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

Schmidt Hammer Test: specified for civil engineering to test concrete strength. There are two types: **N**-type for concrete and **L**-type for rocks.

Using conditions:

1- The surface must be clean.
2- Faraway from cracks.
3- Knowing the direction during measuring.
4- Hammer type and number must be recorded.
5- Measuring must be on hard surface.

How to use:

R= Rebound No.

Taking 15 measurements. Neglecting higher and lower abnormal values.

The most use of Hammer:

1- Knowing the direction.
2- Recording Hammer type and number.
3- Measuring must be on hard surface.
4- Taking at least **five** measurements for each surface of the same rock

Example: The following values were measured using **Schmidt Hammer:**

R = 62,59,63,62,43, 61,59,58,60,60,60,76, 62,63,64

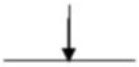
Neglecting the larger and smaller values

Average R $= \frac{Readings\ Sum}{Number\ of\ measurements}$

Average R $= \frac{793}{13} = 61$

Example:

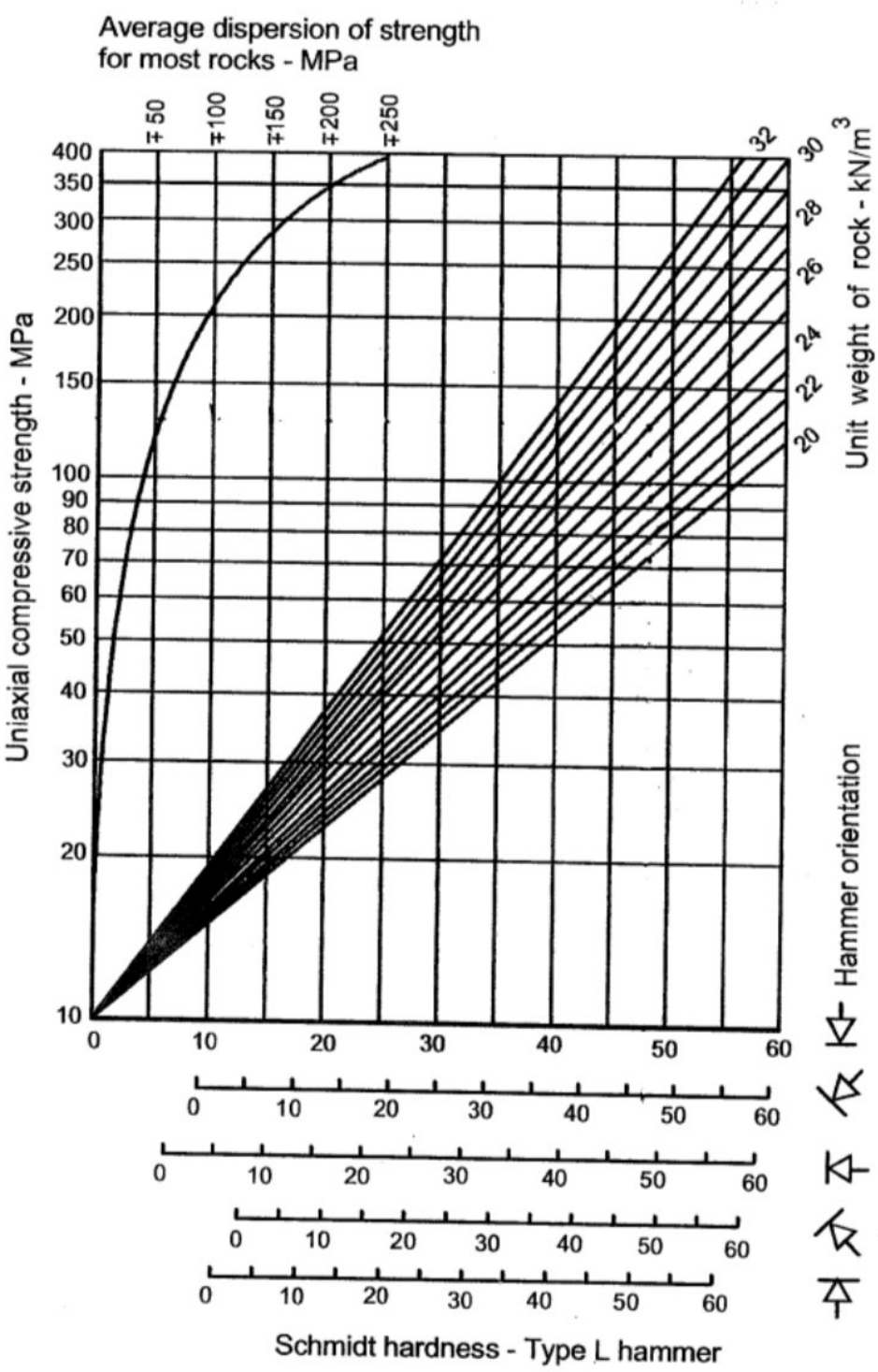
Computing **UCS** from **Schmidt Hammer** using the attached figure:



