UNIVERSITI SAINS MALAYSIA

First Semester Examination
2014/2015 Academic Session

December 2014 / January 2015

EBS 417/3 - Geomechanics
[Geomekanik]

Duration : 3 hours
[Masa : 3 jam]

Please ensure that this examination paper contains FIFTEEN printed pages and SEVEN pages APPENDIX before you begin the examination.
[Sila pastikan bahawa kertas peperiksaan ini mengandungi LIMA BELAS muka surat dan TUJUH muka surat LAMPIRAN yang bercetak sebelum anda memulakan peperiksaan ini.]

This paper consists of SEVEN questions. TWO questions in PART A and FIVE questions in PART B.
[Kertas soalan ini mengandungi TUJUH soalan. DUA soalan di BAHAGIAN A dan LIMA soalan di BAHAGIAN B.]

Instruction: Answer **FIVE** questions. Answer **ALL** questions from PART A and **THREE** questions from PART B. If a candidate answers more than five questions only the first five questions answered in the answer script would be examined.
*[**Arahan**: Jawab **LIMA** soalan. Jawab **SEMUA** soalan dari BAHAGIAN A dan **TIGA** soalan dari BAHAGIAN B. Jika calon menjawab lebih daripada lima soalan hanya lima soalan pertama mengikut susunan dalam skrip jawapan akan diberi markah.]*

The answers to all questions must start on a new page.
[Mulakan jawapan anda untuk semua soalan pada muka surat yang baru.]

You may answer a question either in Bahasa Malaysia or in English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

In the event of any discrepancies in the examination questions, the English version shall be used.
[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

PART A / *BAHAGIAN A*

1. [a] Briefly explain the following topics:

(i) Liquid Limit

(ii) Plastic Limit

(iii) Plasticity Index

(iv) Type of soil classification analysis

Secara ringkas, jelaskan topik-topik berikut:

(i) Had Cecair (LL)

(ii) Had Plastik (PL)

(iii) Indeks Keplastikan (PI)

(iv) Jenis-jenis analisis pengelasan tanah

(20 marks/*markah*)

[b] Distinguish between fine sand, silt and clay.

Bezakan di antara pasir halus, kelodak dan lempung/tanah liat.

(30 marks/*markah*)

[c] The following results were obtained from a liquid limit test:

Number of taps	6	8	12	26	28	31
Water contents (%)	53.4	52.2	48.3	40.0	38.8	37.1

Plot the water content against the log of number of taps. Determine the liquid limit and the plasticity index if the plastic limit was 18%.

Keputusan berikut diperolehi daripada ujian had cecair:

Bilangan ketukan	6	8	12	26	28	31
Kandungan air (%)	53.4	52.2	48.3	40.0	38.8	37.1

Plotkan kandungan air lawan log bilangan ketukan. Tentukan had cecair dan indeks keplastikan jika had plastik adalah 18%.

(50 marks/*markah*)

2. [a] A sandstone rock mass at a depth of 250 m contains three discontinuity sets. One set comprises bedding planes; these are slightly weathered, slightly rough surfaces, and are continuous with an orientation of 180/10. Another set is jointing; these are highly weathered, slightly rough, separation < 1 mm and have an orientation of 185/75. The third set is also jointing; again, this is slightly weathered and slightly rough, and has an orientation of 090/80. The strength of the intact rock has been assessed as 55Mpa, and values for the RQD and average discontinuity spacing are reported as 60% and 0.4 m, respectively. Tunnelling conditions are anticipated to be wet.

Use the RMR (Appendix 1) system to classify this rock mass, and assess the stability of a 10 m wide excavation being driven from East to West.

Jisim batu pasir pada kedalaman 250 m mengandungi tiga set ketakselanjaran. Set pertama terdiri daripada satah perlapisan; sedikit terluluhawa, sedikit kasar di permukaan, dan mempunyai selanjaran pada arah 180/10. Set kedua adalah kekar; sangat terluluhawa, sedikit kasar pada permukaan, bukaan < 1 mm dan mempunyai arah selanjaran pada 185/75. Set ketiga juga merupakan kekar; juga sedikit terluluhawa dan sedikit kasar, dan mempunyai selanjaran arah pada 090/80. Tegasan pada batuan utuh adalah 55 Mpa, nilai bagi RQD dan purata jarak ketakselanjaran adalah dilaporkan sebagai 60% dan 0.4m. Terowong dijangka berada di dalam keadaan lembap.

Gunakan sistem klasifikasi RMR (Lampiran 1) untuk mengelaskan jisim batuan dan penilaian kestabilan bagi proses pengorekan selebar 10 m yang bakal dilakukan dari Timur ke Barat.

(70 marks/*markah*)

[b] Plot the poles of the following discontinuities, using Appendix 2:

(i) dip 55° towards 110°

(ii) dip 44° towards 120°

(iii) dip 30° towards 335°

(iv) dip 75° towards 090°

(v) dip 60° towards 105°

(vi) dip 50° towards 130°

Determine the estimate general dip and trend of these structures

Plot kutub-kutub ketakselanjaran berikut, menggunakan Appendiks 2:

(i) miring 55° ke arah 110°

(ii) miring 44° ke arah 120°

(iii) miring 30° ke arah 335°

(iv) miring 75° ke arah 090°

(v) miring 60° ke arah 105°

(vi) miring 50° ke arah 130°

Anggarkan kemiringan am dan tren struktur-struktur ini?

(30 marks/*markah*)

PART B / *BAHAGIAN B*

3. [a] Evaluate the use of Factor of Safety (FoS) in slope stability analysis.

Berikan penilaian berkenaan kegunaan Faktor Keselamatan (FoS) di dalam analisis kestabilan cerun.

(40 marks/*markah*)

[b] Distinguish between the "short term" and "long term" stability of a slope.

Bezakan di antara kestabilan cerun "jangka pendek" dan "jangka panjang".

(30 marks/*markah*)

[c] Discuss the best practice for the ground investigation of an existing slope, or the ground onto which a slope is to be built.

Bincangkan amalan terbaik untuk menjalankan penyiasatan lapangan terhadap cerun sedia ada ataupun tapak di mana cerun akan dibina.

(30 marks/*markah*)

4. [a] Discuss any five corrective measures for failing slopes.
(Note: Partial marks will be given for diagram)

Bincangkan mana-mana lima langkah pembetulan kegagalan cerun. (Nota: Sebahagian markah diberikan untuk gambarajah)

(75 marks/*markah*)

[b] A granular soil has a saturated unit weight of 19.5kN/m^3 and angle of shearing resistance of 32^0. A slope is to be made of this material. If the factor of safety is to be 1.4, determine the safe angle of the slope.

