제 3 주제

암반시공에서의 안전

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목　　　차

3.3 안 정 분 석

1) Plane Failure

2) Wedge Failure

3) Toppling

3.4 안정에 영향을 미치는 요소

1) 안정을 저해하는 요소

2) 안정을 증진시키는 요소

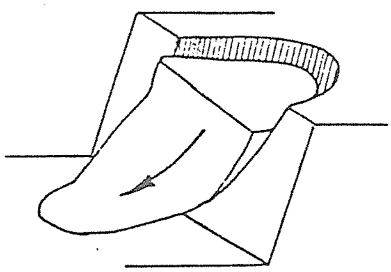
4. 터 널

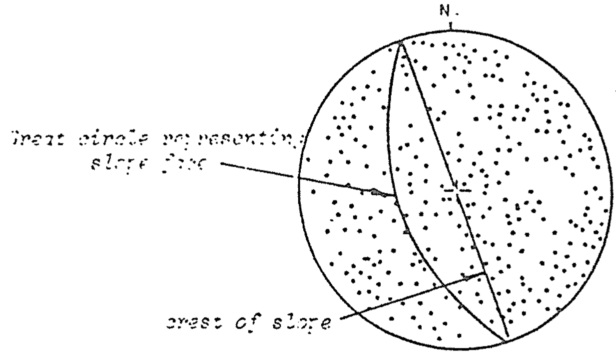
4.1 붕괴형태

4.2 지보 설계의 기본이론

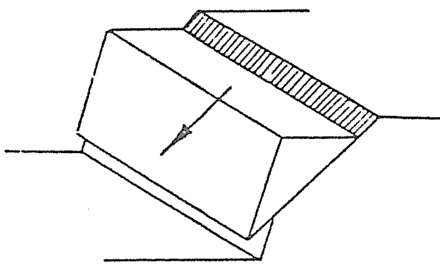
4.3 계측의 중요성

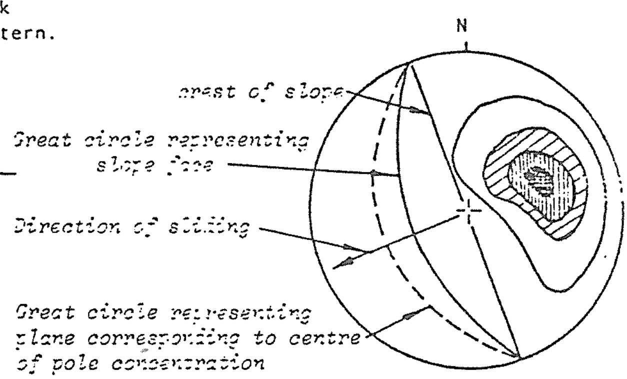
5. 결 론



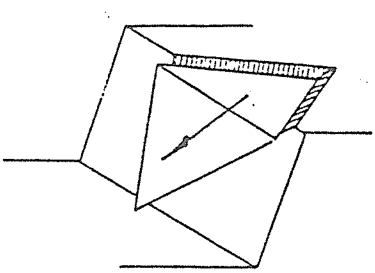


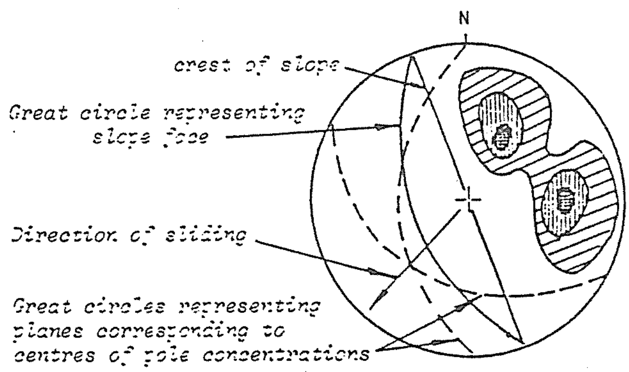
a. Circular failure in overburden soil, waste rock or heavily fractured rock with no identifiable structural pattern.



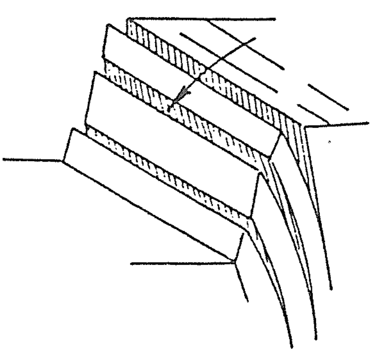


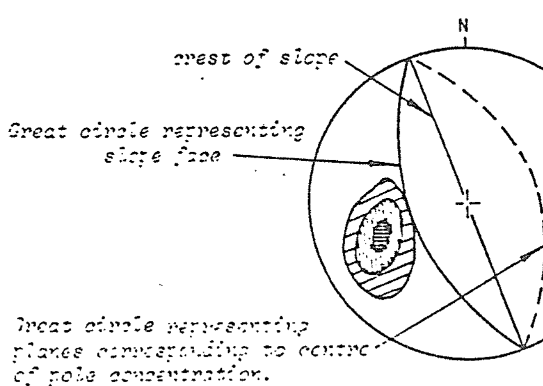
b. Plane failure in rock with highly ordered structure such as slate.





c. Wedge failure on two intersecting discontinuities.





d. Toppling failure in hard rock which can form columnar structure separated by steeply dipping discontinuities.

: Main types of slope failure and stereoplots of structural conditions likely to give rise to these failures.

