Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2023/2024

COURSE NAME	:	ENGINEERING GEOLOGY
COURSE CODE	:	BFC 21303
PROGRAMME CODE	:	BFC
EXAMINATION DATE	:	JANUARY / FEBRUARY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ 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 **EIGHT (8)** PAGES.

Q1 The following questions pertain to topics related to the divisions of the Earth, the physical properties of minerals, and the categories of igneous, sedimentary, and metamorphic rocks.

(a) Discuss briefly **TWO (2)** types of crusts according to their physical and chemical properties.

(5 marks)

(b) Discuss briefly **TWO (2)** reasons why the color of a mineral cannot be solely relied upon for mineral identification.

(4 marks)

(c) Discuss **TWO (2)** elements of rock textures that are utilized in the classification of rocks, which are influenced by the solidification of magma either underground or on the Earth's surface.

(4 marks)

(d) Explain the process of lithification, which transforms unconsolidated sediments into sedimentary rock.

(6 marks)

(e) Explain **TWO (2)** types of metamorphism: regional metamorphism and dynamic metamorphism.

(6 marks)

Q2 The following questions pertain to topics related to the weathering issue and geological structures.

(a) Explain **THREE (3)** factors that influence the rate of weathering on exposed bedrock as it undergoes weathering by various agents.

(6 marks)

(b) Typical distinctive characteristics of weathering classification of granite rock based on visual and simple tests such as observation on their color, texture, reaction with water, and ability to break a rock piece by bare hand. Discuss briefly **THREE (3)** unique characteristics of weathering grade 3.

(6 marks)

(c) Discuss briefly **TWO (2)** unique characteristics of transported alluvium soil.

(4 marks)

(d) Discuss briefly **TWO (2)** factors that influence the deformation behavior of rocks.

(4 marks)

(e) Explain and provide sketches of **TWO (2)** types of fold structures in rock formation.

(5 marks)

Q3 The following questions pertain to topics related to the site investigation and rock test.

(a) At the Tangkak site, a single borehole labelled BH1 was drilled, and rock coring was conducted over a length of 1.5 meters. The rock core sample is presented in **Figure Q3.1.** Calculate the Rock Quality Designation (RQD), the total core recovery, and the solid core recovery.

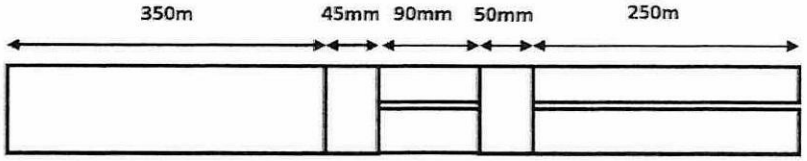


Figure Q3.1 BH1 at Tangkak site

(6 marks)

(b) Explain the procedure of using the volumetric method to determine Rock Quality Designation (RQD).

(5 marks)

(c) Explain the principle of the seismic refraction method used to determine the 2-dimensional subsurface seismic velocity.

(6 marks)

(d) Discuss briefly **TWO (2)** rock testing methods used to determine compressive rock strength.

(4 marks)

(e) Explain how discontinuities affect the strength of intact rock.

(4 marks)

Q4 A highway was constructed across the hilly area and cut slope has through a granite rock formation at 65 m height. The excavation through the granite material from weathering grade six to the fresh rock. The rock slope face cutting in the dip direction of 012° and dip angle 60°. The discontinuity mapping and rock testing were conducted to obtain the discontinuity sets, slope geometry, and rock parameters as summarized in **Table Q4.1**.

Table Q4.1 Parameter of granite rock slope

Parameters	Values
Joint set 1 (dip direction/dip angle)	192°/70°
Joint set 2 (dip direction/dip angle)	010°/20°
Joint set 3 (dip direction/dip angle)	90°/70°
Joint set 4 (dip direction/dip angle)	004°/40°
Slope face dip direction	020°
Slope face angle (slope angle)	60°
Upper slope face dip direction	010°
Upper slope face angle	0°
Height of slope/wedge	65 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 (Ω) = (ψ_T)	30°
Bars for Y25	10 ton = 100 kN

(a) Analyse the possible failure modes at the constructed slope using **Figure APPENDIX A.1** and **Table APPENDIX B.1**.