Satu tanah granul mempunyai berat unit tepu 19.5kN/m^3 dan sudut rintangan ricih 32^0. Sebuah cerun dibina menggunakan tanah tersebut. Andaikan faktor keselamatan yang diperlukan adalah 1.4, tentukan sudut selamat bagi cerun tersebut jika

(i) The slope is in dry condition.

Cerun dalam keadaan kering.

(10 marks/*markah*)

(ii) If seepage occurs at and parallel to the surface of slope.

Jika resipan terjadi pada dan selari dengan permukaan cerun.

(15 marks/*markah*)

5. [a] Three lengths of rock core, of similar composition and all at 54 mm diameter have been subjected to point load failure testing. The failure forces applied for the three tests were found to be 28.5 kN, 29.6 kN and 31.4 kN. Of the following, which average Point Load Index (I_s) and calculated unconfined compressive strength (S_c) values best approximate the true strength parameters for this rock material (Justify your choice):

(i) I_s = 10.05 MPa, S_c = 200.1 MPa

(ii) I_s = 10.05 MPa, S_c = 241.2 MPa

(iii) I_s = 10.85 MPa, S_c = 268.1 MPa

(iv) I_s = 10.85 MPa, S_c = 291.0 MPa

Panjang tiga teras lubang gerudi, yang berkomposisi sama dan semuanya pada kepanjangan 54 mm garis pusat telah dikenakan ujian Kegagalan Titik Beban. Daya kegagalan yang dikenakan untuk ketiga-tiga ujian didapati pada 28.5 kN, 29.6 kN and 31.4 kN. Daripada yang disenaraikan, nilai purata Indek Beban Titik (I_s) dan kekuatan mampatan unipaksi (S_c) yang manakah yang paling mewakili kekuatan parameter untuk batuan tersebut (Berikan justifikasi pemilihan anda).

(6) *I_s = 10.05 MPa, S_c = 200.1 Mpa*

(ii) I_s = 10.05 Mpa, S_c = 241.2 Mpa

(iii) I_s = 10.85 Mpa, S_c = 268.1 Mpa

(iv) I_s = 10.85 Mpa, S_c = 291.0 Mpa

(30 marks/*markah*)

[b] In open pit mine operations, methods exist to stabilize sliding wedge failure through application of tensioned anchors across potential planes of sliding. Discuss one scenario under which placement of tensioned anchors might create a reduction in stability for a potential sliding wedge

Dalam operasi lombong dedah, kaedah wujud untuk menstabilkan gelonsoran oleh kegagalan baji melalui penggunaan penunjuk tuju yang ditegangkan keseluruhan satah yang berpotensi untuk gagal. Bincangkan satu senario di mana penggunaan penunjuk tuju-ditegangkan mungkin dapat menggurangkan potensi ketidakstabilan bagi kegagalan baji untuk berlaku.

(40 marks/*markah*)

[c] Discuss how rock mass characterization techniques can be used by mining engineers to influence excavation and support system design of mines during pre-development.

Bincangkan bagaimana teknik pencirian jisim batuan boleh digunakan oleh jurutera lombong di dalam mempengaruhi penggalian dan reka bentuk sistem sokongan lombong semasa pra-pembangunan lombong.

(30 marks/*markah*)

6. [a] A 35 m high face for a road cut is to excavate northward into a rock mass, and a geotechnical drilling programmed has revealed the following information:

	Dip	dip direction	Ø	c	Spacing
Bedding planes	60°	180°	35	0	3m
Fault X	65°	125°	25	0	-
Fault Y	35°	245°	30	0	-

The intersection of the two faults will daylight on the slope face, and the water table has been located a few meters below the proposed excavation. In a nearby excavation Fault X formed a wedge intersection with Fault Z having a dip of 55°, a dip direction of 012° and a Ø of 31°; the fault is also planar and smooth and has zero cohesion. Very shortly after this wedge intersection daylighted out its slope, the wedge failed.

Using accompanying design charts (Appendix 3), determine the factor of safety of the wedge formed by Fault X and Fault Y.

In addition:

[b] What is the recommended maximum stable slope angle? You may need to use the stereonet enclosed.

[c] If it were required to maintain the slope face at a steeper angle, at what angle to the horizontal should rock anchors be drilled to enable minimum anchor tension to be employed?

[d] Assuming that the slope angle in (a) is adopted, do you have to do anything to the drainage of the slope, should the slope become fully saturated?

[e] If some heavy machinery were to move onto the top of the wedge block during the dry season would failure occur?

Give explanations for each of the answers (a) to (b)

[a] *Satu muka cerun setinggi 35 meter untuk potongan jalan akan dikorek ke arah utara dalam jisim batuan, dan program penggerudian geoteknik telah menghasilkan maklumat berikut:*

	Miring	*Arah miring*	*Ø*	*c*	*Jarak*
Satah berlapis-lapis	*60°*	*180°*	*35*	*0*	*3m*
Fault X	*65°*	*125°*	*25*	*0*	-
Fault Y	*35°*	*245°*	*30*	*0*	-

Persilangan kedua-dua sesar akan terdedah di muka cerun, dan air di dalam tanah telah dikesan terdapat beberapa meter di bawah aras tempat pengorekan yang dicadangkan. Di satu tempat pengorekan yang berhampiran, sesar X membentuk persilangan baji dengan sesar Y yang mempunyai kemiringan 55°, arah miring 012° dan Ø bernilai 31°; sesar ini juga berbentuk planar dan licin dan mempunyai kejeleketan kosong. Baji ini gagal tidak lama setelah persilangan terdedah di muka cerun.

Dengan menggunakan carta yang disediakan (Lampiran 3), tentukan faktor keselamatan baji yang dibentuk oleh sesar X dan sesar Y

Sebagai tambahan:

[b] *Sudut cerun apakah yang disyorkan sebagai sudut cerun maksimum yang stabil? Anda boleh menggunakan stereonet yang disediakan.*

[c] *Sekiranya ia diperlukan untuk mengekalkan sudut cerun pada sudut yang lebih curam, sudut apakah kepada mendatar sepatutnya "rock anchor" digerudi untuk membolehkan tegangan 'anchor' yang minimum digunakan?*

[d] *Diandaikan sudut cerun dalam (a) digunakan, adakah perlu dan melakukan sesuatu kepada saliran di sekitar cerun sekiranya cerun menjadi tepu*

[e] *Jika mesin yang berat bergerak di atas permukaan blok baji semasa musim kemarau, adakah cerun akan gagal?*

Berikan penerangan bagi setiap jawapan yang diberikan bagi setiap jawapan (a) hingga (b)

(100 marks/*markah*)

7. A 12 m high rock slope with a face angle of 65° has been excavated in a wide range of geological environments. At the bottom of the stratigraphic sequence are thick interbedded Jurasic age marine shales and siltstones and these were overlain by Cretaceous coal measures rocks comprises of siltstones and minor sandstones.

