Heaven's Light is Our Guide

Rajshahi University of Engineering & Technology

Course Title: Mechanics of Materials Sessional – ii

Course Code: CE 2214

Group – 1

Name of the Experiment:

Determination of the tensile strength of Mild Steel (MS) bar.

Year: 2nd year even semester

Experiment No: 01

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Introduction:

Elasticity and Plasticity: When external forces are applied on a body, made of engineering materials, the molecular forces acting between the molecules offer resistance against deformation or displacement of the particles continues till full resistance to the external forces is set up. If the forces are now gradually diminished, the body will return, wholly or partially to its original shape. Elasticity is the property by virtue of which a material deformed under the load is removed. If a body regains completely its original shape it is said to be perfectly elastic.

Plasticity is the converse of elasticity. A material in plastic state is permanently deformed by the application of load, and it has no tendency to recover. Every elastic material passes the property of plasticity. Under the action of large forces, most of the engineering materials become plastic and before in a manner to a viscous liquid. The characteristics of the material by which it undergoes inelastic strain beyond those of the elastic limit is known as plasticity.

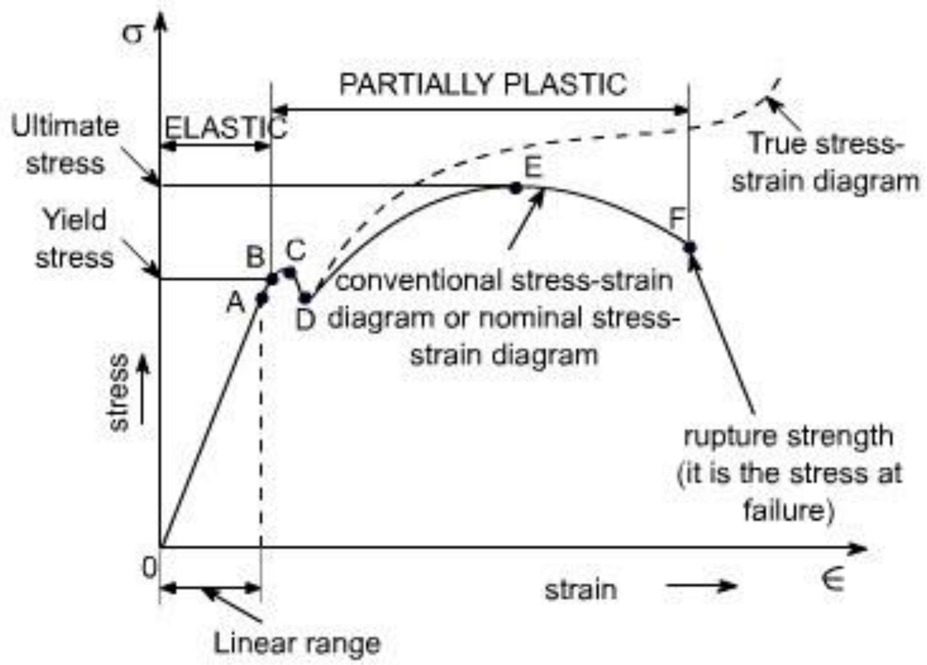

Figure: Stress-strain diagram of MS bar in tension

Stress: Stress is the intensity of internal force developed when an external force is applied on an engineering material. It is symbolically expressed as:

$$\sigma = \frac{P}{A}$$

Strain: Strain is a measurement of deformation produced by the application of external load on deformation per unit length. It is symbolically expressed as:

$$\in = \frac{\Delta}{L}$$

Proportional Limit (Point A): It is the limiting value of the stress up to which stress is proportional to strain.

Elastic Limit (Point B): This is the limiting value of stress and then released, strain disappear completely and the original length is regained. This portion follows Hook's Law.

Elastic recovery: The recovered deformation after removal of load.

Yield Stress (Point C and D): Soon after the stress the elastic limit, low carbon steel attains its yield point stress. The yield point of a material is defined as that will cause an increase in deformation without increase in load. When the yield stress is reached elongation takes place over and atoms move into new portions and a return to the original shape of the test piece is impossible.

Ultimate Strength/Tensile Strength (Point E): This is the minimum stress that the material can resist. The ultimate strength represents the ordinate to the highest point in the stress-strain diagram and is equal to the maximum load, carried by the specimen divided by the original cross-sectional area.

Necking: In the vicinity of the ultimate stress, the reduction in area of the bar becomes clearly visible and a pronounced necking of the bar occurs.

Rapture Strength (Point F): The stress at which the specimen finally fails is called rapture point. For structural steel, rapture strength is somewhat lower than the ultimate strength.

Modulus of Rigidity: It is defined as the ratio of the shearing stress to shearing strain, within elastic limit.

