

AMP 262 (Fluids and Solid Mechanics Laboratory)

Lab Manual (Solids)

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Uniaxial tension test

Objective To obtain the stress-strain relation of mild steel using a circular cylindrical specimen and determine Young's modulus E , proportional limit σ_{pl} , yield stress σ_y , 0.2% offset yield strength, ultimate tensile stress σ_u , percentage elongation, variation of % elongation with gauge length wrt cross head movement, modulus elastic resilience and modulus of toughness.

Apparatus The universal testing Machine (UTM) is a machine using which several tests can be performed, e.g. tension, compression bending, buckling indentation. The load is added to a specimen by the movement of a moving plate holding the movable set of jaws relative to a fixed plate holding the fixed set of jaws.

A typical tensile testing machine consists of a load cell, crosshead, extensometer, specimen grips, electronics and a drive system. It is controlled by testing software used to define machine and safety settings and store test parameters specified by testing standards such as ASTM and ISO. The amount of force applied to the machine and the elongation of the specimen are recorded throughout the test. Measuring the force required to stretch or elongate a material to the point of permanent deformation or break helps designers and manufacturers predict how materials will perform when implemented for their intended purpose. The specimen has a larger diameter at the ends with a smooth fillet connecting to the reduced diameter of the central portion to ensure that the effect of the holding jaws' is not significant on the state of stress within the gage length.

Draw the sketches of the machine, specimen using pencil

Procedure: Measure the diameter of the specimen. Mark several gauge length marks on the specimen for gauge lengths of 40, 60, 80, 100 mm. Adjust the position of the specimen in the wedge grips. Set the machine for start applying the load gradually with test speed of 1 mm/min and read the extension from the display. Increase the extension till the specimen fractures into two pieces. Note down the maximum load applied, measure the minimum diameter of the necked section and the final deformed lengths between the marked gage points by assembling together the fractured pieces.

Preload condition:

Before the test start we will have to insure that machine is at zero force condition.

Observations and caluclations

Diameter of the specimen $d_0 = \frac{(\quad)}{3}$ mm = m

Gauge length $L_0 = \dots$ mm = m

Readings from spreadsheet: Attach the Excel Sheet at every 10 readings

Maximum load $P_{max} =$ kgf = N

Load at fracture $P_f =$ kgf = N

Minimum diameter of the neck $d_f =$ mm = m

The initial and final lengths L_i and L'_i of various segments of the specimen are listed in Table 2 along with the computed percentage elongations. The percentage elongation in plotted versus gauge length in Figure 2.

L_i	
L'_i	
elongation	
$100(L_i - L'_i)/L_i$	

$$\text{Undeformed area } A_0 = \frac{\pi}{4} d_0^2 = m^2$$

In linear range $E = \frac{\sigma}{\epsilon} = \frac{P/A_0}{\Delta L/L_0} = N/m^2$

From Figure 3, the loads P_{pl}, P_y corresponding to proportional limit and yield limit are

$$P_{pl} = kgf = N, P_y = kgf = N$$

Proportional limit $\sigma_{pl} = \frac{P_{pl}}{A_0}$ Pa

Yield stress $\sigma_y = \frac{P_y}{A_0} =$ Pa

Ultimate stress $\sigma_u = \frac{P_{max}}{A_0} =$ Pa

True fracture stress $\sigma_f = \frac{P_f}{A_f} =$ Pa

Final gauge length $L_f =$ m

Nominal average strain at fracture $= \frac{(L_f - L_0)}{L_0} =$

Nominal (for L_0) strain at fracture for infinitesimal length $= \left(\frac{d_0}{d_f}\right)^2$

True strain at fracture for infinitesimal length $= 2 \ln \frac{d_0}{d_f} =$

For $L_0 = \dots$ m and $d_0 =$ m, we have for mild steel

Percentage elongation $= \frac{(L_f - L_0)}{L_0} \times 100 =$ %

Percentage reduction in area $= \frac{(A_0 - A_f)}{A_0} \times 100 =$ %

Modulus of elastic resilience $= \frac{\sigma_{pl}^2}{2E} = J/m^3$

Work = Area under load versus extension curve = number at squares product of two scales =

Modulus of toughness = work/ load

The sketch of the final deformed specimen will be drawn by students itself in Figure 1

Discussion of result and source of error:

Conclusions:

Compression Test

Objective: To study the behaviour of material under uniaxial compression.

