UNIVERSITY OF TORONTO

FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION, April 2001

Fourth Year

CIV523S - GEOTECHNICAL DESIGN

Examiner - M.W. Grabinsky

This examination is open book. Calculators are allowed. Examination time is 2½ hours.

Do all questions. The relative value of each question is indicated, and the total for the examination is 100. Do all work on the examination paper. Indicate if your work is carried over onto the back of a page.

Graduate students: In assessing your responses, there will be greater demand on clarity of presentation and explanation, and on quality of engineering judgement.

NAME ______________________________

STUDENT NUMBER ______________________________

Question	Value	Mark
1 – Deep Excavations	20	
2 – Groundwater Control	20	
3 – Soft Ground Tunneling	20	
4 – Earth Dams	20	
5 – Risk Management	20	
Totals :	100	

1. Deep Excavations

An excavation 20 m long, 10 m wide and 15 m deep is to be excavated in a deep clay deposit in 1.5 m cuts, using a soldier pile and lagging wall system. The clay has $\gamma = 20\ kN/m^3$ and $c_u = 50$ kPa. Plot the Factor of Safety against base instability, with depth of excavation. At what depth are deformations expected to become "substantial"? What can you say about the required depth of the wall system at the last stage of excavation?

2. Groundwater Control

A 5 m wide by 10 m long by 25 m deep service shaft is to be excavated through a soil profile defined as follows: a sand/silt layer to 20 m depth with a phreatic surface at 2 m depth; underlain by a 10 m thick clay deposit; underlain by a deep sand/silt deposit with a phreatic surface at 2 m above ground elevation. The excavation is to be carried out using a soldier pile and lagging system, and there are nearby stagnant surface sources of potential groundwater contamination. Describe the types of groundwater control strategies that might be used to facilitate construction.

3. Soft Ground Tunneling

A 3 m diameter sewer trunk is to be excavated in clay using an open-face tunneling machine. The clay has $\gamma = 20$ kN/m^3 and $c_u = 75$ kPa. The depth of cover is expected to vary between 2 and 15 meters. Plot the anticipated Factors of Safety against face instability for lined and unlined cases, and make recommendations regarding forms of ground support for this project.

4. Earth Dams

For the *actual* dam (Dam A) that was used as the basis for this year's term project, explain why a zoned embankment dam was constructed in front of the existing tailings (upstream construction) dam.

5. Risk Management

Describe how boulder size frequency was estimated for construction purposes in the Sheppard Subway Expansion Project, and how this information was used by the owner to manage the risks associated with construction.

Rock Mechanics – CIV 524
Department of Civil Engineering
Final Examination, April 18th 2001

All questions are of equal value.
The student is to answer all four questions.

<u>Question 1</u>

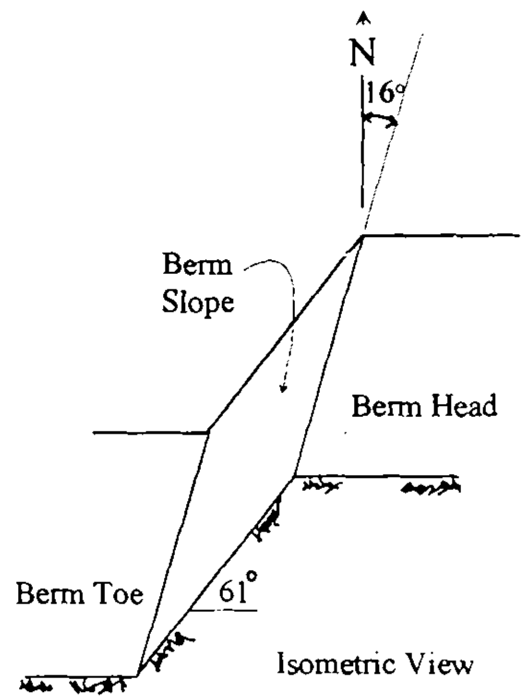
Given is a berm cut into a very long slope as shown in the figure below. The zones at the toe and head of the berm are horizontal. The traces of two discontinuities have been identified on the berm surface and at the head of the berm. The azimuths of the traces, in the direction of their plunge are given below.

