[OCD013]

UNIVERSITY OF BOLTON

OFF CAMPUS DIVISION

WESTERN INTERNATIONAL COLLEGE FZE

BENG(HONS) CIVIL ENGINEERING

TRIMESTER ONE EXAMINATION 2021/2022

GEOTECHNICAL ENGINEERING AND GROUND IMPROVEMENT

MODULE NO: CIE6003

Date: Thursday 13th January 2022 **Time: 10:00 – 13:00**

INSTRUCTIONS TO CANDIDATES:

There are FIVE questions on this paper.

Answer ANY FOUR questions.

All questions carry equal marks.

Marks for parts of questions are shown in brackets.

This examination paper carries a total of 100 marks.

Formula sheet / supplementary information is provided at the end of question paper.

All working must be shown. A numerical solution to a question obtained by programming an electronic calculator will not be accepted.

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Q1

a) A 400 mm diameter concrete pile is driven for a10.00 m into layered soils and the details are as follows:

Loose sand	2.50m thick	(γ=16.0 kN/m^3; N = 18)
Dense sand	2.0m thick	(γ = 18.0 kN/m^3; N = 21)
Compact Sand	10.0m thick	(γ_{sat} = 19.0 kN/m^3; N = 33)

The water table is at 4.50m from ground level. Determine the safe working load of this pile by adopting factors of safety of 1.50 and 2.50 for the shaft and end bearing resistance respectively.

Use **Figures Q1-1, Q1-2, Q1-3** and the formulae provided on page 12.

(18 marks)

b) In the above scenario if the pile is constructed as a bored and cast-in-situ pile, how will that affect the pile capacity? Estimate the pile load capacity and illustrate your answer with the help of equations if all the other data remain the same.

NOTE: Clearly state any assumptions made in your calculations

(7 marks)