Modulus of Rapture/Modulus of Toughness: The work done on a unit volume of material, as a simple tensile force is gradually increased from zero to the value causing rapture is defined as modulus of toughness.

Hook's Law: A law stating that the strain in a solid is proportional to the applied stress, within the elastic limit of that solid.
Mathematically,

$$\sigma \propto \varepsilon$$

$$\sigma = E\varepsilon$$

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

Here, E is the slope of stress-strain and is called the modulus of elasticity.

Objectives:

1. To determine the average yield stress of MS bar.
2. To determine the average ultimate stress of MS bar.
3. To determine the actual diameter of MS bar.
4. To determine the unit weight of MS bar.
5. To determine the elongation of MS bar.
6. To determine the bending and re-bending of MS bar.

Apparatus:

1. Mild steel sample bar
2. Slide calipers
3. Digital balance
4. Scale
5. Universal Testing Machine (UTM

Procedure:

1. The length of the MS bar sample was measured with scale.
2. The diameter of the MS bar sample was measured with slide calipers.
3. The whole steel bar was weighed by balance.
4. The mild steel was ready to measure its tensile strength and placed in Universal Testing Machine after marking in 8-inch gap.
5. From the machine, the reading of yield point was recorded.
6. The maximum load was recorded and load was applied till the sample broke.
7. The final length between the gauge marks was taken by fitting the two ends of the broken pieces together.

Data Table:

Table 1: Tensile Strength test of Mild Steel Bar

Group No.	01	02	03
Nominal Diameter (cm)			
Length of the Bar (cm)	100.2	100.0	99.9
Weight of the Bar (gm)	905	884	836
Initial gauge length (cm)	20.32	20.32	20.32
Final gauge length (cm)	24.13	23.75	24
Yield Load (kN)	50.729	51.750	49.708
Yield Stress (MPa)	441.12	466.21	470.72
Ultimate Load (kN)	75.237	73.195	60.941
Ultimate Stress (MPa)	654.234	659.41	577.09
Bending	OK	OK	OK
Rebending	OK	OK	OK

Calculations:

Length of the steel bar, L=100.2 cm
Weight of the steel bar, W=905 gm
Specific gravity of MS steel, γ=7.85 gm/cm^3
Actual diameter of the mild steel bar, $d = \sqrt{\frac{4*W}{\pi*L*r}} = \sqrt{\frac{4*905}{3.1416*100.2*7.85}} = 1.21cm$
Machine load for yield stress, $P_{My} = 52\ kN$
Actual load for yield stress, $P_{Ay} = (1.0212 * 52 - 2.3734)kN = 50.729\ kN$
Machine load for ultimate stress, $P_{Mu} = 75.97\ kN$
Actual load for ultimate stress, $P_{Au} = (1.0212 * 75.97 - 2.3734)kN = 75.237\ kN$
Cross Sectional area of the MS bar =$\frac{\pi}{4}d^2 = \frac{\pi}{4}(1.21)^2 = 1.15\ cm^2$
Yield Stress =$\frac{50729}{115}N/mm^2 = 441.12MPa$
Ultimate Stress =$\frac{75237}{115}N/mm^2 = 654.234MPa$
Unit weight of mild steel bar, $w = \frac{4*W}{\pi d^2 L} = \frac{4*905}{301416*(1.21)^2*100.2} = 7.85\ gm/cm^3$
Initial gauge length, $L_1 = 20.32\ cm$
Final gauge length, $L_2 = 24.13\ cm$
Elongation, $\mathit{\Delta} = L_2 - L_1 = 3.81cm$
Strain, Ɛ $= \frac{\Delta}{L} = \frac{3.81}{20.32} = 0.1875$
Percentage Strain $= 0.1875 * 100\% = 18.11\%$
Average Yield Stress $= \frac{441.12+466.21+470.72}{3}MPa = 459.35MPa$
Average Ultimate Stress $= \frac{654.234+659.41+577.09}{3}MPa = 630.24MPa$
Average actual diameter $= \frac{1.21+1.19+1.16}{3}cm = 1.18cm$
Average unit weight $= \frac{7.85+7.94+7.91}{3}gm/cm^3$
Average elongation $= \frac{3.81+3.45+3.68}{3}cm = 3.64cm$

Results:

The average yield stress = 459.35 MPa

The average ultimate stress = 630.24 MPa
The average actual diameter = 1.18 cm
The average unit weight = 7.90 gm/cm3
The average elongation = 3.64 cm
Bending test = OK
Re-bending test = OK

Discussions:

1. All the measurement was observed very carefully but due to error in machine all the measurement was affected to an extent.
2. The yield point was the point where the steel bar continues to elongate and, in this limit, stress was proportional to strain.
3. The actual rupture stress was higher than true rupture stress because the cross-sectional area of the steel bar decreases but for the ultimate stress, the load was divided by the initial cross-sectional area.