Experiment setup: UTM test specimen of cast iron, mild steel etc. different lubricating agent like grease and graphite hardened and smooth platens.

Procedure: Mark gauge length b_0 and measure diameter D_0 . Place specimen between the platens centrally and apply lubricant both end faces of the specimen. Apply compressive load P gradually and measure the distance b between gauge marks and diameter D for set of values of P . observe if there is any buckling tendency expansion at the ends and bulging in the specimen is noted. For brittle material study, the fracture surfaces repeat for different materials. Plot $\sigma - \epsilon$ & $\sigma_t - \epsilon_t$ relation and make compressive study of behaviour.

$$\epsilon = \frac{b-b_0}{b_0} \quad \sigma = \frac{P}{A_0} = \frac{P}{\left(\frac{\pi D_0^2}{4}\right)}$$

Assuming constant volume for post elastic deformations

$$\left(\frac{\pi D^2}{4}\right)L = \left(\frac{\pi D_0^2}{4}\right)L_0 = D^2 = \frac{D_0^2}{1 + \epsilon}$$
$$\sigma_t = \frac{P}{A} = \frac{P}{\frac{\pi D^2}{4}} = \left(\frac{P}{A_0}\right)(1 + \epsilon) = \sigma(1 + \epsilon)$$
$$\epsilon_t = 2\ln\left(\frac{D}{D_0}\right)$$

Observation and Calculations:

- 1 Draw sketch of experimental setup unreformed and deformed specimen and the fracture surface.
- 2 Tabulate the observation and calculate $\sigma, \epsilon, \sigma_t, \epsilon_t$.

Table 1 (Mild Steel)

P (kgf)	$b = ()/3$ (mm)	$D = ()/3$ (mm)	ϵ	σ	σ_t	ϵ_t	Remarks

- 3 Report σ_u^c for brittle materials.

Table 2 (Cast Iron)

P (kgf)	$b = ()/3$ (mm)	$D = ()/3$ (mm)	ϵ	σ	σ_t	ϵ_t	Remarks

Discussion and sources of error:

Conclusion:

Torsion test

Objective: To obtain twisting moment-twist relationship of a mild steel specimen. To determine shear modulus yield stress τ_y in pure shear, theoretical ultimate torque based on elastic-perfectly plastic model of material.

Apparatus: The test is performed on a torsion testing machine using a circular specimen whose flat ends are fixed by collets into the “fixed” dynamometer end and the movable motor end of the machine. The dynamometer is basically a torque arm which magnifies the response by lever systems. One of the following four scales can be selected; 1500, 3000, 7500, 15000 kgf.cm with resolutions of 5, 10, 20 and 50 respectively. The motor end can be rotated by constant speed motor at the following rates: $3\frac{1}{3}$, 10, 30, and 90°/min by appropriate setting of the gearbox. The reversed rotation can be applied and the dynamometer can also record torques in the reversed direction. **A sketch of the machine, specimen and torque-meter should be drawn by students (Figure 1).** The motor is mounted on a chassis which is free to move axially on the bed of the machine so as to avoid any application of axial force on the specimen. The specimen has flats at ends at right angles to each other so that the play between the holding collets and the specimen is minimised, so as to avoid application of bending moment in addition to the twisting moment. A torque-meter is fixed to the parallel portion of the specimen with a gage length of approx. 76 mm. It measures the relative twist between the two cross sections at the end of the gage length.

