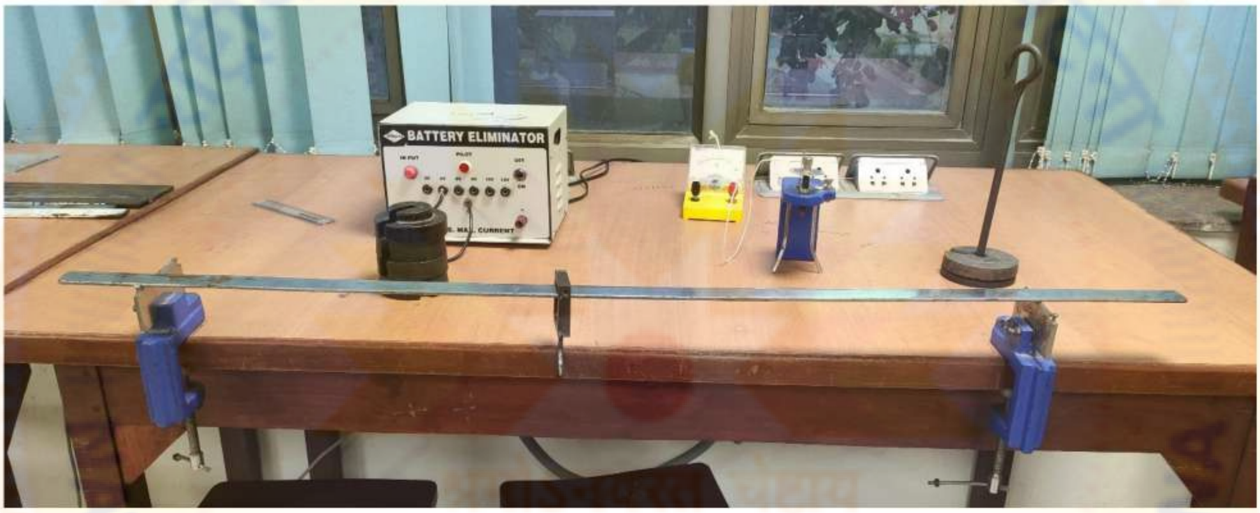
LABORATORY MANUAL FOR DETERMINATION OF YOUNG MODULUS OF RECTANGULAR BEAM



EXPERIMENT

AIM

To determine the Young's modulus of a rectangular beam by bending beam method.

APPARATUS

1. Metallic Beam
2. Knife Edge – 02
3. Voltmeter
4. Spherometer
5. Hanger with weight
6. Slide Caliper

THEORY

A metallic beam length L is kept on two knife edges 'A' and 'B' and loaded at the mid-point with a load $\boldsymbol{W}$, let '$\boldsymbol{\delta}$' be the depression at the mid-point, then the Young's modulus of elasticity of the material of the beam is:

$$Y = \frac{WL^3}{48(\delta)I_g} \text{-------------------} (1)$$

Where I_g = Geometrical moment of Inertia of the beam.
In case of rectangular beam, the moment of inertia is given by

$$I_g = \frac{b\,d^3}{12} \text{------------------------}(2)$$

Where, $\boldsymbol{b}$ = breadth and $\boldsymbol{d}$ = depth or thickness of the beam

Combining equation (1) and (2)
We get:

$$\boxed{\therefore Y = \frac{WL^3}{4(\delta)b\,d^3} = \frac{mgL^3}{4(\delta)b\,d^3}}$$