These strata form bedding planes dipping 35° into the excavation and had been cut by several set of discontinuites with the major discontinuity strike at an angle of 55° to bedding planes. The 6.5 m deep tension crack is found 5 m behind the crest, and is filled with water to a height of 4 m above the sliding surface.

The slope has the following dimensions:

-	Height of the ground water level:	H_W = 8.5 m
-	Angle of friction of the plane:	ϕ = 34°
-	Cohesion of the plane:	c = 21 kN/m^2
-	Unit weight of the rock:	γ_r = 24 kN/m^3
-	Unit weight of water:	γ_w = 9.81kN/m^3

12 m cerun batuan dengan sudut muka 65° telah digali di pelbagai persekitaran geologi. Di bahagian bawah urutan stratigrafi terdapat lapisan tebal antara syal marin dan batu lodak berusia Jurasic dan ini dilapisi oleh arang batu Cretaceous yang mengandungi batu lodak dan sedikit batu pasir.

Strata ini membentuk satah perlapisan miring 35° ke dalam penggalian dan telah dipotong oleh beberapa set ketakselanjaran dengan jurus ketakselanjaran utama pada sudut 55° ke satah perlapisan. Retak ketegangan pada kedalaman 6.5 m didapati pada 5 m di belakang puncak, dan diisi dengan air dengan ketinggian 4 m di atas permukaan gelonsoran.

Cerun tersebut mempunyai dimensi berikut:

- *Ketinggian paras air bawah tanah:* $H_w = 8.5\ m$
- *Sudut geseran satah:* $\varphi = 34°$
- *Kejeleketan satah:* $c = 21\ kN/m^2$
- *Berat unit batuan:* $\gamma r = 24\ kN/m^3$
- *Berat unit air:* $\gamma w = 9.81 kN/m^3$

[a] Please illustrate the slope profile based on the above given details and derive an equation for the factor of safety of the slope that includes all forces acting on the rock mass above the plane.

$$\text{FoS} = \frac{cA + \Sigma N \tan ø}{\Sigma S}$$

$A = (H + b \tan\Psi_s - z) \operatorname{cosec}\Psi_p$

$U = 1/2\gamma_w z_w (H + b \tan \Psi_s - z) \operatorname{cosec}\Psi_p$

$V = 1/2\gamma_w z^2_w$

$W = 1/2\gamma_r H^2 [(1 - z/H)^2 \cot\Psi_p \text{ x } (\cot\Psi_s \tan\Psi_p - 1)]$

$W = \gamma_r [(1 - \cot\Psi_f \tan\Psi_p) (bH + 1/2H^2 \cot\Psi_f + 1/2b^2 (\tan\Psi_s - \tan\Psi_p)]$

Sila gambarkan profil cerun berdasarkan butir-butir yang diberikan di atas dan terbitkan persamaan untuk faktor keselamatan cerun yang merangkumi semua daya yang bertindak pada jasad batuan di atas satah tersebut.

$$FoS = \frac{cA + \Sigma N \tan o}{\Sigma S}$$

$A = (H + b \tan\Psi_s - z) \operatorname{cosec}\Psi_p$

$U = 1/2\gamma_w z_w (H + b \tan \Psi_s - z) \operatorname{cosec}\Psi_p$

$V = 1/2\gamma_w z^2_w$

$W = 1/2\gamma_r H^2 [(1 - z/H)^2 \cot\Psi_p \text{ x } (\cot\Psi_s \tan\Psi_p - 1)]$

$W = \gamma_r [(1 - \cot\Psi_f \tan\Psi_p) (bH + 1/2H^2 \cot\Psi_f + 1/2b^2 (\tan\Psi_s - \tan\Psi_p)]$

(50 marks/*markah*)

[b] Determine the factor of safety of the slope using the deterministic method.

Tentukan faktor keselamatan cerun menggunakan kaedah berketentuan.

(30 marks/*markah*)

[c] Determine the factor of safety of the slope if the slope was reinforced with prestressed bolts that are installed with a plunge of 10°.

Tentukan faktor keselamatan cerun jika cerun diperkukuhkan dengan bolt prategasan yang dipasang dengan tunjaman 10°.

(20 marks/*markah*)

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APPENDIX 1

LAMPIRAN 1

A. CLASSIFICATION PARAMETERS AND THEIR RATINGS									
	Parameter		Range of values						
1	Strength of intact rock material	Point-load strength index	>10 MPa	4 - 10 MPa	2 - 4 MPa	1 - 2 MPa	For this low range - uniaxial compressive test is preferred		
		Uniaxial comp. strength	>250 MPa	100 - 250 MPa	50 - 100 MPa	25 - 50 MPa	5 - 25 MPa	1 - 5 MPa	< 1 MPa
	Rating		15	12	7	4	2	1	0
2	Drill core Quality *RQD*		90% - 100%	75% - 90%	50% - 75%	25% - 50%	< 25%		
	Rating		20	17	13	8	3		
3	Spacing of discontinuities		> 2 m	0.6 - 2 . m	200 - 600 mm	60 - 200 mm	< 60 mm		
	Rating		20	15	10	8	5		
4	Condition of discontinuities (See E)		Very rough surfaces Not continuous No separation Unweathered wall rock	Slightly rough surfaces Separation < 1 mm Slightly weathered walls	Slightly rough surfaces Separation < 1 mm Highly weathered walls	Slickensided surfaces or Gouge < 5 mm thick or Separation 1-5 mm Continuous	Soft gouge >5 mm thick or Separation > 5 mm Continuous		
	Rating		30	25	20	10	0		
5	Groundwater	Inflow per 10 m tunnel length (l/m)	None	< 10	10 - 25	25 - 125	> 125		
		(Joint water press)/ (Major principal σ)	0	< 0.1	0.1, - 0.2	0.2 - 0.5	> 0.5		
		General conditions	Completely dry	Damp	Wet	Dripping	Flowing		
	Rating		15	10	7	4	0		

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS (See F)						
Strike and dip orientations		Very favourable	Favourable	Fair	Unfavourable	Very Unfavourable
Ratings	Tunnels & mines	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	

C. ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS					
Rating	100 ← 81	80 ← 61	60 ← 41	40 ← 21	< 21
Class number	I	II	III	IV	V
Description	Very good rock	Good rock	Fair rock	Poor rock	Very poor rock

D. MEANING OF ROCK CLASSES					
Class number	I	II	III	IV	V
Average stand-up time	20 yrs for 15 m span	1 year for 10 m span	1 week for 5 m span	10 hrs for 2.5 m span	30 min for 1 m span
Cohesion of rock mass (kPa)	> 400	300 - 400	200 - 300	100 - 200	< 100
Friction angle of rock mass (deg)	> 45	35 - 45	25 - 35	15 - 25	< 15

