UNIVERSITI SAINS MALAYSIA

First Semester Examination
Academic Session of 2005/2006

Peperiksaan Semester Pertama
Sidang Akademik 2005/2006

November 2005

EBS 417E/3 – GEOMECHANICS
GEOMEKANIK

Time : 3 hours
Masa : 3 jam

Instruction to candidates:

Before you begin with the examination, make sure that this paper is made up of 17 (seventeen) printed pages.

The paper consists of 8 (eight) questions. 4 (four) questions in Section A and 4 (four) questions in Section B. Answer FIVE questions with at least 2 (TWO) questions from each section.

Begin your answer for every question number on a fresh page.

Answer all questions in English Language. However you may choose to answer a maximum of TWO questions in Malaysian Language.

Arahan kepada calon:

Sila pastikan bahawa kertas peperiksaan ini mengandungi 17 (tujuh belas) muka surat bercetak sebelum anda memulakan peperiksaan.

Kertas soalan ini mengandungi 8 (lapan) soalan. 4 (empat) soalan dalam Bahagian A dan 4 (empat) soalan dalam bahagian B. Jawab 5 (lima) soalan dengan sekurang-kurangnya 2 (dua) soalan bagi setiap bahagian.

Mulakan jawapan bagi setiap bilangan soalan di muka surat yang baru.

Jawab semua soalan dalam Bahasa Inggeris. Namun demikian anda dibolehkan memilih menjawab sehingga DUA soalan dalam Bahasa Malaysia.

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SECTION A

BAHAGIAN A

1. (a) How is soil described and classified?

(5 marks)

(b) Define the following

(i) Porosity

(ii) Void ratio

(iii) Well graded soil

(iv) Uniformly graded soil

(v) Gap graded soil

(5 marks)

(c) A sample of saturated clay was placed in a container and weighed. The mass was 612 grams. The clay in its container was placed in an oven for 24 hours at 105^{0}C and the mass was reduced to 510 grams. The mass of the container was 102 grams. If the specific gravity of solid is 2.7, determine the (i) water content (ii) void ratio, (iii) bulk unit weight, (iv) dry unit weight, and (v) effective unit weight.

(10 marks)

1. (a) Bagaimanakah tanah diterangkan dan dikelaskan?

(5 markah)

(b) Takrifkan perkara berikut:

(i) keliangan

(ii) nisbah ruang

(iii) tanah bergred rapi

(iv) tanah bergred seragam

(v) tanah bergred sela

(5 markah)

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(c) *Suatu sampel tanah lempung tepu diletakkan di dalam suatu bekas dan ditimbang. Jisimnya ialah 612 gram. Lempung di dalam bekasnya telah diletakkan ke dalam ketuhar selama 24 jam pada suhu 105^{0}C dan jisimnya telah berkurangan kepada 510 gram. Jisim bekas ialah 102 gram. Jika graviti tentu pepejal ialah 2.7, tentukan (i) kandungan air (ii) nisbah rongga, (iii) berat unit pukal (iv) berat unit kering, dan (v) berat unit berkesan.*

(10 markah)

2. (a) What factors affect the shear strength of soils?

(5 marks)

(b) A cuboidal soil sample, with 50 mm sides, fails in a simple shear constant-volume test under a vertical load of 500 N, a horizontal load of 375 N and a shear load of 150 N. The excess pore water pressure developed is 60 kPa.

(i) Plot Mohr's circles for total and effective stresses.
(ii) Determine the friction angle and the undrained shear strength, assuming the soil as nondilating.
(iii) Determine the failure stress.
(iv) Find the magnitudes of the principal axis of stress to the horizontal.
(v) Determine the shear and normal stresses on a plane oriented at 20^0 clockwise to the horizontal.

(15 marks)

2. *(a)* *Apakah faktor-faktor yang memberi kesan kepada kekuatan ricih tanah?*

(5 markah)

(b) *Suatu sampel tanah berbentuk kiub, dengan sisi berukuran 50 mm, gagal dalam ujian ricih mudah berisipadu-tetap dengan beban tegak 500 N, beban mendatar 375 N dan beban ricih 150 N. Tekanan lebihan air liang yang terbentuk ialah 60 kPa.*

(i) Plot bulatan Mohr untuk tegasan jumlah dan tegasan berkesan.
(ii) Tentukan sudut geseran dan kekuatan ricih tak tersalir dengan andaian bahawa tanah ini tidak mengembang.

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(iii) Tentukan tegasan gagal.

(iv) Cari magnitud paksi utama tegasan mendatar.

(v) Tentukan tegasan ricih dan tegasan normal ke atas satah 20^0 ikut jam kepada mendatar.

(15 markah)

3. (a) Define active and passive earth pressures and derive using Rankine's theory the coefficient of active earth pressure.

(8 marks)

(b) A 5 metre high smooth vertical wall retains a soil level with the top of the wall. The bulk unit weight of the soil is 20 kN/m^3 and the angle of internal friction is 25^0. A tank is placed adjacent with the top of the wall and when filled with water has a resultant bearing load of 35 kN/m^2. Determine the total thrust per linear metre on the wall and its point of application.

(12 marks)

3. (a) Takrifkan tekanan bumi aktif dan pasif dan terbitkan pekali tekanan bumi aktif dengan menggunakan teori Rankine.

(8 markah)

(b) Sebuah dinding licin setinggi 5 meter menahan tanah yang rata dengan bahagian atas dinding. Berat unit pukal tanah ialah 20 kN/m^3 dan sudut geseran dalaman ialah 25^0. Sebuah tangki diletakkan bersebelahan dengan bahagian atas dinding dan apabila diisi dengan air mempunyai jumlah beban galas 35 kN/m^2. Tentukan jumlah daya per meter panjang dinding dan titik aplikasinya.

(12 markah)

...5/-

4. (a) Define (i) total stress (ii) effective stress (iii) induced stress.

(6 marks)

(b) A concrete dam as shown in Figure Q4 is constructed over a soil with a sloping impervious bedrock, and a cut-off wall is positioned as shown to reduce seepage. Determine the seepage per day per metre length of dam if k for the underlying soil is 3 x 10^{-3} mm/s. Sketch the uplift pressure diagram, and give the pressure at points A, B and C.