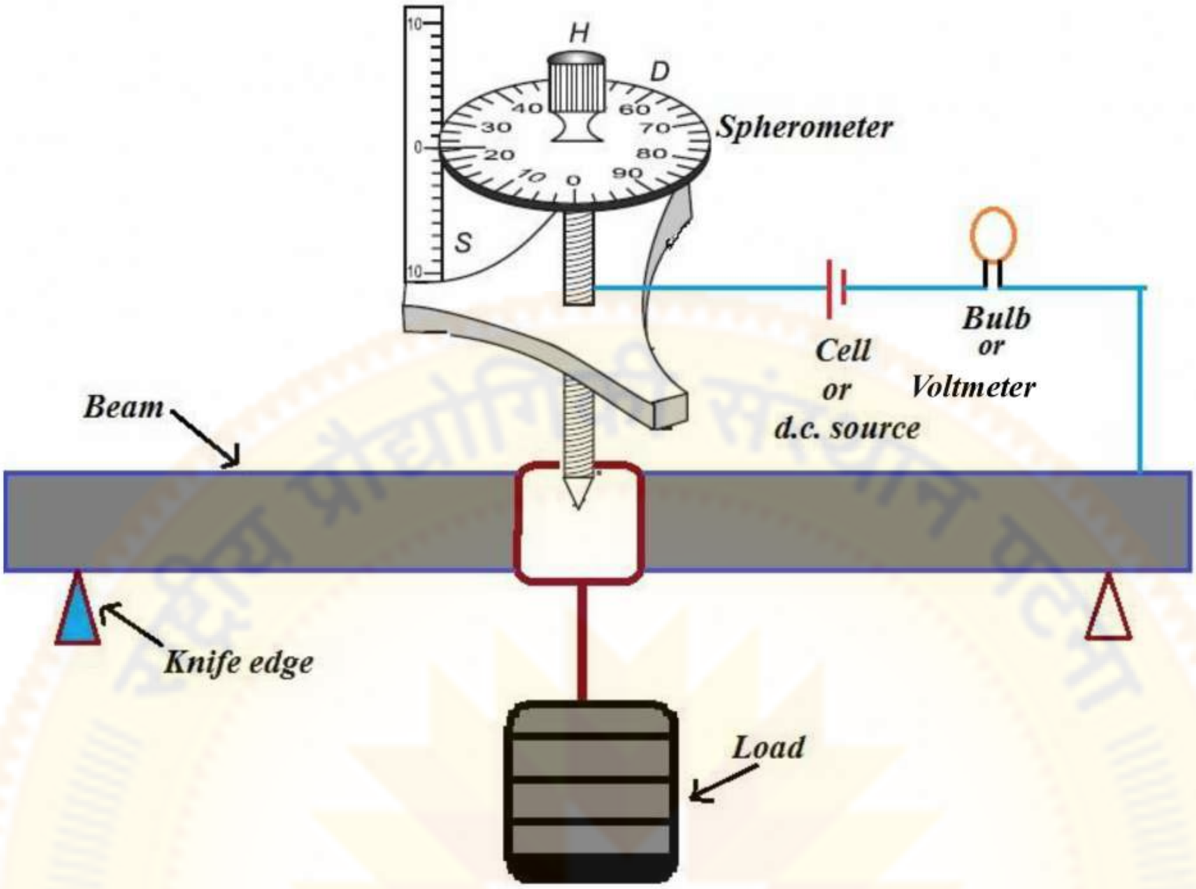


Fig. Arrangements of the apparatus for determination of depression of the beam.

PROCEDURE

1. Two knife edges are fixed along the length of the working table. The two knife-edges are fixed at a known distance (80, 90 cm) and they must be kept parallel to each other and perpendicular to the edge of the table.

2. The mid- point of the two knife edges is located and the hanger is hanged from the mid-point.

3. Pitch and least- count of the spherometer is calculated.

4. First of all, the tip of the screw of spherometer is brought in contact with the pointer attached with the hanging arrangement.

5. Initial disc reading of the spherometer is taken and a known weight is added to the hanger. Then the depression at the mid-point is measured by nothing and final disc reading of the spherometer.

6. The reading is repeated with different loads and in each case the depression at mid-point is calculated.

7. 'b' and 'd' of the beam is measured with the help of slide calipers.

8. A graph is plotted between load and depression at mid-point. From the graph the final value of Young's modulus is calculated

9. Measurement of 'b' and 'd'

10. Calculate least count of slide calipers.

OBSERVATIONS

Length is measured by the meter scale.
Least count of the scale = 1mm
Length of the rectangular bar (L)=..... m

[A] Table for determination of breadth of the rectangular bar ($\boldsymbol{b}$)

- Instrument used: Vernier Calliper
- Least count (L.C) of the instrument: 0.01 cm (show calculation for determining L.C)

No. of obs.	Main Scale Reading (MSR) (cm)	Ver. Reading (VSR)	b Total Reading (MSR+VSR×L.C) (cm)	Mean breadth (b) (cm)
1. 2. 3.				