그림 1

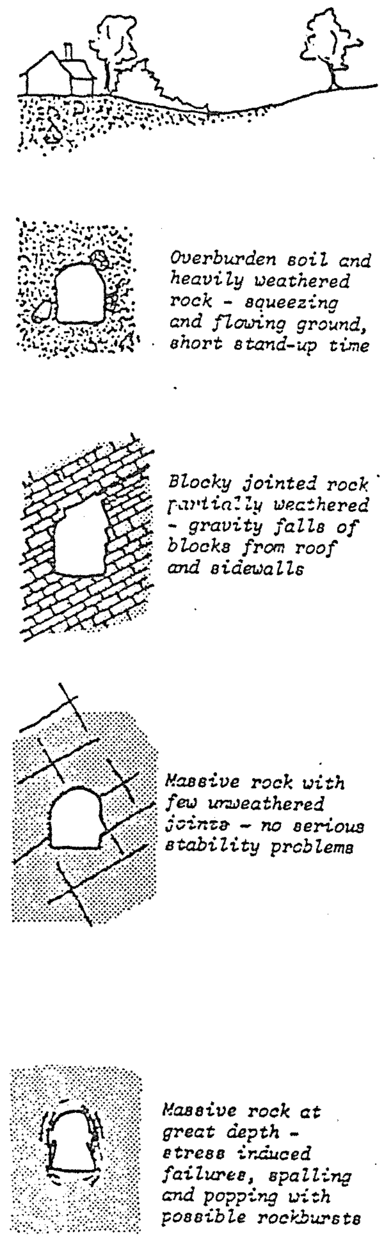
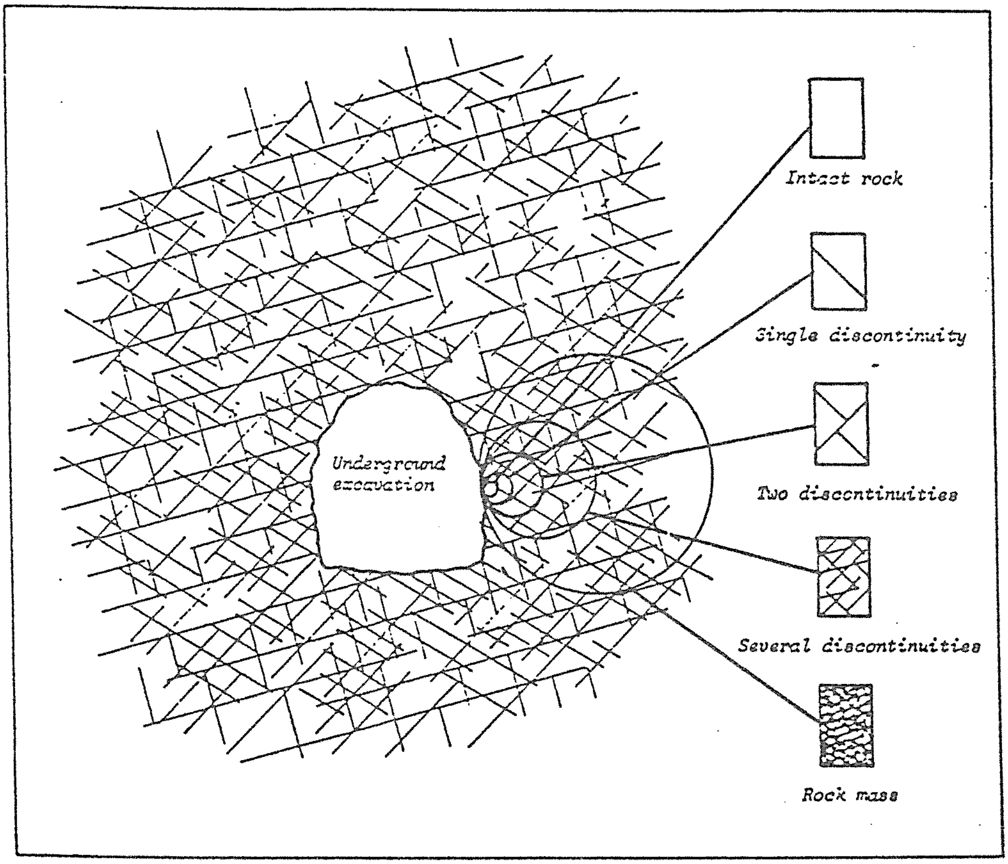
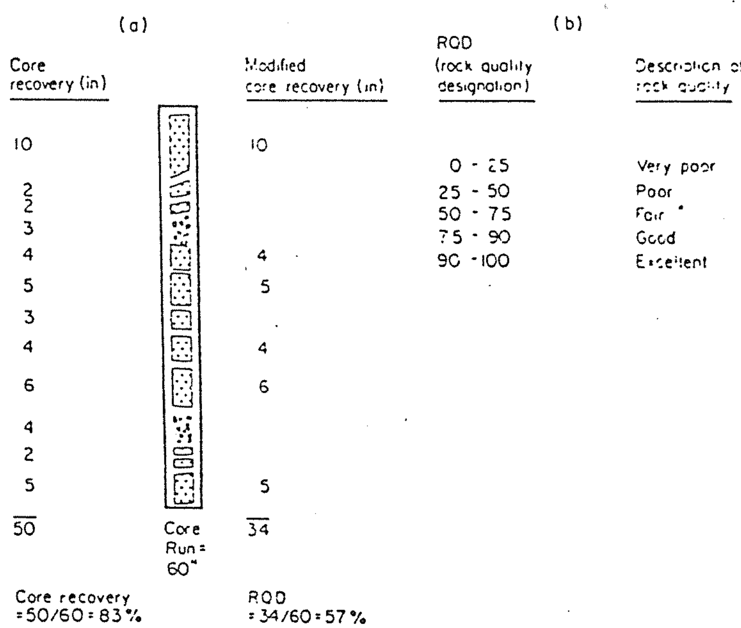

Overburden soil and heavily weathered rock - squeezing and flowing ground, short stand-up time
Blocky jointed rock partially weathered - gravity falls of blocks from roof and sidewalls
Massive rock with few unweathered joints - no serious stability problems
Massive rock at great depth - stress induced failures, spalling and popping with possible rockbursts

그림 2



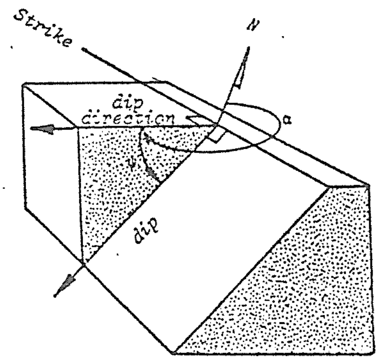
: Idealised diagram showing the transition from intact rock to a heavily jointed rock mass with increasing sample size.

그림 3

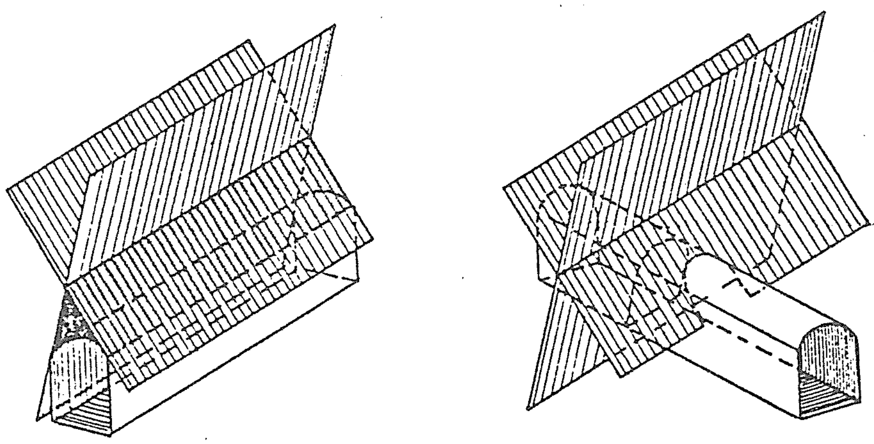


Modified core recovery as an index of rock quality[15]

그림 4



Definition of geological terms



Unfavourable orientation *Optimum orientation*

Influence of excavation orientation upon the formation of unstable wedges in rock masses containing major structural discontinuities.