Average = 55 γ**= 26 KN/m³**

UCS (For Schmidt hammer test) = 185 MPa (+ -) 80 MPa

UCS = 105 – 265 MPa


Average dispersion of strength
for most rocks - MPa
∓50
∓100
∓150
∓200
∓250
Uniaxial compressive strength - MPa
400
350
300
250
200
150
100
90
80
70
60
50
40
30
20
10
32
30
28
26
24
22
20
Unit weight of rock - kN/m3
Hammer orientation
0 10 20 30 40 50 60
Schmidt hardness - Type L hammer

1.3- Shear Strength of Intact Rock:

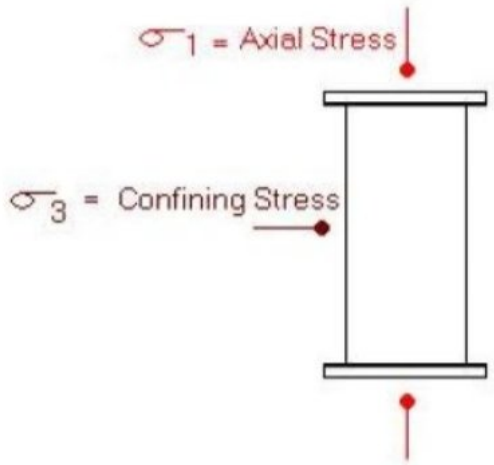
Shear Strength values of Intact Rocks determined with two characteristics:

1- **Internal Cohesion, C_i**
2- **Internal Friction Angle, φ_i**

In Soil cohesion, C = zero

Shear strength of intact rocks determined by **Triaxial Compression Test**:

$$\tau = C + \sigma n$$



To compute shear strength value of an intact rock we must know the followings:

1- **C (Cohesion)**
2- **φ (Friction Angle)**
3- **σ_n** (Normal **Stress)**

Shear Strength Parameters for Intact Rocks: C_i & φ_i

Since failure occurs inside the intact rock, the formula will be:

