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):

$(\rho) = Wheit/Volume = gmcm3, Nmm3$

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 cm3}
1 L = 10^3 cm^3
Specific Gravity: (**Gs**)
Unit weight: (γ) = N/mm^3, $KNm3$, $Lbinch3$
2- Porosity:

$n = Volume\ of\ Voids/Total\ Volume = V_v/V_t = V_v/V_s+V_v$

3- Void Ratio:

$e = Vv/Vs$

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:

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

total volume الحجم الكلي = V_T

total weight الوزن الكلي = W_T

volume of solids حجم المواد الصلبة = V_s

weight of solids وزن المواد الصلبة = W_s

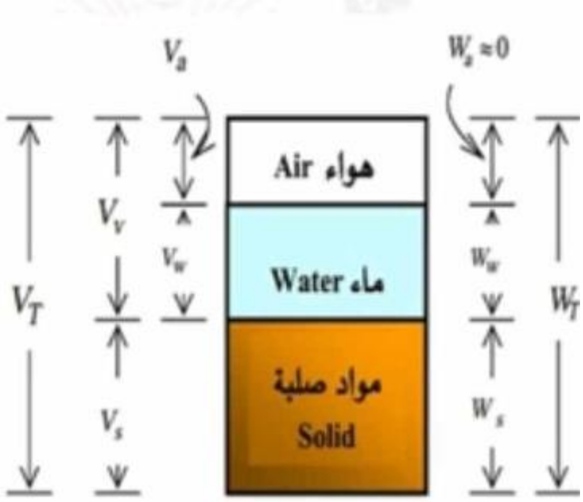
volume of voids حجم الفراغات = V_v

weight of water وزن الماء = W_w

volume of water حجم الماء في الفراغات = V_w

air weight of وزن الهواء = W_a

volume of air حجم الهواء في الفراغات = V_a



نحسب ω من العلاقة:

$$\omega = \frac{W_w}{W_s}$$

ونحسب W_w و W_s :

$$\gamma_w = \frac{W_w}{V_w} \Rightarrow W_w = \gamma_w . V_w = \gamma_w . s . e$$

$$G = \frac{\gamma_s}{\gamma_w} = \frac{\frac{W_s}{V_s}}{\gamma_w} \Rightarrow W_s = G . \gamma_w . V_s = G . \gamma_w$$

$$\omega = \frac{W_w}{W_s} = \frac{\gamma_w . s . e}{G . \gamma_w} \Rightarrow \boxed{\omega G = s . e}$$

ملاحظة: في حالة الإشباع $s = 1 \Leftarrow$ رطوبة الإشباع $\omega_{sat} = \frac{e}{G}$

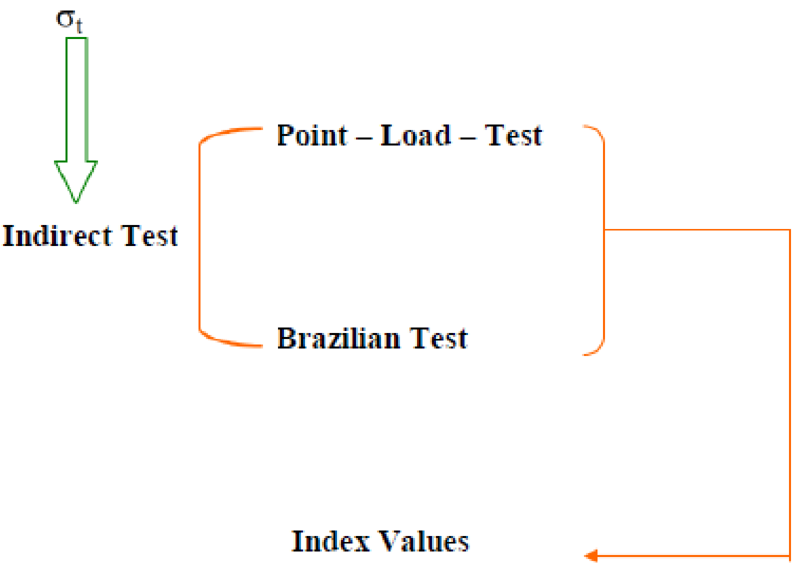
B- Mechanical Properties for Intact Rocks:

1- **Strength**
2- **Deformation**

1- Strength:

1.1 Tensile Strength of Intact Rock:

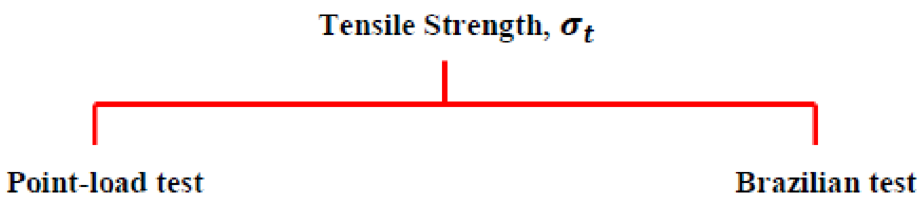
Rock samples are weak in tension.