E. GUIDELINES FOR CLASSIFICATION OF DISCONTINUITY conditions					
Discontinuity length (persistence) Rating	< 1 m 6	1 - 3 m 4	3 - 10 m 2	10 - 20 m 1	> 20 m 0
Separation (aperture) Rating	None 6	< 0.1 mm 5	0.1 - 1.0 mm 4	1 - 5 mm 1	> 5 mm 0
Roughness Rating	Very rough 6	Rough 5	Slightly rough 3	Smooth 1	Slickensided 0
Infilling (gouge) Rating	None 6	Hard filling < 5 mm 4	Hard filling > 5 mm 2	Soft filling < 5 mm 2	Soft filling > 5 mm 0
Weathering Ratings	Unweathered 6	Slightly weathered 5	Moderately weathered 3	Highly weathered 1	Decomposed 0

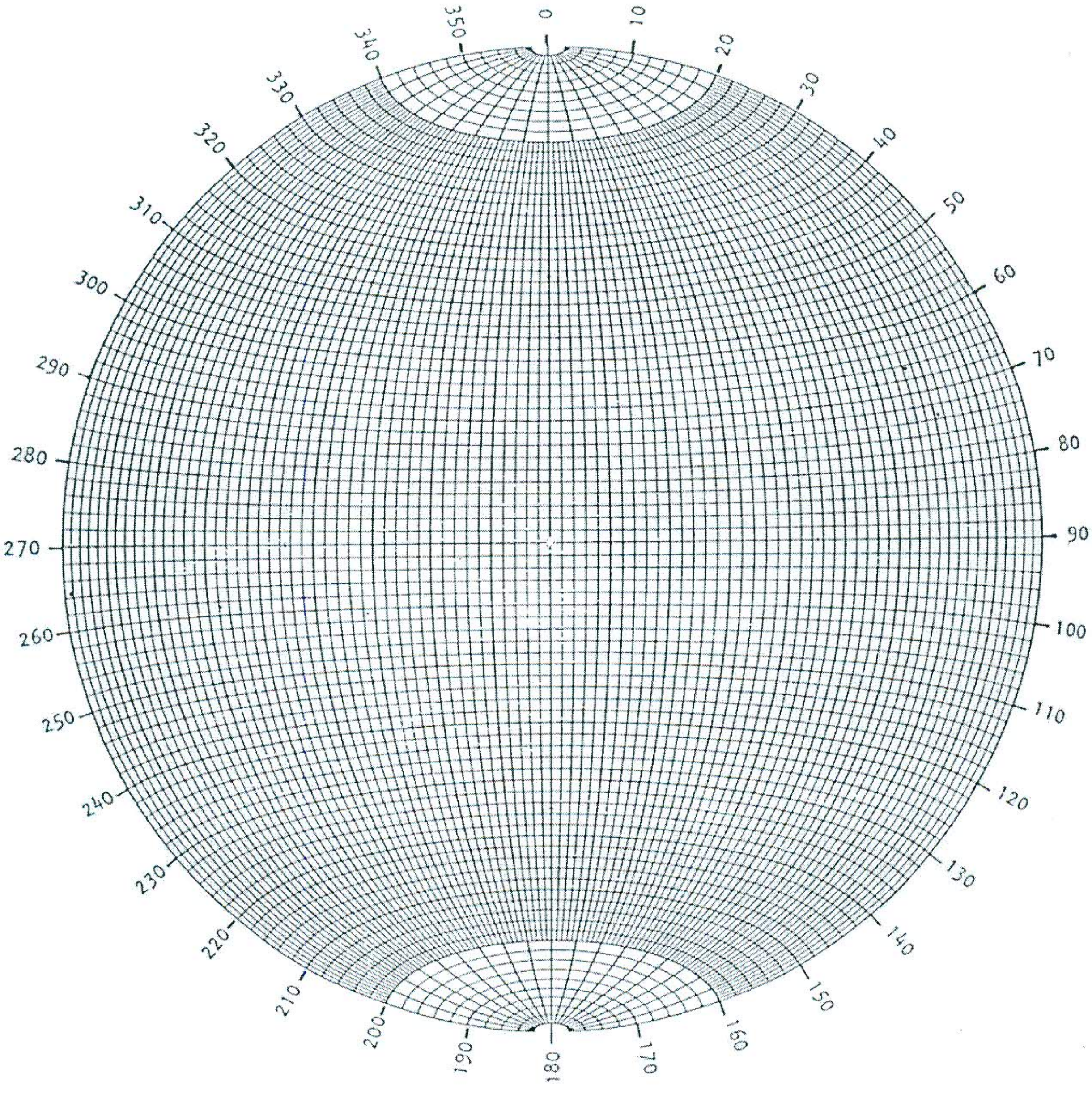
F. EFFECT OF DISCONTINUITY STRIKE AND DIP ORIENTATION IN TUNNELLING**			
Strike perpendicular to tunnel axis		Strike parallel to tunnel axis	
Drive with dip - Dip 45 - 90°	Drive with dip - Dip 20 - 45°	Dip 45 - 90°	Dip 20 - 45°
Very favourable	Favourable	Very unfavourable	Fair
Drive against dip - Dip 45-90°	Drive against dip - Dip 20-45°	Dip 0-20 - Irrespective of strike°	
Fair	Unfavourable	Fair	

* Some conditions are mutually exclusive . For example, if infilling is present, the roughness of the surface will be overshadowed by the influence of the gouge. In such cases use A.4 directly.

