LW N°01: Tensile & Compression Test

The strength of a material depends on its ability to sustain a load without undue deformation or failure. This property is inherent in the material itself and must be determined by experiment. One of the most important tests to perform in this regard is the ***tension*** or ***compression*** test

1. Objectives

1.1. Define the following:

- ✓ Engineering stress and strain; True stress and strain
- ✓ Engineering and true stress-strain curves.

1.2. Determine the following mechanical properties:

- ➢ Modulus of elasticity or Young's modulus E;
- ➢ The proportional limit σ_{pl};
- ➢ The yield strength σ_y ;
- ➢ Tensile strength (ultimate stress) σ_u ;
- ➢ The fracture stress σ_f ;
- ➢ Poisson's ratio υ

2. Test specimens

Ordinary uniaxial tensile test specimens are generally cylindrical or flat, carefully polished and calibrated (see figure 1). The length of the calibrated part must be proportional to the cross-section according to the following empirical expression:

$$l_0 = K.\sqrt{S_0} \qquad k = 5{,}65;$$

$$l_0 = 5{,}65.\sqrt{S_0} \approx 5d_0;$$

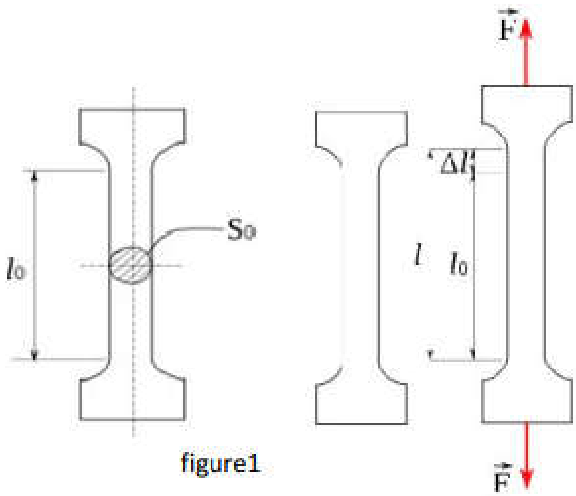


figure1

3. Laboratory Equipment Description

Testing machines are used to determine the mechanical characteristics of materials. Explosive and universal testing machines of all systems are used. The appearance of the testing machine with an electromechanical exciter is shown in figure 2.

