1- Introduction

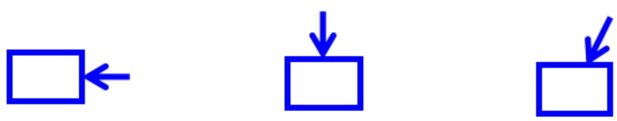
Rock Mechanics: the science concerning study of rock behavior, determining its physical and mechanical properties and study the outer effects on its strength and deformation.

Types of rocks: Igneous, Sedimentary and Metamorphic. They differ according to their mineral composition, grain size and formation environment.

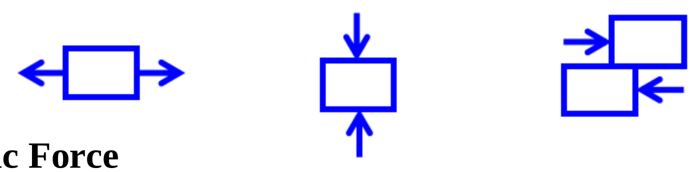
Mountains form as **rock masses** that contain:

1- **Intact rock:** solid rock samples containing no cracks (on eye naked).
2- **Discontinuity surfaces:** cracks surfaces and joints.
Rock Mass: contains rock sample (Intact rock) and crack surfaces and joints visible by naked eye.
Discontinuity surfaces: crack surfaces and joints visible by naked eye, they vary with various rocks. They are:
Joints, Fractures, Bedding planes, Slate Cleavage, Schistosity, Shear zones.

Types of Forces:
1- **Static Force:** classified according to:
a- **Direction:** Horizontal Force, Vertical Force, Inclined Force.



b- **Action:** Tension Force, Compression Force, Shear Force



2- **Dynamic Force**

2- Types of Engineering Properties: divided into:

1- **Physical properties:** originated with the rock formation and controlled by geological factors like: rock type, color, grain size and weathering degree. Physical properties can be identified by knowing weight and size of the rocks.
2- **Mechanical properties:** influenced by outer circumference factors like forces and stresses. In this respect, it is demanded to break the rock samples to estimate their strength.

Mechanical properties of rocks can be determined through computing their strength versus forces and stresses, where:
Strength = Force/ Area

Types of Strength: Tension, Compression, and Shear

Strength: ability of rock sample to resist force, load or stress.
Strength value: amount of Stress (tension, compression or shear) at failure.

Types of Strength:

1- **Tensile Strength**
2- **Compressive Strength**
3- **Shear Strength**

The rock sample will break if the applied force is vertical and not associated with shear.

The rock sample will break if the applied compressive force surpasses the sample's strength.

Geological Factors Controlling the Engineering Properties of Rocks:

1- Rock Type
2- Degree of Weathering
3- Grain Size
4- Mineral Composition
5- Porosity and Intensity of fracturing
6- Anisotropy

3- Engineering Properties of Intact Rocks

A-Physical Properties for Intact Rocks:

Their values and characteristics were usually controlled by geological factors like: Rock Type, Grain size and Mineral composition.

The most important physical properties of rocks are:

1. Density, Specific Gravity, Unit Weight.
2. Porosity, **n**
3. Void ratio, **e**
4. Permeability, **k**
5. Absorption, **Abs**.

1- Density (ρ), Specific Gravity(Gs) & Unit weight(ɣ):

$$= \frac{Wheit}{Volume} = \frac{gm}{cm^3}, \frac{N}{mm^3}$$

Volume computation:

Regular Shapes:

Irregular Shape:

Regular Shapes: volume calculation via Mathematical formulas:

Volume of Cube = X * Y * Z

Volume of Cylinder = Area * L = πr^2 * L

Where: **πr^2 =** area of the circle

Irregular Shapes:

By submerging the irregular rock sample in a known volume water using a graded cylinder, where the excessive water represents the sample volume.

{1 mL = 1 cm^3}

1 L = 10^3 cm^3

Specific Gravity: **(Gs)**

Unit weight: (γ) = N/mm^3, $\frac{KN}{m^3}$, $\frac{Lb}{inch^3}$

2- Porosity:

$$n = \frac{Volume\ of\ Voids}{Total\ Volume} = \frac{V_v}{V_t} = \frac{V_v}{V_s+V_v}$$

3- Void Ratio:

$$e = \frac{V_v}{V_s}$$

4- Permeability:

Each permeable sample is porous, but not each porous sample is permeable.