(14 marks)

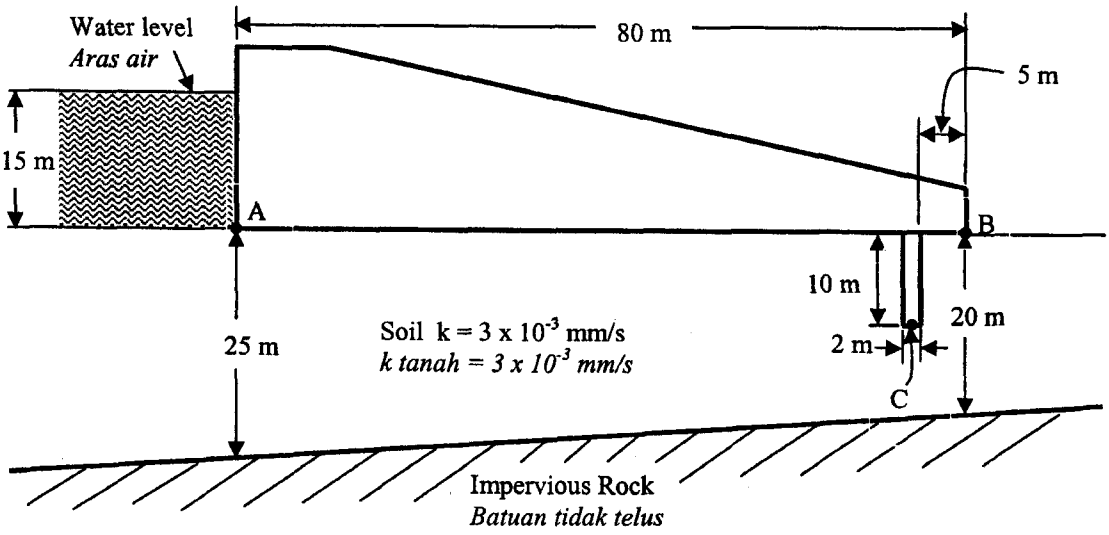


Figure Q4

Rajah Q4

4. *(a) Takrifkan (i) tegasan jumlah (ii) tegasan berkesan (iii) tegasan aruhan*

(6 markah)

(b) Sebuah empangan konkrit seperti ditunjukkan di dalam Rajah Q4 dibina di atas tanah dengan batuan hampar yang mencerun, dan suatu dinding penghalang diletakkan di bawah empangan untuk mengurangkan resipan. Tentukan resipan per hari per meter panjang empangan sekiranya nilai k untuk tanah ialah 3 x 10^{-3} mm/s. Lakar rajah tekanan angkat atas, dan berikan tekanan di titik A, B dan C.

(14 markah)

...6/-

Section B

Bahagian B

5. It is planned to install a new pump chamber in an underground mine at a depth of 1,200 metres. At this depth the virgin vertical stress is estimated to be 31 MPa. Stress investigation results from a hydraulic fracturing test carried out in vertical borehole at a point 800 metres depth were as follows:

P_{C1} = the peak pressure to cause an initial vertical fracture was 33 N/mm^2

P_{C2} = the second peak pressure initiating a crack opening was 24 N/mm^2

P_S = the shut in pressure was 16 N/mm^2

The vertical crack direction was found to be 040^0 (WCB). The equilibrium equation for hydraulic fracture is:

$$3\sigma_{h\,min} - \sigma_{h\,max} - P_{C1} = -To \quad \text{(usual notation)}$$

The chamber is shaped as shown in Figure Q5.

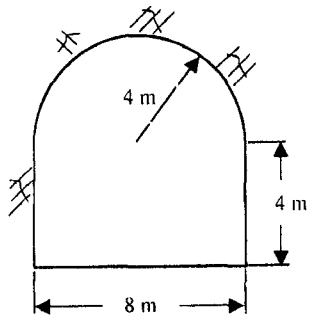


Figure Q5

$$\sigma_{walls} = P_z(2.3 - \frac{\sigma_h}{\sigma_v})$$

$$\sigma_{roof} = P_z(3.2\frac{\sigma_h}{\sigma_v} - 1) \quad \text{(usual notation)}$$

The ratio of field to laboratory rock strength is approximately 0.8, and the uniaxial compressive strength of the laboratory cores is 160 MPa.

Determine the most suitable orientation for the long axis of the chamber, and hence calculate the factor of safety for the chamber. Also advise on the proximity of a 3 metres diameter drive at the same level as the chamber and parallel to its long axis.

(20 marks)

...7-

5. *Ia telah dirancangkan untuk mengadakan satu ruang untuk pam baru dalam sebuah lombong bawah tanah di kedalaman 1,200 meter. Pada kedalaman ini, tegasan tegak dara telah dianggarkan 31 MPa. Keputusan penyiasatan tegasan daripada ujian rekahan hidraulik yang telah dilakukan di dalam lubang gerudi tegak di kedalaman 800 meter adalah seperti berikut:*

P_{C1} = *tekanan puncak yang menyebabkan mulanya rekahan tegak ialah 33 N/mm*^{2}.

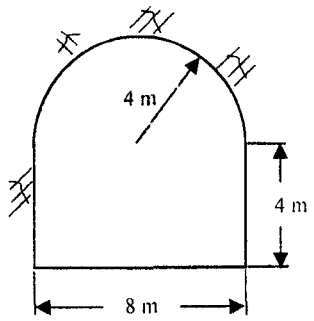
P_{C2} = *tekanan puncak kedua yang memulakan pembukaan keretakan ialah 24 N/mm*^{2}.

P_S = *tekanan semasa ditutup ialah 16 N/mm*^{2}

Arah keretakan tegak didapati pada 040^0 *(WCB). Persamaan perseimbangan untuk rekahan haidraulik ialah:*

$$3\sigma_{h\,min.} - \sigma_{h\,mak.} - P_{C1} = -T_o$$ *(tatatanda biasa)*

Ruang dibentuk seperti Rajah Q5.



Rajah Q5

$$\sigma_{dinding} = P_z(2.3 - \frac{\sigma_h}{\sigma_v})$$

$$\sigma_{bumbung} = P_z(3.2\frac{\sigma_h}{\sigma_v} - 1)$$ *(tatatanda biasa)*

Nisbah kekuatan batuan di lapangan dan di makmal dianggarkan sebagai 0.8, dan kekuatan mampatan unipaksi bagi teras di makmal ialah 160 MPa.

Tentukan orentasi yang paling sesuai bagi paksi panjang ruang, dan kirakan faktor keselamatan bagi ruang ini. Juga beri nasihat mengenai kedudukan sebuah terowong bergarispusat 3 meter pada aras yang sama dengan ruang dan selari dengan paksi panjangnya.