Q1 continues over the page…

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Q1 continued…

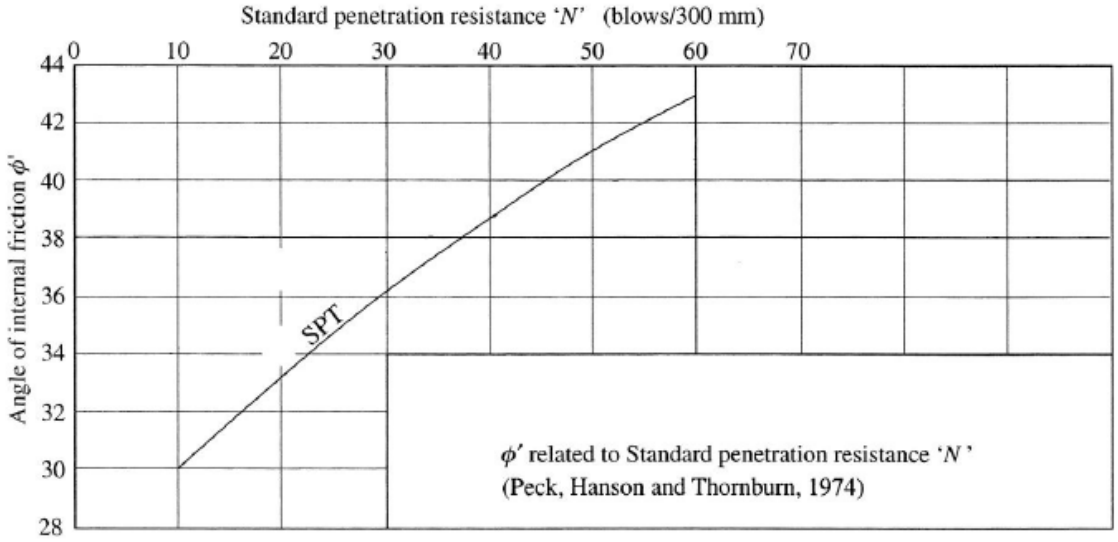

Figure Q1-1

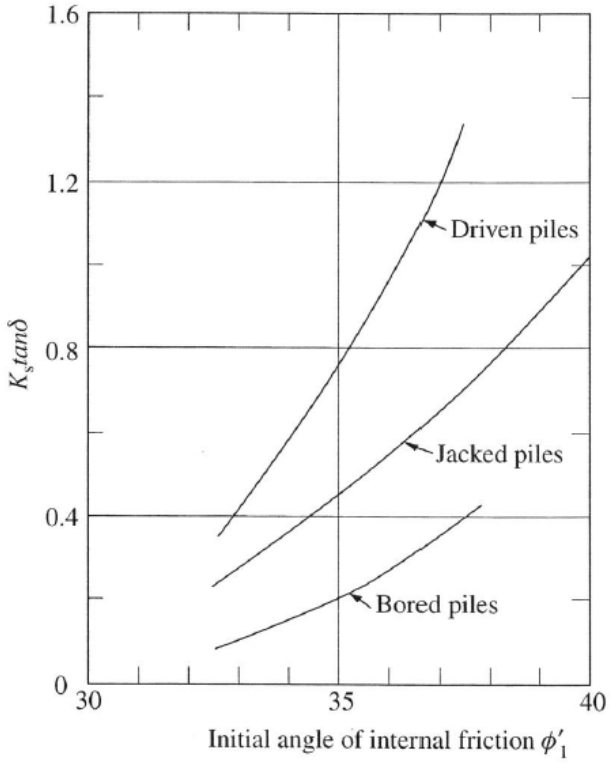

Figure Q1-2

Q1 continues over the page…

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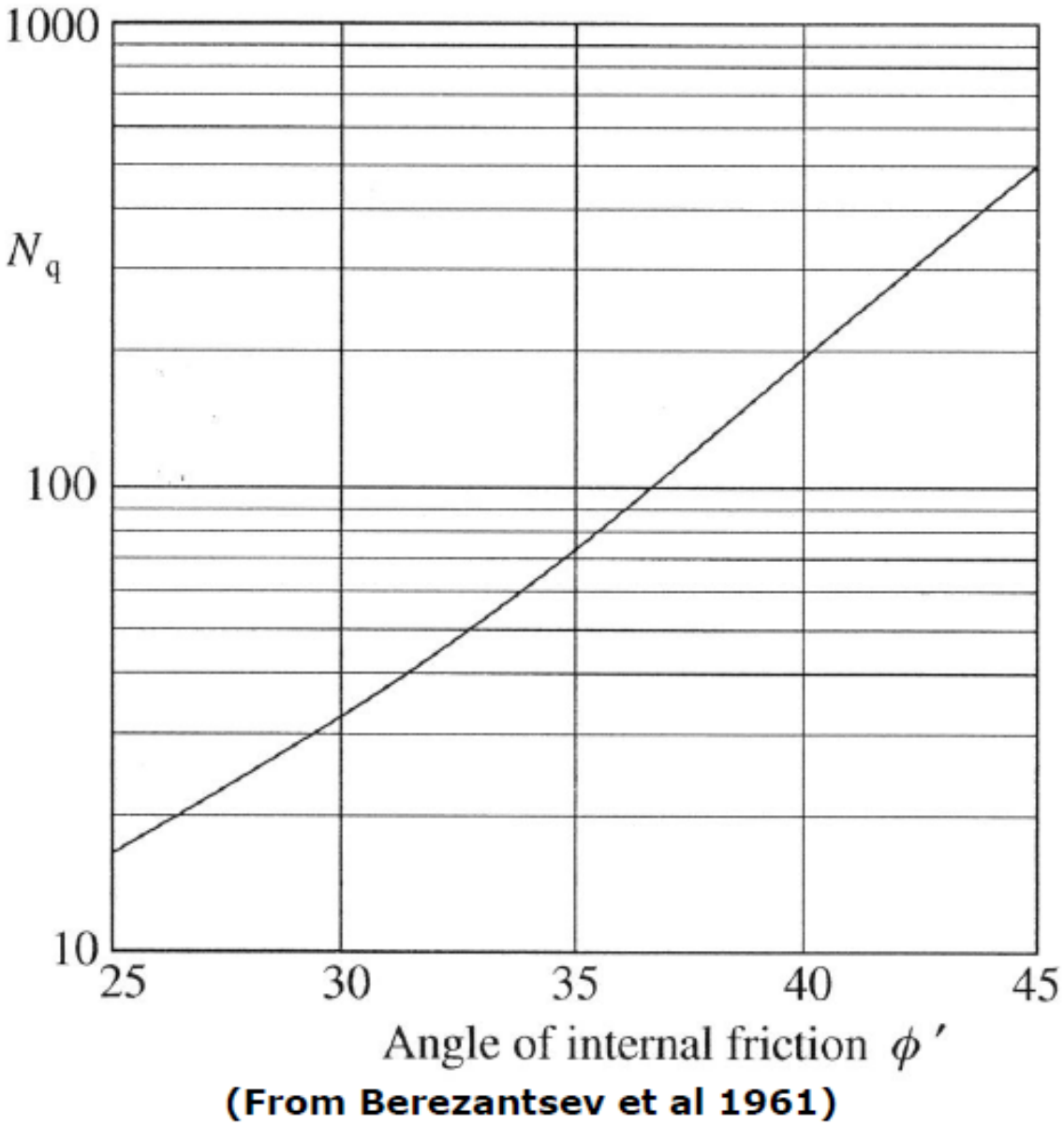
Q1 continued…