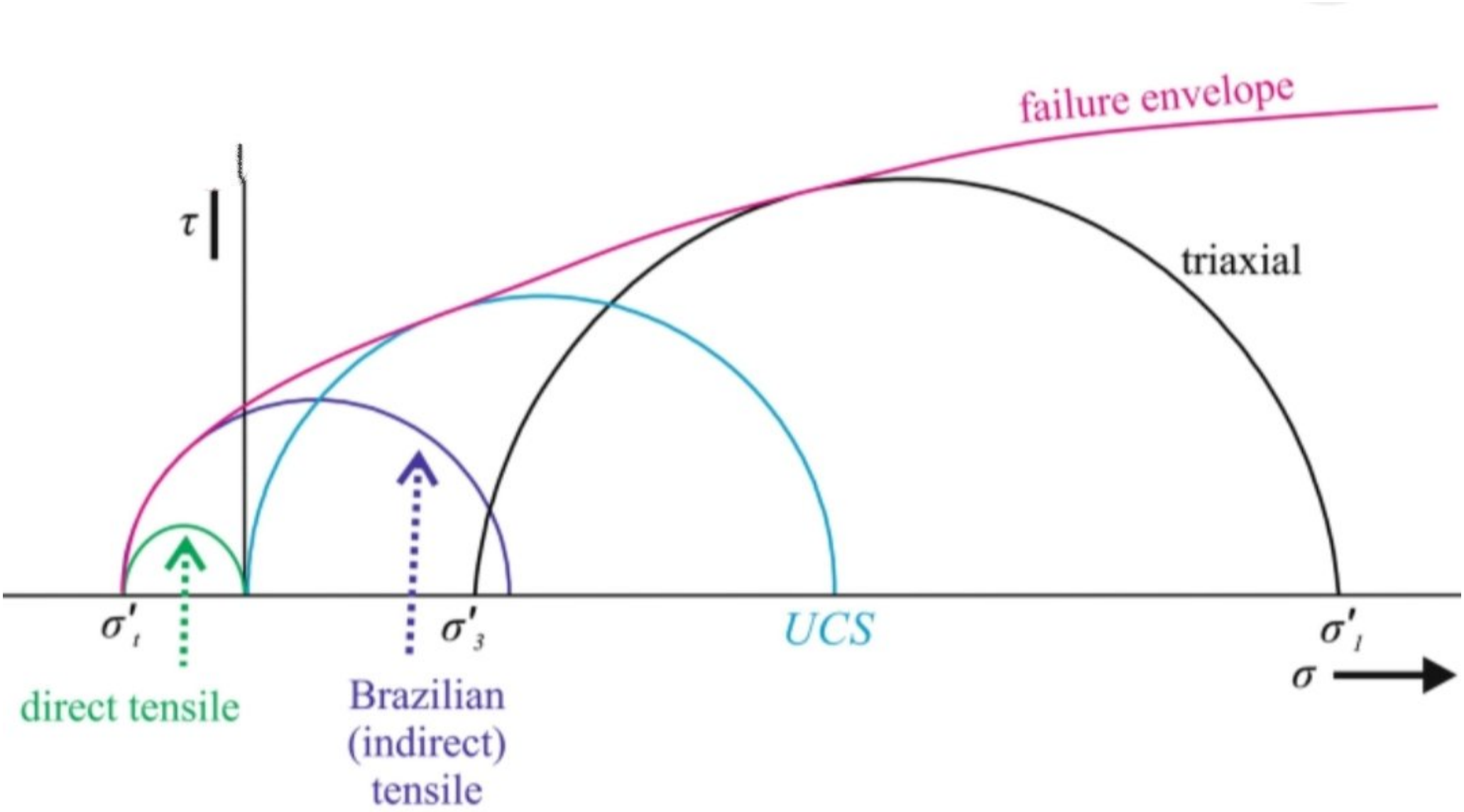
$$\tau = C_i + \sigma_n * Tan(\emptyset_i)$$