Permeability is calculated with: 1- quantity 2- velocity 3- time

5- Saturation index:

$$\textbf{Absorption, (Abs)} = \frac{W_{sat.} - W_{dry}}{W_{dry}} * 100$$

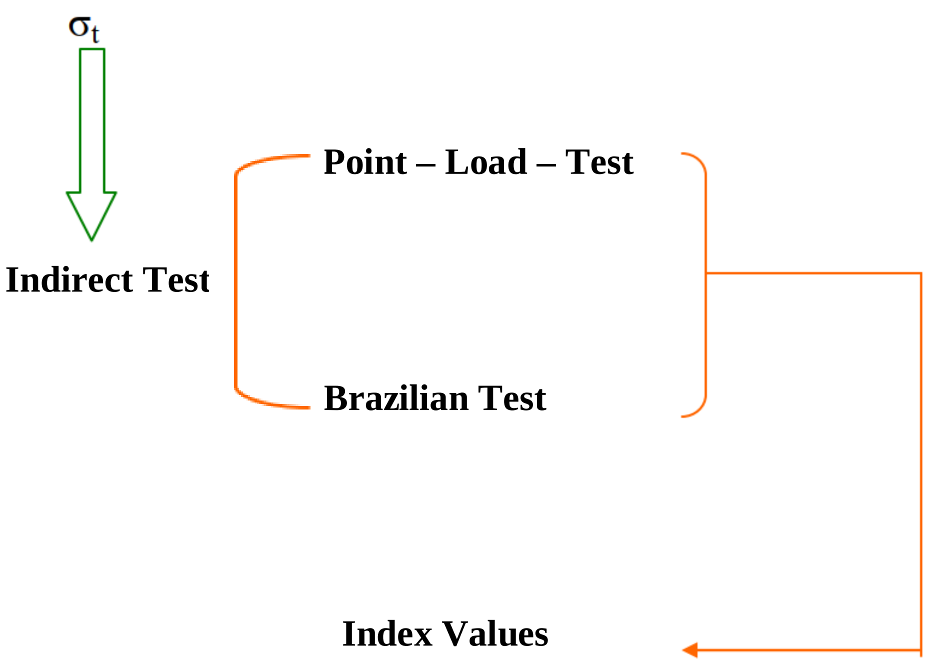
B- Mechanical Properties for Intact Rocks:

1- Strength **2- Deformation**

1- Strength:

1.1 Tensile Strength of Intact Rock:

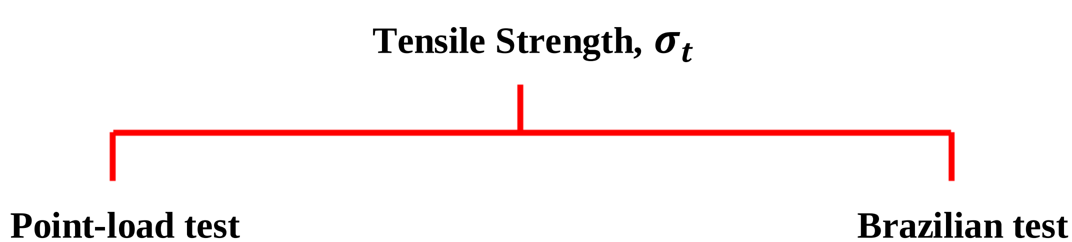
Rock samples are weak in tension.



Indirect Test: non direct rock tests

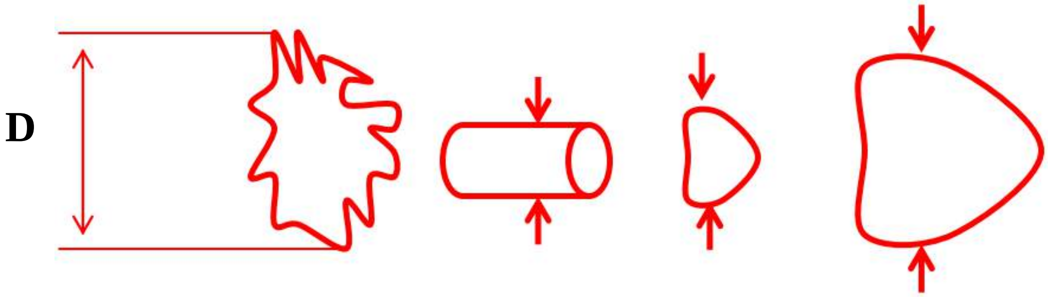
1- Point – Load Test
2- Brazilian Test

The results are called **Index Values**



The first test to determine **Tensile Strength** is the **Point-Load- Test**

I_s= Point- Load Index = $\frac{P}{D^2}$



ISRM: International Society for Rock Mechanics:

This society had unified **D** for sample

I_s (50) = Point-load index for sample of **50** mm Diameter:

D (mm)	**I_s (MPa)**	**I_s (50) (MPa)**
30	11	9.6
50	9.5	9.5
70	8	9.3

Tensile Strength, σ_t= (1~5) I_s(50) σ_t= (3) * I_s(50) (average)

This relationship between σ_t and I_s(50) is called Empirical Relationship (Linear Numerical).