Procedure: Measure the various dimensions of the specimen and mark them on **its sketch in Figure 2. Centring of the specimen into the torque meter is necessary for accurate result which each student will individually do.** The following speeds are selected for various intervals of time and the readings of dynamometer. Readings are taken at certain intervals of time using a stopwatch. The angle of twist is measured by torque meter within the elastic limit when angle of twist is small. Before starting we will apply some pre twist to the specimen. Once yield is reached the torque arm is disengaged. For post-elastic deformations, the angles of twist is approximated as the rotation of the crosshead attached to the motor.

All students must do centring individually.

Speed	For interval of time Apprx.	Reading period 5 s for 1 st and 10 s for 2 nd minute, 30s for rest.
$3\frac{1}{3}$ /min	Till yield	1 min
10°/min	2 min	2 min
30°/min	2 min	2 min
90°/min		Till fracture

Observations and calculations:

Diameter of parallel portion $D = (\quad)/3\text{mm} = \quad \text{m}$

Gage length $L = (\quad)/3\text{mm} = \quad \text{m}$

Torque meter gage length = $\quad \text{mm}$

The twist θ obtained from torque-meter and the corresponding reading M_t of the dynamometer at the same instant of the time are presented in Table 1. These are

$\theta(Rad)$	$M_t(kgf.cm)$

So on till fracture

Plot this in Figure 3. A straight line is fitted to the points in the linear range and its slope is determined as

$$\frac{M_t}{\theta} = kgf \cdot \frac{cm}{rad} = N.m/rad$$

In the linear elastic range, for small deformation, the twisting moment M , rate of twist θ/L , shear modulus G and shear stress $\sigma_{x\theta}$ at radius r in a circular cylindrical body subjected to pure end torque are related by

$$\frac{\sigma_{x\theta}}{y} = \frac{M_t}{I_p} = \frac{G\theta}{L}, I_p = \frac{\pi R^4}{2} = \frac{\pi D^4}{32}$$

$$G = \left(\frac{M_t}{\theta}\right) \frac{32L}{\pi D^4} = GPa$$

The speed of the motor, time, θ of crosshead and the dynamometer readings are given in Table 2. The graph of twisting moment M_t (kgf.cm) versus rotation θ (degrees) of the crosshead is given will be drawn by students (Figure 3).

Time	θ	M_t	Time	θ	M_t	Time	θ	M_t

Twisting moment at yield M_{ty} = kgf.cm = N.m

For M_{ty} , $\sigma_{x\theta}$ at R = yield stress τ_y in shear = $\frac{M_{ty}}{I_n} R$

$$\tau_y = \frac{16M_{ty}}{\pi D^3}$$

Ultimate torque M_{tu} from experiment = kgf.cm= N.m.

Fully plastic twisting moment M_{tp} for elastic perfectly plastic material is given by

$$M_{tp} = \int_0^R r \{ \tau_y (2\pi r dr) \} = \frac{2\pi}{3} R^3 \tau_y \quad \text{N.m}$$

$$\frac{M_{tp}}{M_{ty}} =$$

$$\frac{M_{tu}}{M_{ty}} =$$

$$\frac{M_{tu}}{M_{tp}} =$$

$$\text{Modulus of elastic resilience in shear} = \frac{\tau_y^2}{2G} = J/m^3$$

The fracture specimen and the fracture surface are drawn in Figure 4 (will be drawn by students). Mild steel, being ductile, fractures in perpendicular axis since shear stress is maximum on this surface.

Discussion of results and source of error:

Conclusions

Izod and Charpy Impact Test

Objective: To study the toughness or energy absorbing properties of various materials under two types of impact A) Izod and B) Charpy Impact.

Theory and Background:

In quasi static test on materials, wherein the load is so slowly applied, the inertia may be ignored. Under dynamic tests, the rate of application of the load is many orders faster than in the quasi static cases. The behaviour of the material may change substantially under these condition of loading especially in the presence of stress concentration around notches and at low temperature i.e. a ductile material (under static loading) may become brittle.

(A) Impact testing:

The ordinary static testing is not satisfactory when we want to determine the suitability of a material to resist sudden shock or impact. Machines have been designed in which a specimen receives a simple shock and the energy absorbed by specimen is taken as a measure of the resistance of the material to impact, or its dynamic toughness.