(8 marks)

(b) Calculate the factor of safety for the planar failure mode when the tension crack is completely filled with water using **Figure APPENDIX A.2**.

(4 marks)

(c) Calculate the factor of safety for wedge failure mode when the tension crack is completely filled with water using **Figure APPENDIX A.3**.

(9 marks)

(d) Suggest **TWO (2)** advantages and disadvantages of reducing the dip angle of a new rock slope from 60° to 40°.

(4 marks)

- END OF QUESTIONS -

APPENDIX A

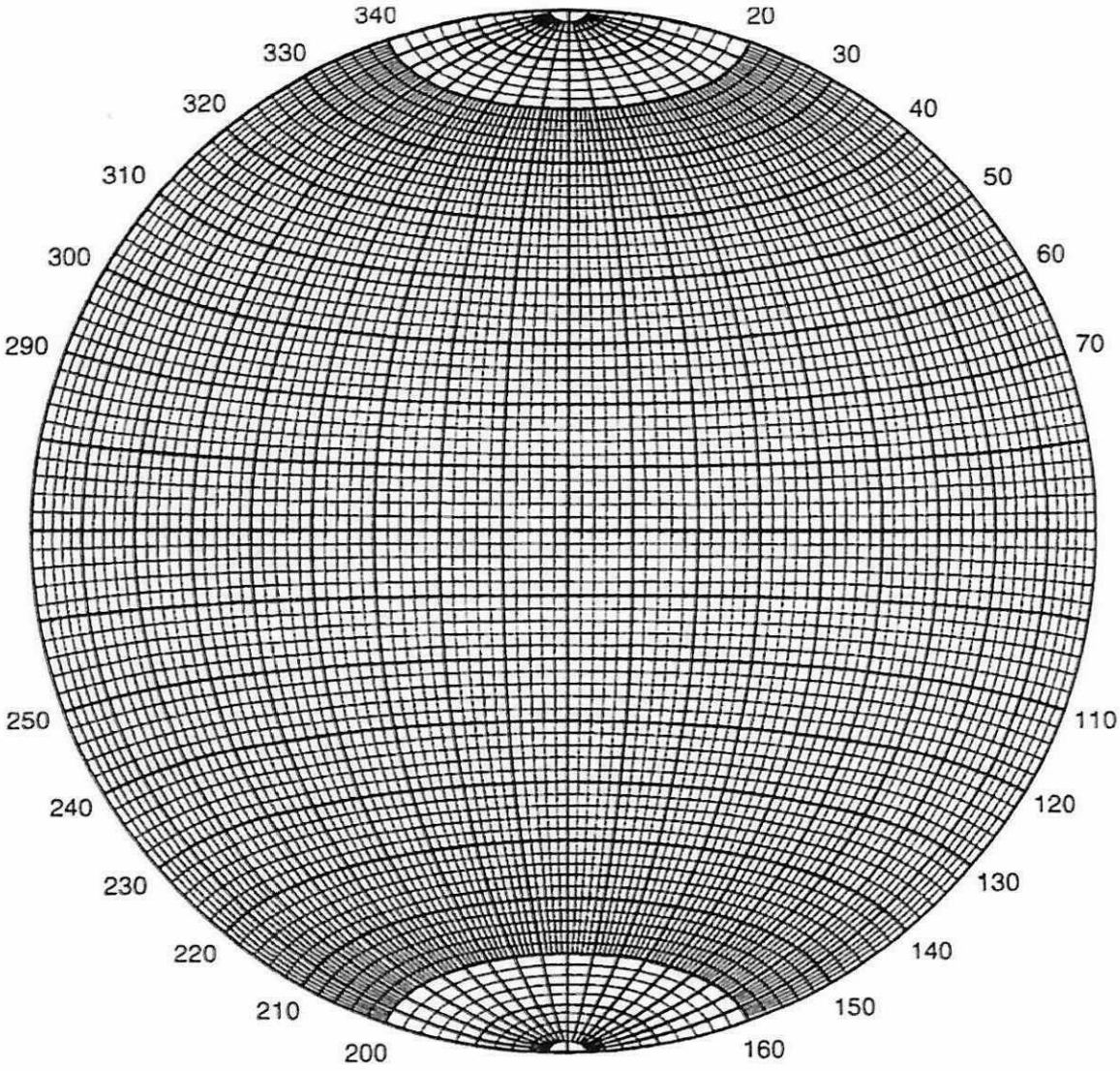
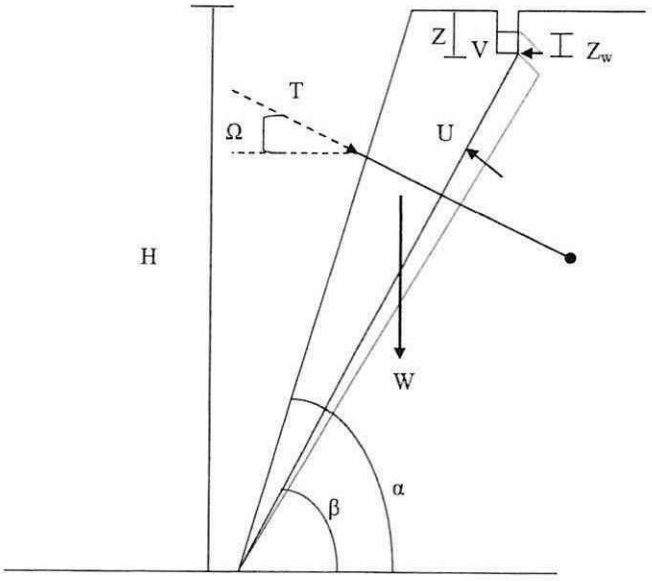