그림 5

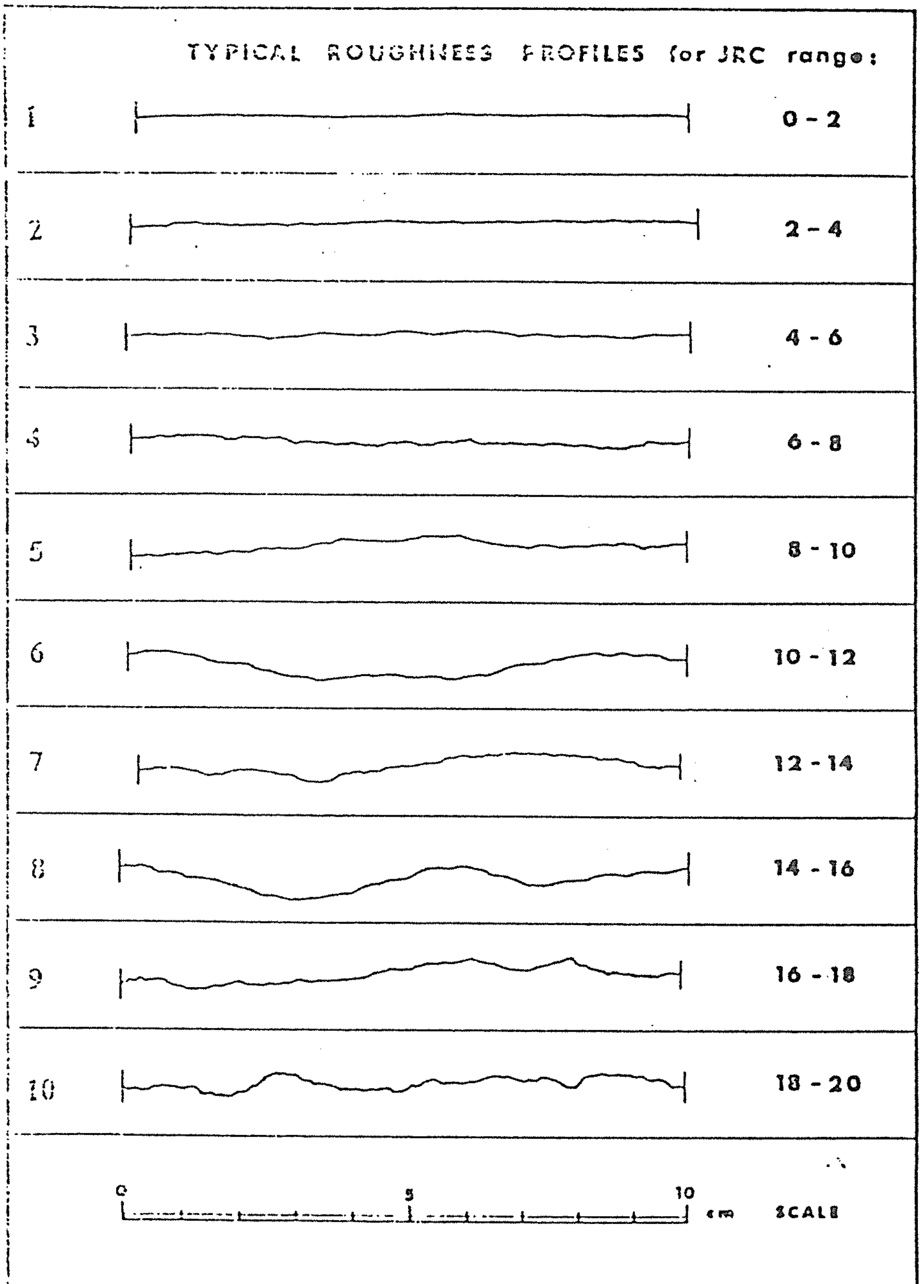


Fig. 19. Roughness profiles and corresponding range of JRC values associated with each one [6].

formula:

$$\phi_{peak} = JRC \log_{10}\left(\frac{JCS}{\sigma_n'}\right) + \phi_r$$

where

JRC = joint roughness coefficient

JCS = joint wall compression strength

$\phi_r = \phi_{(residual)}$

그림 6

ENGINEERING CLASSIFICATION OF INTACT ROCK*

(A) ON THE BASIS OF UNIAXIAL COMPRESSIVE STRENGTH

Class	Strength	Uniaxial compression, kg/cm^2	Point-load index†	Rock type
A	Very high	>2200	>95	Quartzite, diabase, dense basalts
B	High	1100-2200	50-95	Majority of igneous rocks, stronger metamorphics, well-cemented sandstone, hard shales, limestones, dolomites
C	Medium	550-1100	25-50	Shales, porous sandstones, limestones, schistose metamorphic rocks
D	Low	275-550	13-25	Porous and low-density rocks, friable sandstones, clay-shales, chalk, halite, and all altered rocks
E	Very low	<275	<13	As for class D

(B) ON THE BASIS OF MODULUS RATIO‡

Class	Modulus ratio	Value	Rock fabric
H	High	>500	Steeply dipping schistosity or foliation
M	Medium (average)	200-500	Interlocking fabric, little or no schistosity
L	Low	<200	Closure of foliations or bedding planes affects deformation

그림 7.

ROCK-MASS DISCONTINUITIES		
Discontinuity	**Definition**	**Characteristics**
Fracture	A separation in the rock mass, a break.	Signifies joints, faults, slickensides, foliations, and cleavage.
Joint	A fracture along which essentially no displacement has occurred.	Most common defect encountered. Present in most formations in some geometric pattern related to rock type and stress field. Open joints allow free movement of water, increasing decomposition rate of mass. Tight joints resist weathering and the mass decomposes uniformly.
Faults	A fracture along which displacement has occurred due to tectonic activity.	Fault zone usually consists of crushed and sheared rock through which water can move relatively freely, increasing weathering. Waterlogged zones of crushed rock are a cause of *running ground* in tunnels.
Slickensides	Preexisting failure surface; from faulting, landslides, expansion.	Shiny, polished surfaces with striations. Often the weakest elements in a mass, since strength is often near residual.
Foliation planes	Continuous foliation surface results from orientation of mineral grains during metamorphism.	Can be present as open joints or merely orientations without openings. Strength and deformation relate to the orientation of applied stress to the foliations.
Foliation shear	Shear zone resulting from folding or stress relief.	Thin zones of gouge and crushed rock occur along the weaker layers in metamorphic rocks.
Cleavage	Stress fractures from folding.	Found primarily in shales and slates; usually very closely spaced.
Bedding planes	Contacts between sedimentary rocks.	Often are zones containing weak materials such as lignite or montmorillonite clays.
Mylonite	Intensely sheared zone.	Strong laminations; original mineral constituents and fabric crushed and pulverized.
Cavities	Openings in soluble rocks resulting from groundwater movement, or in igneous rocks from gas pockets.	In limestone range from caverns to tubes. In rhyolite and other igneous rocks range from voids of various sizes to tubes.

