Bangladesh University of Engineering and Technology

Mechanical Engineering Department

Course No. ME 244 (Mechanics of Solids Sessional)
0.75 credits

Experiments –

EXPERIMENT # 01.

a. Tension Test of Metal
b. Hardness Test

EXPERIMENT # 02.

a. Compression Test Of Wooden Block
b. Impact Test

EXPERIMENT # 03.

a. Helical Spring Test
b. Hydrostatic Pressure Test Of Thin Walled Cylinder

EXPERIMENT # 04.

a. Slender Column Test
b. Study Of Beam

EXPERIMENT # 05.

a. Direct Shear Test Of Metal
b. Torsional Shear Test Of Metal

General Instructions –

1. Report to the class 5 minutes before the due time.
2. Give attendance to the SM lab and submit your report before your attendance is given
3. There will be an oral examination after each experiment.
4. Bring all necessary instruments, graph papers, pencils, scale for report writing
5. Do not come close to the impact testing machine. Keep a distance from all moving parts and be careful about your safety.

Report Writing

1. Prepare report before you come to the class.
2. Write only on one side of an 80 gms A4 paper.
3. Use plastic file and the designated color of your group.
4. The report should contain the following points --
    a. Objectives
    b. Apparatus (with specification)
    c. Experimental setup (Schematic diagram)
    d. Data Table / Calculated table
    e. Sample Calculation
    f. Graphs
    g. Results
    h. Discussion
        i. Discuss the graphs and results
        ii. Discuss about the experimental setup if it could be improved
        iii. Discuss the different parameters that could affect the result
        iv. Discuss any assumptions made
        v. Discuss any discrepancies in the experimental procedure and result
        vi. Discuss what you have learnt and the practical application of this knowledge
    i. Question answers and Assignment if any.
    j. Reference
5. Reference books-
    a. Timoshenko
    b. COX
    c. Olsen
    d. Popov
    e. Singer
    f. Dr. Amalesh Chandra Mandal and Dr. Md. Quamrul Islam
    (Mechanics of Material – Laboratory Practice, Bring this book every day)

EXPERIMENT NO. 1(A)
TENSION TEST OF MILD STEEL SPECIMEN

OBJECTIVES

a. To test a mild steel specimen till failure under tensile load.
b. To draw stress-strain diagram.
c. To determine:
   - (i) Proportional limit
   - (ii) Modulus of elasticity
   - (iii) Yield point
   - (iv) Ultimate strength
   - (v) Breaking strength
   - (vi) Percentage elongation
   - (vii) Percentage reduction in cross-sectional area
   - (viii) Modulus of Resilience
   - (ix) Modulus of Toughness

THEORY

When a specimen is subjected to the action of a force shown in the figure it is deformed, no matter how small the force is. If the specimen is elongated due to the application of the force, the specimen is said to be in tension and the force may be termed as tensile force.

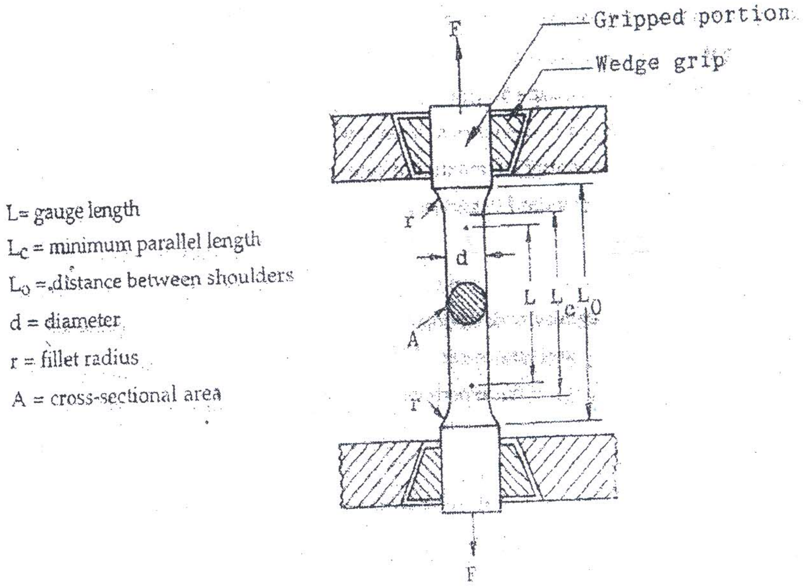


Figure: Standard round tension specimen in a tensile testing machine.

One standard value of gage length of round specimen is (50± 0.10) mm and the corresponding diameter is (12.5± 0.25) mm, fillet radius is 10 mm, minimum parallel length is 60 mm according to ASTM standard.

