Final Examination

Dec. 13th, 2008

1. As for the rock slope of which dip direction/dip is 090/50, show the process of judging whether a joint pyramid 0001 is removable or not by using a testing matrix. The orientations of 4 joints sets in the slope are as below. (20)

1) normal vector calculation
x = sin a sin b, y = sin a cos b, z = cos a

Plane	Dip	Dip direction	x	y	z
1	75	10	0.1677	0.9513	0.2588
2	65	130	0.6943	-0.5826	0.4226
3	40	220	-0.4132	-0.4924	0.766
4	10	270	-0.1736	0	0.9848
5(slope)	50	90	0.766	0	0.6428

2) Finiteness test

		k					E
i	j	1	2	3	4	5	
1	2	0	0	-1	1	1	0
1	3	0	1	0	-1	-1	0
1	4	0	1	-1	0	-1	0
1	5	0	1	-1	1	0	0
2	3	-1	0	0	1	1	0
2	4	-1	0	1	0	1	0
2	5	-1	0	1	-1	0	0
3	4	1	-1	0	0	1	0
3	5	1	-1	0	-1	0	0
4	5	1	-1	-1	0	0	0

→ Finite block

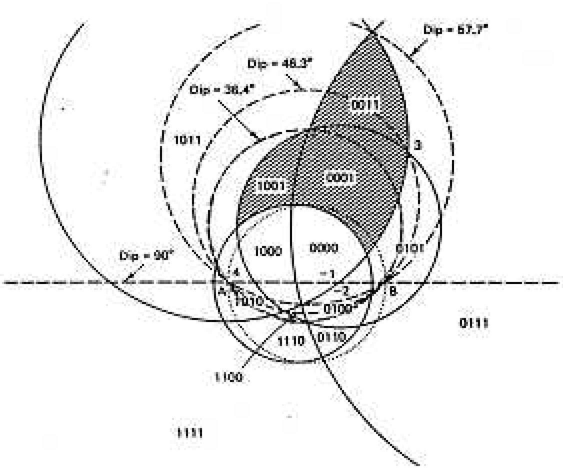
3) Removability test

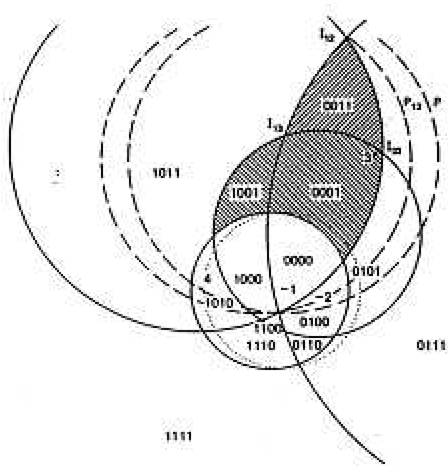
		k				E
i	j	1	2	3	4	
1	2	0	0	-1	1	0
1	3	0	1	0	-1	0

1	4	0	1	-1	0	0
2	3	-1	0	0	1	0
2	4	-1	0	1	0	0
3	4	1	-1	0	0	0

→ Tapered block (finite but non-removable)

2. Compare two design processes using the following projections. Solid lines indicate joints in a rock mass while dashed lines indicate slope surfaces. (10)

