OCW

Universidad del País Vasco Euskal Herriko Unibertsitatea

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FUNDAMENTALS OF GEOTECHNICAL ENGINEERING

ASSIGNMENTS

LESSON 5
SETTLEMENT ANALYSIS

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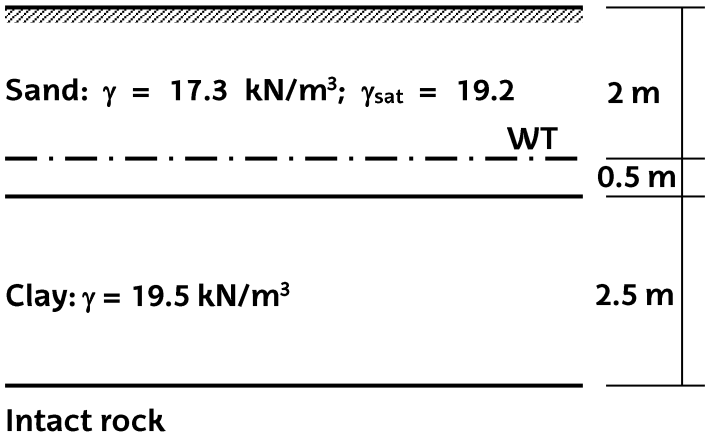
EXERCISE 1

The figure below shows the soil profile at a construction site. A foundation is to be constructed 0.5 m below the ground surface using rectangular footings 1.5 m by 1.75 m. These footings will carry a uniform load of 200 kN/m^2.

Calculate the total settlement of the layer of sand, taking into consideration that the average number of blows in the SPT within the depth of influence of the footing is N_{avg} = 12.



Answer: s = 21.62 mm.

EXERCISE 2

A planned construction site lies on a deposit of sand having a thickness greater than 12 m. There, a square mat footing 10 m long is to be constructed. This foundation will be located 1 m below the ground surface and will carry a uniform load of 100 kN/m^2.

The bulk unit weight of sand is 20 kN/m^3 and the water table is located 7 m below the ground surface.

The average number of blows in the SPT along the stratum was 20.

Determine:

1. Immediate settlement of the foundation, using the Burland and Burbidge's method.
2. Total settlement.
3. Is that settlement allowable?

Answers: s_i = 11.12 mm; s = 16.68 mm.

EXERCISE 3

A square footing 3 m long is located 1.5 m below the ground surface. This foundation rests on a 10-m stratum of sand, which lies over a gravel stratum.

The bulk unit weight of sand is 18.3 kN/m^3 and the water table is well below the depth of influence of the foundation.

The average number of blows in the SPT along the sand stratum was 15.

Determine the maximum uniform load "q" that the foundation can carry so that the total settlement is less than 25 mm.

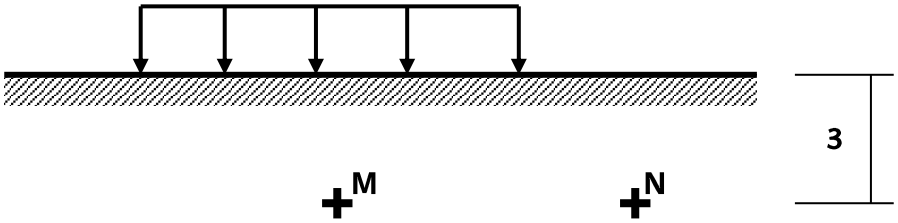
Answer: q_{max} = 219.46 kN/m^2

EXERCISE 4

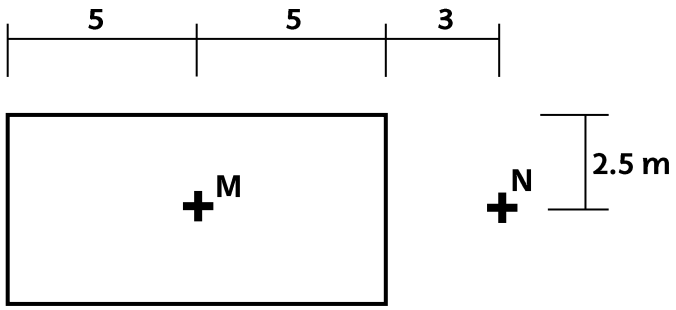
A building is to be constructed in an area where the ground surface is horizontal. The foundation of this building, 5 m by 10 m, will be placed on the soil surface and will carry a uniform load of 150 kN/m^2. Subsurface sampling indicates that the ground is constituted by a thick silty clay stratum.

