UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	ENGINEERING GEOLOGY
COURSE CODE	:	BFC 21303
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER **ALL QUESTIONS** IN **PART A.** 2. ANSWER **TWO (2) QUESTIONS** IN **PART B.** 3. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 4. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK.

THIS QUESTION PAPER CONSISTS OF **FOURTEEN (14)** PAGES

PART A

Q1 A 10-meter-long road cutting is driven through a granite mass at a location on the Kota Bharu-Kuala Krai highway in Kelantan as shown in **Figure APPENDIX A.1**. To assess the rock slope stabilization, a scanline survey was conducted on the rock slope, and the slope's discontinuities were mapped and analysed.

(a) Determine the number of joints that intercepts with the scanline in **Figure APPENDIX A.1.**

(2 marks)

(b) The discontinuities contours plot of the studied slope is presented in **Figure APPENDIX A.2**. Determine the dip direction and dip angle of the contours joint sets by using **Figure APPENDIX A.3**.

(8 marks)

(c) Based on **Figure APPENDIX A.4,** a mapping window has implemented on the slope for Rock Mass Rating (RMR) analysis. If the window size is 1 m × 1 m, determine the volumetric joint, Jv in cubic meter unit (m^3) and Rock Quality Designation (RQD).

(8 marks)

(d) A bore log sample with length of 1500 mm were drilled on top of the slope at one location denoted as BH1 shown in **Figure APPENDIX A.4**. Determine the rock quality designation (RQD), solid core recovery (SCR), total core recovery (TCR) and fracture index (FI) from the BH1 core sample as shown in **Figure APPENDIX A.5**.

(12 marks)

(e) Based on the answer from **Q1(b)**, analyse the entire rock slope failure modes with its criterion based on **Table APPENDIX A.6.** and **Figure APPENDIX A.3**. Given the slope dip direction and dip angle is 323° /60 ° and friction angle is 30°.

(10 marks)

PART B

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

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

(3 marks)

(b) Weathered rock mass is a very complex structure that is difficult to be predicted. For that reason, many specified classification systems were established.

(i) Discuss **THREE (3)** differences characteristics between weathering grade II and V for weathered granite rock.

(3 marks)

(ii) Sketch and classify a weathering profile for a granitic rock including the percentage of rock: soil and weathering grade of each weathering zone.

(4 marks)

(c) Explain the difference between colluvium and alluvium in terms of their formation processes, characteristics, and depositional environments.

(6 marks)

(d) The geological structure of rocks refers to the arrangement and relationship of rock layers or formations within the Earth's crust, and it is crucial in the civil engineering field. Sketch and discuss the differences between:

(i) Ductile and brittle behaviour of rock in fold and fault formation.

(ii) Strike-slip fault and reverse dip-slip fault.

(iii) Disconformity and paraconformity structure.

(10 marks)

(e) Fault is one of the rock deformation that occur due to movement of continental plate. Sketch and explain the risks that might be occur if a building constructed in the fault zone.

(4 marks)

Q3 Soil investigation (SI) plays a crucial role in civil engineering due to the implementation such as in foundation design, risk assessment, optimized design, and construction planning.

(a) Identify **THREE (3)** information that could be obtained from the boring operation and **TWO (2)** limitations of boring test in the site investigation.

(5 marks)

(b) Discuss **FIVE (5)** advantages of geophysics survey in civil and environmental investigation.

(5 marks)

(c) Standard testing and sample preparation procedures (ISRM 1982) are mainly to minimize factors affecting data obtained from a test. Discuss **FIVE (5)** factors or parameters that possible affecting laboratory testing.

(5 marks)

(d) The directional angle of force towards schistosity affects the rock strength. Explain this statement.

(5 marks)

(e) Propose a suitable index test and explain in detail the test procedure and related equation to be used to determine the uniaxial compression strength (UCS) of granite rock.

(10 marks)

Q4 A railway track cutting 60 m deep is driven through a granite rock formation in Sungai Lembing, Kuantan, Pahang. The rock slope face cutting in the direction of 260^0 and dip angle 70^0. The rock slope has been mapped and analysed. **Table APPENDIX B.1** summarized the data of discontinuity sets, slope geometry and rock parameters. Based on the failure mode analysis, J2(250^o /46^o) was identified as planar failure. Intersection between J2(250^o /46^o) and J3(320^o /70^o) was produced wedge failure with angle of intersection is 44^o. Meanwhile J1(075^o /60^o) was identified as topple failure.