(From Berezantsev et al 1961)

Figure Q1-3

Total 25 marks

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Q2

A wide cutting with side slopes of 30^0 is excavated in saturated clay to a vertical depth(H) 10.0m as shown in **Figure Q2-1**. Soil properties are as follows:

Unit weight, γ = 22.5 kN/m^3

Undrained cohesion, c_u = 45.0 kN/m^2

Undrained angle of friction, φ = 0°

a) Determine the factor of safety, F, against the short-term failure by rotational analysis of the trial circle shown in **Figure Q2-1**. Assume that a water filled tension crack is present near the crest of slope.

Details of the trial sector are as follows:

Radius, R	= 17.3m
Sector angle, θ_c	= 67.4°
Area of slipped mass	= 71.6 m^2
Lever arm, d	= 5.90 m
y_c	= 8.2 m

(12marks)

b) Estimate the factor of safety against failure for the above slope using the Taylor's stability chart shown in **Figure. Q2-2** assuming bedrock is at depth of 2.0m beneath the toe of the slope.

(8 marks)

c) Provide a brief explanation of any differences in the factors of safety obtained by the analyses in parts a) and b) above.

(5 marks)

Total 25 marks

Q2 Figure Q2-1 & Q2-2 shown over the page….

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Q2 continued…

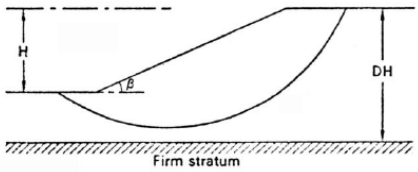

Figure Q2-1 Trial Slip Circle

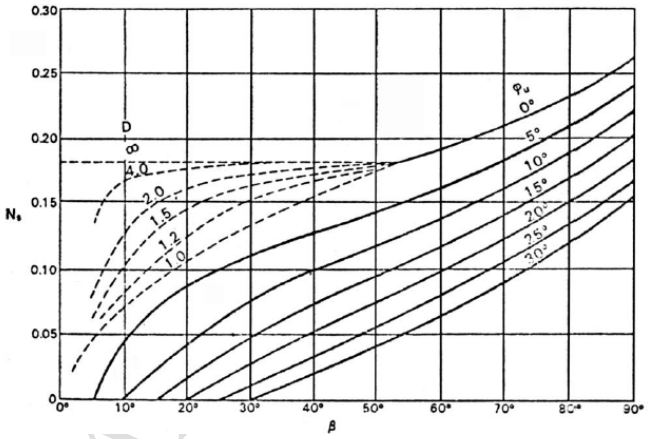

Figure Q2-2 Taylor's Chart

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Q3

a) The following results were obtained from an odometer test on a specimen of saturated clay. Assume specific gravity Gs = 2.7. The stress is increased from 250 to 500 KN/m^2 and maintained for 24 hours and it had been observed that the thickness decreased from 19.20mm to 18.84mm. The water content was found to be 25% and thickness was 18.98mm after the stress was completely removed and the sample was allowed to swell for 24hours. Calculate

   i) The void ratio at 250KN/m^2 and 500KN/m^2

   ii) The co-efficient of compressibility m_v for this stress stage

(10 marks)

b) Compare and contrast modes of failure in

   i) Moderately compressible soil

   ii) Highly compressible soil

(5 marks)

c) Determine the width of the foundation for a strip foundation is required to support a load of 600KN/m run at a depth of 1.2m in a soil with the following properties;

   γ =18.0 KN/m^3

   C =15.0 KN/m^3

   Φ = 32°

   Use Factor of safety of 3 against bearing capacity failure (net allowable or safe bearing capacity)

(10 marks)

NOTE: Clearly state any assumptions made in your calculations to determine the safe bearing capacity. Use **Table Q3** and the formulae provided on page 8.