** Modified after Wickham et al (1972).

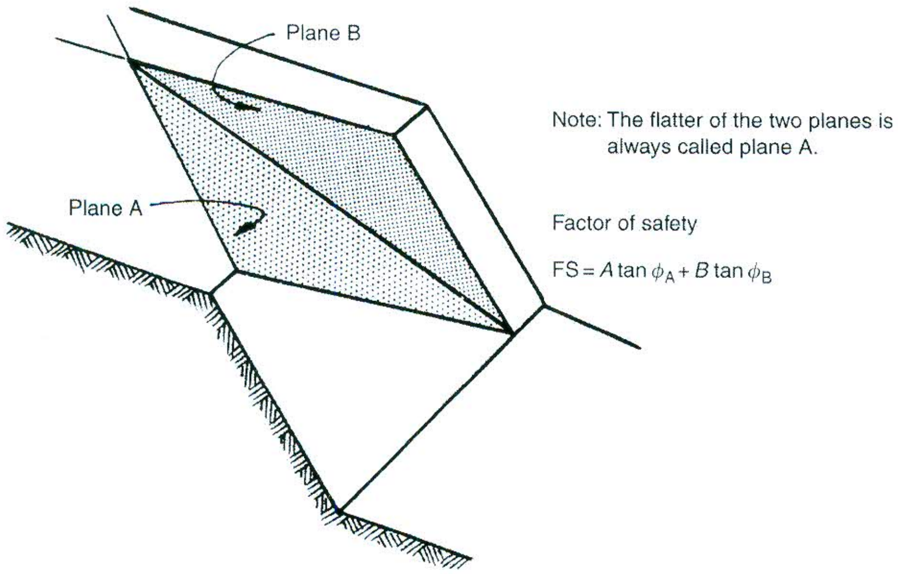
APPENDIX 2

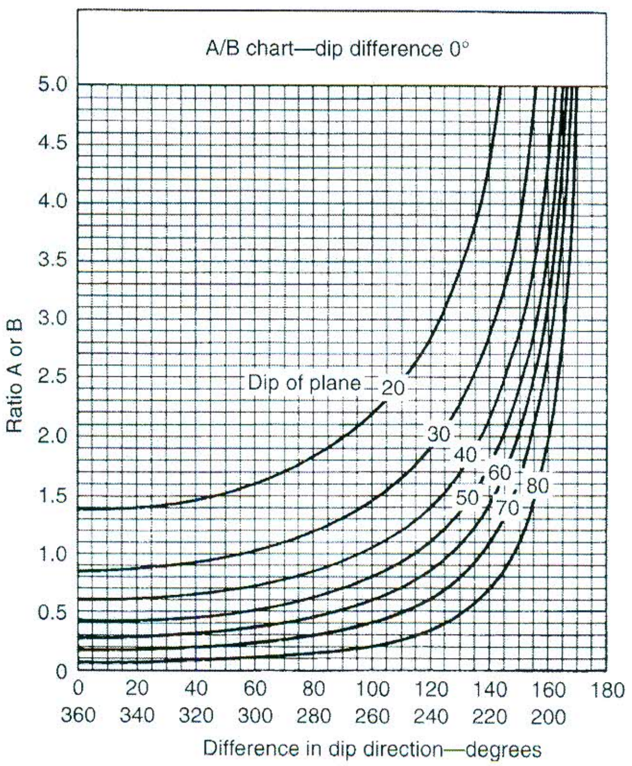
LAMPIRAN 2

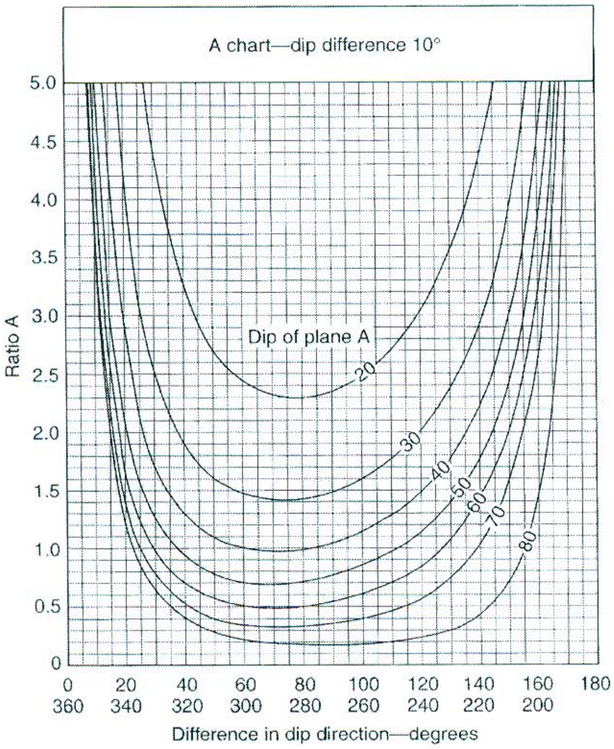


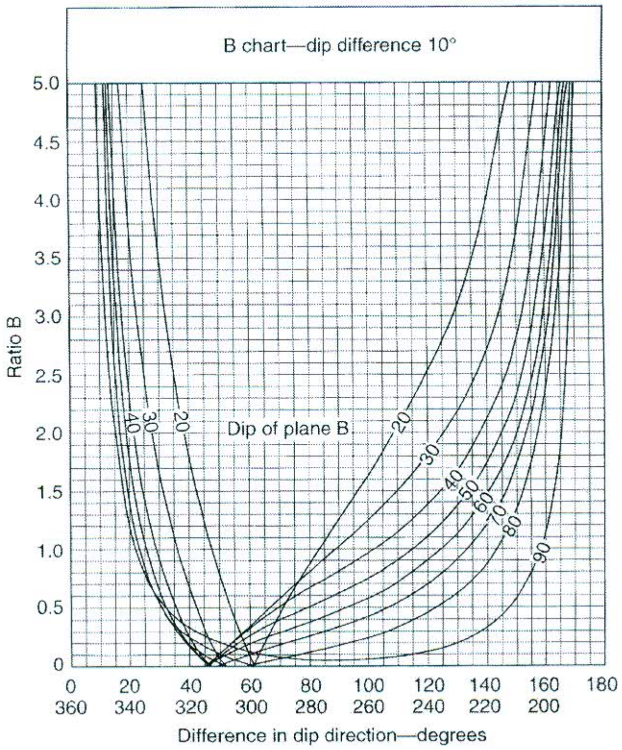
APPENDIX 3

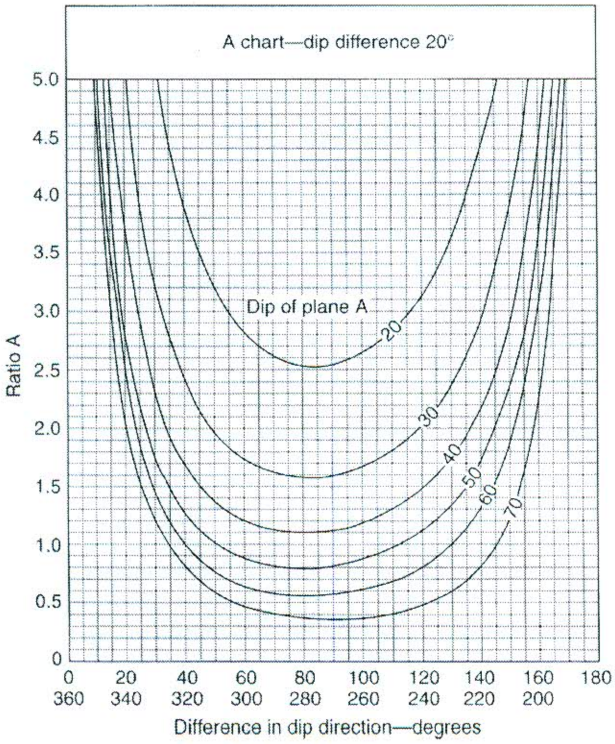
LAMPIRAN 3

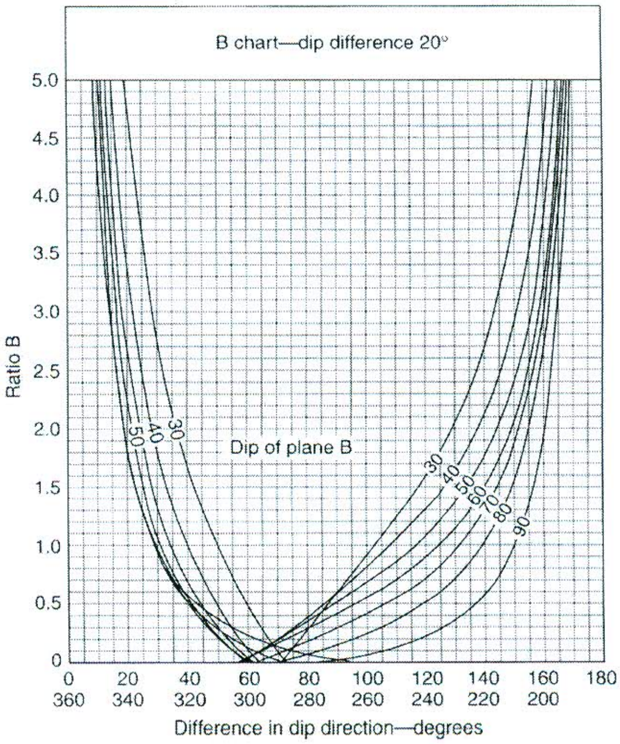


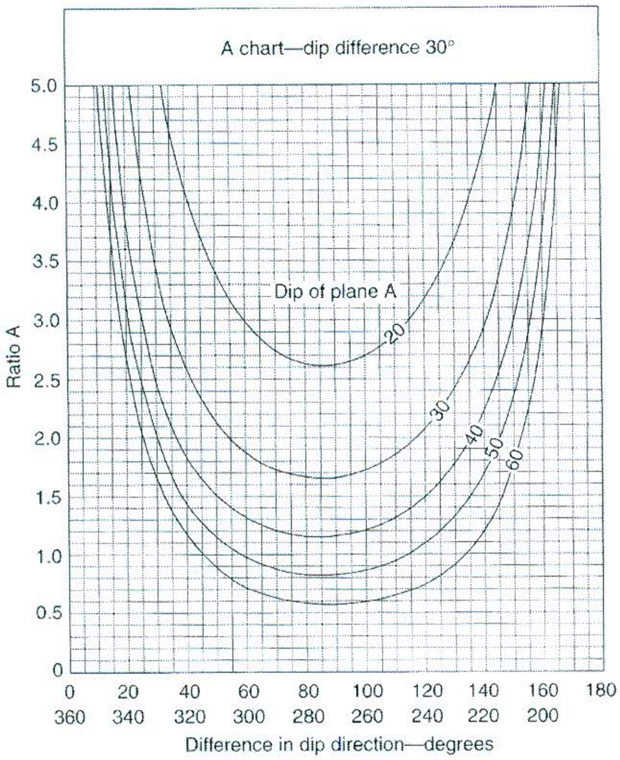


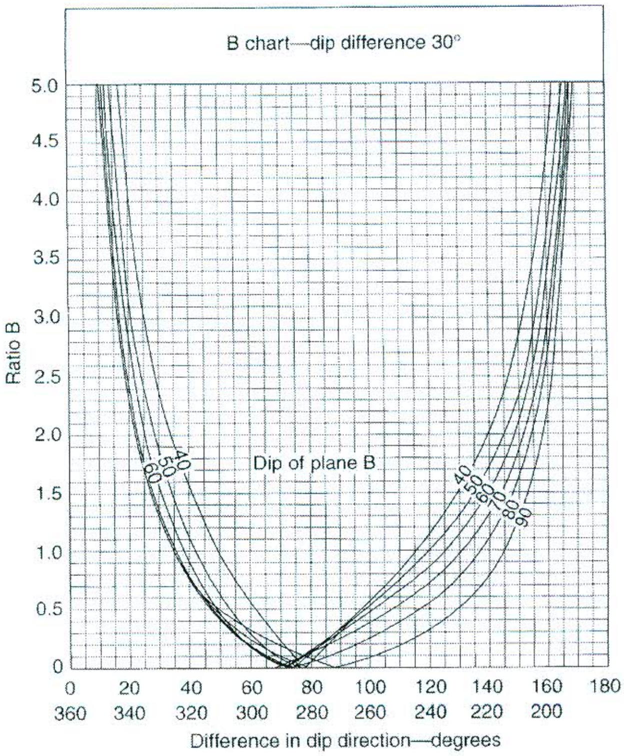