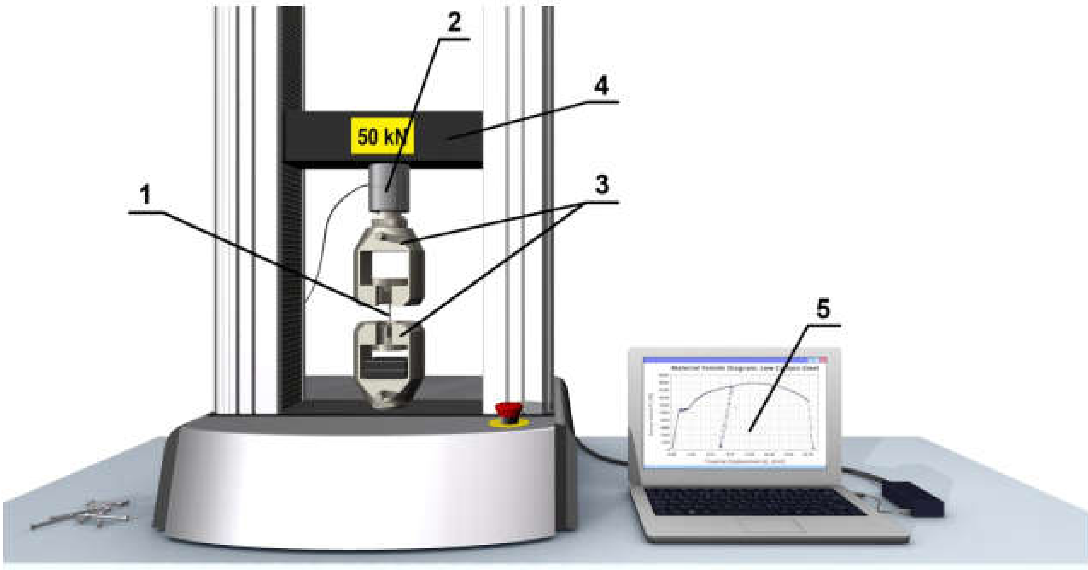


Figure 2 – Laboratory Equipment General View:
1 – Test Sample; 2 – Dynamometer; 3 – Grips; 4 – Traverse; 5 – Laptop

4. Governing Equations

The following equations of engineering stress and strain:

$$\sigma_e = \frac{F}{A_o} \quad (1.1)$$

$$\varepsilon_e = \frac{L - L_o}{L_o} \quad (1.2)$$

Where:-

F: the load (N)
A_o: initial cross-sectional area (m^2)
σ_e: engineering stress (Pa)
L_o: the initial length of the specimen (m)
L: is the measured length of the specimen (m)
ε_e: engineering strain (*dimensionless*)

The true stress and strain are given by:

$$\sigma_T = \frac{F}{A} \quad (1.3)$$

Where:-

A: the cross-sectional area of the specimen (m^2).

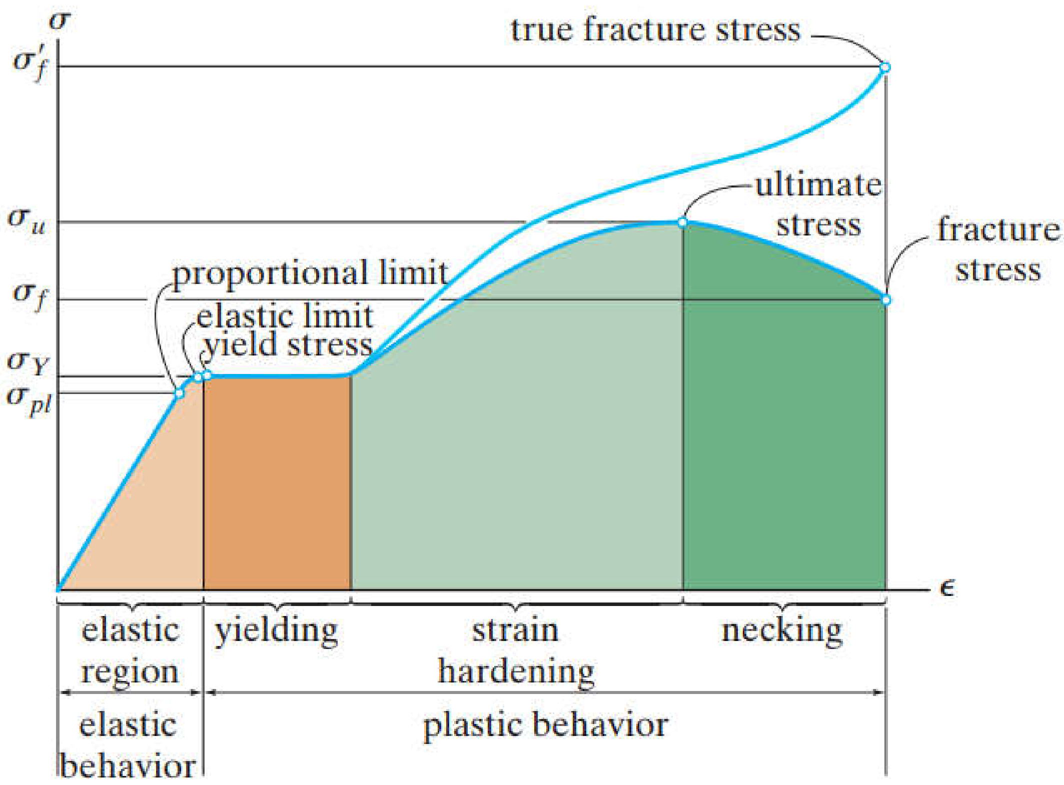
σ_T: true stress (Pa).

