Figure 2.1 Young’s modulus- Uniform bending

Figure 2.2 Model Graph
AIM
To find the Young’s modulus of the given material of the beam by uniform bending.

GENERAL OBJECTIVE
To evaluate the elastic behavior of the given wooden beam by pin and microscope experimental method and to find its Young’s modulus

SPECIFIC OBJECTIVES
1. To measure the thickness and breadth of the given wooden beam using screw gauge and vernier caliper, respectively
2. To determine the elevation of the given wooden beam loaded on both ends by uniform bending method
3. To find the slope from the graph drawn between the load versus elevation
4. To calculate the Young’s modulus of the wooden beam from the mean elevation and slope obtained from table and graph, respectively
5. To analyze the elastic behavior of the given wooden beam from the results obtained

APPARATUS REQUIRED
- Wooden beam
- Weight hanger with slotted weights
- Knife edges
- Travelling microscope
- Vernier caliper
- Screw gauge
- Metre scale
LEAST COUNT FOR SCREW GAUGE

Least Count (LC) = \( \frac{\text{Pitch}}{\text{Number of head scale divisions}} \)

\[
\text{Pitch} = \frac{\text{Distance moved}}{\text{Number of rotations given}} = \frac{5 \text{ mm}}{5} = 1 \text{ mm}
\]

\[
\text{LC} = \frac{1 \text{ mm}}{100} = 0.01 \text{ mm}
\]

TABLE – I

*To determine the thickness \((d)\) of the beam using screw gauge*

Zero Error (ZE) : ………… divisions

Zero Correction (ZC) : …………mm

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Pitch Scale Reading PSR (10^{-3} \text{ m})</th>
<th>Head Scale Coincidence HSC divisions</th>
<th>Observed Reading OR = PSR + (HSC (\times) LC) ((10^{-3} \text{ m}))</th>
<th>Correct Reading CR = OR (\pm)ZC ((10^{-3} \text{ m}))</th>
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</thead>
<tbody>
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</table>

Mean \((d)\) = ………… \(\times10^{-3} \text{ m}\)
FORMULA

Young’s modulus of the material of the beam

\[ Y = \frac{3MgaL^2}{2sbd^3} \quad \text{(N/m}^2\text{)} \]

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Explanation</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y</td>
<td>Young’s modulus of the material of the beam</td>
<td>N/m(^2)</td>
</tr>
<tr>
<td>M</td>
<td>Load applied</td>
<td>kg</td>
</tr>
<tr>
<td>L</td>
<td>Distance between the knife edges</td>
<td>m</td>
</tr>
<tr>
<td>a</td>
<td>Distance between the load and the nearest knife edge</td>
<td>m</td>
</tr>
<tr>
<td>g</td>
<td>Acceleration due to gravity</td>
<td>m /s(^2)</td>
</tr>
<tr>
<td>b</td>
<td>Breadth of the beam</td>
<td>m</td>
</tr>
<tr>
<td>d</td>
<td>Thickness of the beam</td>
<td>m</td>
</tr>
<tr>
<td>s</td>
<td>Elevation produced for ‘M’ kg load</td>
<td>m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unit</th>
<th>Equivalent Units</th>
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</thead>
<tbody>
<tr>
<td>N/m(^2)</td>
<td>kg m(^{-1}) s(^{-2})</td>
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</tbody>
</table>

PREREQUISITE KNOWLEDGE

1. Elastic materials

   Materials which can completely regain their original condition of shape and size on removal of deforming forces are said to be elastic

2. Plastic materials

   Materials which retain the deformed nature even after the removal of deforming forces are said to be plastic

3. Hooke’s law

   Within the elastic limit, the stress is directly proportional to the strain
LEAST COUNT FOR VERNIER CALIPER

Least Count (LC) = Value of 1 Main Scale Division (MSD)/ Number of divisions in the vernier

10 MSD = 1 cm
Value of 1 MSD = 1/10 cm = 0.1 cm
Number of divisions in the vernier = 10
LC = 0.1/10 = 0.01 cm

TABLE - II

To determine the breadth (b) of the beam using vernier caliper

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Main Scale Reading MSR (10^-2 m)</th>
<th>Vernier Scale Coincidence VSC (divisions)</th>
<th>Observed Reading OR = MSR + (VSC x LC) (10^-2 m)</th>
<th>Correct Reading CR = OR ± ZC (10^-2 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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Mean (b) = ........... x 10^-2 m
PROCEDURE