그림 8

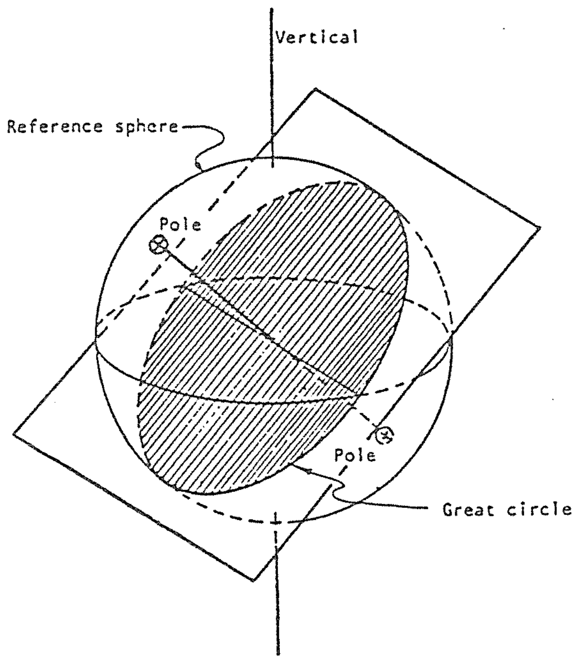


Figure 23 : Great circle and its poles which define the inclination and orientation of an inclined plane.

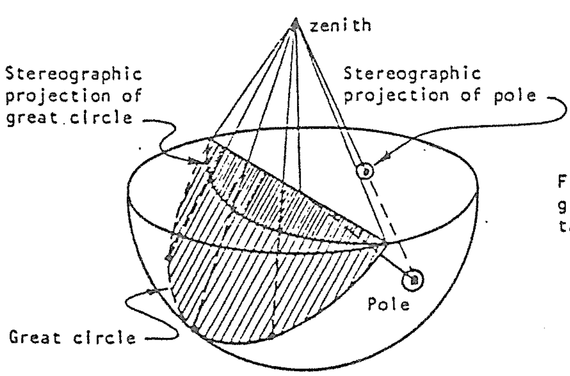


Figure 24 : Stereographic projection of a great circle and its pole onto the horizontal plane of the lower reference hemisphere.

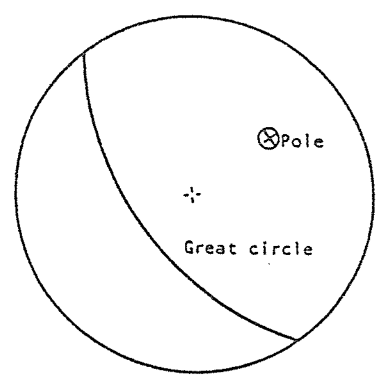
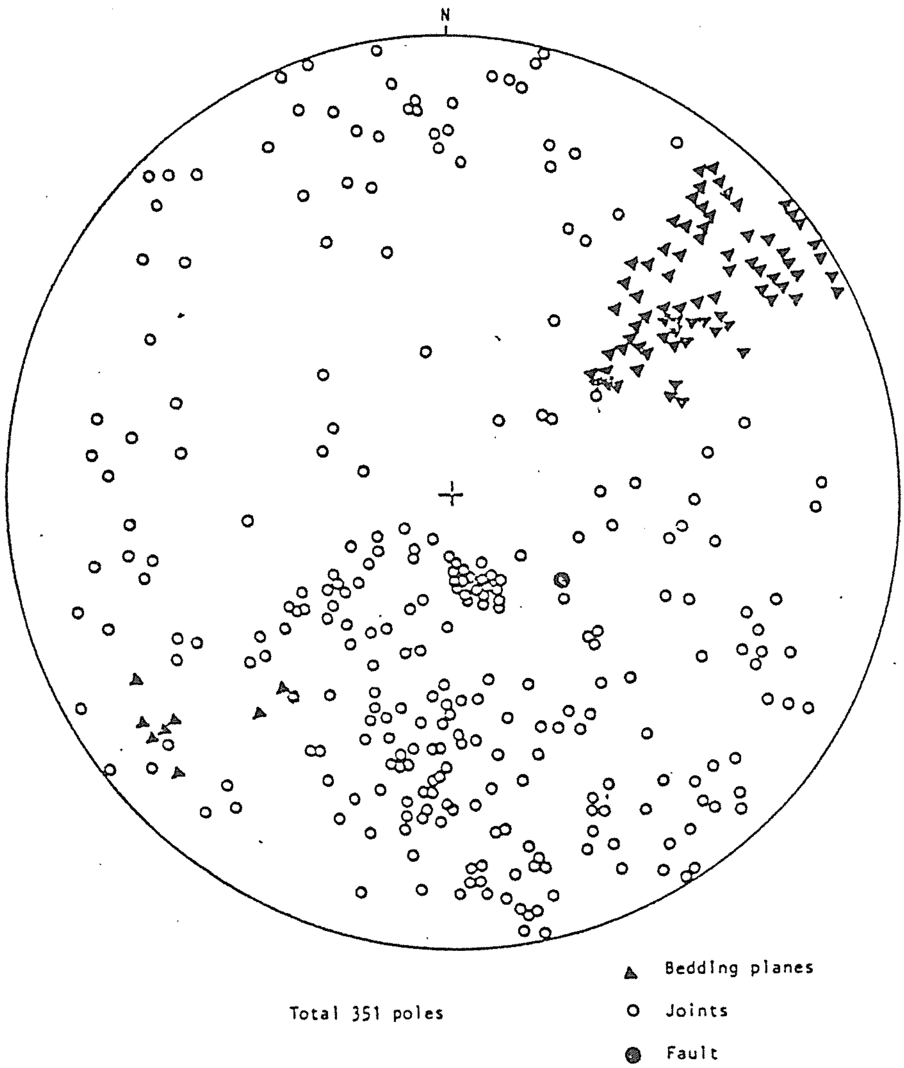


