UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2022/2023

COURSE NAME	:	ENGINEERING GEOLOGY
COURSE CODE	:	BFC 21303
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY/ AUGUST 2023
DURATION	:	3 HOURS
INSTRUCTIONS	1.	ANSWER ALL QUESTIONS
	2.	THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.**
	3.	STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

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Q1   A highway was constructed across the hilly area and cut slope has through a granite rock formation at 90 m height . The rock slope face cutting in the dip direction of 350° and dip angle 70°. The discontinuity mapping and rock testing were conducted to obtain the discontinuity sets, slope geometry, and rock parameters as summarized in **Table Q1**.

(a)   Analyse the entire rock slope failure modes using **Figure Q1(a)** with its criterion based on **Table Q1(a)**.

(6 marks)

(b)   Calculate the factor of safety for the planar failure mode using the formula in **Figure Q1(b)** when the tension crack is completely filled with water. Then, if the analysis factor of safety less is than 1.5, stabilize the rock slope to the factor of safety 1.5.

(6 marks)

(c)   Calculate the factor of safety for wedge failure mode using the formula in **Figure Q1(c)** when the tension crack is completely filled with water.

(8 marks)

(d)   Recommend a new rock slope geometry either on the dip angle or dip direction in order to avoid any potential rock slope failure modes and predict the consequences of the recommendation.

(5 marks)

Q2   (a)   Discuss **THREE (3)** in-direct testing methods for evaluating the rock strength.

(5 marks)

(b)   The Malaysia geological map shows the rock stratigraphy distribution across Malaysia. Explain **THREE (3)** benefits obtained from this map for the purpose of the site investigation work.

(5 marks)

(c)   One borehole was drilled at the Bukit Perdana Batu Pahat site denoted as BH1 as shown in **Figure Q2(c)**. Rock coring at the length of 1500 mm. Calculate the rock quality designation, the total core recovery, and the solid core recovery.

(5 marks)

(d)   Explain the other method to obtain rock quality designation if no borehole data is provided.

(5 marks)

(e)   Explain the parameters adopted in the rock mass rating (RMR).

(5 marks)

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Q3 (a) Explain the statement that the foliation and force directional angle affect the rock strength.

(5 marks)

(b) Explain the differences between weathering grades 3 and 4 via referring to the typical weathering of sedimentary rock.

(5 marks)

(c) Soil and surficial deposits can be either residual or transported in origin. Discuss the characteristics of residual soil and alluvium.

(5 marks)

(d) Discuss the types of faults and how its influence the ground stability.

(5 marks)

(e) Explain the reason granite bedrock in tropical countries is relatively much deeper than in desert countries.

(5 marks)

Q4 (a) Discuss **THREE (3)** types of plate boundaries that slowly moving relatively apart.

(5 marks)

(b) Granite rock consists of minerals of quartz, feldspar and mica, meanwhile marble is made of calcite. Discuss the importance to know mineral types and understand Moh's scale of mineral hardness for the purposes of underground excavation.

(5 marks)

(c) Igneous rock textures are controlled by the process of magma solidification. Discuss the element of textures that are adopted from igneous classification.

(5 marks)

(d) There are many types of clastic sedimentary rock that exist on Earth planet. Explain how the classification of the clastic sedimentary rocks is made.

(5 marks)

(e) Explain the grades classification of the foliated regional metamorphism rock if the parent rock is shale.

(5 marks)

- END OF QUESTIONS -

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Table Q1: Parameter of granite rock slope

Parameters	Values
Joint set 1 (dip direction/dip angle)	002°/50°
Joint set 2 (dip direction/dip angle)	164°/74°
Joint set 3 (dip direction/dip angle)	90°/70°
Joint set 4 (dip direction/dip angle)	340°/10°
Slope face dip direction	350°
Slope face angle (slope angle)	70°
Upper slope face dip direction	350°
Upper slope face angle	0°
Height of slope / wedge	90 m
Unit weight of the rock	25 kN/m^3
Depth of tension crack	3 m
Unit weight of water	9.81 kN/m^3
The cohesion of all discontinuities	150 kPa
Friction angle for all discontinuities	30°
Inclined angle of anchor $(\Omega) = (\psi_T)$	30°
Bars for Y25	10 ton = 100 kN

