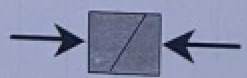
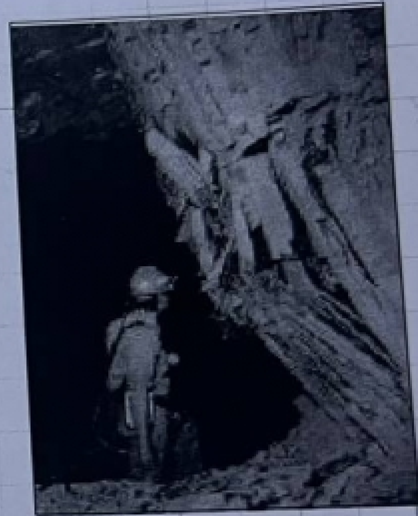
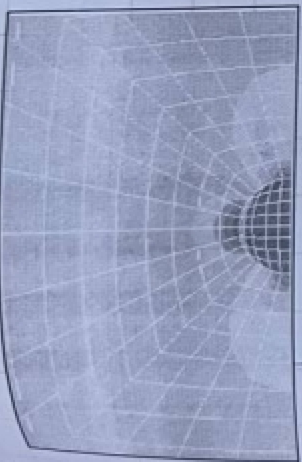
Rock Mechanics and Rock Engineering



Overview



Rock mechanics is the theoretical and applied science of the mechanical behaviour of rock and rock masses. Rock mechanics deals with the mechanical properties of rock and the related methodologies required for engineering design.



The subject of rock mechanics has evolved from a different disciplines of applied mechanics. It is a truly interdisciplinary subject, with applications in geology and geophysics, mining, petroleum and geotechnical engineering.

2

Rock Mechanics and Rock Engineering

Rock mechanics involves characterizing the intact strength and the geometry and mechanical properties of the natural fractures of the rock mass.

Rock engineering is concerned with specific engineering circumstances, for example, how much load will the rock support and whether reinforcement is necessary.

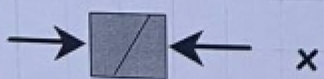
Nature of Rock

A common assumption when dealing with the mechanical behaviour of solids is that they are:

- homogeneous
- continuous
- isotropic

However, rocks are much more complex than this and their physical and mechanical properties vary according to scale. As a solid material, rock is often:

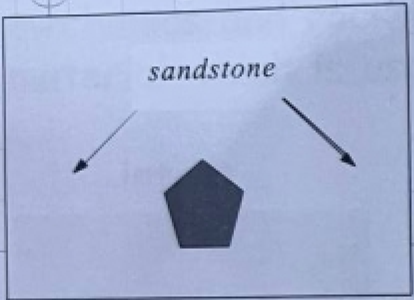
- heterogeneous
- discontinuous
- anisotropic