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

(8 marks)

(b) Determine the number of anchor bars required to stabilize the rock slope if the required factor of safety according to slope stability guidelines by Jabatan Kerja Raya (JKR) is 1.5.

(4 marks)

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

(12 marks)

(d) To minimise the cost of stabilization using anchor system, the client requests to find another option by change the slope dip direction and maintaining the slope angle. Based on **Table APPENDIX A.6**, propose a suitable new rock slope dip direction and economic to reduce the potential of rock slope failures.

(6 marks)

- END OF QUESTIONS -

APPENDIX A

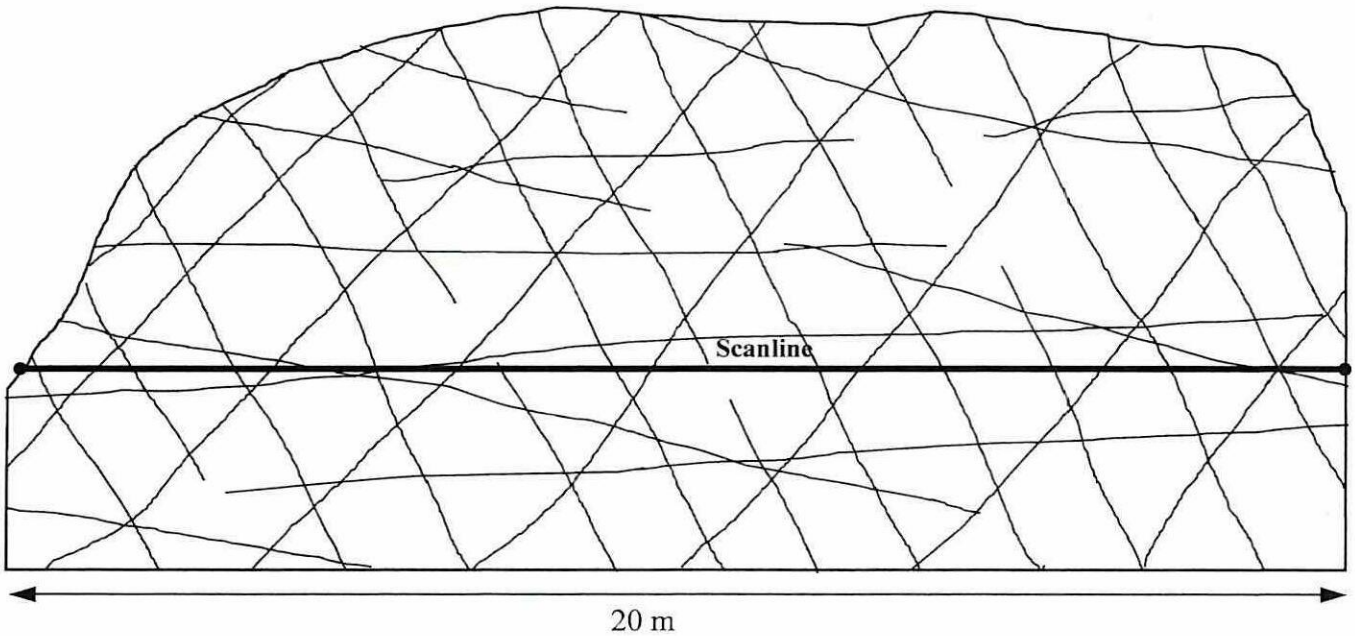


Figure APPENDIX A.1 A scanline survey on a granite slope studied at Kota Bharu-Kuala Krai highway, Kelantan.