Total 25 marks

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Table Q3

ϕ	N_c	N_q	N_γ
0	5.14	1.0	0
1	5.4	1.1	0
2	5.6	1.2	0
3	5.9	1.3	0
4	6.2	1.4	0
5	6.5	1.6	0.1
6	6.8	1.7	0.1
7	7.2	1.9	0.2
8	7.5	2.1	0.2
9	7.9	2.3	0.3
10	8.4	2.5	0.4
11	8.8	2.7	0.5
12	9.3	3.0	0.6
13	9.8	3.3	0.8
14	10.4	3.6	1.0
15	11.0	3.9	1.2
16	11.6	4.3	1.4
17	12.3	4.8	1.7
18	13.1	5.3	2.1
19	13.9	5.8	2.5
20	14.8	6.4	3.0
21	15.8	7.1	3.5
22	16.9	7.8	4.1
23	18.1	8.7	4.9
24	19.3	9.6	5.7
25	20.7	10.7	6.8
26	22.3	11.9	7.9
27	23.9	13.2	9.3
28	25.8	14.7	10.9
29	27.9	16.4	12.8
30	30.1	18.4	15.1
31	32.7	20.6	17.7
32	35.5	23.2	20.8
33	38.6	26.1	24.4
34	42.2	29.4	28.8
35	46.1	33.3	33.9
36	50.6	37.8	40.0
37	55.6	42.9	47.4
38	61.4	48.9	56.2
39	67.9	56.0	66.8
40	75.3	64.2	79.5

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Q 4

a) Draw a neatly constructed graph (on graph paper provided) to show the stress distribution with depth below ground level of

   i) Total stress

ii) Pore water Pressure

iii) Effective stress

for the ground condition shown below in **Figure Q4-1**

(12 marks)

b) List out the assumptions made in Terzaghi's bearing capacity theory comment on the validity of each.

(5 marks)

c) A square foundation (4.5m x 4.5m) is found at 2.4m in a soil with the following properties:

$\gamma = 17.6\ KN/m^3$

$\gamma_{sat} = 20.4\ KN/m^3$

$C = 32.0.KN/m^3$

$\Phi = 28^o$

Using a factor of safety of 3 against bearing capacity failure, determine the net allowable or safe bearing capacity in kN/m^2 when the water table is level with the foundation base.

(8 marks)

NOTE: Clearly state any assumptions made in your calculations to determine the safe bearing capacity. Use **Table Q3** (on page 8) and the formulae provided on page 12.

Total 25 marks

Q4 Figure Q4-1 shown over the page…
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Q4 continued …