1. Calculate total vertical stress increments due to the construction at points M and N (see figure), both at a depth of 3 m.
2. If the undrained elastic modulus is 8000 kN/m^2, calculate the immediate settlement under the centre of the foundation. Interpret the result.

(ELEVATION)



(PLAN)



Answers: $\Delta\sigma_M$ = 108.6 kN/m^2; $\Delta\sigma_N$ = 7.8 kN/m^2; s_i = 107.58 mm.

EXERCISE 5

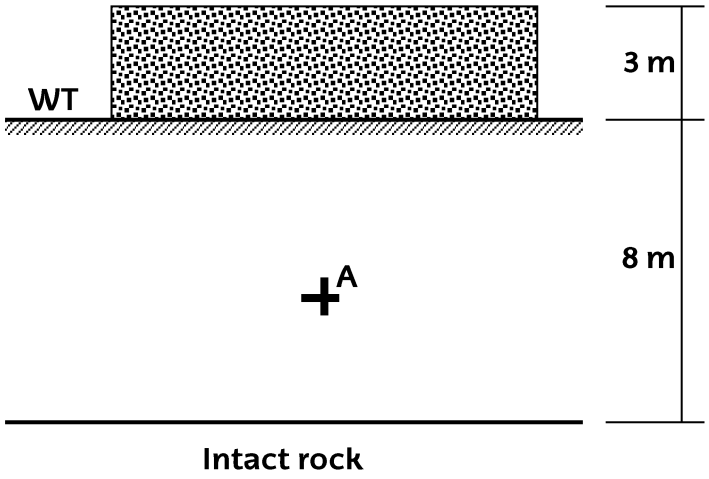
A fill material 3 m high (H_R) is to be located on the ground surface in a rectangular area 50 m wide and 100 m long. Water table is also at the ground surface. This material has a unit weight γ_R of 20 kN/m^3.

Previously, at point A (see figure), located below the centre of the fill material, an undisturbed soil sample has been extracted and taken to the laboratory. There, different tests have provided the following data:

- Unit weight $\gamma = \gamma_{sat} = 19$ kN/m^3.
- $E_u = 10$ MPa.

Also, those tests showed that the soil was clay.

Calculate the immediate settlement under the centre of the fill material.



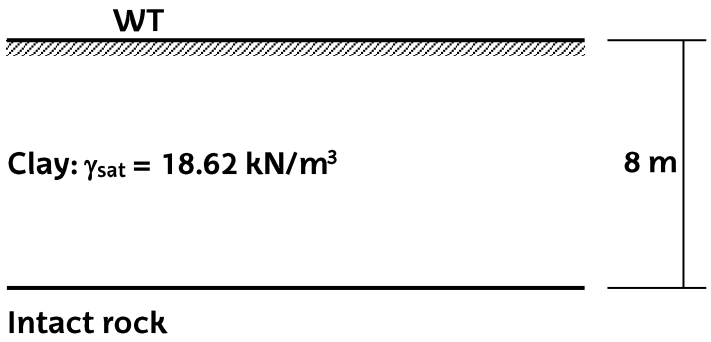
Answer: $s_i = 11.6$ mm.

EXERCISE 6

The figure below shows the soil profile at a construction site where the water table is at the ground surface. A foundation is to be constructed at a depth of 2 m using square footings (flexible type) 4 m by 4 m. These footings will carry a uniform load of 120 kN/m^2.

In the geotechnical survey, an undisturbed soil simple was taken at a depth of 5 m. After completing several tests in the laboratory, the following parameter was obtained: E_u = 12000 kN/m^2.