Indirect Test: non direct rock tests

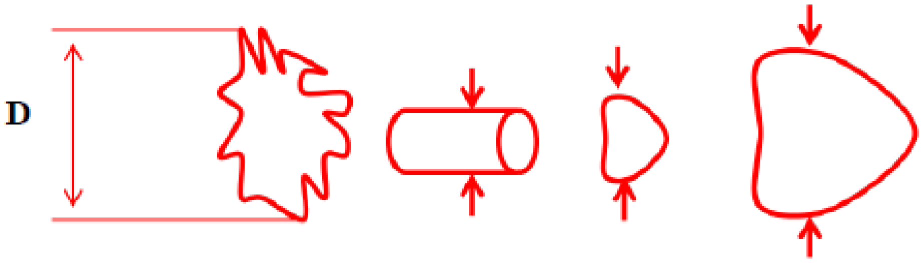
1- **Point – Load Test**
2- **Brazilian Test**

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

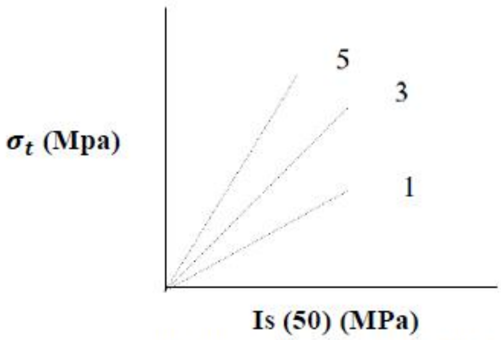
For example:

If the rock is highly weathered ⇒ **1* Is $_{(50)}$**

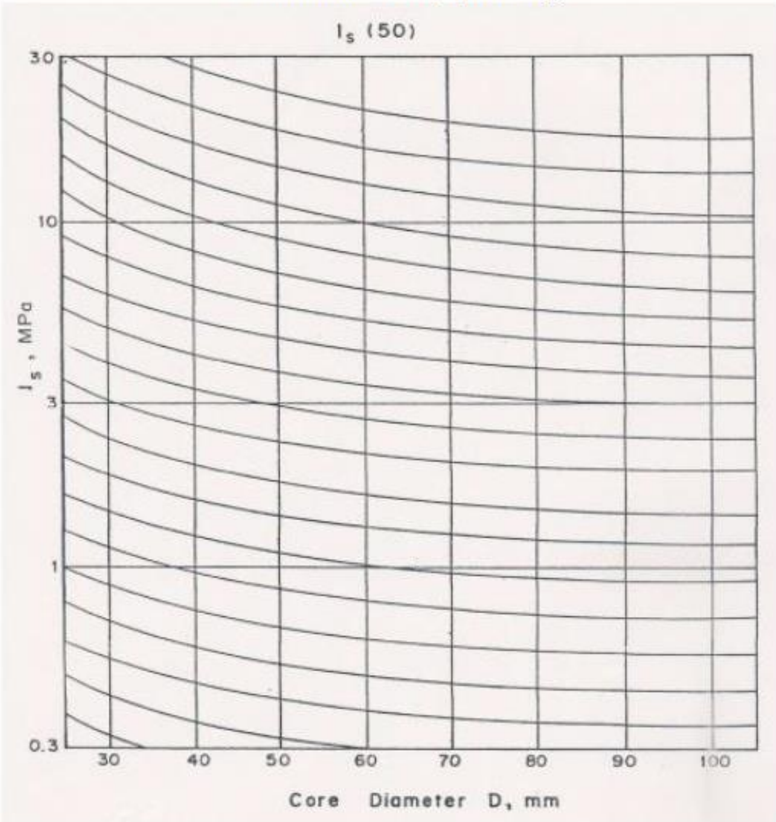
If the rock is moderately weathered ⇒ **3* Is $_{(50)}$**

If the rock is fresh ⇒ **5* Is $_{(50)}$**

Where they are indirect values



Relation between Is (50) and σ_t

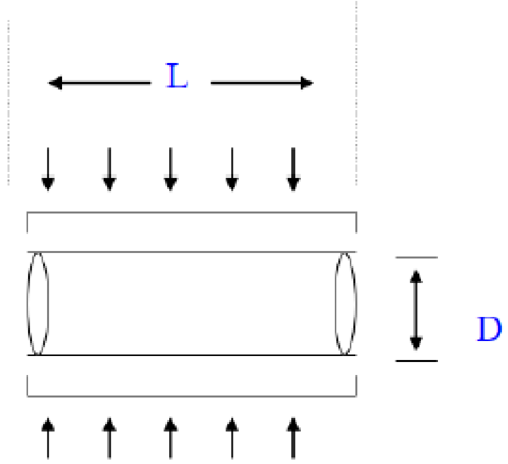


Size correction chart for point load test (After Broch and Franklin, 1972)

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

σ_{uc} = 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)

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

Where 24 ranges between 10 ~ 40

Direct Test

Used only in laboratory

Gives real values

Only one test:

Uniaxial Compression

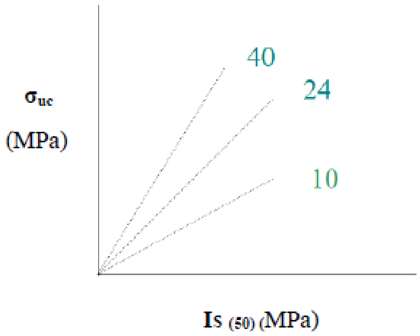
Instrument:

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 $\boldsymbol{\sigma_{uc}}$

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