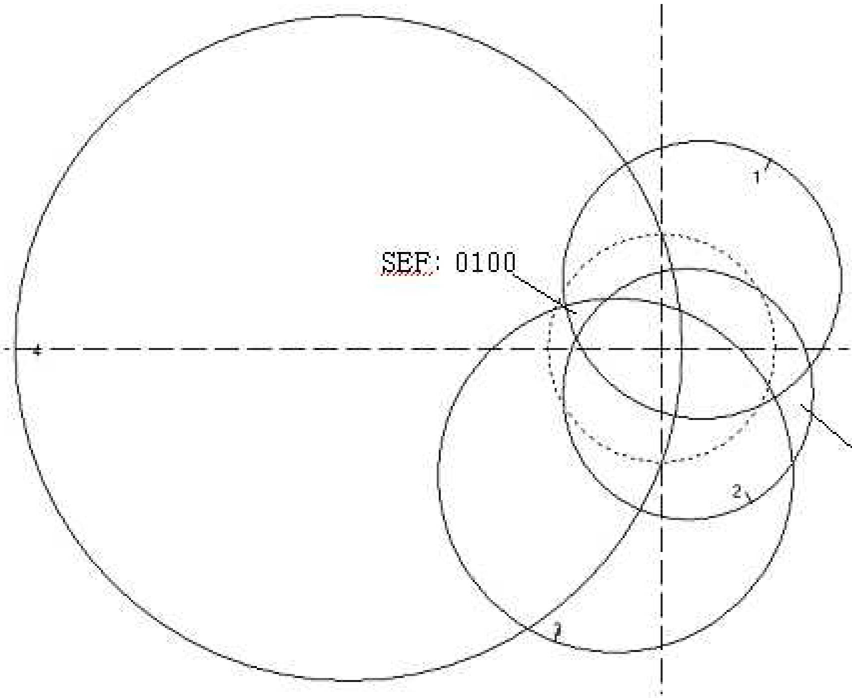




- The left shows a process to determine the dip angle of the slope for a given slope strike (E-W) while the right shows a process to determine the strike of the slope for a given dip angle.

3. The room you are in now has a window whose normal is directed to north. Let's assume that the room is an underground chamber and there are 4 joint sets around the chamber. The great circles of the joint sets are as follow. Obtain the joint pyramids of removable blocks that possibly occur in each of 8 corners (4 in the ceiling and 4 in the floor). Denote the north-east-ceiling corner as NEC, north-west-ceiling corner as NWC, south-east-ceiling corner as SEC, south-west-ceiling corner as SWC, north-east-floor corner as NEF,,, (15)

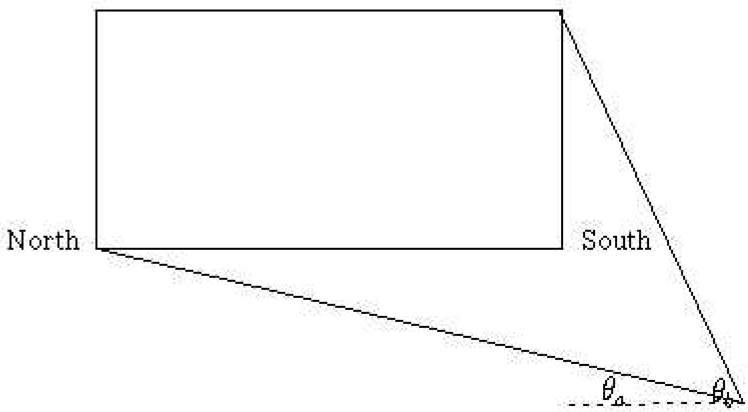
- There are two removable blocks: 1011 at NWC and 0100 at SEF.

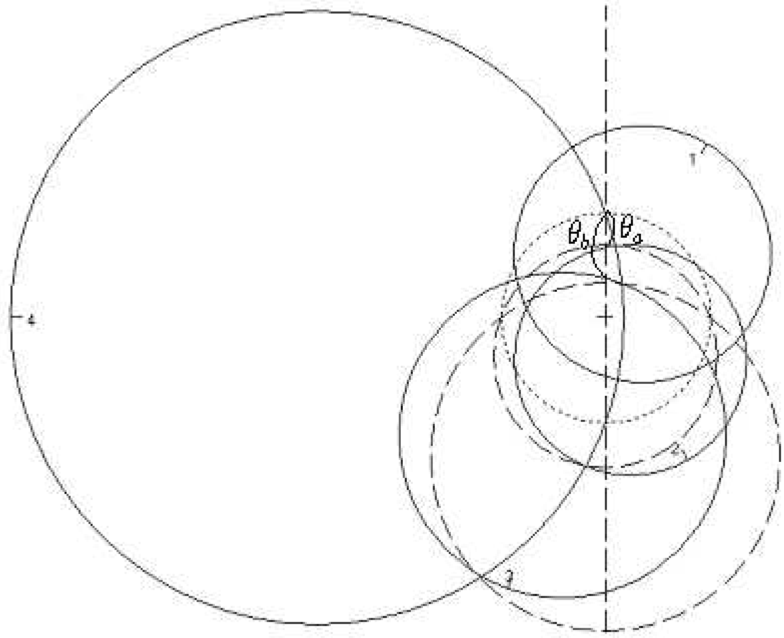


4. Explain the 'tunnel axis theorem'. (10)

- JP is a removable block of a tunnel if and only if $\pm\hat{a} \not\in$ JP

5. Assume that a rectangular-shaped horizontal tunnel is excavated from west to east in a rock mass having the same joint sets as problem 3. Draw the largest cross-section shape of a 0010 block when it is seen from west as below (2D shape). Denote the angles between boundary edges of the block and a horizontal line as θ_a and θ_b, respectively. (15)