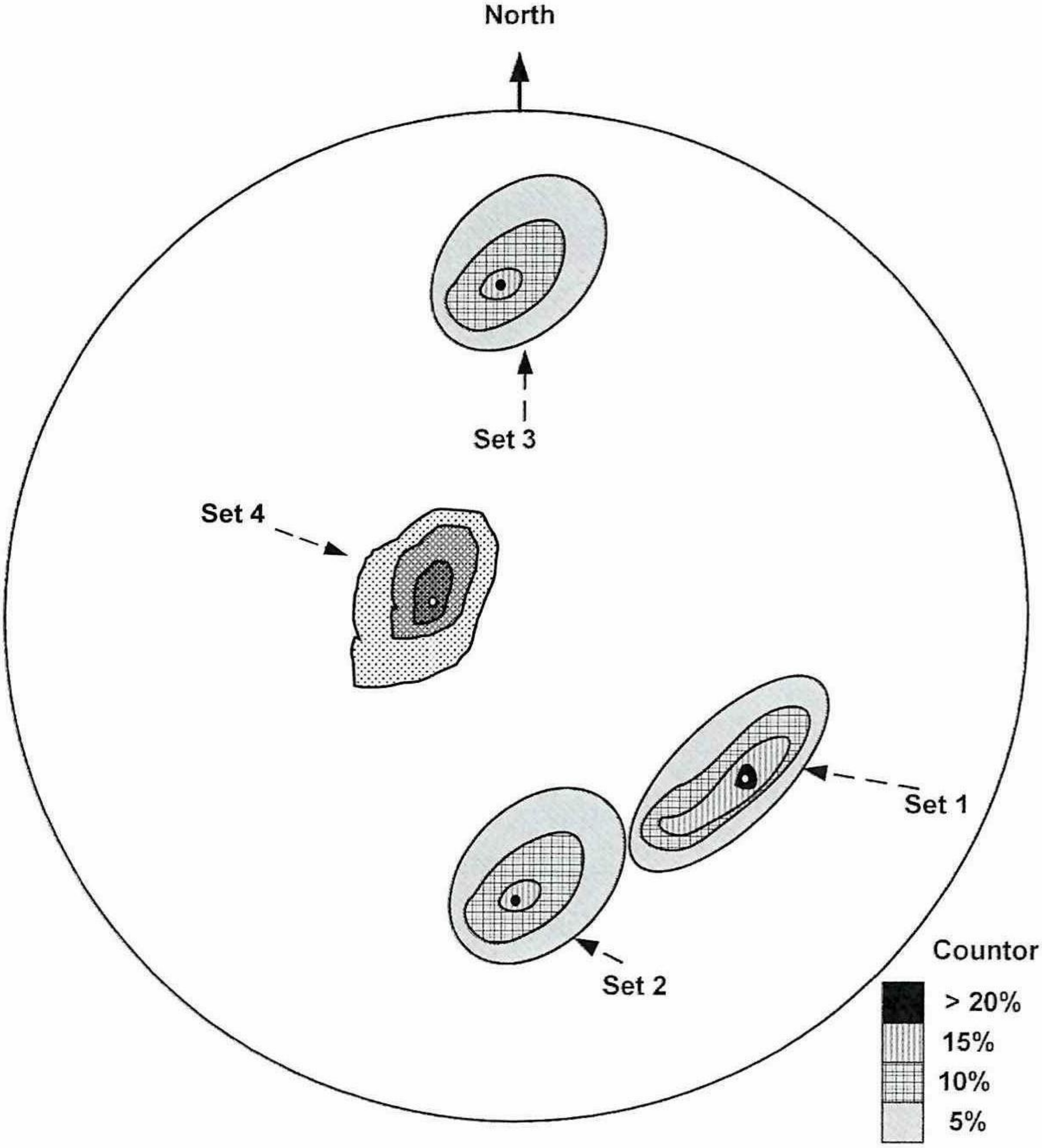


Figure APPENDIX A.2 discontinuities contours plot of the studied slope.