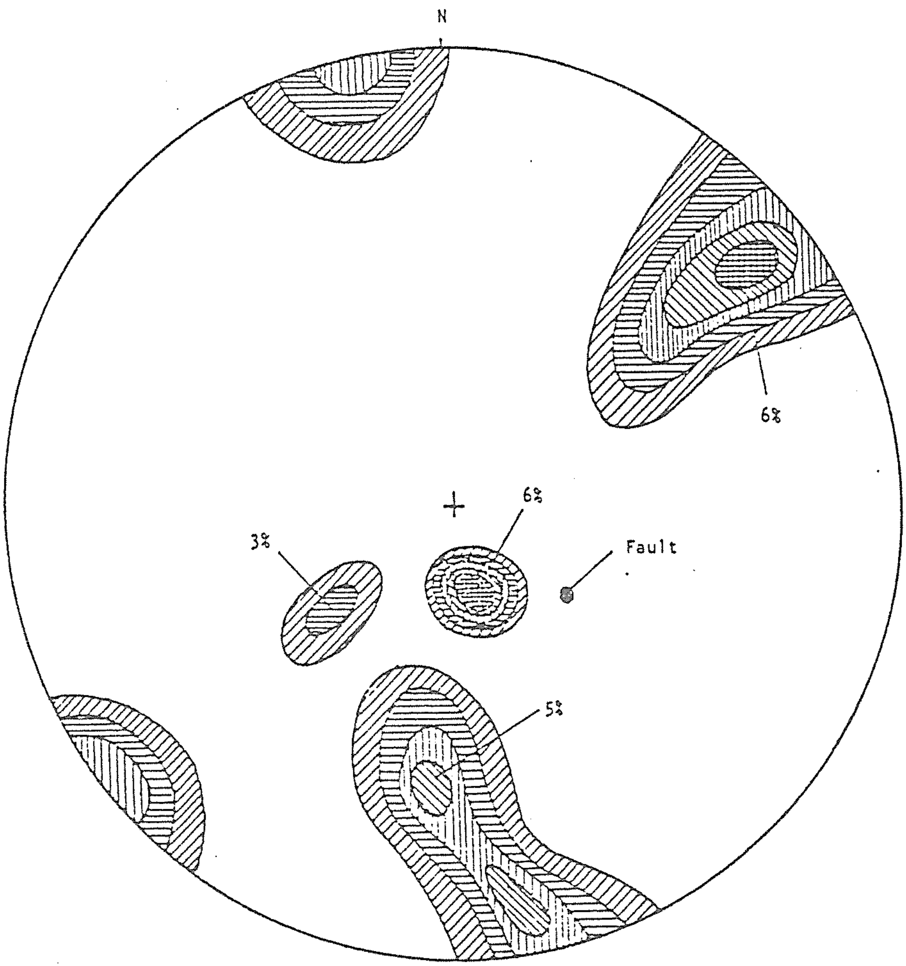
Figure 25 : Stereographic projection of a great circle and its pole.

그림 9



: Plot of 351 poles representing geological planes in
a hard rock mass.

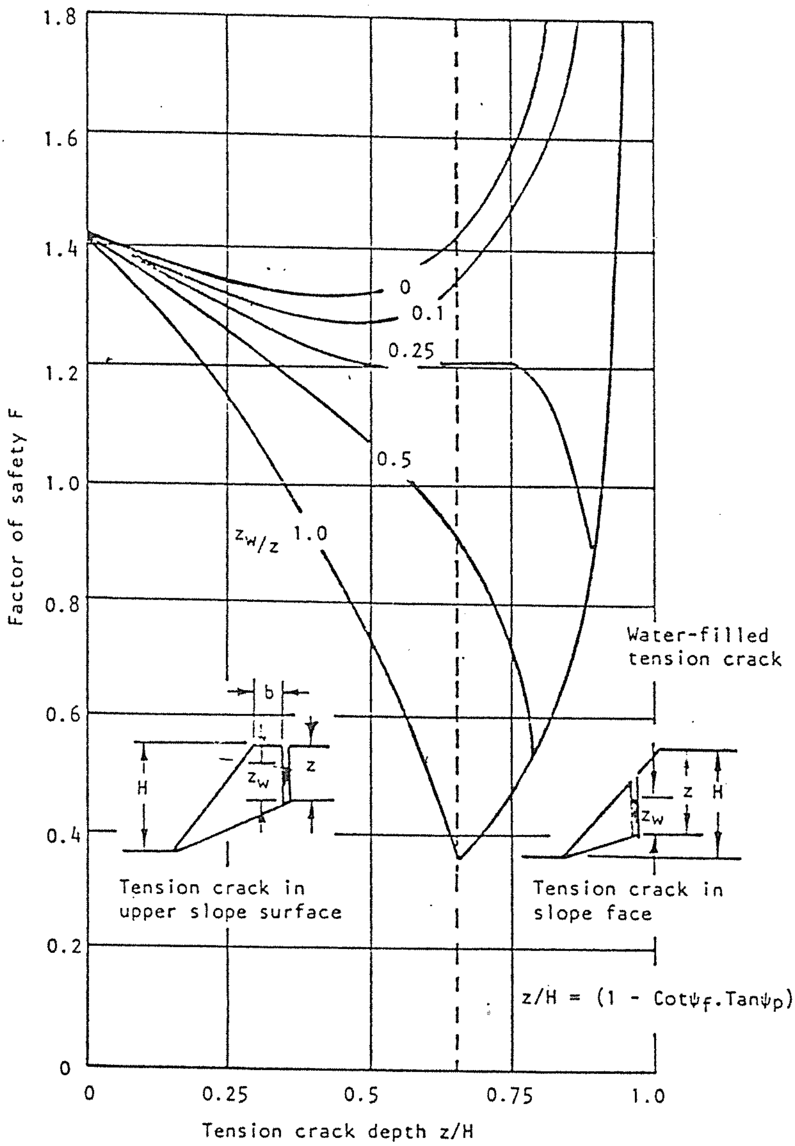
그림 10



	2% - 7 poles
	3% - 10 poles
Total 351 poles	4% - 14 poles
	5% - 17 poles
	6% - 22 poles

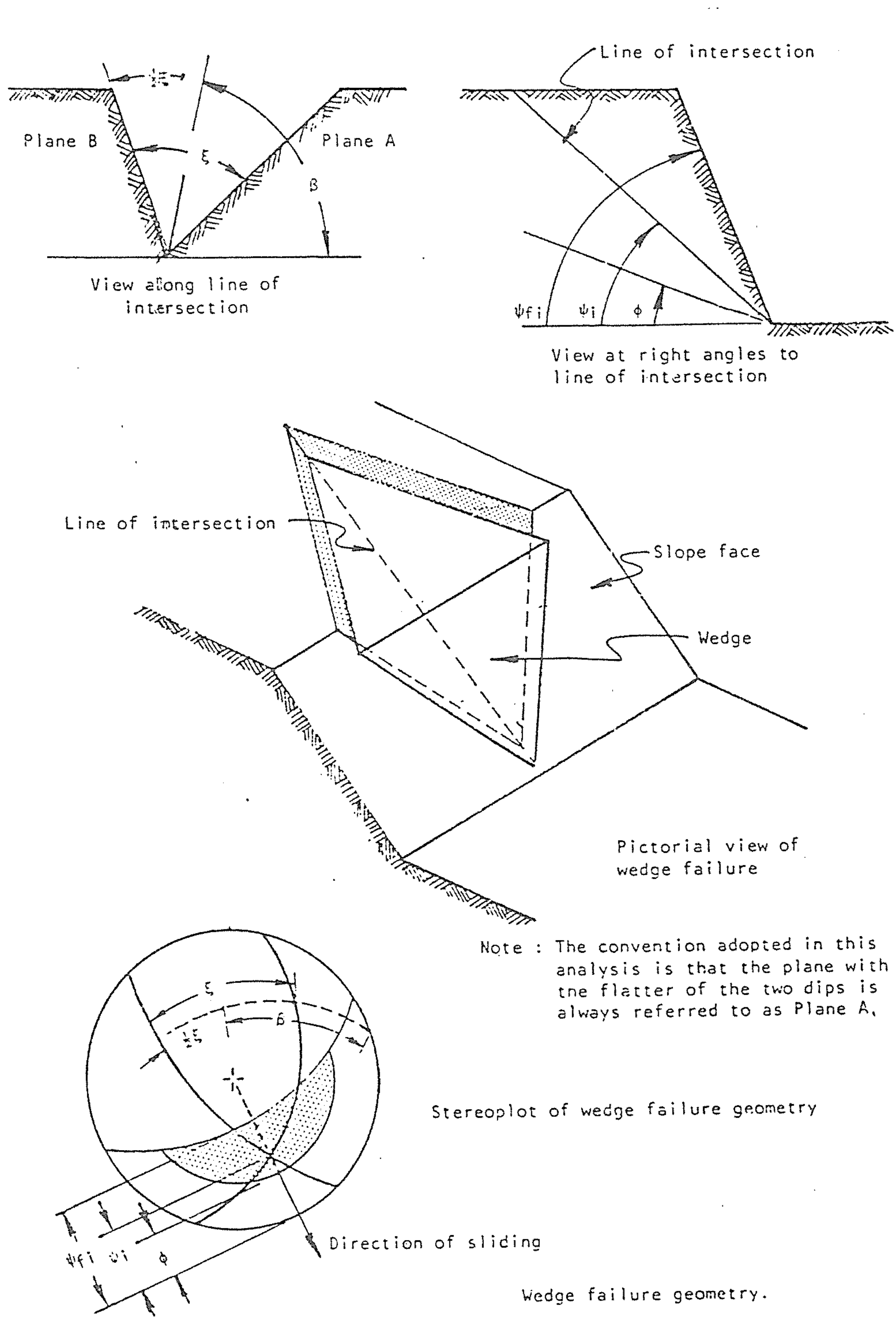
Contours of pole concentrations determined from the pole plot given in figure 32.