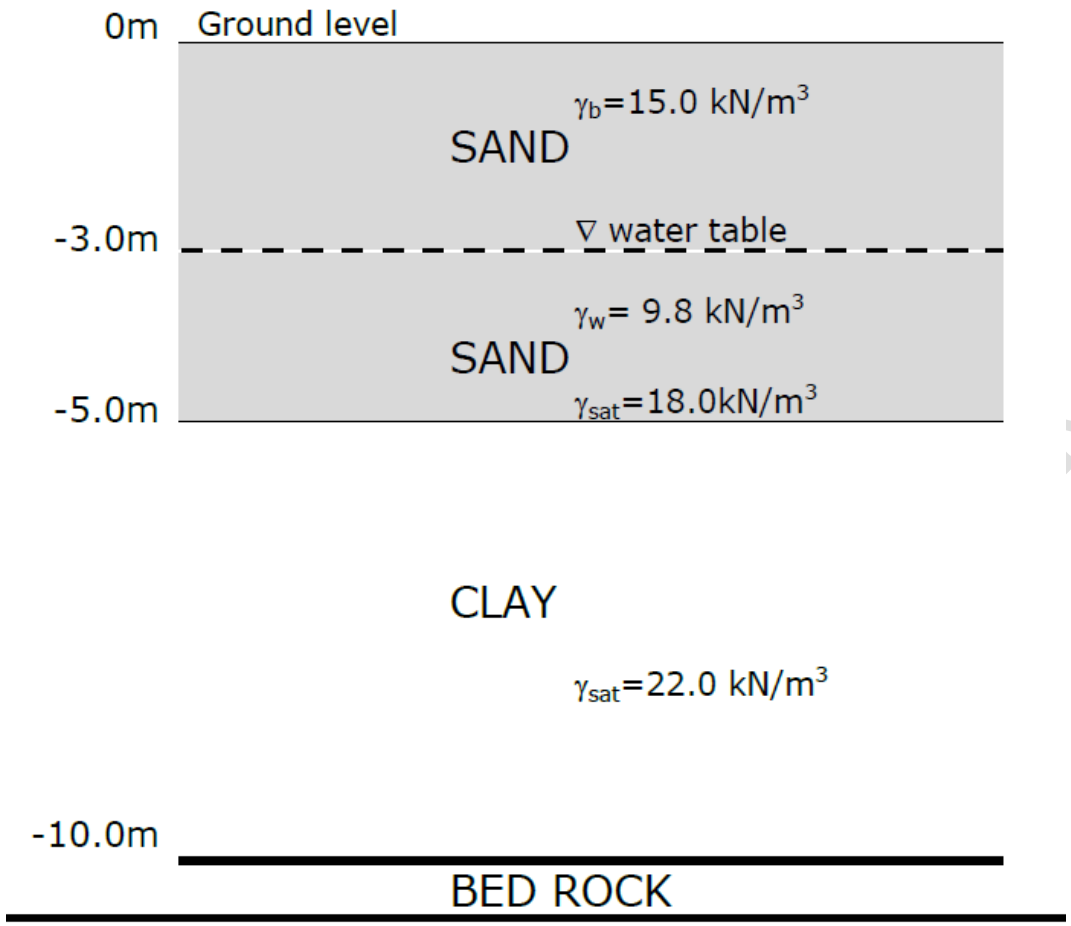

Figure Q4-1 Ground Conditions

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Q5.

Figure Q5 shows a 5.0 m high gravity retaining wall with relevant material properties.

a) Sketch the earth pressure diagram for the retained soil, labelling all relevant values. **(6 marks)**

b) Determine the active pressure on the concrete retaining wall and the height of the resultant thrust above the base of the retaining wall. State any assumption you have made.

(14 marks)

c) Evaluate the advantages and disadvantages of using an embedded retaining wall instead of a gravity retaining wall? Ensure that your answer discusses construction practicality as well as technical aspects concerning the development of earth pressures on either side of the embedded wall.

(5 marks)

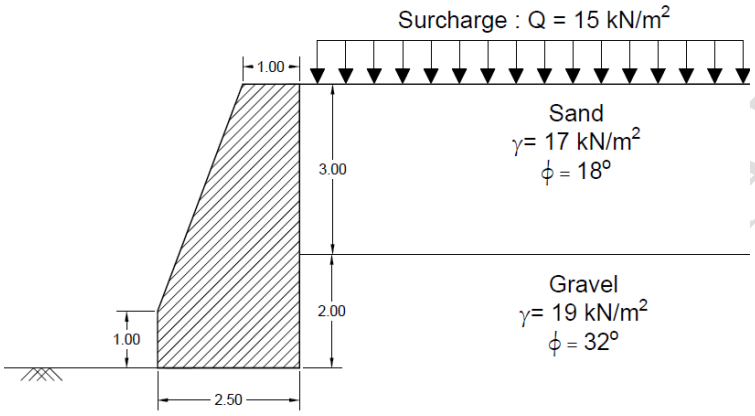

Figure Q5

Total 25 Marks

END OF QUESTIONS

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Supplementary Geotechnical Information

Consolidation:

$\Delta H = m_v \Delta\sigma' H_o$

$$m_v = \frac{\Delta e}{(1 + e_o)} \times \frac{1}{\Delta\sigma'}$$

Shallow Foundations:

C,ϕ soils:

Terzaghi's equation: $q_u = CN_cS_c + \gamma DN_qS_q + 0.5\gamma BN_\gamma S_\gamma$

$$q_{net\ safe} = \frac{q_u - \gamma D}{F} + \gamma D$$

$\gamma_{sub} = \gamma_{sat} - \gamma_w$, *when water table is affecting bearing capacity*

Shape of footing	S_C	S_q	Sr
Strip	1.0	1.0	1.0
Rectangle	$1.0 + (B/L)(N_q/N_c)$	$1.0 + (B/L)\tan\phi'$	$1.0 - (B/L)\ 0.4$
Circle or Square	$1.0 + (N_q/N_c)$	$1.0 + \tan\phi'$	0.6

Earth Pressure: $k_a = \dfrac{1-\sin\phi}{1+\sin\phi}$

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Pile Foundations,

$$Q_u = Q_s + Q_b$$

$$For\ Cohesive\ soils,\quad Q_b = C_u N_c A_b\ ,\quad Q_s = \alpha.\bar{C_u}\ A_s$$

$$For\ cohesionless\ soils,\quad Q_b = N_q.\sigma_v'.A_b,\quad Q_s = K_s.\tan\delta.\bar{\sigma_v}.A_s$$

$$\sigma_v = \gamma.D$$

Slope Stability,

$$F = \frac{C_u R^2 \theta_{c(rad)}}{W_t.D_t + 0.5\gamma_w {Z_c}^2.y_c}$$

$$Z_c = \frac{2C_u}{\gamma}$$

$$Stability\ Number, Ns = \frac{Cu}{F\gamma H}.$$

F

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