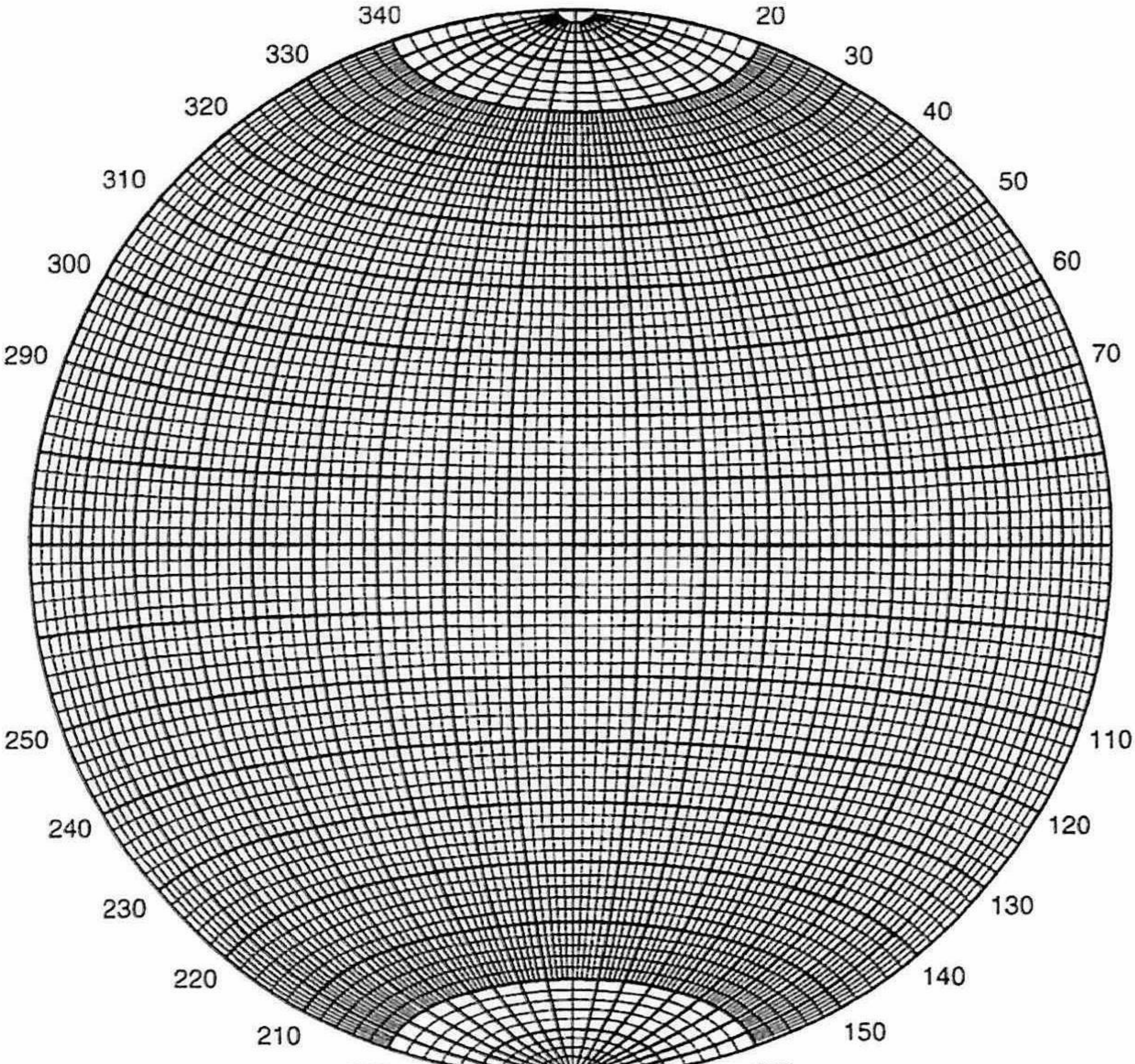


Figure APPENDIX A.3 Equatorial equal-area stereo-net marked in 2° intervals

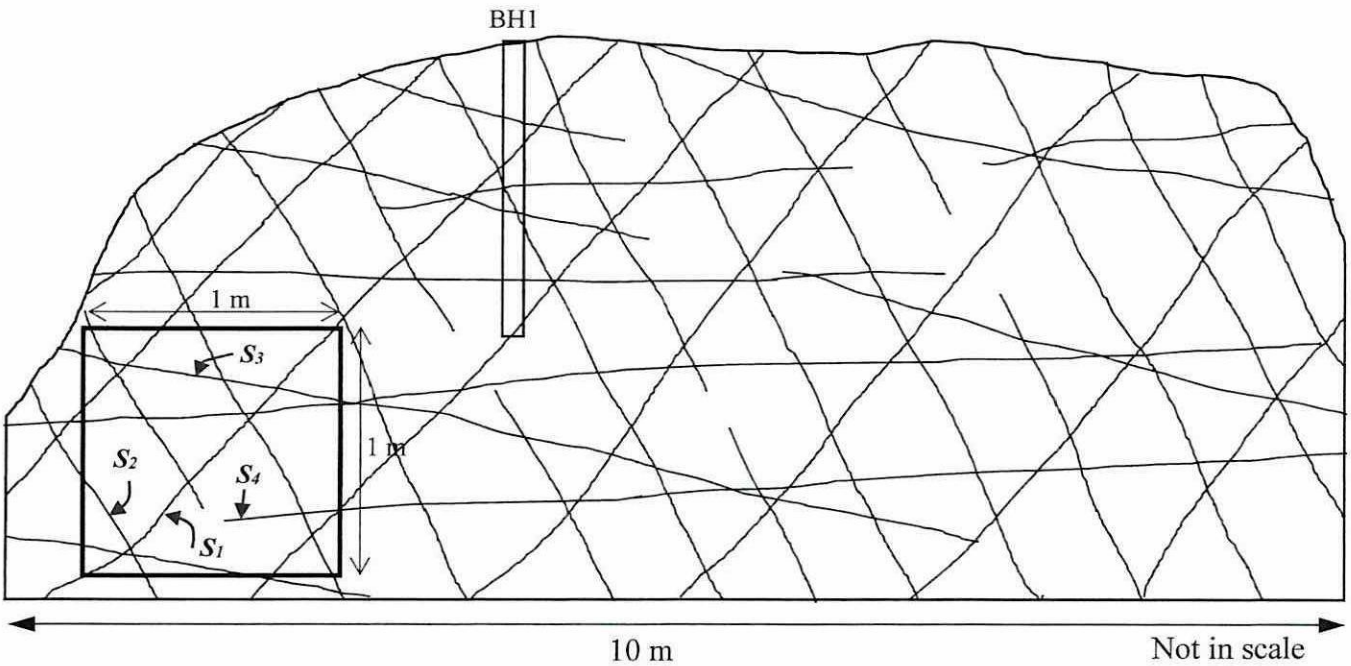


Figure APPENDIX A.4 Window mapping of 1 m × 1 m on