6. The driving force of a sliding block is obtained by subtracting the force of capacity (resistance) from the force of demand (component of a resultant force in sliding direction), while a safety factor is obtained by dividing the capacity by the demand. Define the safety factors of a single face sliding and double face sliding blocks by using the resultant force ($\vec{r}$), inward normal vectors of sliding faces ($\hat{v_i}$, $\hat{v_j}$) and joint friction angles (ϕ_i, ϕ_j) when i and j are the sliding faces of single face sliding (i) and double face sliding (i,j). (15)

- Single face sliding: $S.F. = \dfrac{|\vec{r} \cdot \hat{v_i}| \tan\phi_i}{|\vec{r} \times \hat{v_i}|}$

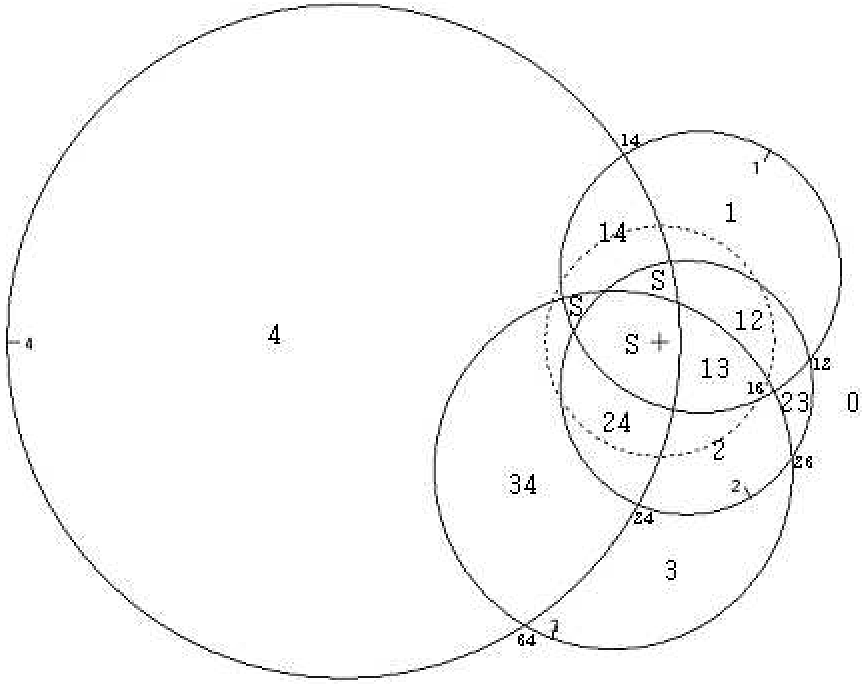
- Double face sliding: $S.F. = \dfrac{N_i \tan\phi_i + N_j \tan\phi_j}{\vec{r} \cdot \hat{s_{ij}}}$

$$\text{where } \hat{s_{ij}} = \frac{\hat{v_i} \times \hat{v_j}}{|\hat{v_i} \times \hat{v_j}|} sign[\hat{v_i} \times \hat{v_j} \cdot \vec{r}]$$

$$N_i = \frac{|(\vec{r} \times \hat{v_j}) \cdot (\hat{v_i} \times \hat{v_j})|}{|\hat{v_i} \times \hat{v_j}|^2}, \quad N_j = \frac{|(\vec{r} \times \hat{v_i}) \cdot (\hat{v_i} \times \hat{v_j})|}{|\hat{v_i} \times \hat{v_j}|^2}$$

7. Let the gravitational force be the only force imposed on rock blocks. Determine the possible failure mode of each block formed by 4 joints whose great circles are as follow (same as those in problem 3). Assume that the

free plane of each block is located (oriented) so that the block becomes removable. (15)



- Lifting: 1111
- Single face sliding: 0111(1), 1001(2), 1101(3), 1110(4)
- Double face sliding: 0011(12), 0001(13), 0110(14), 1011(23), 1000(24), 1100(34)
- Stable: 0010, 0100, 0000