A.1 Izod test: Bending of a notched cantilever

The impact machine used in our laboratory has the provision of carrying out all the three impact test by changing the support attachment and striker head. It has swinging pendulum with a fixed weight, with different starting position for the Izod and Charpy test, giving different initial potential energies.

This test uses a 10 mm × 10 mm cantilever test piece of total length 75 mm. A "V" notch is provided at 28 mm from one end, the depth of the notch is 2 mm, its angle is 45° and its root radius is 0.25 mm. The specimen is fixed vertically at the base, the cantilever portion above the notch is 47 mm long. The hammer strikes near the top of the specimen and then moves further, after the fracture of the specimen. The difference of potential energy between the initial and final position of the hammer gives the energy absorbed in the impact. A sliding pointer on the scale records this difference directly.

Energy due to friction:

Student must draw a sketch of the specimen marking L , b , d .

A.2 Charpy test: Bending of a simply supported notched beam

The specimen used for Charpy test, like the Izod test is 5 mm × 10 mm in section and has a 2 mm deep notch with 45° angle and 0.25 mm root radius. The length of the specimen is 55 mm and the notch is at its centre. The beam is supported horizontally by two standard supports and the hammer strikes it from the notch less side. Thus in either case tensile stresses at the notch tends to open and cause failure.

Energy due to friction:

Student must draw a sketch of the specimen marking L , b , d .

Test requirements

1. Temperature is very important factor in the measurement of toughness. Most materials show loss of toughness with fall in room temperature. Reduced temperature in many metals and polymer can lead to increase in yield stress relative to fracture stress in tension such that the metal fractures like a brittle material instead of like a ductile material after significant plastic deformation. There are generally 3 regions. At low temperature the materials give brittle fracture with little change in toughness with temperature. This is low toughness low temperature region. Then there is a transition range with rapid increase in toughness with temperature. The change from ductile yielding to brittle structure can be quite abrupt and is referred to as the ductile – brittle transition temperature. Conduct Charpy test for the same materials at room temperature and after cooling the specimen to 0° C.
2. Brittle fracture and ductile fracture have characteristic appearances, which can be easily recognised.
3. Large-value of stress concentration in marginally ductile material, particularly notch-type concentrations can lead to brittle failure. The high rate of strain can raise yield stress σ_y and the stress concentration can introduce hydrostatic tension, reducing fracture stress σ_f in tension. Both effects promote brittle behaviour, materials which are sensitive to this effect are called notch sensitive.
4. Accuracy of the notch is also an important factor, small changes in the shape, root radius and finish of the notch may create large difference in the test results.
5. Positioning of the specimen in the machine is important but is generally done by template.

Observation and calculations:

	Izod						Charpy		
Initial energy of hammer	17 kgf.m Room Temp.			17 kgf.m Sub Zero			15 J		
Final energy of hammer									
Friction									
Energy absorbed									
Type of fracture									

Material dimensions

L =

b =

d =

Notch position =

Notch angle =

Root radius =

Discussion of result and source of error:

Conclusions:

Buckling test on column

Objective: To obtain buckling load of aluminum rods under axial compressive load for various values of slenderness ratio and compare with theoretical value of Euler's buckling load.

Procedure: A universal testing machine is used to apply the compressive load. Two kinds of support are used. The fixed and condition is simulated by specially prepared supports with large base area and a central machine hole. The end of the circular cylindrical rods is accurately turned to exactly fit these holes without any play thus producing the fixed end conditions of full restraint on transverse displacement and rotation about a transverse axis. For the hinged condition, the specimen ends are rounded and rest in the spherical cavity in the support. The ends are free to rotate in the cavity but the cavity provides a constraint for transverse displacement.

The diameter of the specimens is measured at three sections along its length. The clear intermediate length between two supports is measured. The specimen is mounted between the supports in UTM such that the two ends supports are correctly centered to avoid eccentric loading.