Stress: When an external force is applied on the specimen an internal force is developed in order to resist the external force. The internal force per unit area at any section is called stress. Stress is denoted by σ.

$$\text{Therefore, } \sigma = \frac{F}{A} \text{ N/mm}^2 \text{ (MPa)}$$

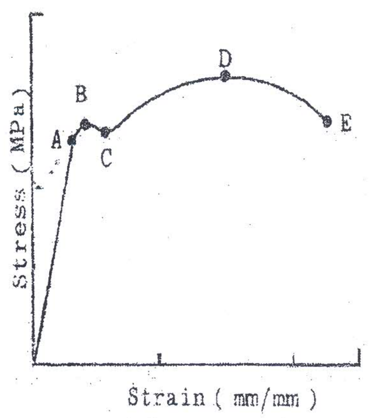
Where F is applied load; A is the original area of cross-section of the specimen.

Strain: When the force is applied on the specimen, it is deformed. For the tensile force the specimen is elongated. The elongation per unit length is called strain.
Strain is denoted as ε

$$\text{Therefore, } \varepsilon = \frac{\delta}{L}$$

Where, δ is the deformation over the length L

Stress-Strain diagram:



A - proportional limit
B - upper yield point
C - lower yield point
D - ultimate strength
E - breaking strength

Figure: Typical stress strain diagram for mild steel.

Proportional Limit: The point in the stress strain diagram up to which the stress is proportional to strain is called the proportional limit.

Yield point: The point in the stress- strain diagram at which there is an increase in strain with no further increase in stress is called the yield point. In the case of mild steel there are two yield points, upper and lower.

Ultimate strength: The maximum stress in stress strain diagram is called the ultimate strength or tensile strength.

Breaking strength: The stress at which the specimen breaks away is called the breaking strength.

Percentage reduction in area: The difference between the original cross section area and the cross section area at the neck (when the rupture takes place) divided by the original area and multiplied by 100 is termed as the percentage reduction in area.

$$\text{Percentage reduction in area} = \frac{A-a}{A} \times 100$$

Where, A is the original cross section area

a is the cross section area at the neck

Ductility: Ductility is defined as that property which permits material to be deformed without fracture. It is frequently assumed that a material having elongation greater than 5% in 50 mm gauge length is ductile.

Modulus of Elasticity: Below the proportional limit, stress is proportional to strain and the proportionality constant is called the modulus of elasticity. This is denoted by E,

Therefore, $E = \frac{\sigma}{\varepsilon}$ N/mm^2 (MPa)

Modulus of elasticity is a measure of material stiffness.

Modulus of resilience: The modulus of resilience is defined as the ability of a material to absorb energy within its proportional limit. This may calculated as the area under the stress-strain curve from the origin up to the proportional limit as shown in the figure as shaded area.

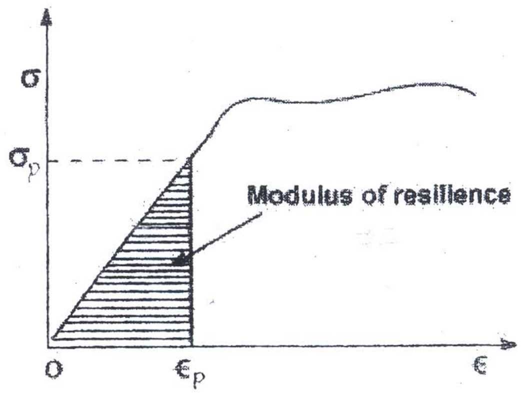


Figure: Modulus of resilience

Modulus of resilience is denoted by, U_p

Therefore, $U_p = \frac{1}{2}\sigma_p \varepsilon_p$

Where σ_p is the proportional limit, since one can write $\sigma_p = E\varepsilon_p$

So, $U_p = \frac{\sigma_p^2}{2E}$

Modulus of Toughness: Toughness is the ability of a material to absorb energy and plastically deform before it fractures. Toughness is calculated by evaluating the area under the stress-strain curve. It is denoted by U_T

$$U_T = \int_0^{\varepsilon_f} \sigma \times d\varepsilon$$

Where ε_f is the strain at fracture

Simply it may be calculated from $U_T = \sigma_u \, \varepsilon_f$

Where, σ_u is the ultimate strength.

Another method to determine Modulus of Toughness is $U_T = \frac{\sigma_u + \sigma_y}{2} \times \varepsilon_f$

Where, σ_y is the yield strength

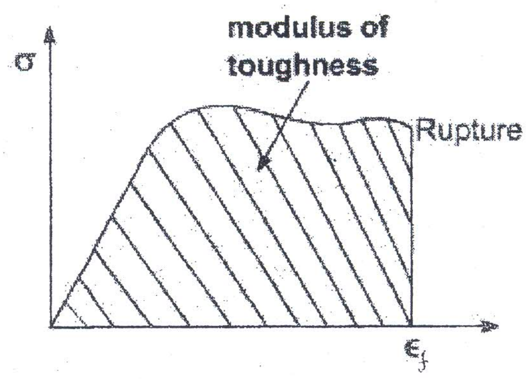


Figure: Modulus of toughness

APPARATUS

1. Universal Testing Machine
2. Extensometer
3. Slide Calipers
4. Percentage Elongation Scale/ Dial Gauge

PROCEDURE

a. Make sure that the universal testing machine is calibrated.
b. Measure the diameter and gauge length of the specimen by slide calipers.
c. Record extensometer constant and dial gauge constant.
d. Fix the specimen in position.
e. Fix the extensometer with the specimen.
f. Apply load and read simultaneously the load-deformation data.
g. When yield point is reached, stop machine, remove extensometer and fix the dial gauge in the machine. Increase load and take load-deformation data at regular intervals up to the tearing of the specimen.
h. Record the maximum and the breaking load.
i. Remove the broken specimen and measure smallest cross-sectional area and deformed length.