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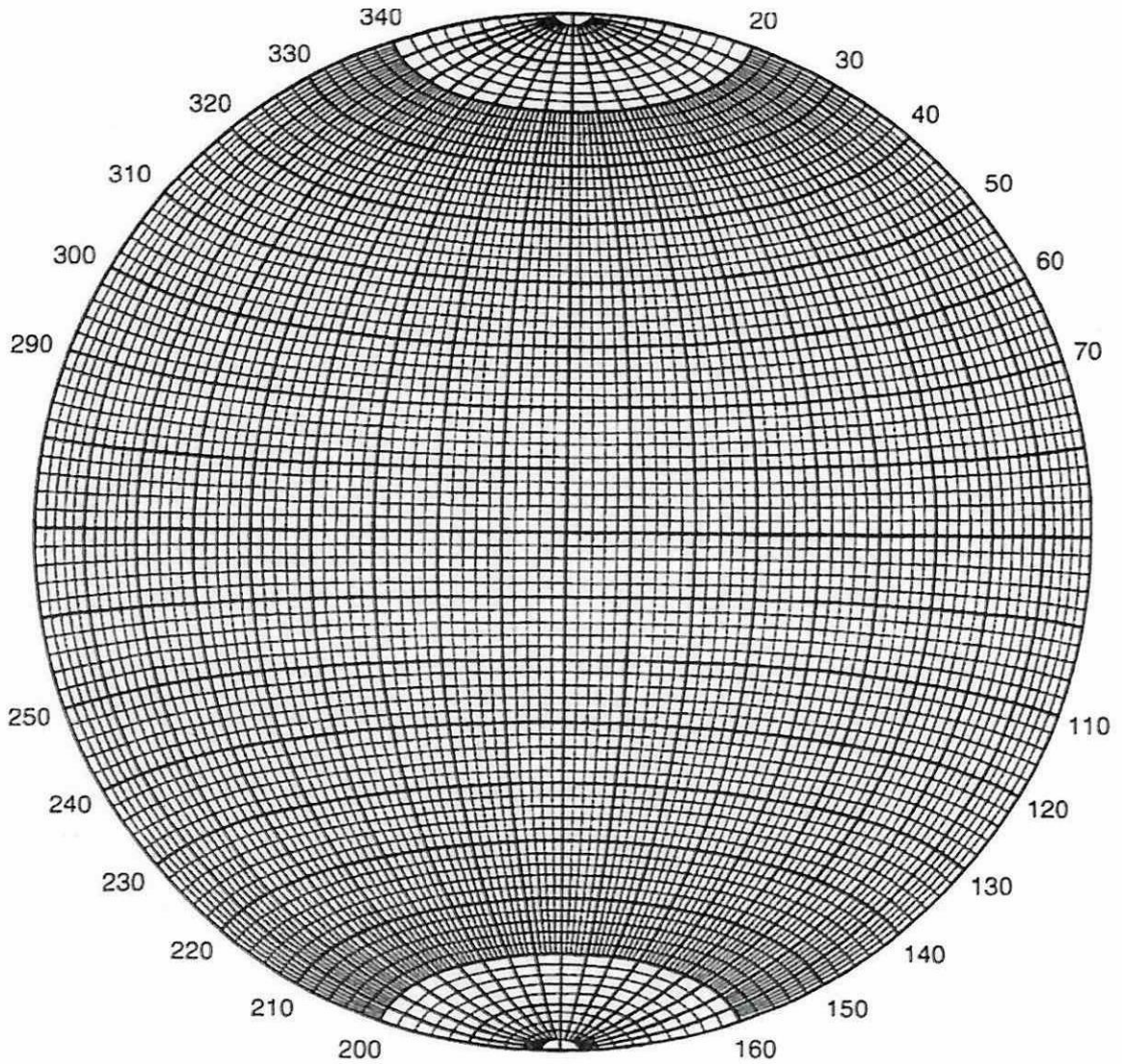
Figure Q1(a): Equatorial equal-area stereo-net marked in 2° intervals

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Table Q1(a): Parameter of granite rock slope

Modes of failure	Criteria are met
Circular	i. Very weak material, highly jointed or fractured or weak soil ii. Homogenous soil
Planar	i. The dip direction of the joint must be laid within $\pm 20^0$ from the slope dip direction. ii. $\psi_f > \psi_p > \phi$ (slope angle> plane angle > friction angle) iii. Release surfaces must be present to define the lateral boundaries of the slide.
Wedge	i. $\psi_f > \psi_i > \phi$ (slope angle > the intersection angle of 2 joints > friction angle)
Toppling	i. The dip direction of the joint must be laid between $\pm 10°$ in the opposite direction of the slope dip direction. ii. $(90^0 - \psi_f) + \phi \leq \psi_t$

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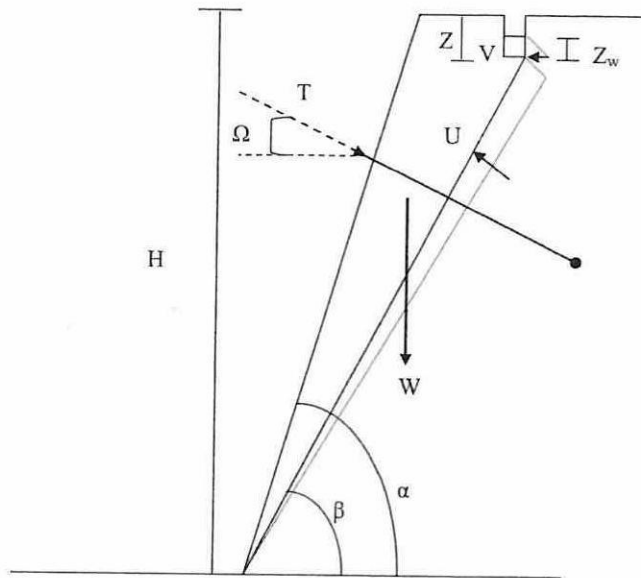
Given:

$$FOS = \frac{cA + (W\cos\beta - U - V\sin\beta + T\sin(\Omega+\beta))\tan\phi}{W\sin\beta + V\cos\beta - T\cos(\Omega+\beta)}$$

