Objective

To determine the tensile strength of a Mild steel bar with the help of universal testing machine also draw stress strain curve..

Apparatus

Universal testing machine, Mild steel specimen

Theory

Universal Testing Machine

A universal testing machine, also known as a universal tester materials testing machine or materials test frame, is used to test the tensile stress and compressive strength of materials. It is named after the fact that it can perform many standard tensile and compression tests on materials, components, and structures.

According to the loading type, there are two kinds of tensile testing machines.

- **Screw Driven Testing Machine:** During the experiment, elongation rate is kept constant.
- **Hydraulic Testing Machine:** Keeps the loading rate constant.
  The loading rate can be set depending on the desired time to fracture.

The Universal Testing Machine Apparatus unit consists of Tension and compression section as well as, a control box connected with computer for obtaining graph and required values

Tension Test

The tensile testing is carried out by applying longitudinal or axial load at a specific extension rate to a standard tensile specimen with known dimensions (gauge length and cross sectional area perpendicular to the load direction) till failure.

The most common type of test used to measure the mechanical properties of a material is the Tension Test. Tension test is widely used to provide basic design information on the strength of materials and is an acceptance test for the specification of materials. The major parameters that describe the stress-strain curve obtained during the tension test are the tensile strength (UTS), yield strength or yield point (σy), elastic modulus (E), percent elongation ($\Delta L\%$) and the reduction in area (RA%). Toughness, Resilience, Poisson's ratio (ν) can also be found by the use of this testing technique.

Stress and strain relationship

When a specimen is subjected to an external tensile loading, the metal will undergo elastic And plastic deformation. Initially, the metal will elastically deform giving a linear relationship of load and extension. These two parameters are then used for the calculation of the engineering stress and engineering strain to give a relationship as illustrated in figure.

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

$$\varepsilon = \frac{L_f - L_o}{L_o} = \frac{\Delta L}{L_o}$$

where	σ	is the engineering stress
	ε	is the engineering strain
	P	is the external axial tensile load
	A_o	is the original cross-sectional area of the specimen
	L_o	is the original length of the specimen
	L_f	is the final length of the specimen

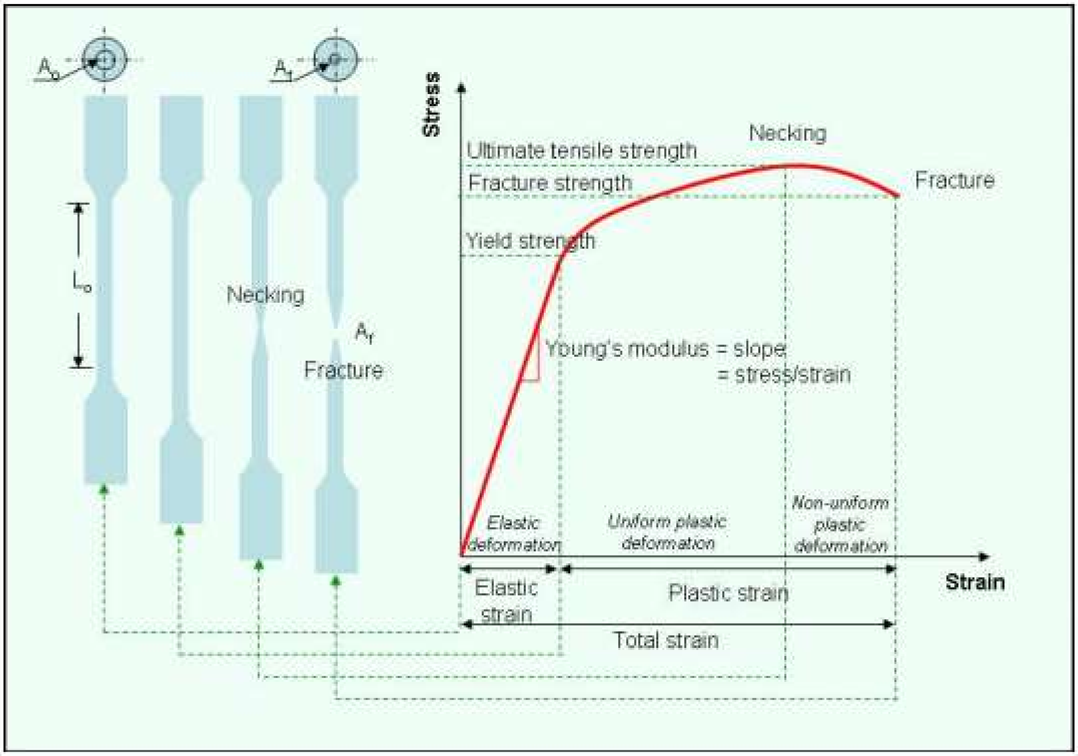

Figure 18 Stress-Strain curve

<u>Elastic *Region*</u>

The part of the stress-strain curve up to the yielding point.