A chart—dip difference 10°
Ratio A
Dip of plane A
20
30
40
50
60
70
80
0 20 40 60 80 100 120 140 160 180
360 340 320 300 280 260 240 220 200
Difference in dip direction—degrees

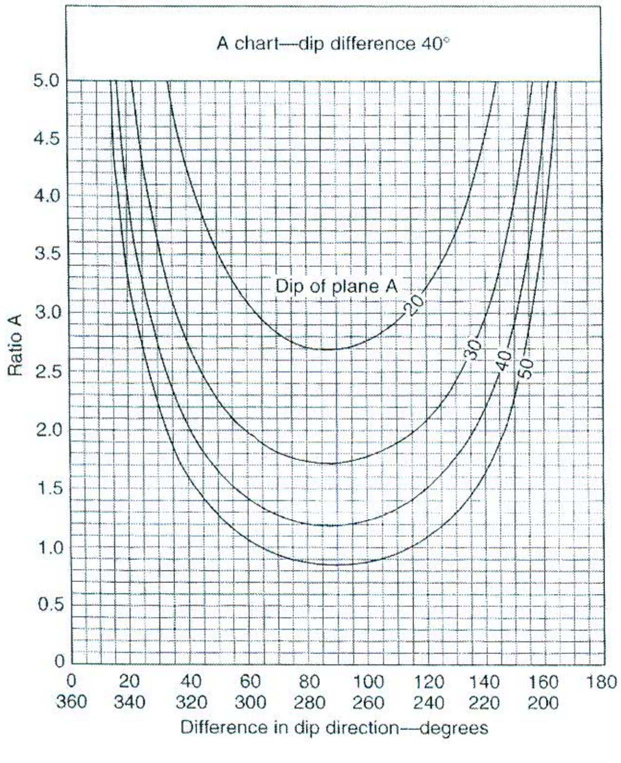

B chart—dip difference 10°
Ratio B
Dip of plane B
40
30
20
20
30
40
50
60
70
80
90
0 20 40 60 80 100 120 140 160 180
360 340 320 300 280 260 240 220 200
Difference in dip direction—degrees