granite slope studied at Kota Bharu-Kuala Krai highway, Kelantan.

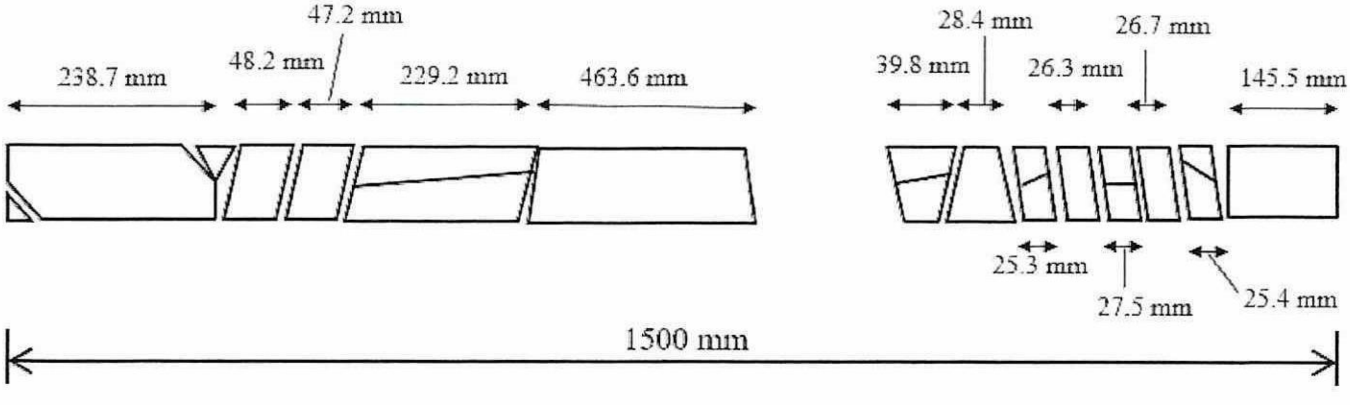


Figure APPENDIX A.5 A borehole sample denoted as BH1 was drilled 1.5 m from on top of the granite slope.