A= failure plane area ϕ = friction angle
c = cohesion   U = vertical water pressure
W = weight of failure block   V = horizontal water pressure
β =failure plane angle α = slope angle
H = height of plane   Z = tensional cracks
T = tension of anchor Ω = inclined angle of anchor
γ_r= unit weight of rock γ_w= unit weight of water
 A = (H-Z).cosec β

$$W = \tfrac{1}{2}\gamma_r H^2\left[\left(1-\left(\tfrac{Z}{H}\right)^2\right)\cot\beta - \cot\alpha\right]$$

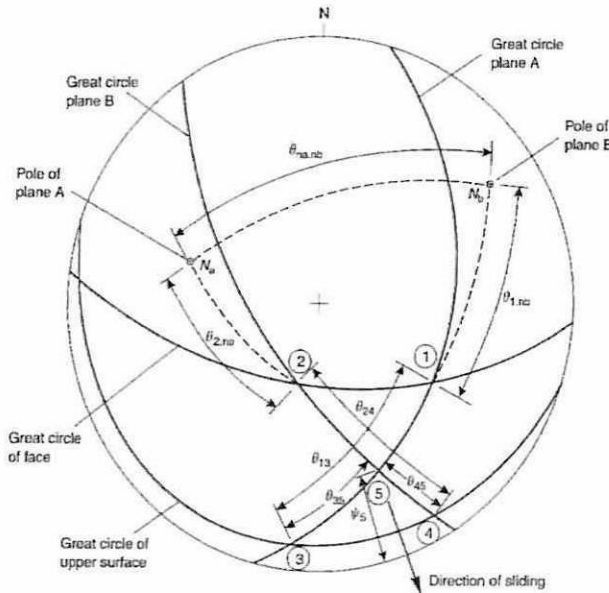U = ½ γ_w.Z_w .(H-Z).cosec β
V =½ γ_w.Z_w^2

$$\cosec\beta = \frac{1}{\sin\beta} \quad \sec\beta = \frac{1}{\cos\beta} \quad \cot\beta = \frac{1}{\tan\beta}$$

Figure Q1(b): Planar failure mode formula

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Given:

$$Fos = \frac{3}{\gamma H_t}(C_a.X + C_b.Y) + (A - \frac{\gamma_w}{2\gamma}.X)Tan\phi_a + (B - \frac{\gamma_w}{2\gamma}.Y)Tan\phi_b$$

C_a = Cohesion ϕ_b = Friction angle
H_t = height of wedge ψ_a = dip angle for plane a
ψ_b = dip angle for plane b ψ_5 = dip angle for wedge intersection
γ = unit weight of rock γ_w = unit weight of water

X, Y, A, B is factor which depend upon the geometry of wedge

$$X = \frac{Sin\theta_{24}}{Sin\theta_{45}Cos\theta_{2.na}} \qquad Y = \frac{Sin\theta_{13}}{Sin\theta_{35}Cos\theta_{1.nb}} \qquad A = \frac{Cos\psi_a - Cos\psi_b Cos\theta_{na.nb}}{Sin\psi_5.Sin^2\theta_{na.nb}}$$

$$B = \frac{Cos\psi_b - Cos\psi_a Cos\theta_{na.nb}}{Sin\psi_5.Sin^2\theta_{na.nb}}$$

Figure Q1(c): Wedge failure mode formula
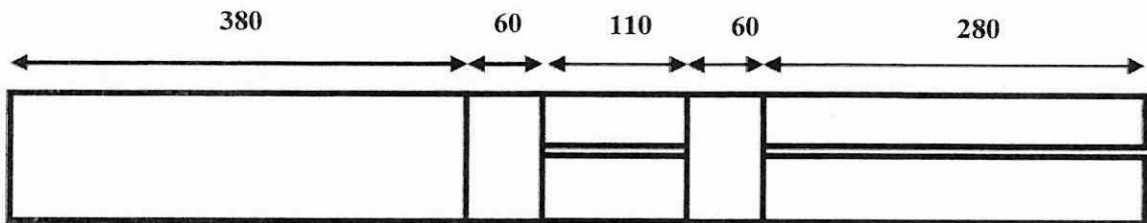
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All dimension in millimeter

Figure Q2(b): BH#1 at Bukit Perdana Batu Pahat site

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