그림 11



Influence of tension crack depth and of depth of water in the tension crack upon the factor of safety of a slope. (Slope geometry and material properties as for example on page 154).

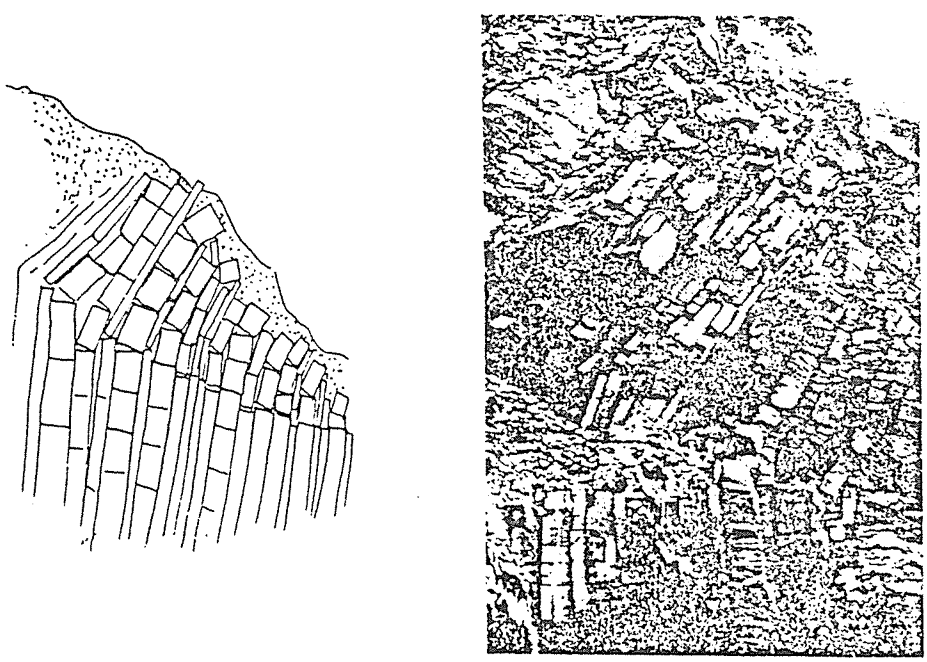
그림 12



Wedge failure geometry.

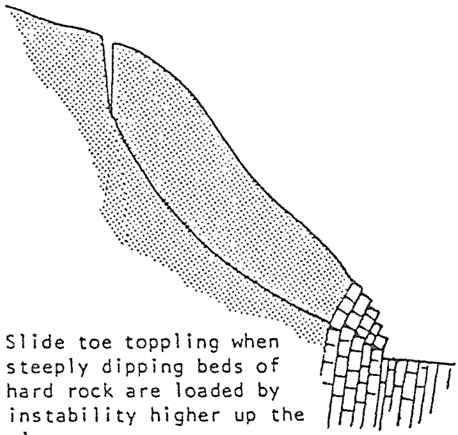
그림 13

: Block toppling can occur in a hard rock mass with widely spaced orthogonal joints.
Photograph by R.E.Goodman.

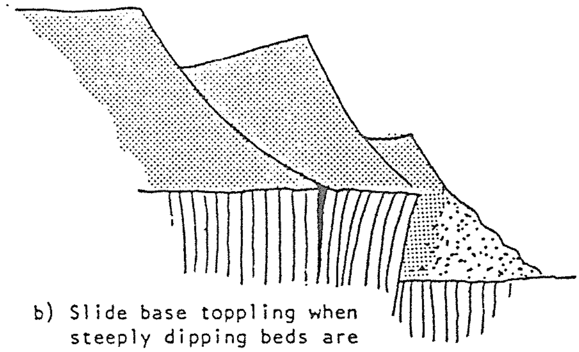


Block flexure toppling is characterised by pseudo-continuous flexure of long columns through accumulated motions along numerous cross joints.
Photograph by R.E.Goodman.

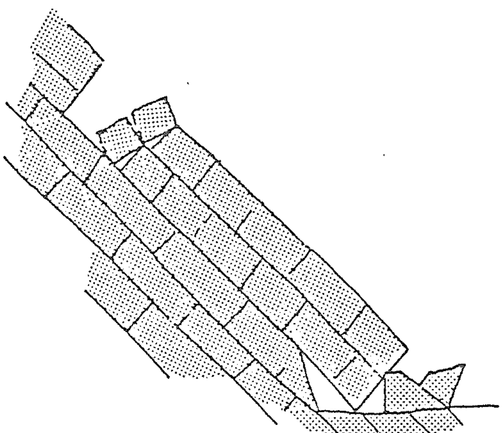
그림 14



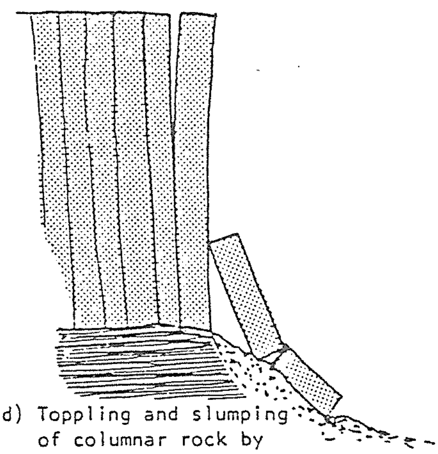
a) Slide toe toppling when steeply dipping beds of hard rock are loaded by instability higher up the slope.