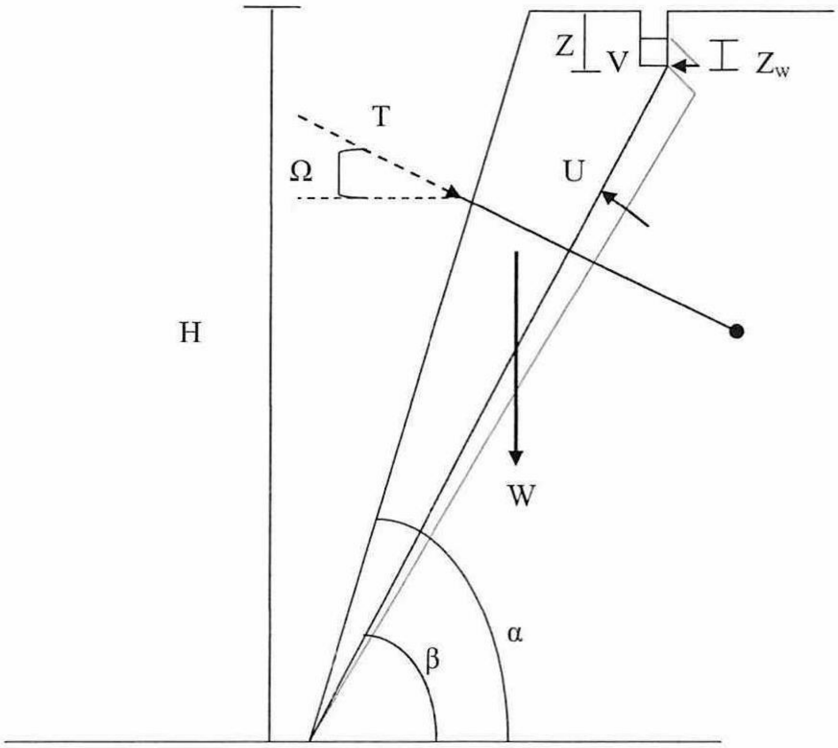
Table APPENDIX A.6 Mode of failures

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 ± 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 ±10° in the opposite direction of the slope dip direction. ii. $(90^0 - \psi_f) + \phi \leq \psi_t$

APPENDIX B

Table APPENDIX B.1 Parameter of granite rock slope

Parameters	Values
Joint set 1 (dip direction/dip angle)	075°/60°
Joint set 2 (dip direction/dip angle)	250°/46°
Joint set 3 (dip direction/dip angle)	320°/70°
Joint set 4 (dip direction/dip angle)	260°/10°
Slope face dip direction	260°
Slope face angle (slope angle)	70°
Upper slope face dip direction	260°
Upper slope face angle	0°
Height of slope/wedge	60 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	100 kPa
Friction angle for all discontinuities	30°
Inclined angle of anchor (Ω) = (ψ_T)	20°
Depth of tension crack on top of the slope	3 m
Bars for Y25	10 ton = 100 kN