(20 markah)

...8/-

6. (a) Discuss the principle and merits of the application of shotcrete as a method of mine support. Include in the discussion the desirable properties of shotcrete, together with aspects of quality control, testing and safety.

(10 marks)

(b) Outline the essential requirements considered necessary for a rock mass classification system for mine support design.

(10 marks)

6. *(a)* *Bincangkan prinsip dan kebaikan penggunaan syotkret sebagai kaedah sokongan di lombong. Masukkan dalam perbincangan anda mengenai sifat-sifat yang dikehendaki untuk syotkret bersama dengan aspek kawalan kualiti, ujian dan keselamatan.*

(10 markah)

(b) *Bincangkan dengan ringkas mengenai keperluan-keperluan yang dianggap perlu untuk sistem pengelasan jisim batuan bagi rekabentuk sokongan lombong.*

(10 markah)

7. A 35 m high face for a road cut is to excavated northward into a rock mass, and a geotechnical drilling programme has revealed the following information:-

	Dip	Dip Direction	ϕ	c	Spacing
Bedding planes	60^0	180^0	35	0	3 m
Fault X	65^0	125^0	25	0	-
Fault Y	35^0	245^0	30	0	-

The intersection of the two faults will daylight on the slope face, and the water table has been located a few metres below the proposed excavation. In a nearby excavation Fault X formed a wedge intersection with Fault Z having a dip of 55^0, a dip direction of 012^0 and a ϕ of 31^0; the fault is also planar and smooth and has zero cohesion. Very shortly after this wedge intersection daylighted out of its slope, the wedge failed.

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Using accompanying design charts (Appendix 1), determine the factor of safety of the wedge formed by Fault X and Fault Y.

In addition:

(i) What is the recommended maximum stable slope angle? You may need to use the streonet enclosed.

(ii) 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?

(iii) Assuming that the slope angle in (i) is adopted, do you have to do anything to the drainage of the slope, should the slope become fully saturated?

(iv) If some heavy machinery were to move onto the top surface of the wedge block during the dry season would failure occur?

Give explanations for each of the answers (i) to (iv)

(20 marks)

7. *Suatu 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*	ϕ	*c*	*Jarak*
Satah berlapis-lapis	60^0	180^0	35	0	3 m
Fault X	65^0	125^0	25	0	-
Fault Y	35^0	245^0	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 Z yang mempunyai kemiringan 55^0, arah miring 012^0 dan ϕ bernilai 31^0; sesar ini juga berbentuk planar dan licin dan mempunyai kejeleketan kosong. Baji ini gagal tidak lama setelah persilangan terdedah di muka cerun.

...10/-

Dengan menggunakan carta yang disediakan (Lampiran 1), tentukan faktor keselamatan baji yang dibentuk oleh Sesar X dan Sesar Y.

Sebagai tambahan:

(i) *Sudut cerun apakah yang syorkan sebagai sudut cerun maksimum yang stabil? Anda boleh menggunakan streonet yang dilampirkan.*

(ii) *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?*

(iii) *Diandaikan sudut cerun dalam (i) digunakan, adakah perlu anda melakukan sesuatu kepada saliran di sekitar cerun sekiranya cerun menjadi tepu.*

(iv) *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 (1) hingga (iv).

(20 markah)

8. (a) A fault has a true dip of 80^0 towards 347^0 and cuts a reef. An ore shoot is developed where the two intersect. The reef outcrops at one locality 25 metres above datum and intersected in two vertical boreholes nearby. In the first borehole 50 metres, due south of the outcrop, the reef is located 5.0 metres above datum. In the second borehole, 100 metres due north east of the outcrop, the reef is encountered 65 metres below datum.

Determine:- (i) the true dip and strike of the reef;

(ii) the plunge and trend of the fault/reef contact.

(10 marks)

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(b) Figure Q8 shows the concentration of the pole plot of discontinuities in an open pit copper mine. The shape of the pit is almost circular. Which part of the pit is having some problems in slope stability? If the dip of fracture set A is 50^0 towards 307^0 and the dip of fracture set B is 61^0 towards 353^0, what is the steepest safe slope angle of that part of the pit? Assume that the angle of friction of the rock is 36^0. Give reasons for your answers.

(10 marks)