Figure APPENDIX A.1 Equatorial equal-area stereo-net marked in 2° intervals.



Given:

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

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

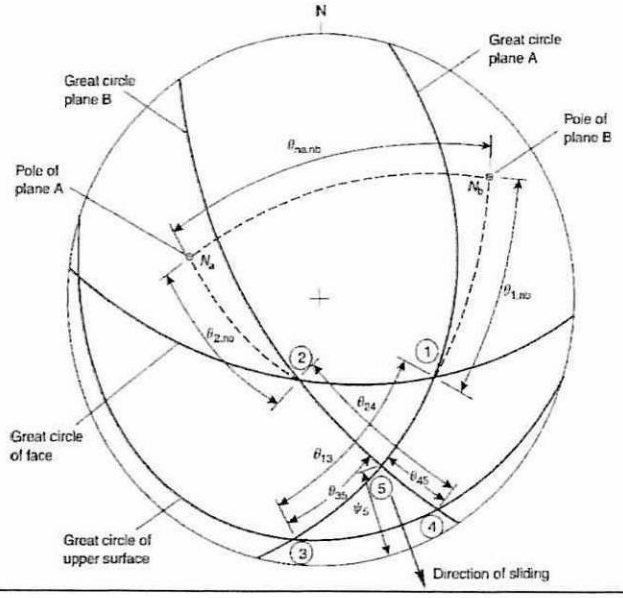
$$W = \tfrac{1}{2}\gamma_r H^2\left[\left(1-\left(\tfrac{Z}{H}\right)^2\right)\cot\beta - \cot\alpha\right]$$

$U = \tfrac{1}{2}\gamma_w.Z_w.(H-Z).\text{cosec}\,\beta$

$V = \tfrac{1}{2}\gamma_w.Z_w^2$

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

Figure APPENDIX A.2 Planar failure mode formula



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

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

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

Figure APPENDIX A.3 Wedge failure mode formula

APPENDIX B

Table APPENDIX B.1 Mode of failures

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. $(90^0 - \psi_f) + \phi \leq \psi_t$