Euler's buckling load P_{cr} is given by

$$P_{cr} = \frac{\pi^2 EI}{l_e^2} = \frac{\pi^2 EA}{(l_e/r)^2}$$
$$\sigma_{cr} = \frac{P_{cr}}{A} = \frac{\pi^2 E}{\left(\frac{l_e}{r}\right)^2}$$

Where $A = \pi R^2$, $I = 2nd\text{moment of area about diametral axis} = \frac{\pi R^4}{4}$ radius of gyration

$$r = \sqrt{\frac{I}{A}} = \frac{R}{2}$$

$l_e = 0.5L$ for fixed supports and $l_e = L$ for hinged supports. L and R the length and radius of column, and l_e is the effective length of pinned-pinned column having the same critical load P_{cr} .

For aluminium specimens used, the experimentally determined values of E and σ_y are $E = 70\text{GPa}$, $\sigma_y = 210\text{MPa}$. Hence the critical value of (l_e/r) for which $\sigma_{cr} = \sigma_y$ is given by

$$\left(\frac{l_e}{r}\right)_c = \left(\frac{\pi^2 E}{\sigma_y}\right)^{\frac{1}{2}} \approx 57$$

The secant formula for eccentrically loaded columns yields

$$\sigma_{max} = \frac{P}{A} \left[1 + \frac{ec}{r^2} \sec \left(\frac{l_e}{2r} \sqrt{\frac{P}{EA}} \right) \right] = \frac{P}{A} \left[1 + \frac{4e}{R} \sec \left(\frac{\pi}{2} \frac{P}{P_{cr}} \right) \right]$$

Letting

$$\sigma_{max} = \sigma_y \text{ we obtain with } P_y = A\sigma_y \text{ as}$$

$$\frac{e}{r} = \frac{1}{4} \left(\frac{P_y}{p} - 1 \right) \cos \left(\frac{\pi}{2} \sqrt{\frac{p}{p_{cr}}} \right)$$

Observations and calculation

Specimen ends condition	Pinned-pinned	Fixed-fixed	Fixed-pinned
Diameter D			
Mean radius R (m)			
Area A (mm ²)			
M.O.I. $I = \frac{\pi r^4}{4} \text{ mm}^4$			
Min. rad. Of gyration r (m)= $R/2$			
Length between supports L (m)			
Effective length l_e (m)			
Slenderness ratio l_e/r			
Euler's buckling load			
Exptl. Buckling load			
P/P_{cr}			
P/P_y			
$\sigma = \frac{P}{A} \text{ MPa}$			
e/R			

$$\sigma_{cr} = \frac{P_{cr}}{A} \text{ MPa}$$

Draw undeformed and deformed specimens.

Draw sketches of specimen (deformed and undeformed) and end supports. Plot graphs of $\sigma \wedge \sigma_{cr}$ versus slenderness ratio (l_e/r).

Discussion of result and Sources of error:

Conclusions:

Hardness test

Objective: To determine the hardness of a given specimen by (A) Brinell and (B) Rockwell hardness testing.

Apparatus:

- A. Brinell hardness testing machine, 5 mm and 10 mm diameter indentors (250 to 3000 kgf).
- B. Rockwell hardness testing machine, hard steel ball indenter (1/16 in.) and diamond cone indenter (120°) (100 and 150 kgf respectively)

Theory and procedure

Hardness of a material of a component had been defined in various ways:

Is the resistance of its surface to plastic deformation, cutting wear, scratching abrasion, indentation or energy absorption under impact? Hardness depends on crystal structure, dislocation, atomic bonds, etc.