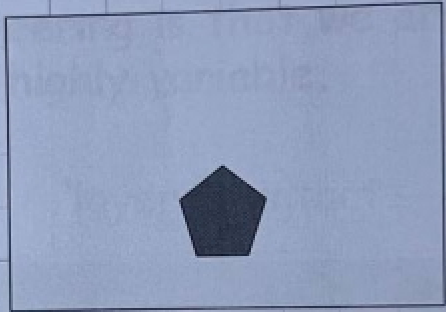
4

Nature of Rock

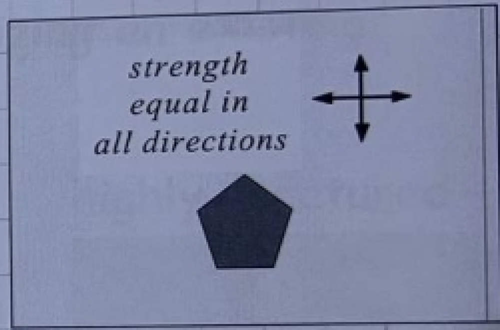
Homogeneous



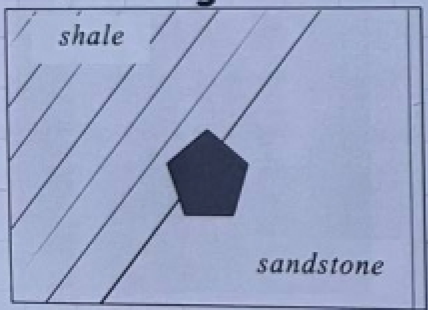
Continuous



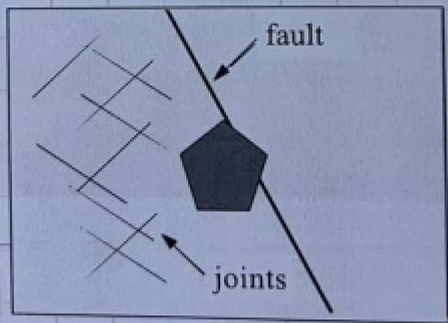
Isotropic



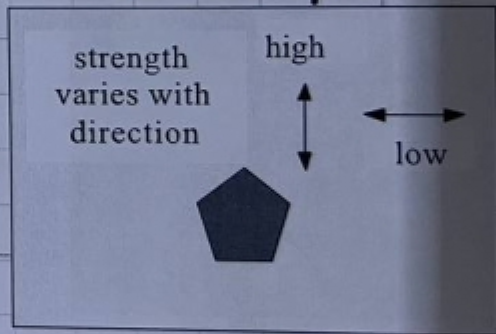
Heterogeneous



Discontinuous



Anisotropic



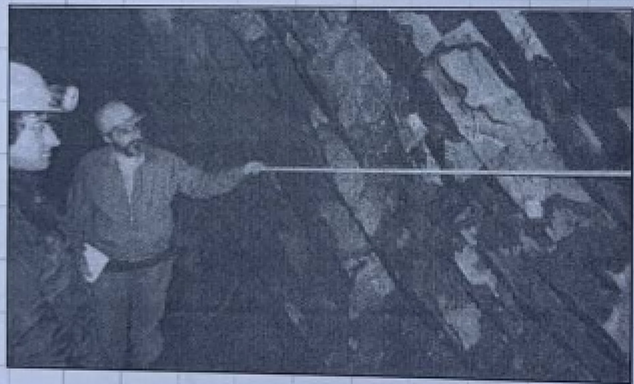

x

Rock as an Engineering Material

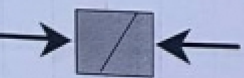
One of the most important, and frequently neglected, aspects of rock mechanics and rock engineering is that we are utilizing an existing material which is usually highly variable.

intact

'layered' intact



highly fractured



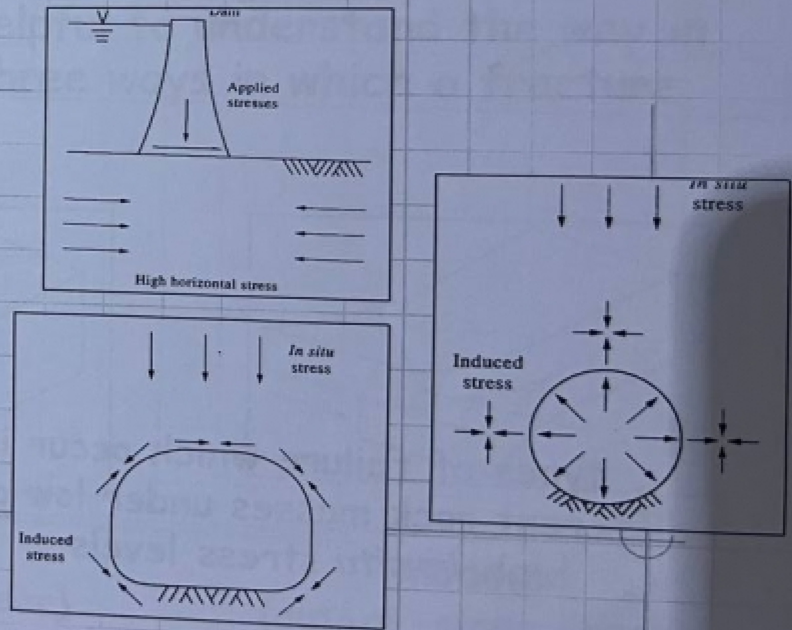
×

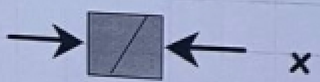
Influence of Geological Factors - Pre-Existing In Situ Rock Stress

When considering the loading conditions imposed on the rock structure, it must be recognized that an *in situ* pre-existing state of stress already exists in the rock.