[B] Table for determination of breadth of the rectangular bar ($\boldsymbol{d}$)

- Instrument used: Vernier Calliper
- Least count (L.C) of the instrument: 0.01 cm (show calculation for determining L.C)

No. of obs.	Main Scale Reading (MSR) (cm)	Ver. Reading (VSR)	d Total Reading (MSR+VSR×L.C) (cm)	Mean depth (d) (cm)
1. 2. 3.				

[C] Table for determination of depression of the rectangular bar (δ)

- Instrument used: Spherometer
- Pitch of the Spherometer: ....
- Least count (L.C) of the instrument: 0.01 mm (show calculation for determining L.C)

Table [C-1] FOR LOAD INCREASING

No. of obs.	Load (kg)	No. of rotation x pitch = (A)	Initial Disc Reading (I)	Final Disc Reading (F)	Diff. (I-F)	Diff. X L.C. (B) (mm)	Depression (A+B) (mm)	Cumulative Depression (δ) (mm)
	0.5						.... (δ_1)	(δ_1)
	1.0						.... (δ_2)	($\delta_1 + \delta_2$)
	1.5						.... (δ_3)	($\delta_1 + \delta_2 + \delta_3$)
	2.0						.... (δ_4)	($\delta_1 + \ldots + \delta_4$)
	2.5						.... (δ_5)	($\delta_1 + \ldots + \delta_5$)

Table [C-2] FOR LOAD DECREASING

No. of obs.	Load (kg)	No. of rotation x pitch = (A)	Initial Disc Reading (I)	Final Disc Reading (F)	Diff. (I-F)	Diff. X L.C. (B) (mm)	Depression (A+B) (mm)	Cumulative Depression (δ) (mm)
	2.5						.... (δ_5)	($\delta_1 + \cdots + \delta_5$)
	2.0						.... (δ_4)	($\delta_1 + \ldots + \delta_4$)
	1.5						.... (δ_3)	($\delta_1 + \delta_2 + \delta_3$)
	1.0						.... (δ_2)	($\delta_1 + \delta_2$)
	0.5						.... (δ_1)	(δ_1)

Table [C-3] for mean depression for each load and calculation of Young's Modulus

L=...., b=...., d=....

$$Y = \frac{mgL^3}{4(\delta)b\,d^3}$$

Load (Kg)	Cumulative Depression for load increasing	Cumulative Depression for load decreasing	Mean Depression (δ_{mean})	Y ($\times 10^{11}$) N/m^2
0.5				
1.0				
1.5				
2.0				
2.5				

CALCULATIONS

Show calculation of Y for each load.

Calculate the average value of Young's modulus.

CALCULATIONS OF YOUNG'S MODULUS FROM GRAPH

Plot a graph between load along X-axis and corresponding mean depression along Y-axis. From the slope of the graph find the value of

- Slope $= \frac{\delta}{m}$; $Y = \frac{mgL^3}{4(\delta)b\,d^3}$

  $\therefore Y = \frac{gL^3}{4b\,d^3} \times \frac{1}{slope}$

ERROR CALCULATIONS

- $Y = \frac{mgL^3}{4(\delta)b\,d^3}$

- **For maximum Error in Y:**

  $$\therefore \frac{\Delta Y}{Y} = \frac{\Delta m}{m} + \frac{\Delta g}{g} + 3\frac{\Delta L}{L} + \frac{\Delta b}{b} + 3\frac{\Delta d}{d} + \frac{\Delta \delta}{\delta}$$

  Δm *and* Δg $=$ *zero, as these are not measured*

  $$\therefore \frac{\Delta Y}{Y} = 3\frac{\Delta L}{L} + \frac{\Delta b}{b} + 3\frac{\Delta d}{d} + \frac{\Delta \delta}{\delta}$$

  Find ΔY.

RESULT

$\therefore Young's\ modulus\ of\ the\ rectangular\ bar\ is\ \boldsymbol{Y_f = Y \pm \Delta Y}$ **N/m²**

PRECAUTIONS

1. Care must be taken to see that the beam does not slip on the knife-edges. A little wax may be used to prevent slipping.
2. The C.G. of the beam must be midway between the knife-edges and weight-hanger must be placed at this point.
3. Excessive load must not be put on the beam.