σ_t= (1~5) * I_s (50) Range

σ_t= (3) * I_s (50) Average

Values from 1 to 5 depend on:

1- Rock strength 2- rock type 3- weathering degree

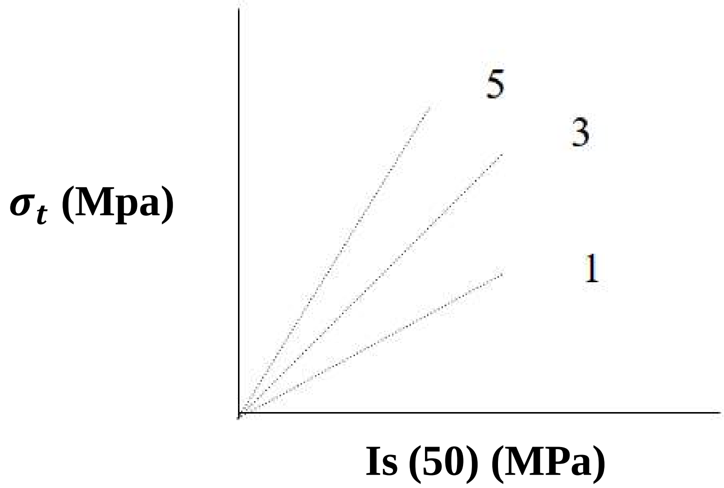
For example:

If the rock is highly weathered ⇨ **1* Is (50)**

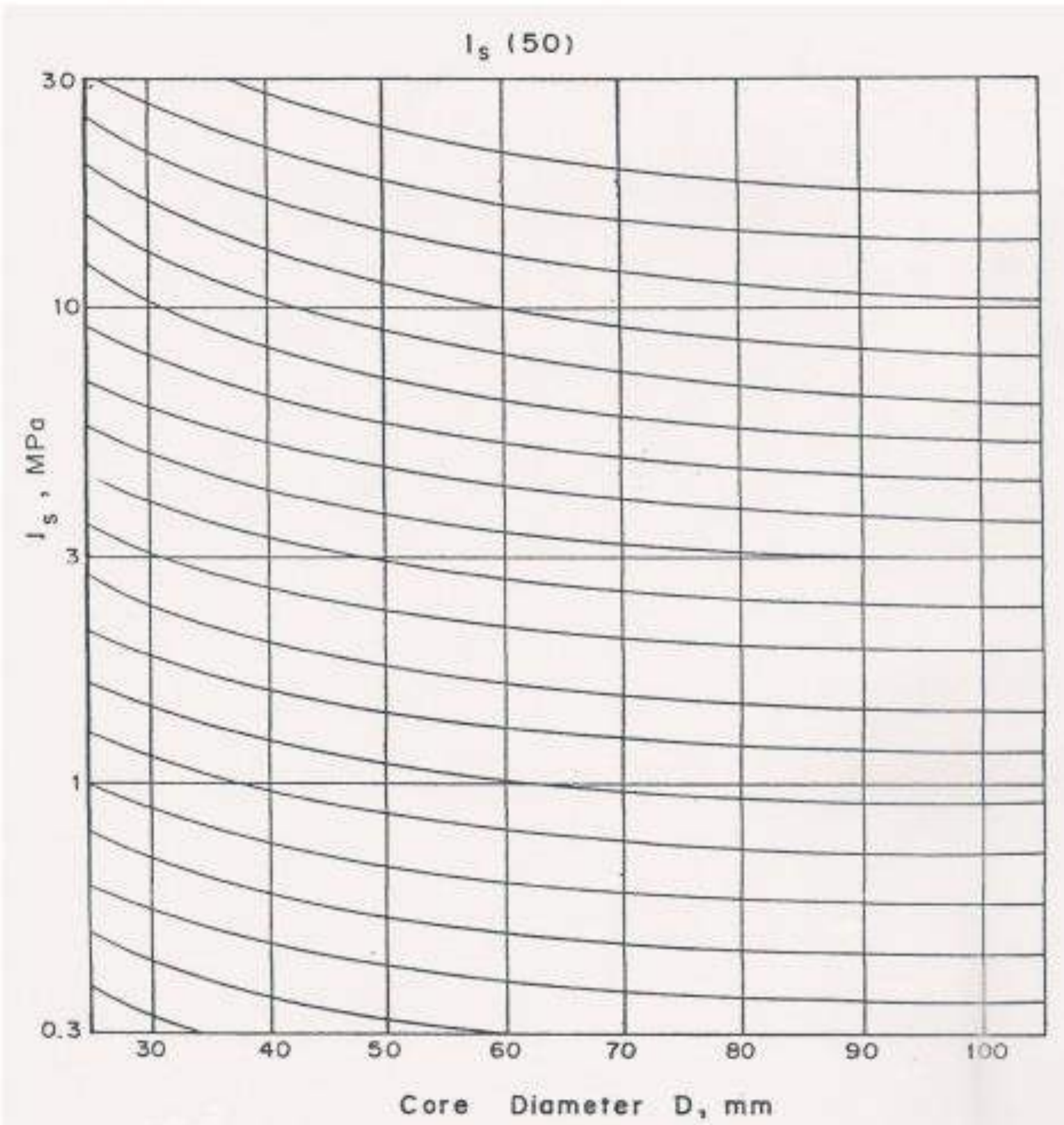
If the rock is moderately weathered ⇨ **3* Is (50)**