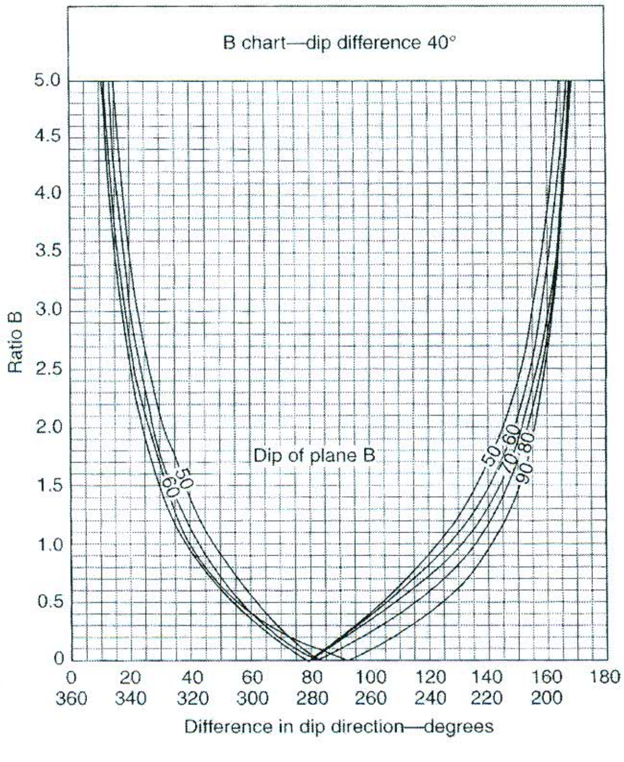

A chart—dip difference 20°
Ratio A
Dip of plane A
20
30
40
50
60
70
0 20 40 60 80 100 120 140 160 180
360 340 320 300 280 260 240 220 200
Difference in dip direction—degrees

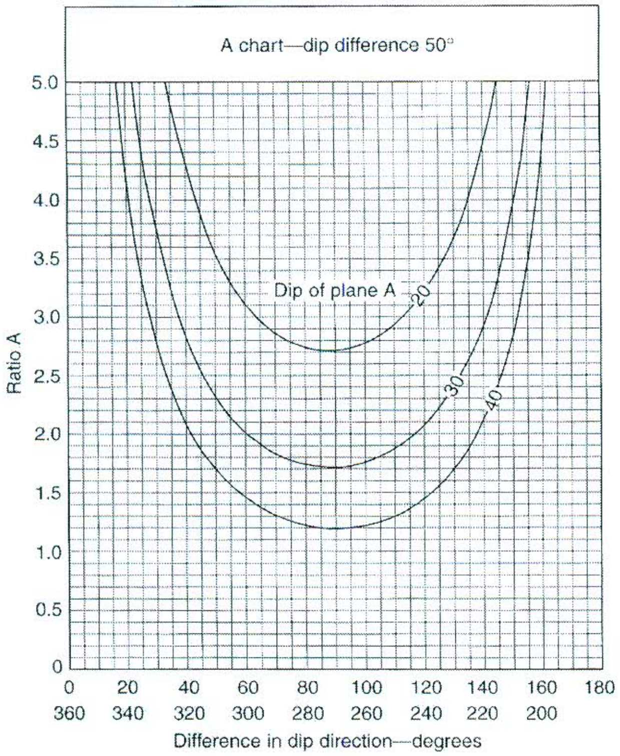

B chart—dip difference 20°
Ratio B
Dip of plane B
50
40
30
30
40
50
60
70
80
90
0 20 40 60 80 100 120 140 160 180
360 340 320 300 280 260 240 220 200
Difference in dip direction—degrees

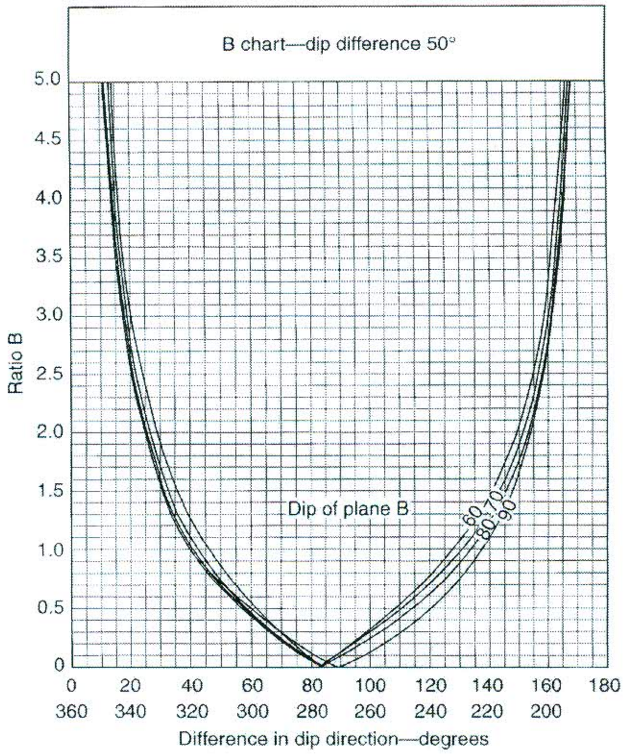

A chart—dip difference 30°
Dip of plane A
20
30
40
50
60
Ratio A
Difference in dip direction—degrees

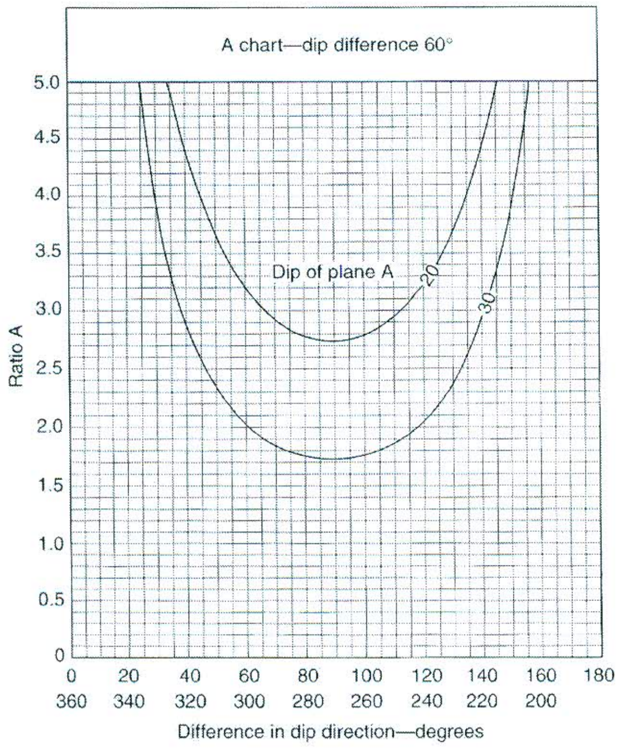

B chart—dip difference 30°
Dip of plane B
40
50
60
70
80
90
Ratio B
Difference in dip direction—degrees