Indentation Hardness Test is one of the most frequently used non-destructive tests for quality control or machine parts or structural members to ensure that the specific piece does have the material property used in design. It is a quick inexpensive test and gives information about yield stress. In indentation hardness tests, a pyramid, cone or ball is pressed into a flat surface by gradual application of load to produce a permanent indentation. Restrain of the surrounding unreformed material means that most of the applied load merely developed hydrostatic compressive stress which does not cause the metal to deform plastically. Hardness H measured as mean normal stress on the projected area of the indentation is $>\sigma_y$, for spherical indenter with d and D being the diameters of the indentation and the indenter. The most common indentation hardness tests are:

- A. Brinell test** A 5 mm diameter (D) hardened steel sphere is pressed into a flat surface of a test specimen under load P of 250 to 1000 kgf. Thereafter, a 10 mm diameter (D) hardened steel sphere is pressed into the flat surface of the test specimen under a load P of 1500 to 3000 kgf. The load is removed after application for 30 s and the diameter d of the indentations is measured by a microscope. Brinell hardness number BHN is defined in kgf/mm^2 as force per unit contact surface area A_c as

$$BHN = \frac{P}{A_c} = \frac{2P}{\pi D}$$

where $P = 3000$ kgf and 10 mm steel indenter are used in a standard test. If the material is soft, then the (250 to 3000 kgf) load and diameter D of ball should be adjusted to keep d/D between 0.3 and 0.5. For $BHN > 500$ kgf/mm^2 tungsten carbide ball should be used (not used in the present experiment). Nearest edge of specimen should be at a distance $>2.5d$ and thickness of the specimen be $>5d$ to avoid spurious side and bottom effects. The spherical indenter, unlike conical and pyramidal indenters, does not provide geometrical similitude for indentations of different size d . The BHN of a given material is not constant for all values of d/D due to the varying inclination at the top of a spherical sector.

B. Rockwell test A hard steel spherical ball of diameter 1.58 mm (1/16 in.) and a diamond conical indenter (120° angle) is forced into the surface and the depth of indentation is measured with a dial gage. A minor load is applied to provide a firm contact with the surface and the dial gauge is set to a reference mark. The major (total) load is then applied for 10 s.

Table 1

Scales	Indenter	Minor (preload) kgf	Major (load) kgf	Total (Load)	Relation to Brinell hardness B
R_B	1/16" hard steel	10	100		$R_B \approx 134-6700/BHN$
R_C	120° diamond cone	10	150		$R_C \approx 115-1500/\sqrt{BHN}$

Observation and Calculations

The captioned sketches of the two machines (specimen, indenter, load, table, etc.) are to be drawn by the students (Figure 1)

1. BHN: flat polished specimen.

The diameter d of the indentation for 4 different loads P is tabulated in Table 2(i), 2(ii) and BHN computed by (1): The BHN versus load P is

Table 2(i) Dia of indenter $D = 5$ mm

P kgf	250	500	750	1000
d mm				
BHN kgf/mm ²				
d/D				

Table 2(ii) Dia of indenter $D = 10$ mm

P kgf	1500	2000	2500	3000
d mm				
BHN kgf/mm ²				
d/D				

The BHN vs load P is plotted in Figure 2 (student must bring printout of this plot).

If d/D for $P = 3000$ kgf is in the range 0.3 to 0.5 then $P_1 = 3000$ kgf, else from Table 2 choose a load P_1 for which $d/D \approx 0.4$ and take 3 indentations corresponding to this load.

$$P_1 = \quad \text{kgf} \quad d = (\quad) / 3 = \quad \text{mm}$$

$$BHN \text{ for the material} = \quad \quad \quad (\text{from } P_1 \text{ and } d) = \quad \text{kgf/mm}^2$$

$$\text{Approximately } \sigma_y = 3.1 \frac{P_1}{\left(\frac{\pi d^2}{4}\right)} = \quad \text{kgf/mm}^2$$

2. **Rockwell:** the observation for various specimens are tabulated in Table 3

Table 3

Specimen	Scale	Indenter	Rockwell hardness					Average
			1	2	3	4	5	
1								
2								

Average to be only considered for bulk indentations (away from the boundary).

Discussion and source of error

Conclusions

Hint: Inter-conversion between BHN and R_B . Check standard textbooks.

Stress Analysis by Electrical Resistance Strain Gauge - I

Objective: To determine Young's modulus E and Poisson's ratio ν of the material of a given mild steel strip using resistance type strain gages.