Discontinuity I

	Azimuth
Trace above berm	N030°W
Trace on berm	N005°W

Discontinuity II

	Azimuth
Trace above berm	N042°E
Trace on berm	S025°W



Find the strike and dip of the two discontinuity planes.

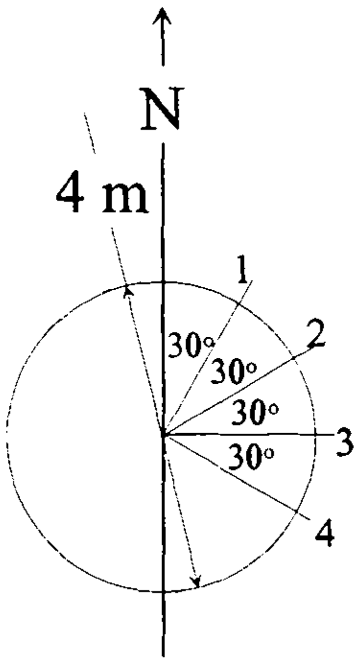
Do the geometric restrictions of this problem allow for the possibility that a wedge formed by the intersection of the two discontinuities and the slope surface may slide out of the slope (disregard geomechanical restrictions). Explain your answer using stereographic projection.

Question 2

Following is a sketch of a vertical pier (shaft) shown in cross section as viewed from above. At a depth of 420 meters a series of flatjack measurements were made in order to determine the far field stresses in the horizontal plane. Four tests were performed at the positions noted in the figure. The pressures required to null the induced deflections are listed for each position in the table. The rock at 420 meters depth has the following properties, and for the sake of computation may be assumed to be uniform with depth.

$E = 24{,}000$ MPa
$\nu = 0.17$
$\gamma = 24$ kN/m3
$q_u = 42$ MPa

Measuring Point	Nulling Pressure (MPa)
1	15.9
2	21.9
3	16.0
4	3.9



Required

Determine the far field in-situ stresses at the depth of 420 meters.

Question 3

A set of tests were preformed on a lightly cemented bedded sandstone. Triaxial tests carried out specimens cored perpendicular to the bedding planes led to the following strength parameters.

$q_u = 5.2$ MPa $\phi_i = 31°$

Direct shear tests were preformed on bedding plane surfaces under various normal stresses, and the following results found.

Normal Stress at failure, σ_f, MPa	0.5	1.0	4.0	8.0
Shear Stress at failure, τ_f, MPa	0.87	1.24	3.50	6.52

Two additional triaxial tests on specimens with bedding planes are to be tested.

Radial Confining Stress σ_c, MPa	β (degrees)
1.0	60
1.0	45

Where β is the direction between the bedding planes and the horizontal plane of the specimen and σ_c is the applied radial pressure.

Determine the expected axial stress which will cause failure of each specimen.