Calculate the immediate settlement under the centre of the footing.



Answer: s_i = 21.6 mm.

EXERCISE 7

The figure in the next page shows a soil profile where a two-floor isostatic steel structure is to be constructed. The foundation will be located 3.5 m below the ground surface using square footings (flexible type). Also, the figure shows the relative position between the two closest footings. Footing 1 imposes at the surface of the soil a load F_1 of 1350 kN, while footing 2 a load F_2 of 1125 kN, and due to constructive requirements the widths of both foundations are different, B_1 = 3.5 m and B_2 = 3.0 m.

1. At points 1 m below the centre of each footing, explain reasonably what point will have the greater total vertical stress at the post-construction state. In this section and also in the following section, only the effect of one footing over the soil below it will be taken into consideration.
2. At that chosen point, calculate the total vertical stress.
3. Verify that allowable settlements are satisfied.

Additional data:

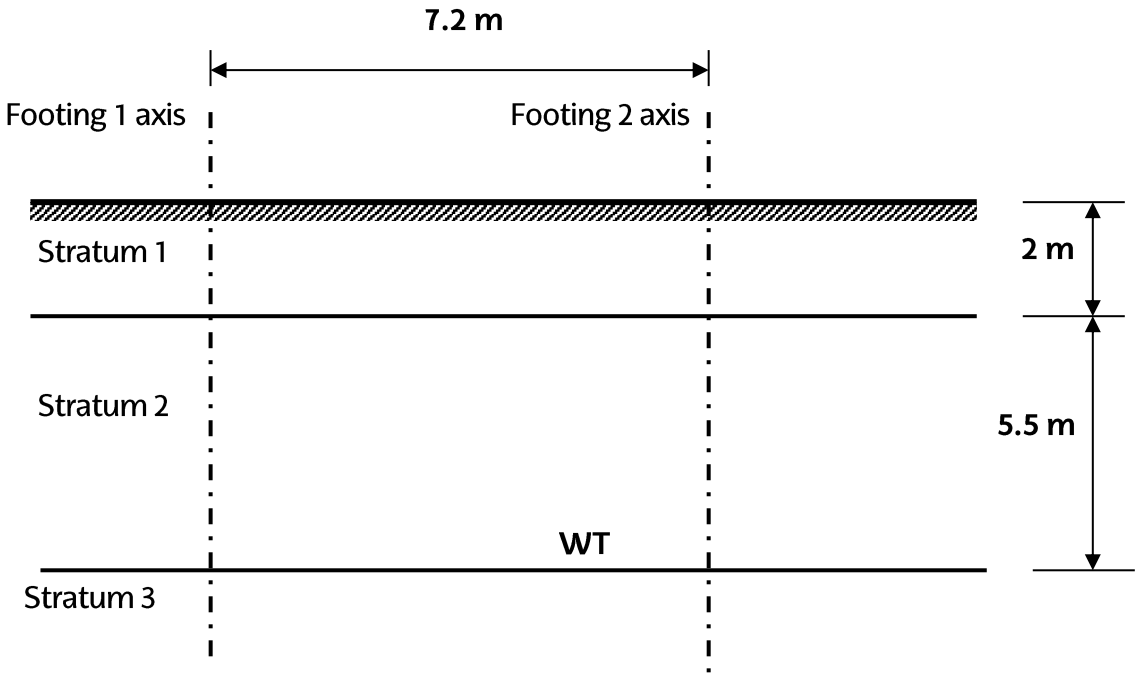
Stratum 1: Artificial ground. Bulk unit weight: 17.5 kN/m^3. Average number of blows in SPT = 10.

Stratum 2: Sand. Bulk unit weight: 17 kN/m^3. Average number of blows in SPT = 10.