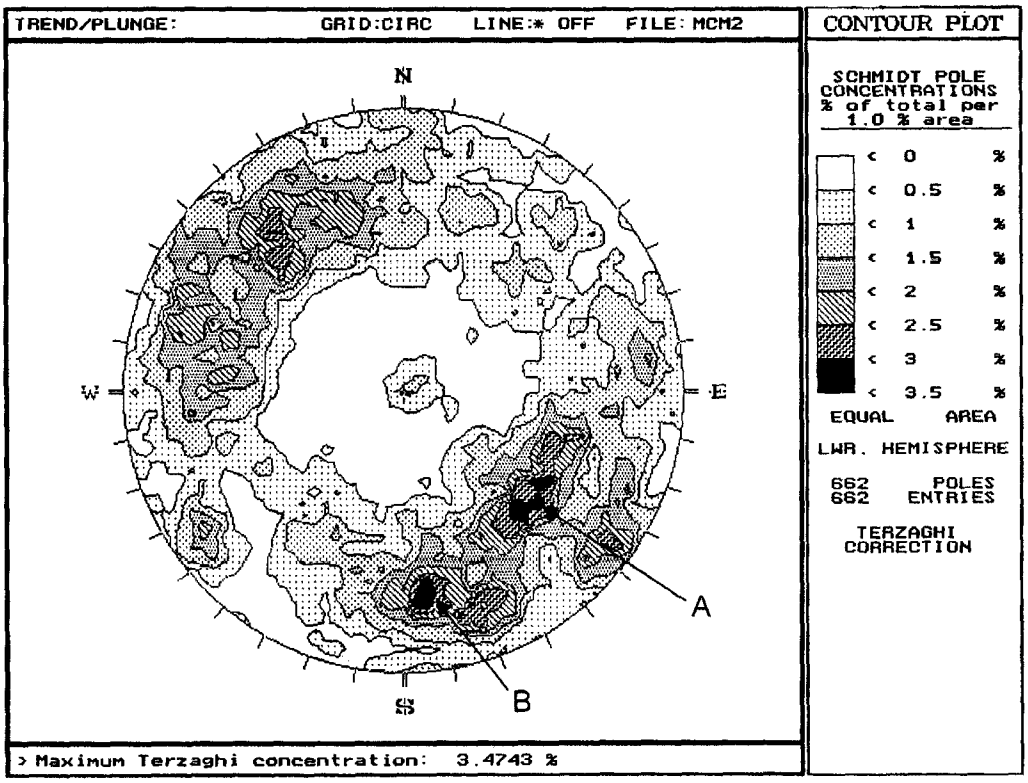

Figure Q8

Rajah Q8

8 (a) *Suatu sesar mempunyai kemiringan benar 80^0 ke 347^0 dan memotong telerang kuarza. Suatu pucuk bijih terbentuk di mana kedua-dua struktur bersilang. Singkapan telerang kuarza ditemui 25 meter di atas datum dan didapati juga bersilang di dalam dua lubang gerudi tegak yang berhampiran. Dalam lubang gerudi pertama yang terletak 50 meter selatan daripada singkapan, telerang didapati berkedudukan 5.0 meter di atas datum. Dalam lubang gerudi kedua, 100 meter barat daya daripada singkapan, telerang didapati berkedudukan 65 meter di bawah datum.*

...12/-

Tentukan:- *(i)* *kemiringan sebenar dan jurus telerang*

(ii) *tunjaman dan tren sentuhan sesar/telerang.*

(10 markah)

(b) *Rajah Q8 menunjukkan penumpuan plot kutub ketakselanjaran di dalam sebuah lombong dedah tembaga. Lubang lombong ini berbentuk seakan-akan bulat. Bahagian manakah bagi lubang lombong ini yang mengalami masalah kestabilan cerun? Jika kemiringan cerun set retakan A ialah 50^0 ke arah 307^0 dan kemiringan set retakan B ialah 61^0 ke arah 353^0, apakah sudut cerun selamat yang paling curam bagi bahagian lubang ini? Andaikan sudut geseran batuan ialah 36^0. Berikan sebab-sebab bagi jawapan-jawapan anda.*

(10 markah)

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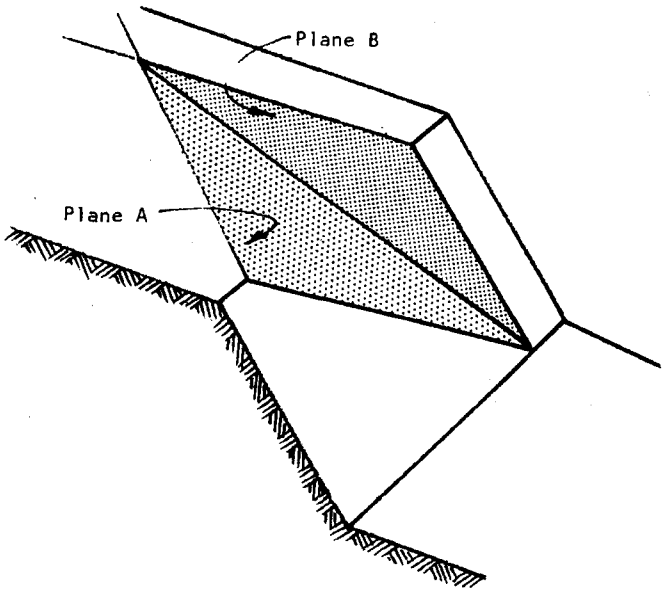
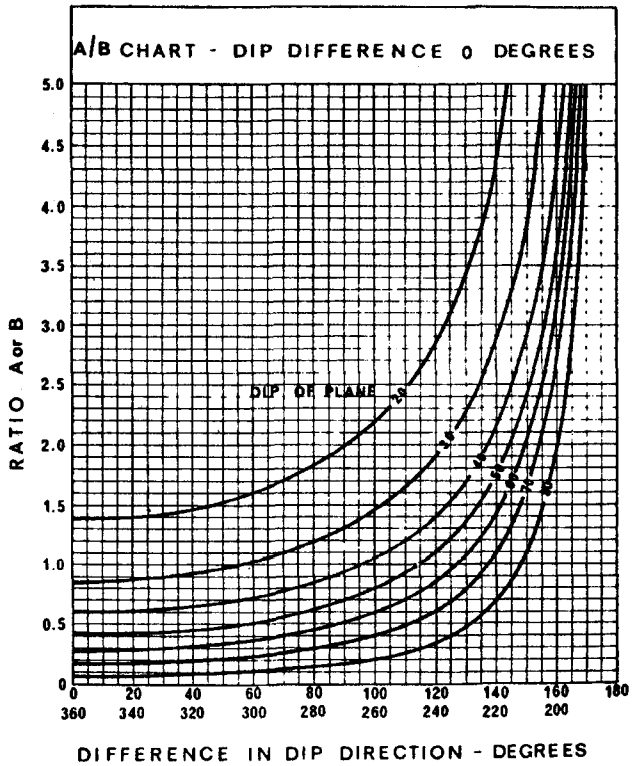
Appendix 1