Elastic deformation is recoverable. In the elastic region, stress and strain are related to each other linearly.

Hooke's Law: σ =Ee

The linearity constant E is called the elastic modulus which is specific for each type of material.

<u>Plastic Region</u>

The part of the stress-strain diagram after the yielding point.

At the yielding point, the plastic deformation starts. Plastic deformation is permanent. At the maximum point of the stress-strain diagram (UTS) at which necking starts.

Tensile Strength is the maximum stress that the material can support.

$$\boldsymbol{\sigma_{UTS} = P_{max}/A_o}$$

Because the tensile strength is easy to determine and is a quite reproducible property, it is useful for the purposes of specifications and for quality control of a product. Extensive empirical correlations between tensile strength and properties such as hardness and fatigue strength are often quite useful for brittle materials; the tensile strength is a valid criterion for design.

<u>Yield Strength</u>

Yield strength is the stress level at which plastic deformation starts. The beginning of first plastic deformation is called ***yielding***. It is an important parameter in design.

The stress at which plastic deformation or yielding is observed to begin depends on the sensitivity of the strain measurements. With most materials there is a gradual transition from elastic to plastic behavior, and the point at which plastic deformation begins is hard to define with precision. Various criteria for the initiation of yielding are used depending on the sensitivity of the strain measurement and the intended use of the data.

0.2% off-set method is a commonly used method to determine the yield strength. σy(0.2%) is found by drawing a parallel line to the elastic region and the point at which this line intersects with the stress-strain curve is set as the yielding point. An illustration of 0.2% off-set method is shown in the Figure.

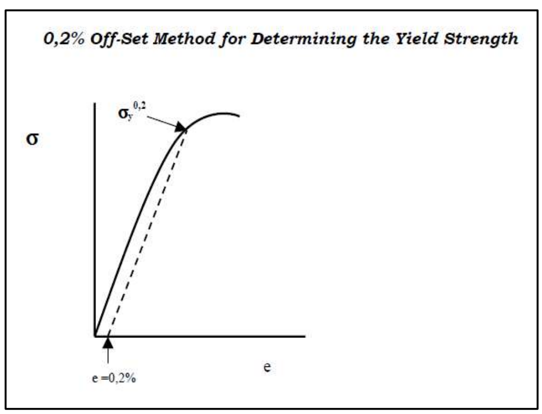

Figure 19 Off-set method

<u>Ultimate Tensile Strength</u>

Beyond yielding, continuous loading leads to an increase in the stress required to permanently deform the specimen as shown in the engineering stress-strain curve. At this stage, the specimen is strain hardened or work hardened. The degree of strain hardening depends on the nature of the deformed materials, crystal structure and chemical composition.

<u>Ductility</u>

Ductility is the degree of plastic deformation that a material can withstand before fracture. A

material that experiences very little or no plastic deformation upon fracture is termed brittle.In general, measurements of ductility are of interest in three ways
To indicate the extent to which a metal can be deformed without fracture in metalworking operations such as rolling and extrusion.
To indicate to the designer, in a general way, the ability of the metal to flow plastically before fracture.To serve as an indicator of changes in impurity level or processing conditions. Ductility measurements may be specified to assess material quality even though no direct relationship exists between the ductility measurement and performance in service.

Ductility can be expressed either in terms of percent elongation (z) or percent reduction in area (q);

$$z = \%\Delta l = \left[\frac{l_f - l_0}{l_0}\right] \times 100$$
$$q = \%RA = \left[\frac{A_0 - A_f}{A_0}\right] \times 100$$

<u>Resilience</u>

Resilience is the capacity of a material to absorb energy when it is deformed elastically.

<u>Toughness</u>

Toughness ***is*** a measure of energy required to cause fracture.

<u>Poisson's Ratio</u>

Poisson's Ratio is the lateral contraction per unit breadth divided by the longitudinal extension per unit length.

$$v = -\left(\frac{\Delta d}{d_0}\right)\left(\frac{\Delta l}{l_0}\right)$$

<u>Procedures</u>

- Firstly, place the steel rod between two jaws of UTM
- One end is placed in upper jaw and other end is placed in lower jaw.
- Apply load with the help of UTM.
- The length of the rod increasing as we applying load with the help of UTM
- Then the point came where necking starts and after few seconds it will break.

<u>Observations</u>

Initial length $=L_o=$
Initial Diameter$=D_o$

Sr.No	Force (KN)	Deformation (δ)	ΔL	Strain=ΔL\L	Stress=F\A ($N\backslash m^2$)
1					
2					
3					
4					
5					
6					
7					

Procedure (Students' own words)

Difficulties / Suggestions

Concluding Remarks / Comments

Questions

1. **Types of errors during the experiment?**

2. **How to improve experimental procedure?**