1. The given beam is supported on two knife edges separated by a distance ‘L’. A pin is fixed vertically at the mid-point.
2. Two weight hangers are suspended, one each on either side of the knife edges so that their distances from the nearer knife edge are equal. The beam is brought to the elastic mood by loading and unloading it several times.
3. With the dead load ‘W’, the pin is focused through microscope. The microscope is adjusted so that the horizontal crosswire coincides with the tip of the pin. The microscope reading is taken.
4. The load is changed in steps of 0.05 kg and in each case the microscope reading is taken during loading and unloading. The readings are tabulated. The elevation at the mid-point for ‘M’ kg is calculated.
5. The distance between the knife edges (L) is measured using a metre scale. The breadth (b) and thickness (d) of the beam are found using vernier caliper and screw gauge, respectively.
LEAST COUNT FOR TRAVELLING MICROSCOPE

Least Count (LC) = Value of 1 Main Scale Division (MSD)/ Number of divisions in the vernier

20 MSD = 1 cm
Value of 1 MSD = 1/20cm = 0.05 cm
Number of divisions in the vernier = 50
LC = 0.05/50= 0.001 cm

TABLE -III

To find elevation‘s’

<table>
<thead>
<tr>
<th>Load M (10^3 kg)</th>
<th>Microscope reading</th>
<th>Mean (10^-2 m)</th>
<th>Elevation ‘s’ for M kg (10^-2 m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Loading</td>
<td>Unloading</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MSR (10^-2 m)</td>
<td>VSC (div)</td>
<td>TR (10^-2 m)</td>
</tr>
<tr>
<td>W</td>
<td>MSR (10^-2 m)</td>
<td>VSC (div)</td>
<td>TR (10^-2 m)</td>
</tr>
<tr>
<td>W + 50</td>
<td>MSR (10^-2 m)</td>
<td>VSC (div)</td>
<td>TR (10^-2 m)</td>
</tr>
<tr>
<td>W + 100</td>
<td>MSR (10^-2 m)</td>
<td>VSC (div)</td>
<td>TR (10^-2 m)</td>
</tr>
<tr>
<td>W + 150</td>
<td>MSR (10^-2 m)</td>
<td>VSC (div)</td>
<td>TR (10^-2 m)</td>
</tr>
<tr>
<td>W+ 200</td>
<td>MSR (10^-2 m)</td>
<td>VSC (div)</td>
<td>TR (10^-2 m)</td>
</tr>
</tbody>
</table>

Mean (s) = ........ × 10^-2 m

*Note: Total Reading (TR) = Main Scale Reading (MSR) + (VSC × LC)
RESULT
The Young’s modulus of the material of the given beam \( Y = \ldots \times 10^{10} \text{ N/m}^2 \)

APPLICATIONS
AFM probe, wings of air craft, helicopter rotator, marine fittings, designing of bridges, bicycle frames and wind mill turbine blades

VIVA VOCE QUESTIONS
1. What is the effect of temperature on elastic modulii?

2. Which dimension among breadth, thickness and length has significant role in Young’s modulus? Why?

3. How do you ensure in your experiment that the elastic limit is not exceeded?

4. What kind of elasticity is observed in (a) suspension bridge (b) an automobile tyre?

STIMULATING QUESTIONS
1. Bridges are declared as unsafe after long use. Reason out.

2. Which one is more elastic, foam or steel? Justify your answer.
OBSERVATION

Mass for the elevation $M = \ldots \times 10^{-3}$ kg
Distance between two knife edges $L = \ldots \times 10^{-2}$ m
Acceleration due to gravity $g = \ldots$ m/s$^2$
Breadth of the beam $b = \ldots \times 10^{-2}$ m
Thickness of the beam $d = \ldots \times 10^{-3}$ m
Elevation produced for ‘M’ kg of load $s = \ldots \times 10^{-2}$ m
Distance between one of the knife edges and the adjacent weight hanger $a = \ldots \times 10^{-2}$ m

CALCULATION

Young’s modulus of the material of the beam

$Y = \frac{3MgaL^2}{2sbd^3}$ (N/m$^2$)