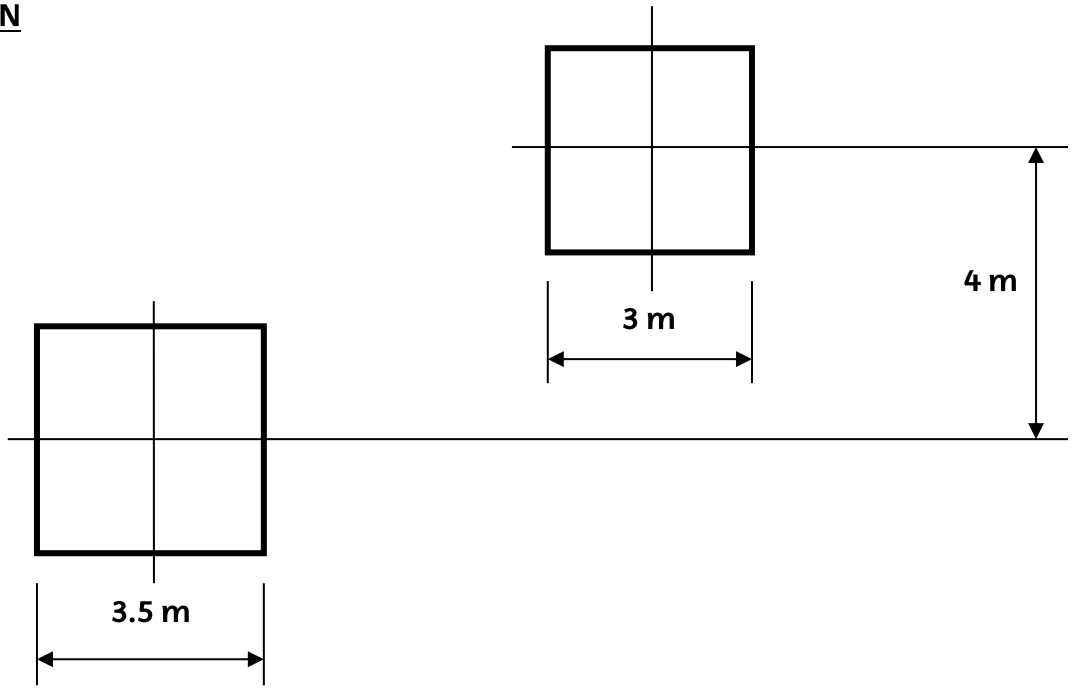
Stratum 3: Clay. Bulk unit weight: 16 kN/m^3. Average number of blows in SPT = 5. Undrained elastic modulus, E_u = 10 MPa.

Answers 2 and 3: σ_{vF} = 132.92 kN/m^2; Satisfied.

ELEVATION



PLAN



EXERCISE 8

The piers of a viaduct rest on 5 m by 10 m rectangular footings (flexible type) on the ground surface. The viaduct crosses two areas, and the characteristics of soils in each area are indicated in the following:

Area 1. Poorly-graded sand (SP) having coarse and medium sand particles.

Bulk unit weight: 18 kN/m^3.

Average number of blows in SPT: 16.

Elastic modulus: 10 MN/m^2.

Area 2. Fat clay (CH).

Bulk unit weight: 19 kN/m^3.

Average number of blows in SPT: 15.

Undrained elastic modulus: 20 MN/m^2.

In both soils, the water table is at the ground surface, and the layer of fresh rock is at a depth of 4 m.

1) Determine the maximum load q_{max} that footings can impose, valid in both areas, taking into consideration the allowable settlements. In the clay stratum, it will be assumed that immediate settlement is 1/3 of total settlement.

2) In clay stratum, if load q is 80 kN/m^2, determine the total vertical stress at a point 0.5 m below the ground surface and located beneath the centre of the footing, at the post-construction state.

In addition and taking into account the consolidation process, determine the pore water pressure and the effective vertical stress:

a) Just after the end of the construction process.

b) After many years have passed.

Answers:

1) q_{max} = 94.96 kN/m^2.

2) a) u = 84.58 kN/m^2, σ'_{v0} = 4.60 kN/m^2; b) u = 4.90 kN/m^2, σ'_{v0} = 84.28 kN/m^2