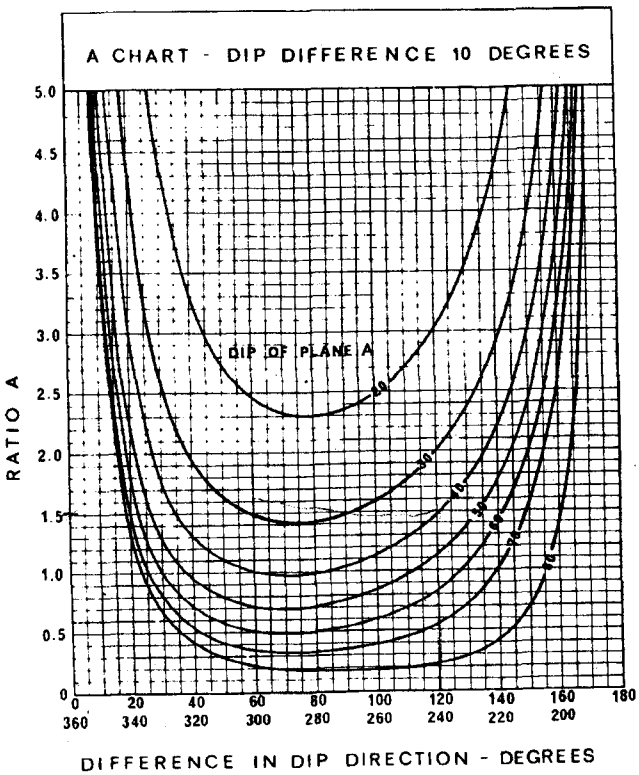
Lampiran 1

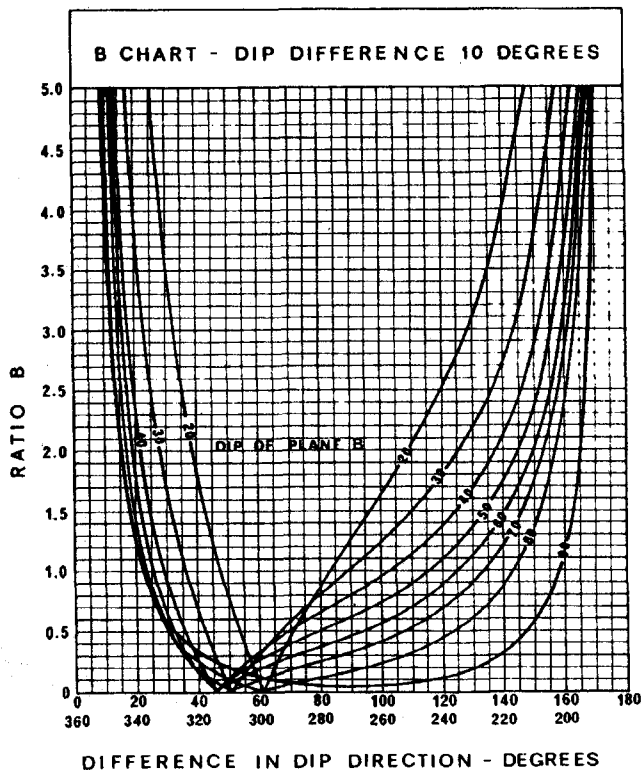
Wedge Stability Charts for Friction only



Note : The flatter of the two planes is always called plane A.







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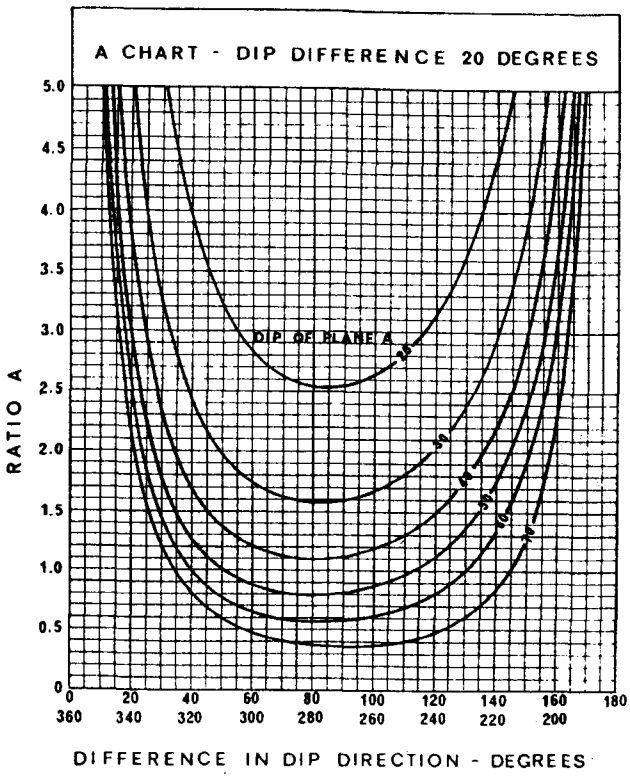
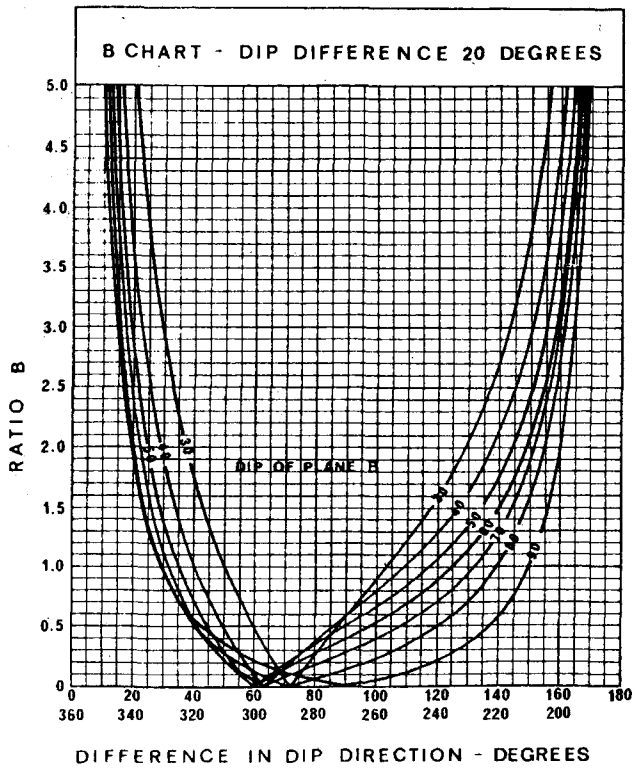
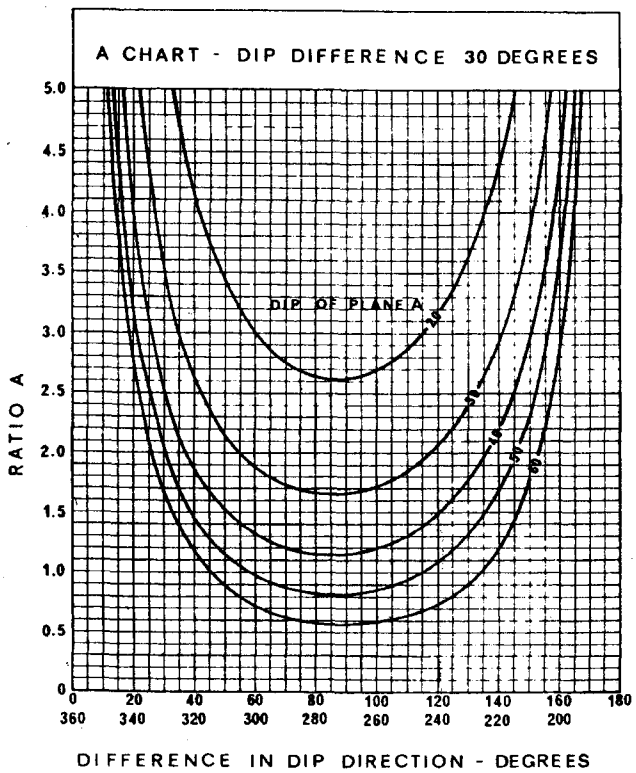
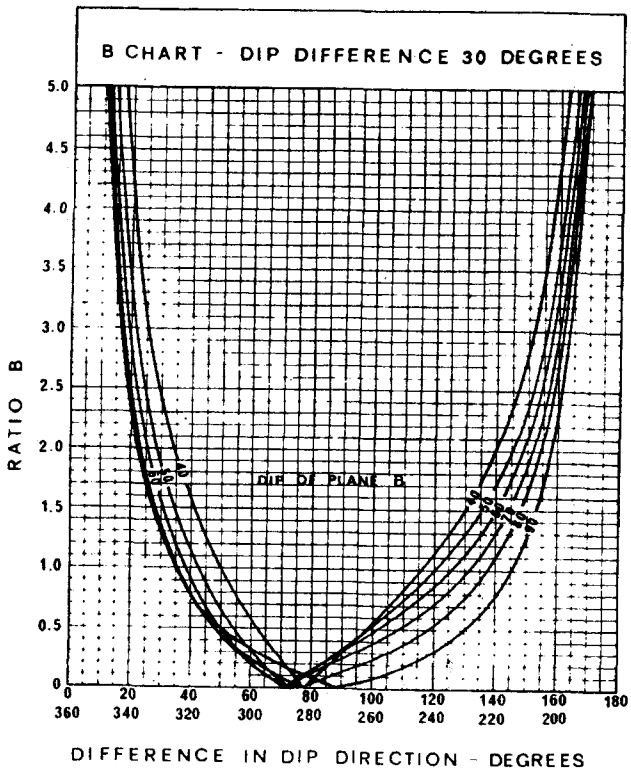
Appendix 1 – ctd