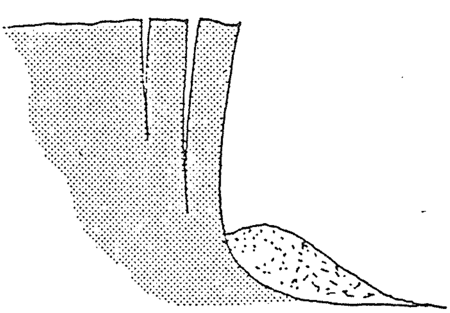
b) Slide base toppling when steeply dipping beds are dragged along by instability of overlying material.



c) Slide head toppling when movement lower in the slope frees block to topple.



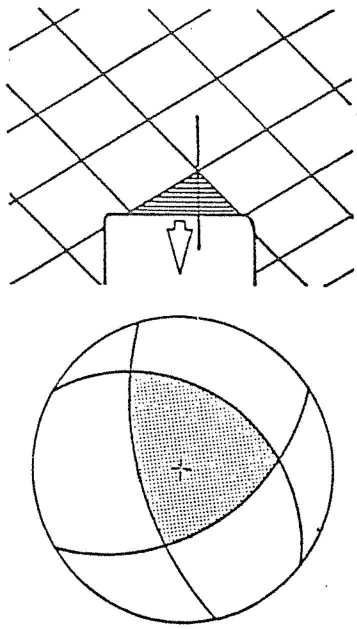
d) Toppling and slumping of columnar rock by weathering of underlying material.



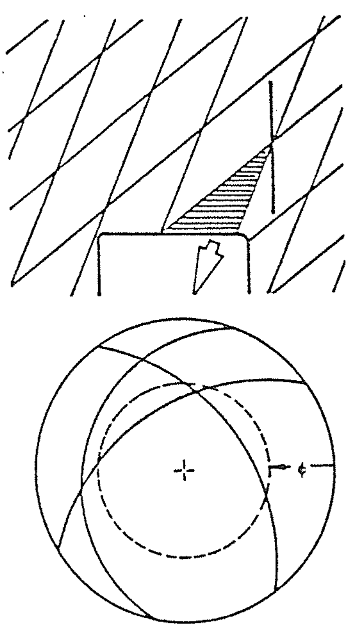
e) Tension crack toppling in cohesive materials.

Figure 119 : Secondary toppling mechanisms suggested by Goodman and Bray.

그림 15

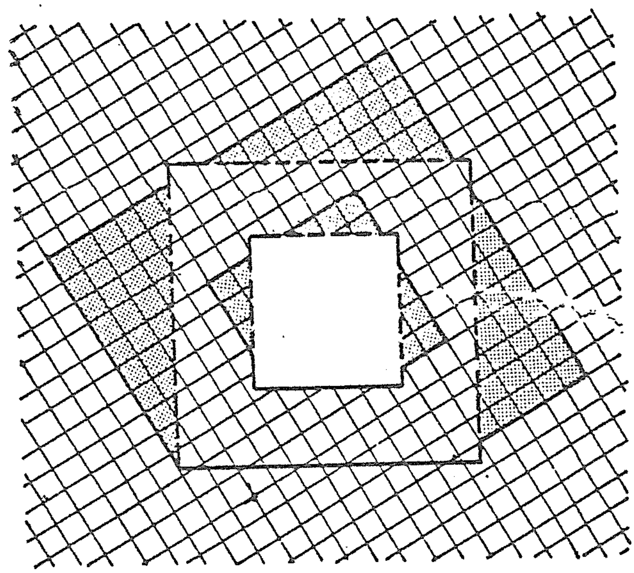


Conditions for gravity falls of roof wedges



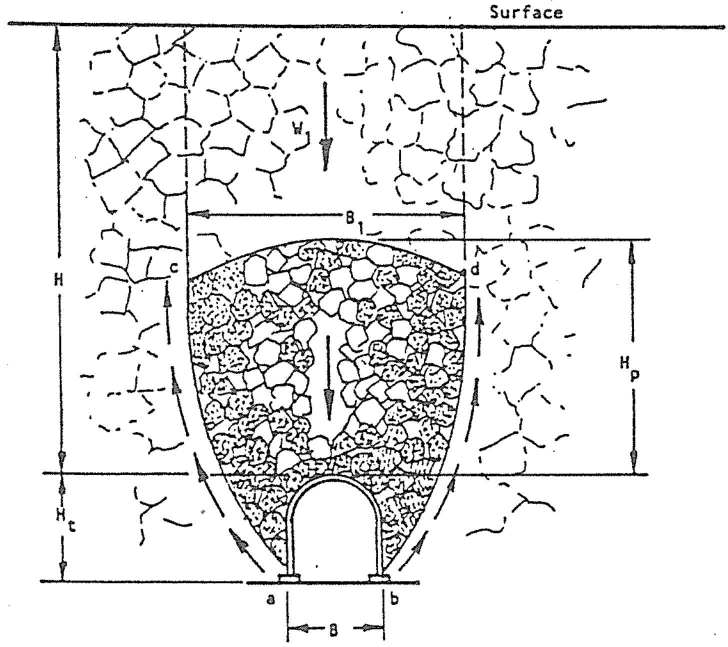
Conditions for sliding failure of roof wedges