In some cases, such as a dam or nuclear power station foundation, the load is applied to this.

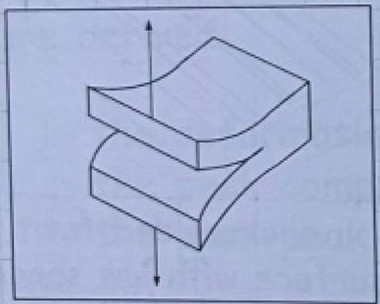
In other cases, such as the excavation of a mine or tunnel, no new loads are applied but the pre-existing stresses are redistributed.



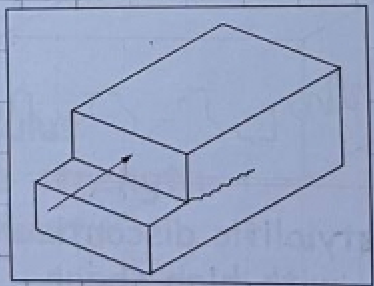


Influence of Geological Factors - Discontinuities and Rock Structure

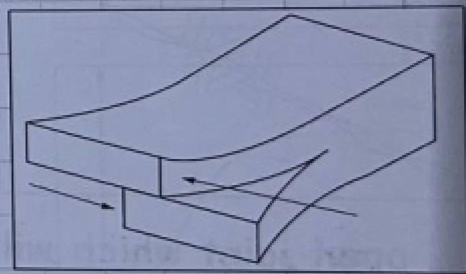
The result in terms of rock fracturing is to produce a geometrical structure (often very complex) of fractures forming rock blocks. The overall geometrical configuration of the discontinuities in the rock mass is termed *rock structure*. It is often helpful to understand the way in which discontinuities form. There are three ways in which a fracture can be formed:



Mode 1
(tensile)



Mode 2
(in-plane shear)



Mode 3
(out-of-plane shear)

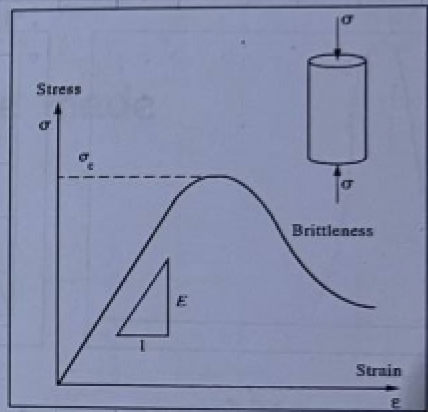
x

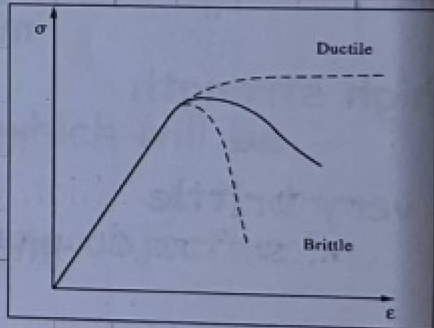
Influence of Geological Factors - Intact Rock

The most useful description of the mechanical behaviour of intact rock is the complete stress-strain curve in uniaxial compression.

From this curve, several features of interest are derived:

- the deformation modulus
- the peak compressive strength
- the post-peak behaviour





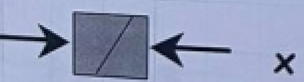
Rock as an Engineering Material

Rock as an engineering material will be used either:

... as a building material so the structure will be made *of* rock
... or a structure will be built *on* the rock
... or a structure will be built *in* the rock

In the context of the mechanics, we must establish:

... the properties of the material
... the pre-existing stress state in the ground (which will be disturbed by the structure)
... and how these factors relate to the engineering objective

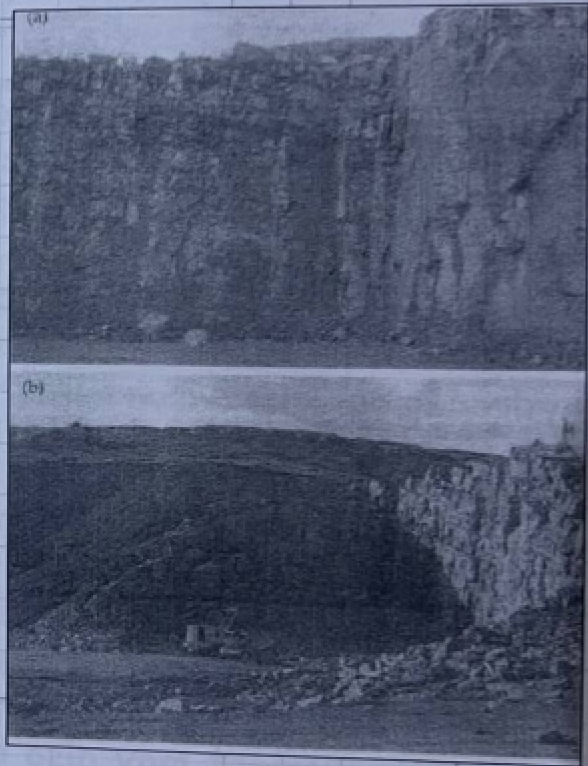


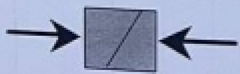
Influence of Geological Factors - Time

Rock as an engineering material may be millions of years old, however our engineering construction and subsequent activities are generally only designed for a century or less.

Thus we have two types of behaviour: the geological processes in which equilibrium will have been established, with current geological activity superimposed; and the rapid engineering process.

The influence of time is also important given such factors as the decrease in rock strength through time, and the effects of creep and relaxation

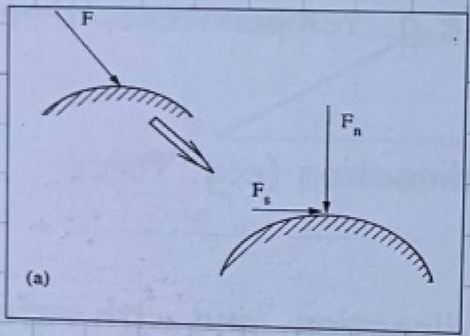


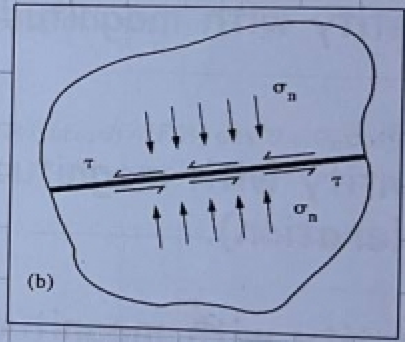


(16) $\tau = c + (\sigma_n - p)\tan\phi$

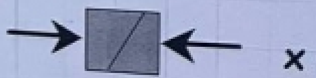
Normal and Shear Stress Components

On a real or imaginary plane through a material, there can be normal forces and shear forces. These forces create the stress tensor. The normal and shear stress components are the normal and shear forces per unit area.



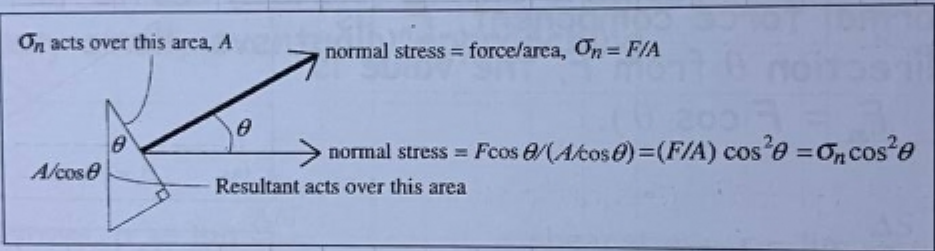


It should be remembered that a solid can sustain a shear force, whereas a liquid or gas cannot. A liquid or gas contains a pressure, which acts equally in all directions and hence is a scalar quantity.



Force and Stress

The reason for this is that it is only the force that is resolved in the first case (i.e. vector), whereas, it is both the force and the area that are resolved in the case of stress (i.e. tensor).



In fact, the strict definition of a second-order tensor is a quantity that obeys certain transformation laws as the planes in question are rotated. This is why the conceptualization of the stress tensor utilizes the idea of magnitude, direction and "the plane in question".