Lampiran 1 -samb.









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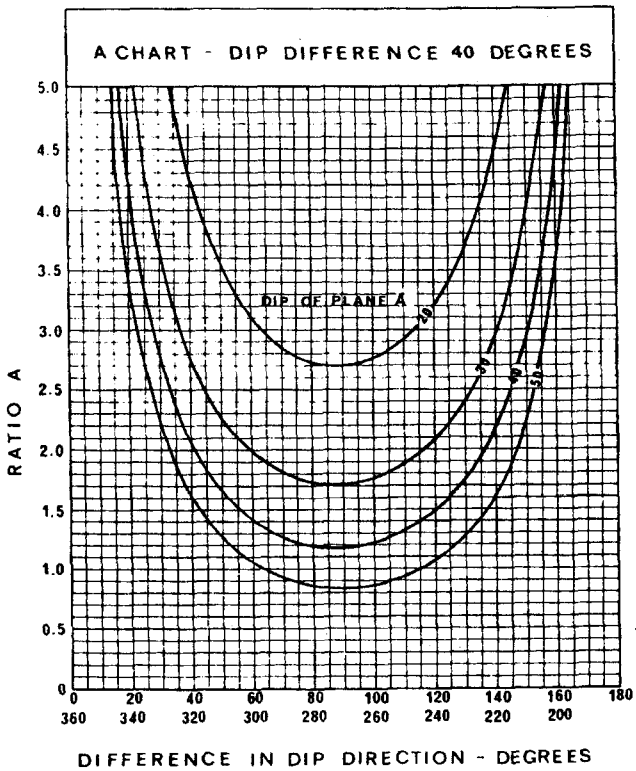
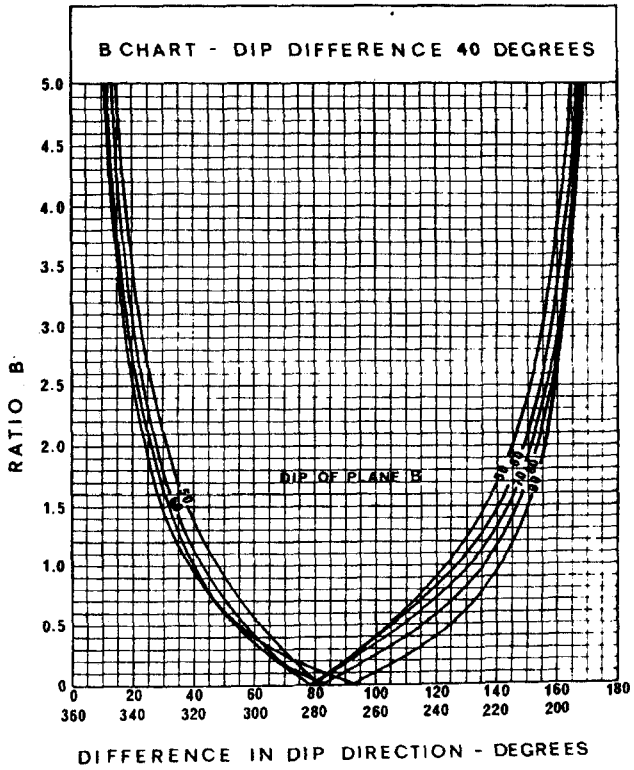
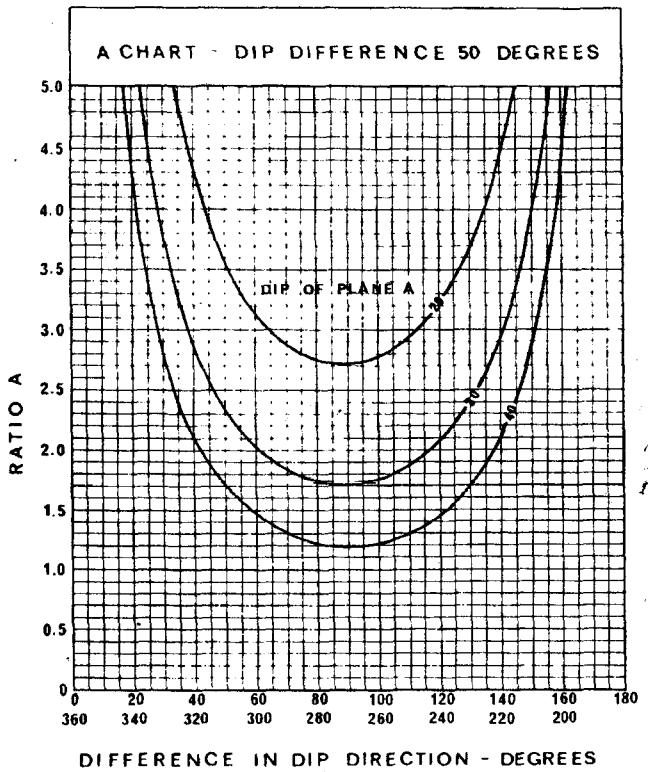
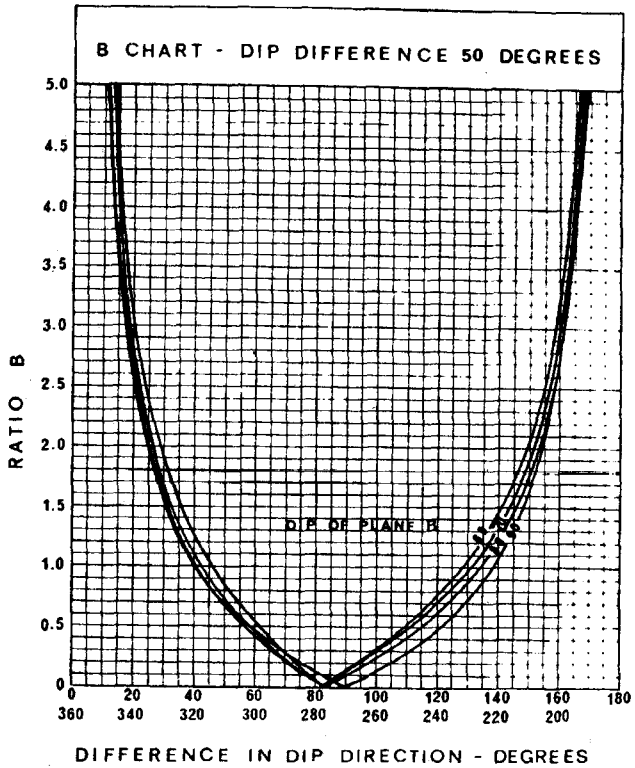
Appendix 1 – ctd