If the rock is fresh ⇨ **5* Is (50)**

Where they are indirect values



Relation between **Is (50)** and σ_t

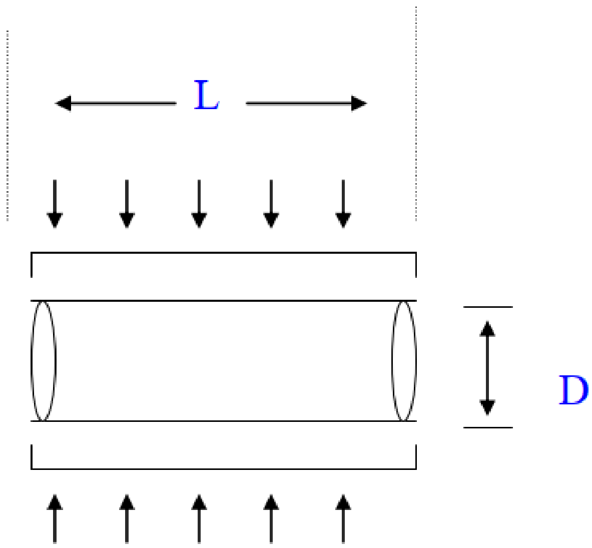


Size correction chart for point load test (After Broch and Franklin, 1972)

The second test to determine **Tensile Strength** is the **Brazilian Test**:

Brazilian Test provides tensile strength values closer to reality than **Point Load Test**.

In **Brazilian Test,** the stress loading is on sample line which must be regular cylindrical. Whereas the sample must not be regular cylindrical in **Point Load Test**.



$$\sigma_t = \frac{2P}{\pi * L * D}$$

1.2- Compressive Strength of Intact Rock, σ_c

Uniaxial Compressive Strength

σuc = UCS

Considered of the best tests and gives real strength value and be assigned in two ways:

Uniaxial Compressive Strength

In direct Test

Used in laboratory and in field

Gives approximate values

With two tests:

a) **Point Load Test**

Specification:

Is (50)

UCS = 24 * Is $_{(50)}$

Where 24 ranges between 10 ~ 40

Direct Test

Used only in laboratory

Gives real values

Only one test:

Uniaxial Compression

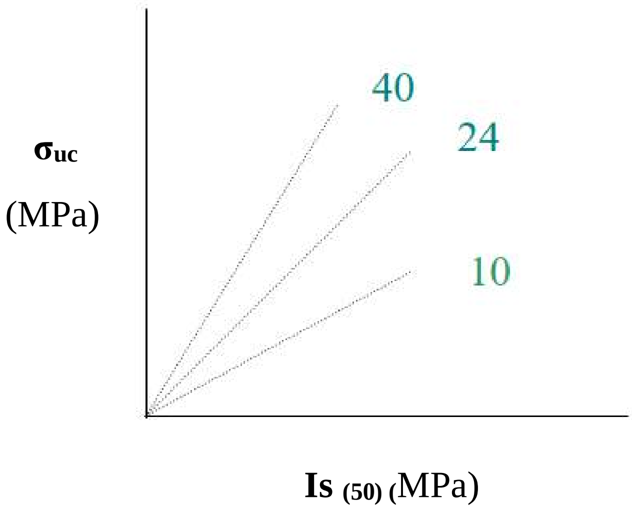
Instrument:

Uniaxial Compression Machine

Instrument Specification

Cylinder Shape

D = 54mm (NX- Size)



L/D (2~2.5)

L= 108 mm - 135 mm

The relation between **Is** $_{(50)}$ and **σ_{uc}**

b) Schmidt Hammer Test: gives indirect values for **strength**