Experimental Setup:

1. A flat test specimen with a set of two active gages fixed on opposite faces in axial (longitudinal) direction away from the ends and two dummy gages fixed on a dummy piece of the same material to form full bridge (I).
2. A set of two active gages fixed on opposite faces in transverse direction away from the ends of the specimen and two dummy gages fixed on a dummy piece of the same material to form full bridge (II).
3. The specimen is loaded using a tensometer.
4. Two strain meters are used to measure micro strain.
5. Use 20 kN load cell for load measurement (load unit in kg).

Procedure:

1. Sketch the specimen indicating the location and orientation of gages.
2. Draw bridge arrangement I and II for measurement of axial and transverse strains ϵ_a , ϵ_t .
3. Measure thickness t and width w of the specimen.
4. Record gauge length and gauge factor of strain gages and accordingly set the gauge factor.
5. Check before test zero load balance the bridge I and II in strain meter.
6. Gradually load the specimen and take readings of $2\epsilon_a$ and $2\epsilon_t$ from the bridges for a set of 8 loads P read from the load cell (load display unit). Only take the upper readings.
7. Plot P versus $2\epsilon_a$ fit straight lines through them. Find the slopes S_1 and S_2 of these lines.
8. Compute $E = \sigma_a/\epsilon_a = [P/(wt)]/\epsilon_a = 2S_1/(wt)$ and $\nu = -\epsilon_t/\epsilon_a = S_2$

Observation

Table for load and micro strain

Sr. No.	Load (kg)	Axial Strain	Transverse Strain
	0		
1.	50		
2.	100		
3.	150		
4.	200		
5.	250		
6.	300		
7.	350		
8.	400		

Dimension:

1. Width of the mild steel strip = 32.4 mm
2. Thickness of the mild steel strip = 4.1 mm
3. Gauge length of strain gauge = 3 mm
4. Gauge factor of strain gauge = 2.1

Discussion and sources of error:

Draw the graph as in point 7 of the procedure

Conclusions:

Stress Analysis by Electrical Resistance Strain Gauge - II

Objective:

A right angle bent cantilever of annular cross section is loaded at the end. The objective is to determine

- a) Maximum shearing strain due to twisting moment alone, and
- b) Maximum axial strain due to bending moment at a given cross-section.

Experimental Setup:

1. A bent hollow circular cantilever pipe with loading arrangement near the free end.
2. Full Bridge I (4 active strain gages) formed by gauge no. 1,2,3, 4 applied at 45-degree angle to axis at the ends of horizontal diameter of pipe.
3. A half bridge II (2 active strain gauges) formed by gauge no. 5 and 6 applied longitudinally at the ends of vertical diameter of pipe.
4. Two strain meters are used to measure micro strains. (shearing strain and bending strain)
5. Use 8×500 gram dead weight for load.

Procedure:

1. **Sketch the specimen indicating the location and orientation of gages.**
2. Draw bridge arrangement I and II for measurement of shearing strain and bending strains.
3. Record gauge length and gauge factor of strain gages and accordingly set the gauge factor.
4. Check before test zero load balance the bridge I and II in strain meter.
5. Gradually load the specimen and take readings of Shearing and bending from the bridges I and II.
6. **Draw the stress-strain graph of shearing strain and bending strain.**

Observation:

Sr. No.	Load (kg)	Shear Strain	Bending Strain
A	0		
B	0.X		

Table for load and micro strain

Sr. No.	Additional Load (kg)	Shear Strain	Bending Strain
1.	0.5		
2	1.0		
3	1.5		
4	2.0		

5	2.5		
6	3.0		
7	3.5		
8.	4.0		

Dimension:

1. Radius outer (R_o)= 13.50 mm
2. Radius inner (R_i) = 11.50 mm
3. C = 25.50 cm
4. B = 29.50 cm
5. A = 11.00 cm
6. Gauge length of strain gauge = 5 mm
7. Gauge factor of strain gauge = 2.1

Discussion and sources of error:

Draw the graph as in point 6 of the procedure

Conclusions:

