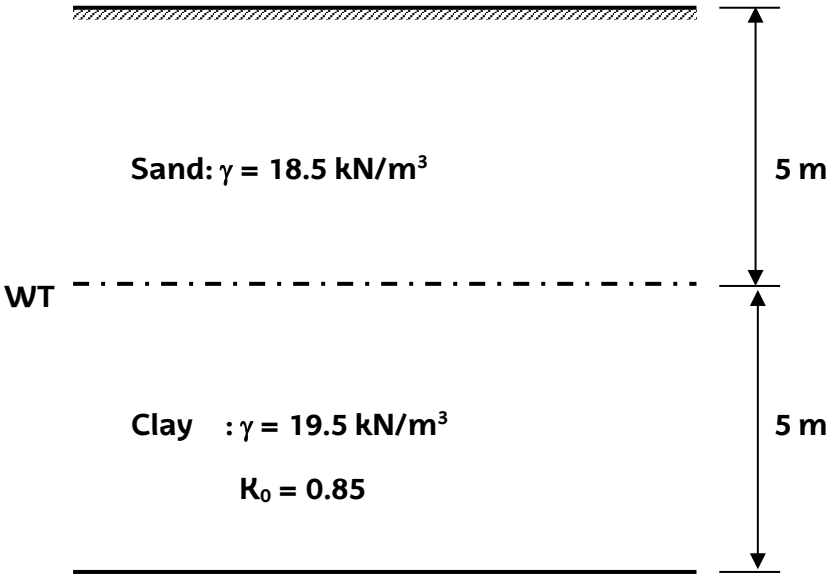


Answer: $\Delta\sigma_v$ = **19.41 kN/m^2**.

EXERCISE 5

A building is to be constructed in an area where the ground surface is horizontal. The foundation of this building, a square mat footing 18 m long, will be placed onto the soil surface and will carry a uniform load of 125 kN/m^2. For any point located at the middle plane of the clay layer just below the centre of any side of the foundation, determine:

1) Total vertical stress, pore water pressure, effective vertical stress, effective horizontal stress and total horizontal stress, at the pre-construction phase.
2) Mohr circles of total and effective stresses.
3) Total vertical stress at the post-construction phase.



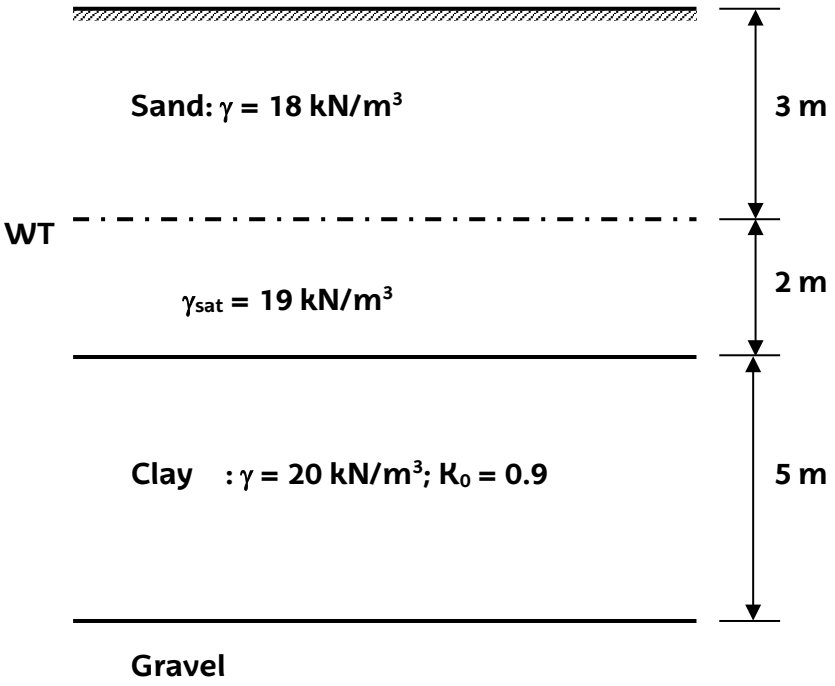
Answers:

1) σ_v = 141.25 kN/m^2; u = 24.5 kN/m^2; σ'_v = 116.75 kN/m^2; σ'_H = 99.24 kN/m^2; σ_H = 123.74 kN/m^2; 3) σ_v = 194.75 kN/m^2.

EXERCISE 6

A building is to be constructed in an area where the ground surface is horizontal. A mat foundation located 1 m below the ground surface will be used to transfer the building load uniformly. The mat footing will be 15 m wide and 20 m long and it is assumed that it will carry a load of 30.000 kN. For a point located at the middle plane of the clay layer just below the centre of the footing, determine:

1) Total vertical stress, pore water pressure, effective vertical stress, effective horizontal stress and total horizontal stress at the pre-construction phase.
2) Mohr circles of total and effective stresses.
3) Total vertical stress at the post-construction phase.



Answers:

1) σ_v = 142 kN/m²; u = 44.1 kN/m²; σ'_v = 97.9 kN/m²; σ'_H = 88.11 kN/m²; σ_H = 132.21 kN/m². **3)** σ_v = 208.91 kN/m².

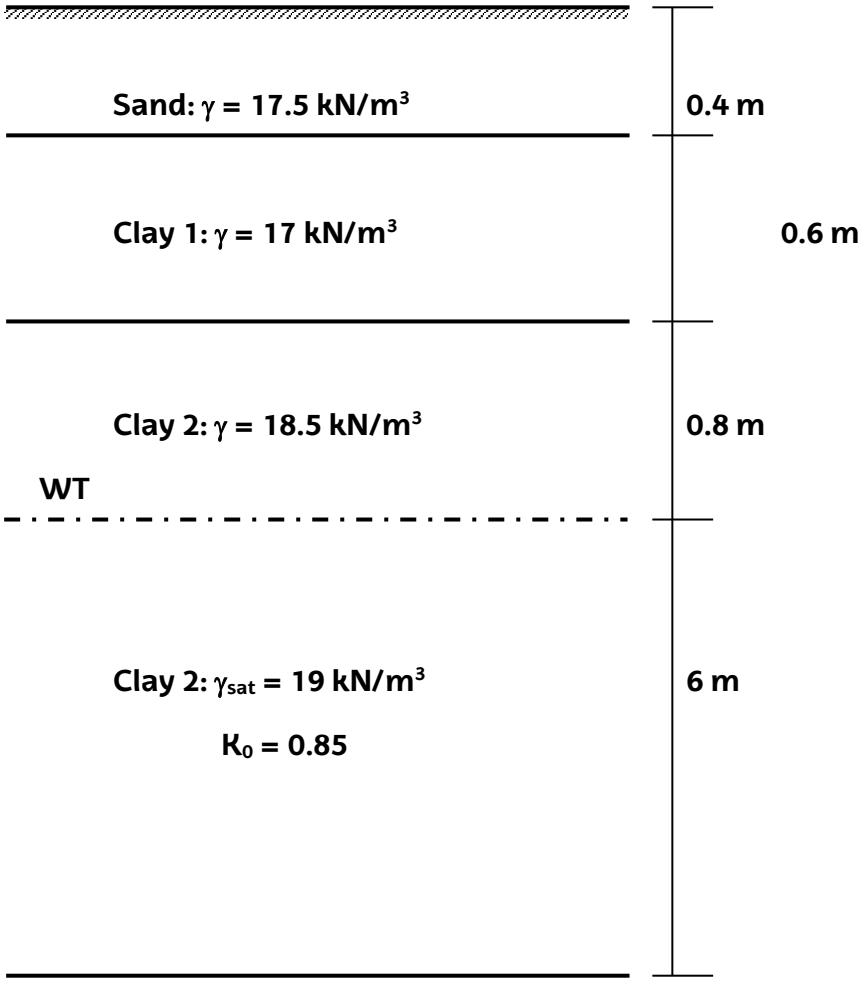
EXERCISE 7

A civil engineering project is to be constructed in an area where the ground surface is horizontal (see figure). A rectangular foundation located 3 m below the ground surface will be used to transfer the construction load uniformly.

1) At the pre-construction phase, calculate and plot Mohr circles of total and effective stresses at any point of the soil mass 3 m below the ground surface.

Assuming that a 3 m by 3.4 m rectangular foundation will carry a uniform load of 115 kN/m^2, determine, at the post-construction phase:

2) Total vertical stress at points 0 m and 1 m below the centre of the foundation.



Answers:

1) σ_v = 54.8 kN/m^2; u = 11.76 kN/m^2; σ'_v = 43.04 kN/m^2; σ'_H = 36.58 kN/m^2; σ_H = 48.34 kN/m^2. 2) σ_v (0 m) = 115 kN/m^2; σ_v (1 m) = 126.78 kN/m^2.