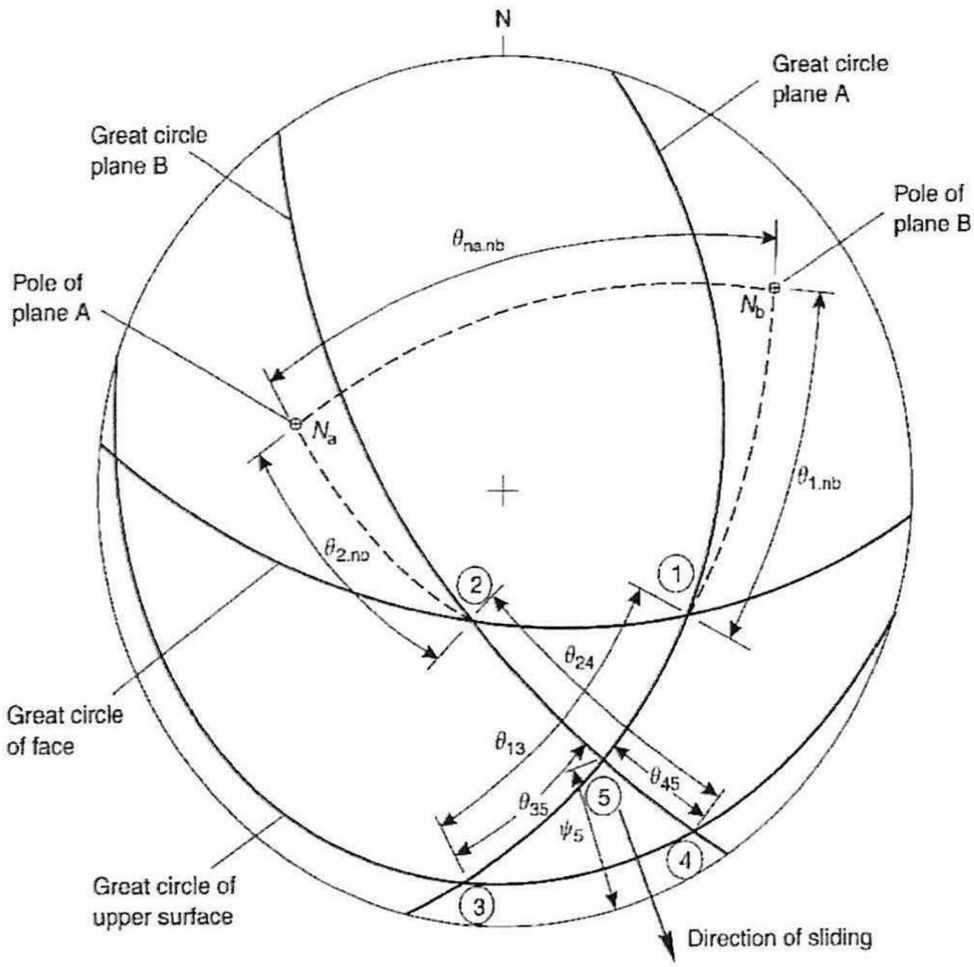
Given:

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

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

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

Figure APPENDIX B.2 Planar failure mode formula



Given:

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 B.3 Wedge failure mode formula

USEFUL EQUATION

$$SCR = R_r + R_w + R_f \qquad \text{Is} = \frac{P\,(1000)}{D_e^2}$$

$$A = (H - Z).\,cosec\,\beta$$

$$I_s = \frac{P(1000)}{D_e^2} \qquad \sigma_c = KI_{s(50)}$$

$$J_V = \frac{N_1}{L_1} + \frac{N_2}{L_2} + \frac{N_3}{L_3} + \cdots + \frac{N_n}{L_n} \qquad RQD = \sum \frac{core\ length > 100\ mm}{total\ core}$$

$$I_{s(50)} = I_s \times F \qquad U = \frac{1}{2}.\gamma_w.Z_w.(H - Z).\,cosec\beta$$

$$S_a = \frac{S1 + S2 + S3 + \ldots\ldots + Sn}{n} \qquad K = 20$$

$$FOS = \frac{3}{\gamma H}(C_a X + C_b Y) + \left(A - \frac{\gamma_w}{2\gamma}.X\right) tan\phi_a + \left(B - \frac{\gamma_w}{2\gamma}.Y\right) tan\phi_b$$

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

$$J_V = \frac{1}{S1} + \frac{1}{S2} + \frac{1}{S3} + \ldots\ldots \frac{1}{Sn} \qquad J_V = \left(\frac{N}{L}\right)^3$$

$$RQD = 115 - 3.3J_V \qquad F = \left(\frac{D_e}{50}\right)^{0.45}$$

$$FOS = \frac{cA + (Wcos\beta - U - Vsin\beta + Tsin(\Omega + \beta))tan\phi}{Wsin\beta + Vcos\beta - Tcos((\Omega + \beta)}$$

$$K = 24 \qquad W = {}^1/_2.\gamma_r.H^2.\left[\left(1 - \left({}^Z/_H\right)^2\right) cot\beta - cot\alpha\right]$$

$$A = W_{average} \times DD_e = \sqrt{\frac{4A}{\pi}} \qquad \sigma_c = (14 + 0.175D)I_{s(50)}$$