Lampiran 1 -samb.









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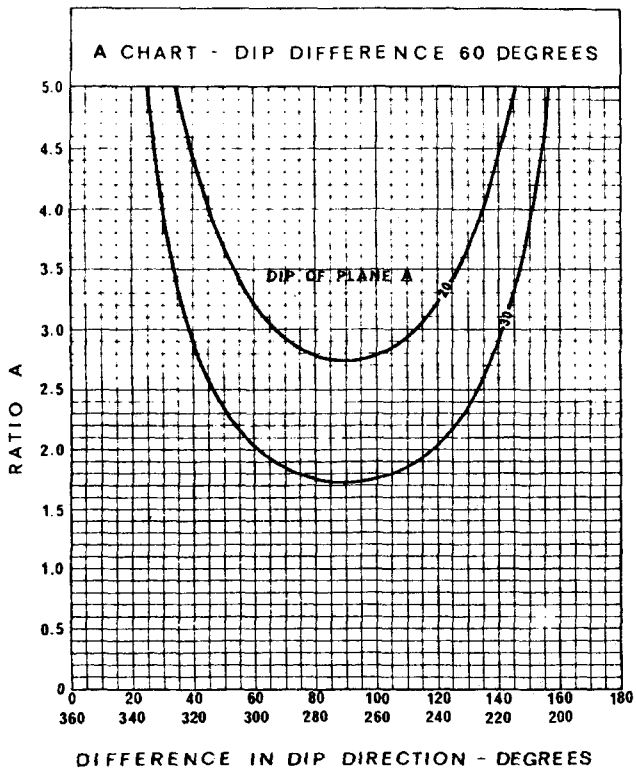
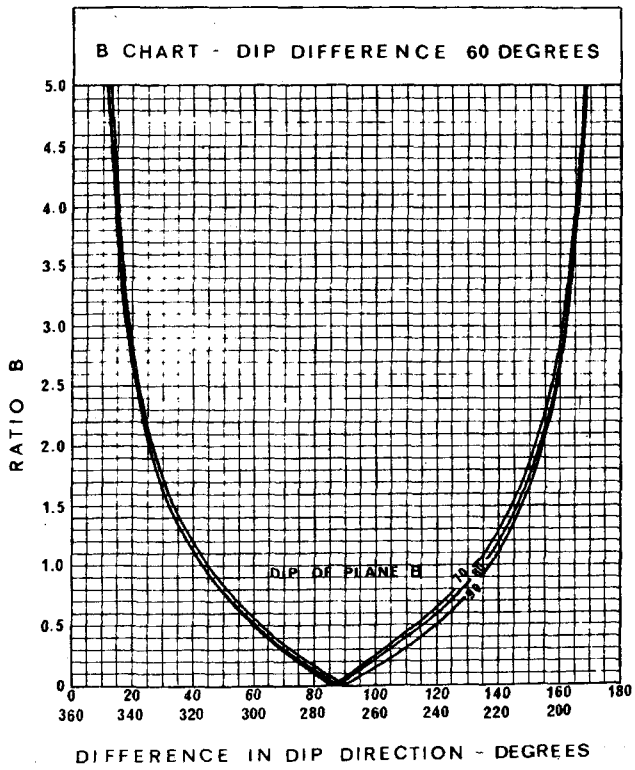
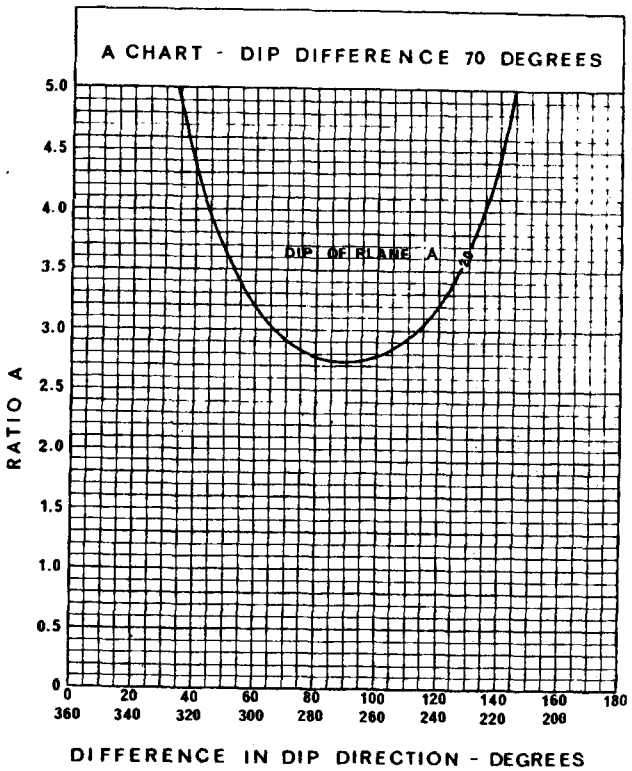
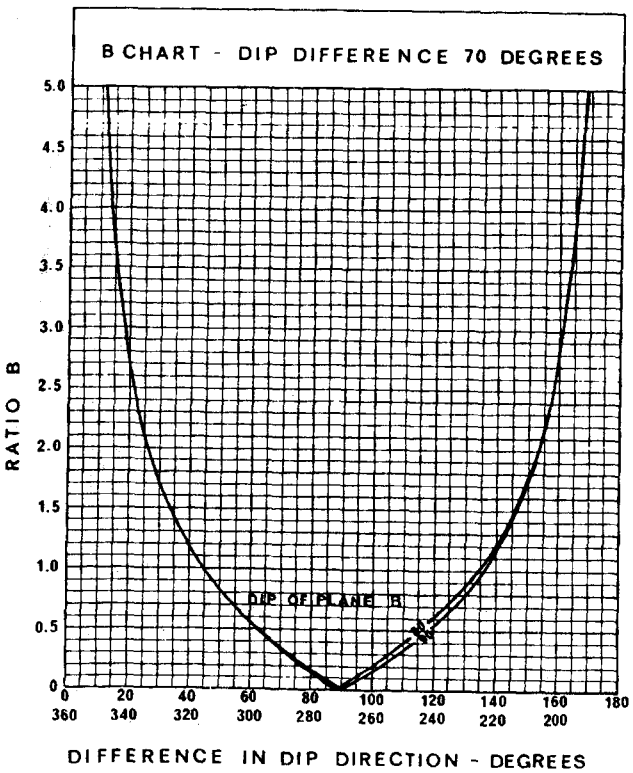
Appendix 1 – ctd