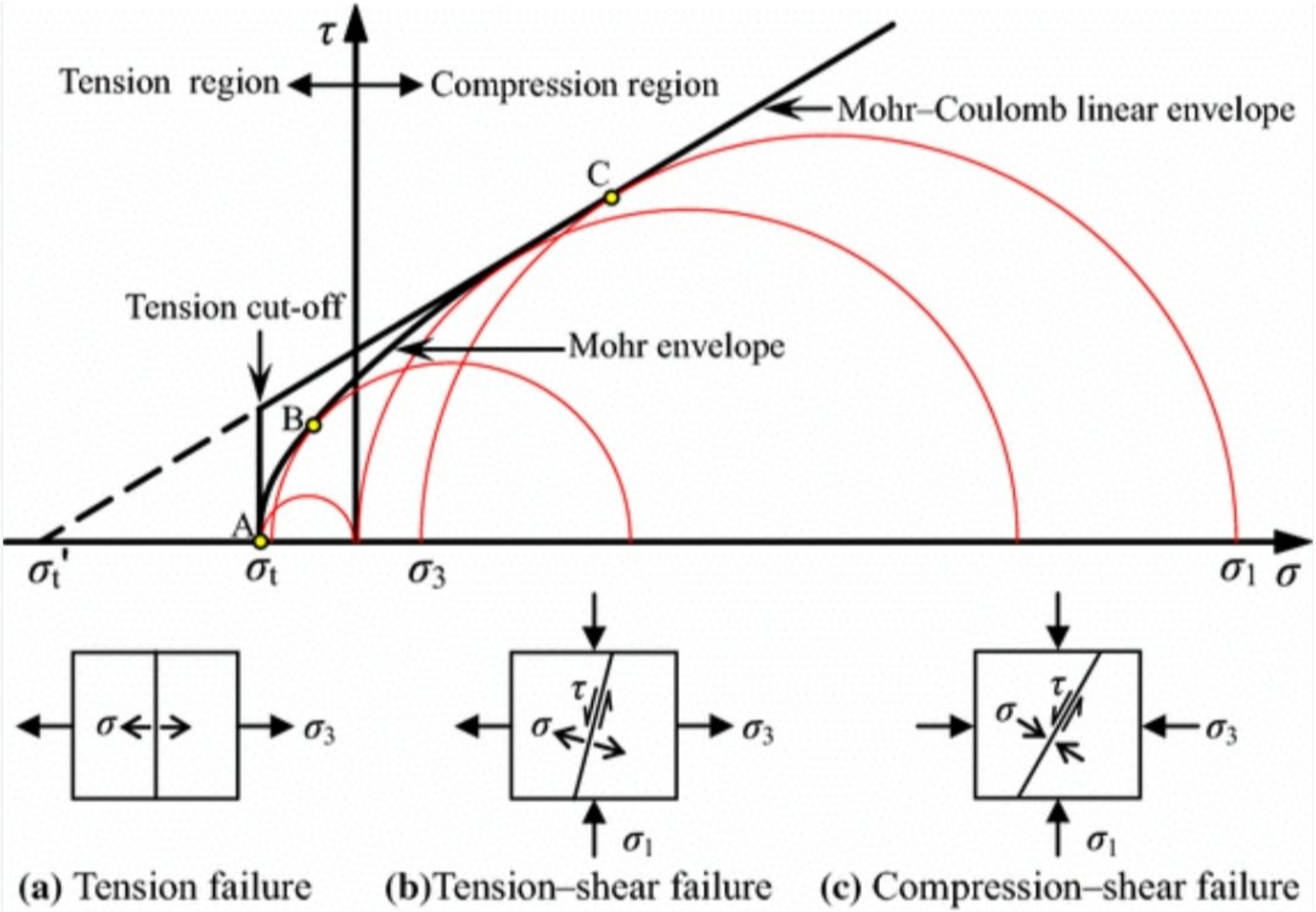
Shear Strength Parameters: -