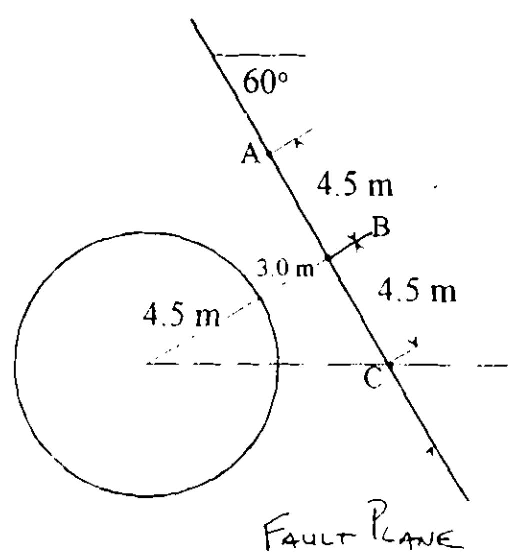
Question 4

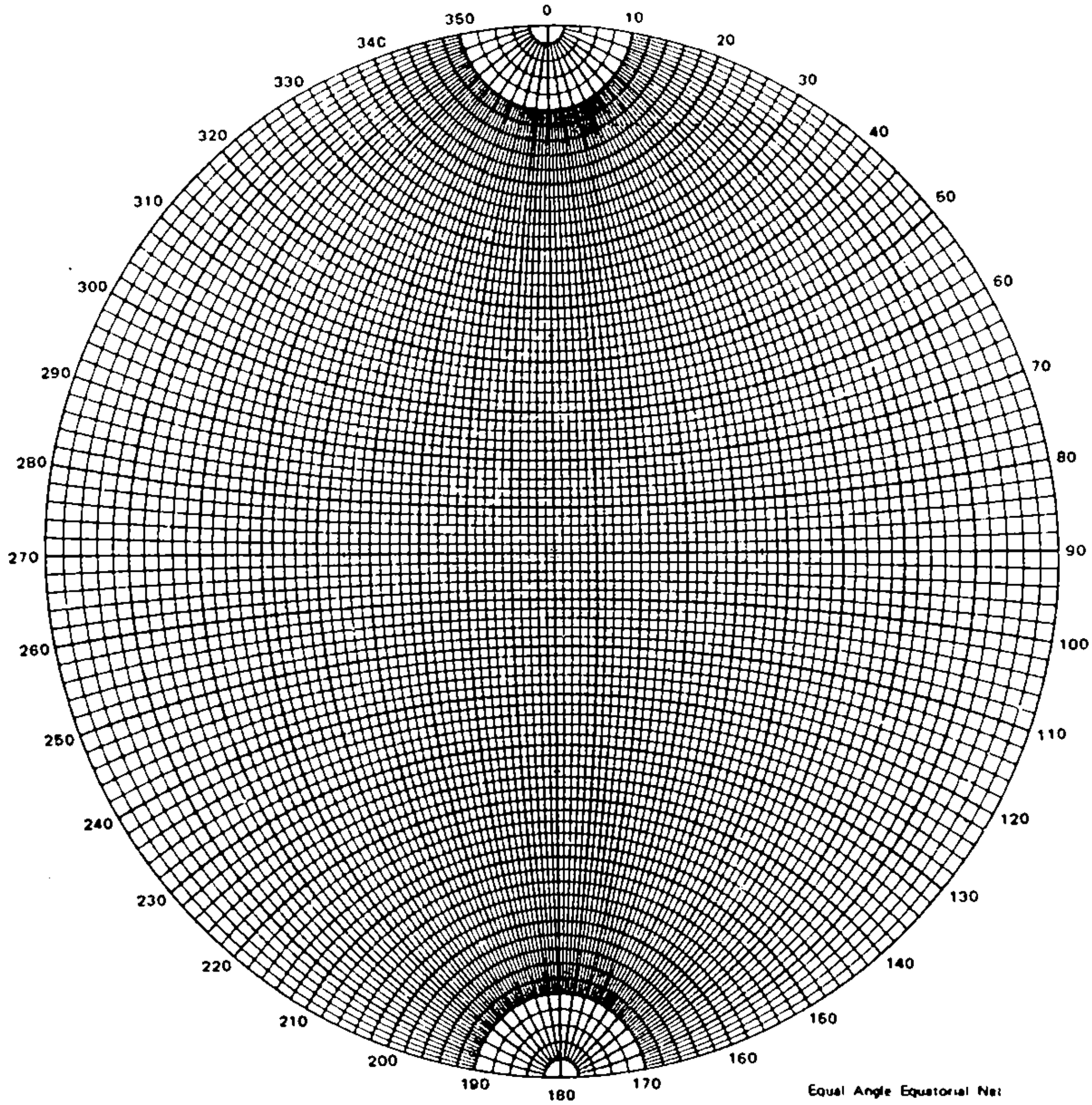
Shown is a horizontal tunnel of circular cross section (radius of 4.5 meters), constructed at a depth of 225 meters in competent limestone. A fault dipping at 60 degrees strikes parallel to the tunnel axis, as shown in the figure.

Determine the normal stress and shear stress acting on the fault plane at points A, B and C as shown in the figure.

It may be assumed that the plane of the page is a principle plane and that the initial far field stresses are lithostatic, developed from gravity alone.
Given are material properties which may be assumed to be uniform with depth.

E = 34,000 MPa $\nu = 0.20$ $\gamma = 24$ kN/m^3

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Equal Angle Equatorial Net

Figure A5.3