Lampiran 1 –samb.









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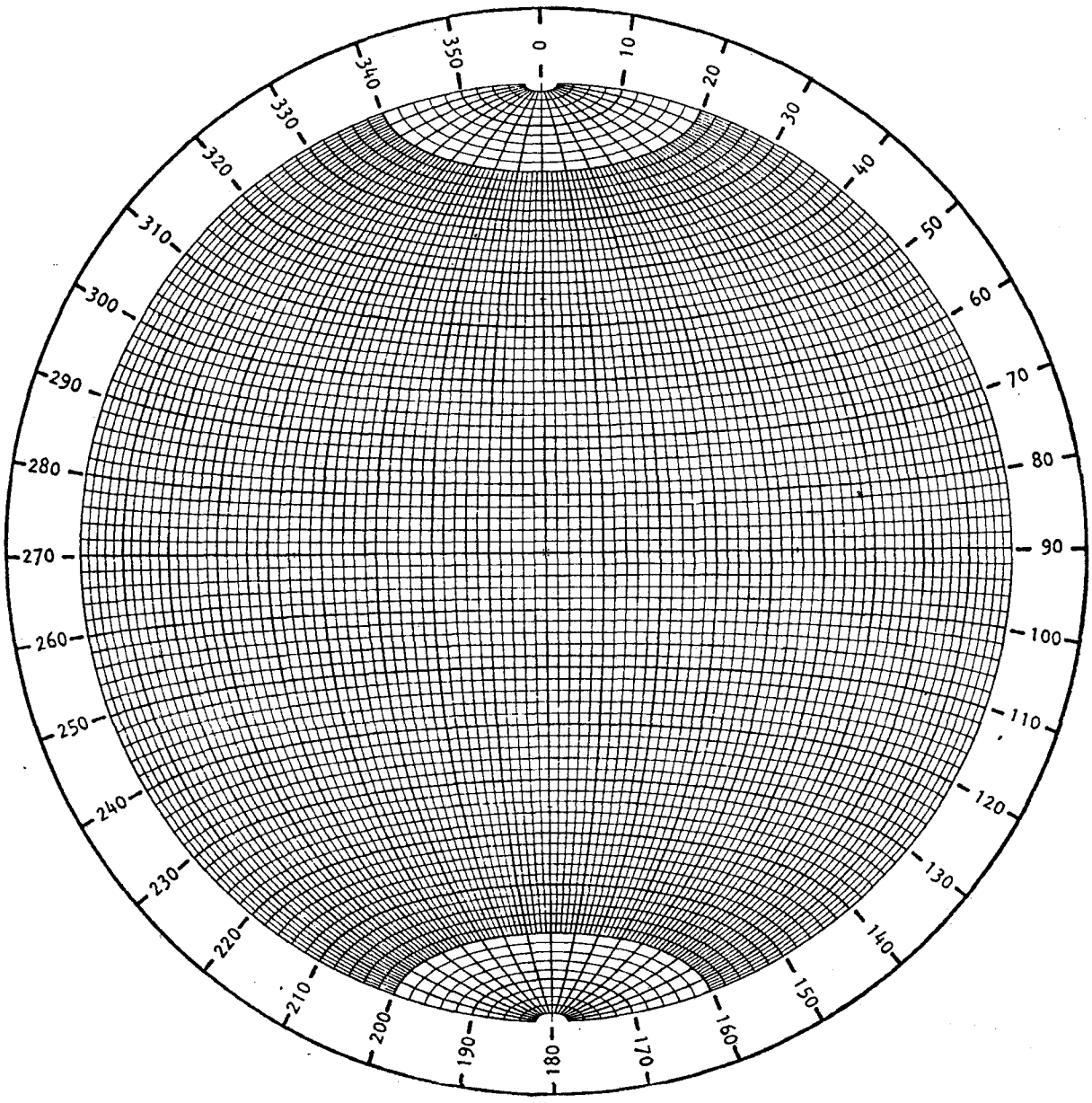
Appendix 2

Lampiran 2

Stereonet



Equatorial equal-area stereonet marked in 2^{o} intervals.

Conputer drawn by Dr. C.M. St John of the Royal School of Mines, Imperial College, London.