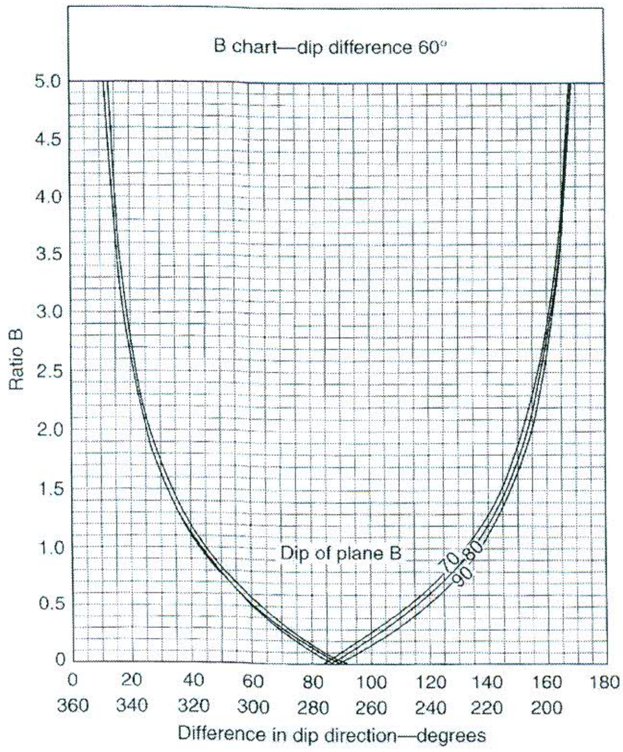

A chart—dip difference 40°
Dip of plane A
20
30
40
50
Ratio A
Difference in dip direction—degrees

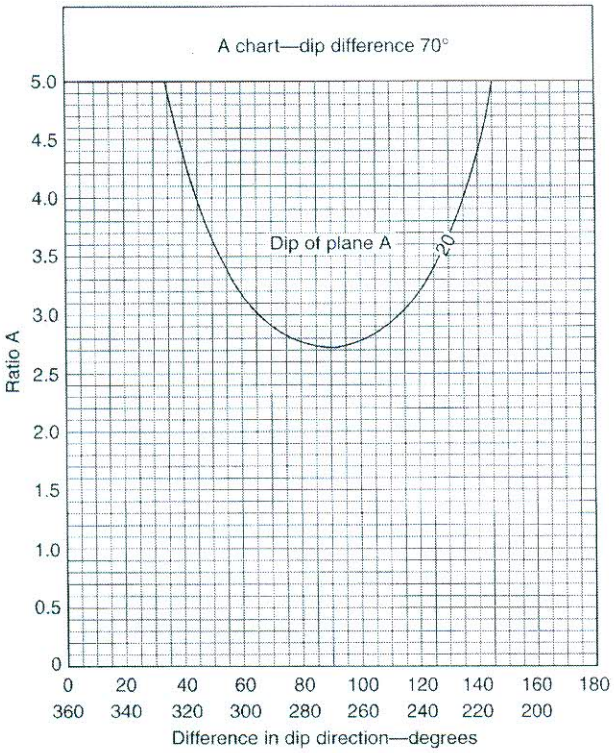

B chart—dip difference 40°
Dip of plane B
50
60
70
80
90
Ratio B
Difference in dip direction—degrees

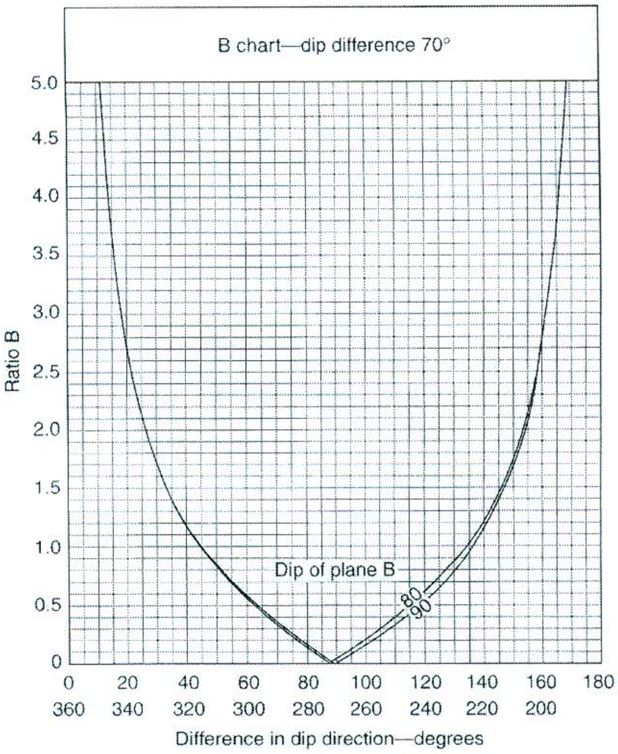

A chart—dip difference 50°
Ratio A
Dip of plane A
20
30
40
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
0 20 40 60 80 100 120 140 160 180
360 340 320 300 280 260 240 220 200
Difference in dip direction—degrees


B chart—dip difference 50°
Ratio B
Dip of plane B
60
70
80
90
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
0 20 40 60 80 100 120 140 160 180
360 340 320 300 280 260 240 220 200
Difference in dip direction—degrees


A chart—dip difference 60°
Ratio A
Dip of plane A
20
30
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
0 20 40 60 80 100 120 140 160 180
360 340 320 300 280 260 240 220 200
Difference in dip direction—degrees


B chart—dip difference 60°
Ratio B
Dip of plane B
70
80
90
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
0 20 40 60 80 100 120 140 160 180
360 340 320 300 280 260 240 220 200
Difference in dip direction—degrees


A chart—dip difference 70°
Ratio A
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Dip of plane A
20
0 20 40 60 80 100 120 140 160 180
360 340 320 300 280 260 240 220 200
Difference in dip direction—degrees


B chart—dip difference 70°
Ratio B
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
Dip of plane B
80
90
0 20 40 60 80 100 120 140 160 180
360 340 320 300 280 260 240 220 200
Difference in dip direction—degrees