RESULTS

Compare the ideal and experimental stress-strain diagram and discuss the results.

DATA SHEET

Dia of specimen; d = _________ mm

Gauge Length, L = _________ mm

Cross-Sectional Area A = _________ mm^2

Extensometer Constant K = _________

Observation No.	Extensometer Reading / Dial gauge Reading	Load, P (kg)	Elongation of Specimen, δ (mm)	Strain, ε (mm/mm)	Stress, σ (MPa)	Remarks

EXPERIMENT NO. 1(B)
HARDNESS TEST

OBJECTIVES

a. To determine the hardness number of metal.

b. To find Brinell hardness number from that of Rockwell hardness number.

c. To find the tensile strength of the metal by knowing the hardness number.

THEORY

There are three principal operational definition of hardness:

Scratch hardness: Resistance to fracture or plastic (permanent) deformation due to friction from a sharp object (Primarily used in mineralogy).

Indentation hardness: Resistance to plastic (permanent) deformation due to impact from a sharp object (Primarily used in engineering and metallurgy).

Rebound hardness: Height of the bounce of an object dropped on the material (related to elasticity).

The most common instruments used to determine the indentation hardness are the Brinell, Rockwell, and Vickers and the corresponding hardnesses are called Brinell hardness, Rockwell hardness, Vickers hardness respectively. There are also different scales in some specific type hardness like Rockwell hardness B (HRB), Rockwell hardness C (HRC) etc. There is a direct connection between the indentation hardness and few other mechanical properties of a material. So, by knowing the hardness number, we can find out the mechanical properties of the material of the test specimen.

To illustrate the concept of indentation hardness, let us consider the following two figures.

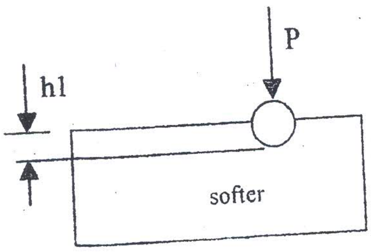


Fig. 1

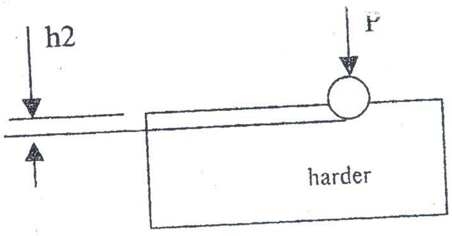


Fig. 2

In both the figures the ball having a diameter "d" is the indentor which is pressed against a piece of material. Now for the same load P, the indentations (permanent deformations) will be different for the soft and hard materials. It is obvious that for the above two cases $h_1 > h_2$. It is also important that the time during which load P is applied should be the same for both cases. The indentation depends on P, d, time during which load is applied, and the hardness of the material. Hence, if all other variables such as P, d and time are kept constant, than h is a function of hardness only. Based on this principal, some standard hardness numbers are established. For each particular scale there is a particular indentor. The indentors may be a ball or pyramid and have different dimensions.

APPARATUS

Rockwell Hardness Tester.

Indentors.

SPECIMEN

Specimens of Aluminum, Mild Steel and Brass.

PROCEDURE

1. For the material whose hardness is to be determined, first took into Table-1 and choose the hardness scale type of indentor, preload and total load from the table.
2. Unscrew the clamping knob and insert holder with indentation body into pressure plunger.
3. From Table-2, find out the combination of weights for preload and test load. Also choose whether the scale is red or black. Also, note the application time of test force.
4. Mount the preloads according to chosen scale. By slowing shifting application lever to the left, set preload.
5. Set the test load at the proper place.
6. Put the standard specimen on support table and traverse the table upward against the indentation body until small and large pointers of dial gauge are approximately "O". The exact "O" position of the pointer is obtained by rotating the knurled outer ring.
7. Ensure that the specimen is flat. Now, shift the application lever to the left to apply test force. Loading is completed as soon as the pointers of dial gauge have settled.
8. Apply load for the specified application time. Time starts as soon as the pointers are settled. Immediately after this specified time, relieve the test force by shifting the application lever in the opposite direction.
9. Read out the hardness in the proper scale (either red or black) after the pointers have settled.
10. If the hardness matches with the inscribed hardness, the machine is well calibrated.
11. Traverse the support table downwards and replace the standard sample by the unknown sample whose hardness is to be determined.
12. Repeat steps 5 to 10 and find out the hardness numbers for brass, aluminum.