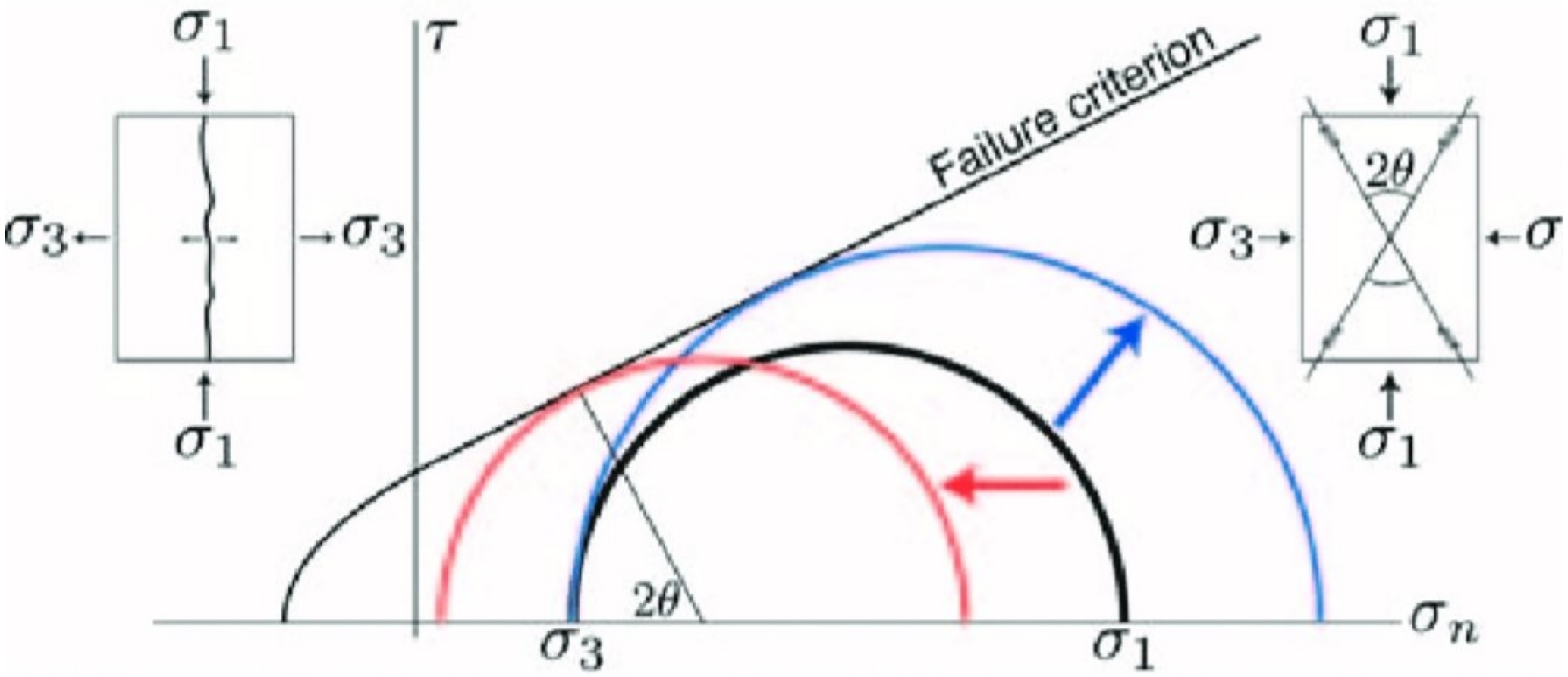
C_i (Internal Cohesion) & $\emptyset_i$ (Internal Friction Angle)