$$\varepsilon_T = \ln\left[\frac{L}{L_o}\right] \quad (1.4)$$

Where:-

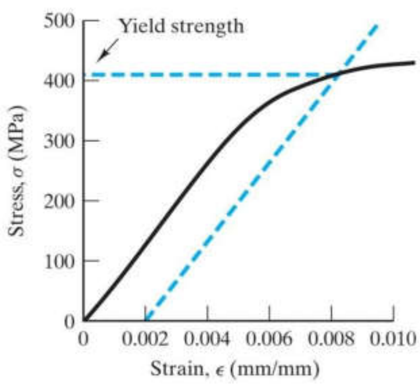
ε_T: the true strain.

5. Engineering and true stress-strain curve



Conventional and true stress-strain diagrams for ductile material (steel) (not to scale)

In most cases, the yield strength (σy) is hard to find so a method called the offset method is used. In this method, you take the offset value of strain ($\varepsilon = 0.002$) and draw a line parallel to the elastic line and the corresponding value of stress to the intersection point with the engineering stress-strain diagram is the yield strength (σy) as the figure below.

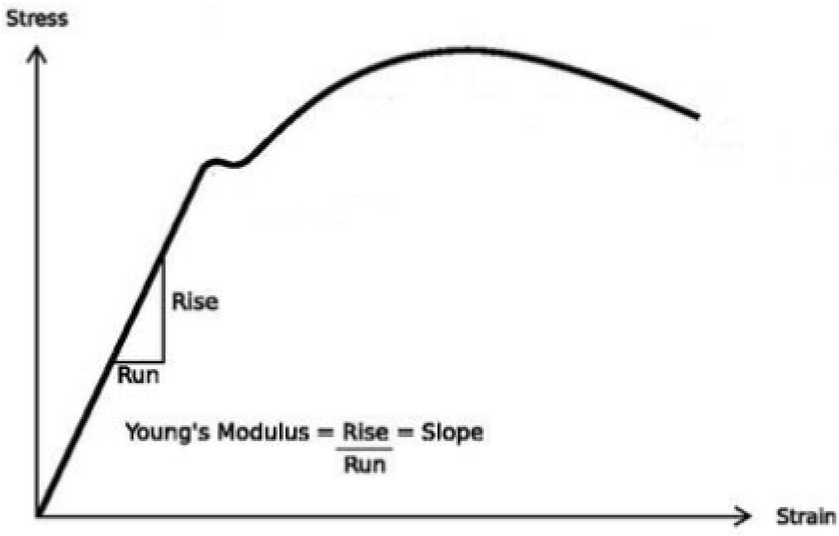


Young's Modulus of Elasticity (E):

Is a material property, that describes its stiffness, "E" can be found using Hock's law:

$$E=\frac{\sigma}{\varepsilon}$$

Also, the Modulus of elasticity can be found graphically as it is the slope of the line in the engineering stress-strain diagram.

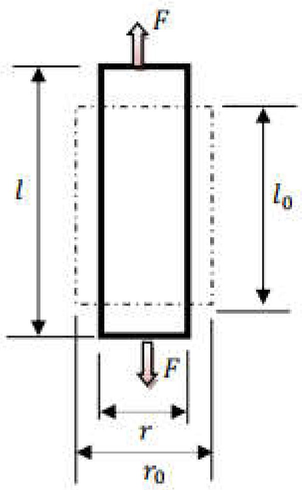


Poisson's ratio (ν):

Axial elongation of bars loaded in tension is accompanied by lateral contraction; the ratio of lateral strain to normal strain is known as Poisson's ratio (ν).

$$\nu = -\frac{\text{lateral strain}}{\text{axial strain}} = -\frac{\varepsilon'}{\varepsilon}$$

The concepts of longitudinal and lateral deformation are illustrated in the bellow figure:



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