그림 16



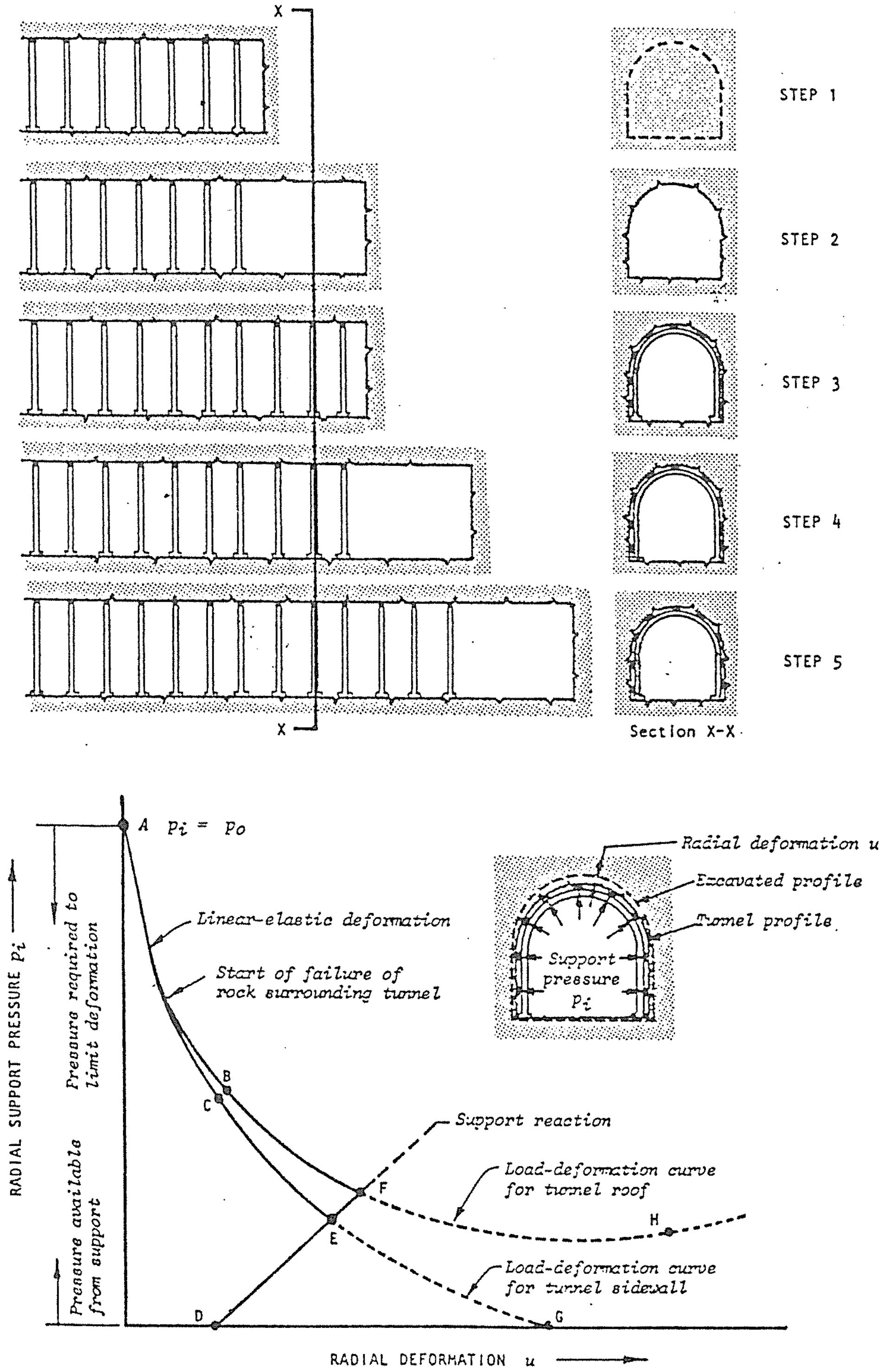
Increase in unstable rock volume with increase in excavation size in example in which the excavation axis is parallel to the strike of the line of intersection of the joints.

그림 17



Simplified diagram representing the movement of loosened rock towards a tunnel and the transfer of load onto the surrounding rock. (After Terzaghi[6]).

그림 18



Hypothetical example of a tunnel being advanced by full face drill and blast methods with blocked steel sets being installed after each mucking cycle. The load-deformation curves for the rock mass and the support system are given in the lower part of the figure. (After Daeman[224]).

그림 19

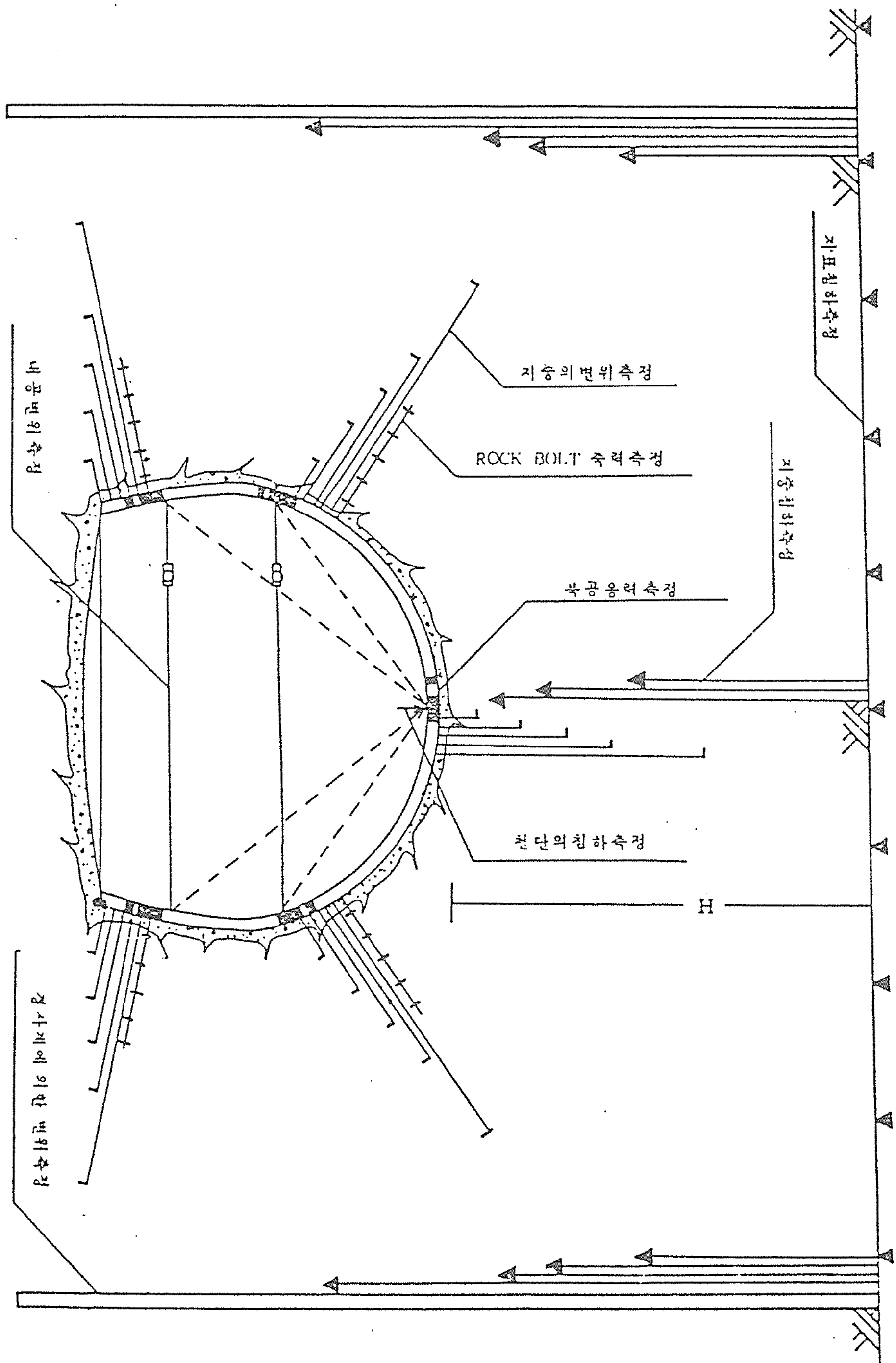

지중의변위측정
ROCK BOLT 축력측정
복공응력측정
천단의침하측정
H
지표침하측정
지중침하측정
내공변위측정
경사계에 의한 변위측정

그림 20