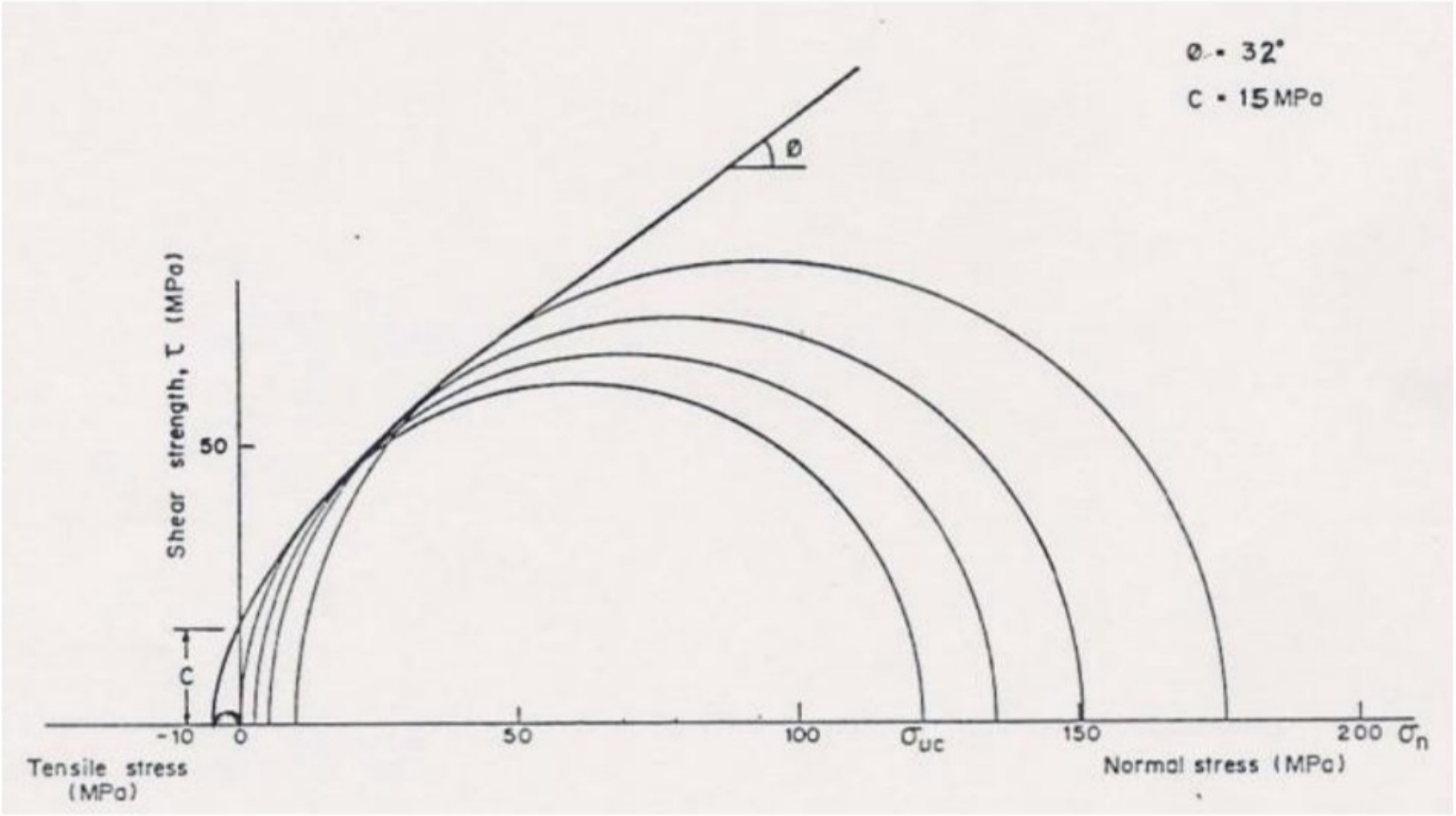
Shear Strength Parameters determined with the Triaxial Compression Tests.

Five tests must be done for five intact rock samples: 3 **Triaxial** tests, 1 **Uniaxial** test and 1 **Tension** test, to draw the relationship between **σ_n** and **τ** using **Mohr Diagram** to find **Shear Strength Parameters C_i & ∅I** and computing shear **τ** from the previous formula with known pressure **σ_n.**


failure envelope
τ
triaxial
σ'_t
σ'_3
UCS
σ'_1
σ
direct tensile
Brazilian
(indirect)
tensile


τ
Tension region
Compression region
Mohr–Coulomb linear envelope
C
Tension cut-off
Mohr envelope
B
A
σt'
σt
σ3
σ1
σ
σ
σ3
τ
σ
σ3
σ1
τ
σ
σ3
σ1
(a) Tension failure
(b)Tension–shear failure
(c) Compression–shear failure


σ_1
σ_3
σ_3
σ_1
τ
Failure criterion
2θ
σ_3
σ_1
σ_n
σ_1
σ_3
σ
σ_1
2θ



Determination of C_i and φ_i from Mohr curve