

## Experiment 3

### Bending test – tensile strength

#### Objective:

1. To investigate the relationship between load, span, width, height and deflection of a beam, placed on two bear affected by a concentrated load at the center.
2. To ascertain the coefficient of elasticity for steel, brass, aluminum and wood.

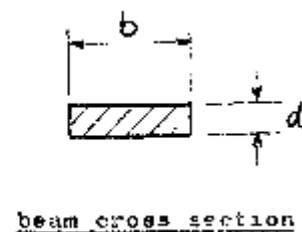
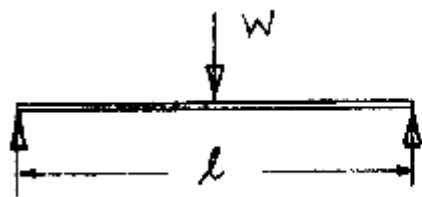
#### Theory

The stress-strain behavior of brittle materials (e.g. ceramic, low toughness composite material) is not usually ascertained by tensile tests as outline in Exp. 1. A more suitable transverse bending test is most frequently employed, in which a rod specimen either a circular or rectangular cross section is bent until fracture using a three- or four-point loading technique. The assessments are conducted according to ASTM Standard C 1161, "Standard Test Method for Flexural Strength of Advanced Ceramics at Ambient Temperature."

In this module, the apparatus has been design to enable students to carry out experiments on simply supported and cantilever beams in order to investigate:-

- (a) the relationship between the deflections and the applied loads
- (b) the effect of variations in 1 length and cross sectional i.e. deflection per unit load.

#### Simply supported beam with central point load



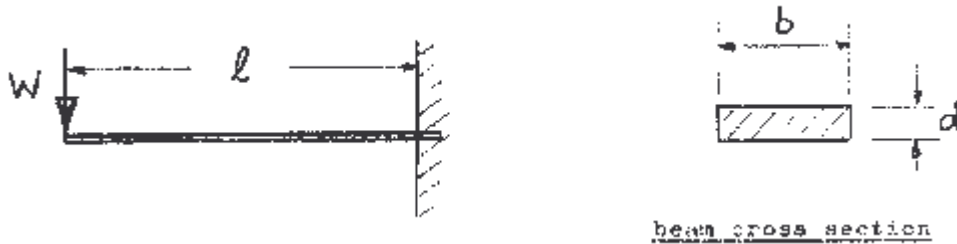
For this arrangement, it can be shown that the deflection under the load i.e. maximum deflection

$$\Delta = \frac{Wl^3}{48EI}$$

where  $I = \frac{bd^3}{12}$

$\therefore$  beam compliance  $\frac{\Delta}{W} = \frac{l^3}{4Ebd^3}$

### Cantilever beam with end point load



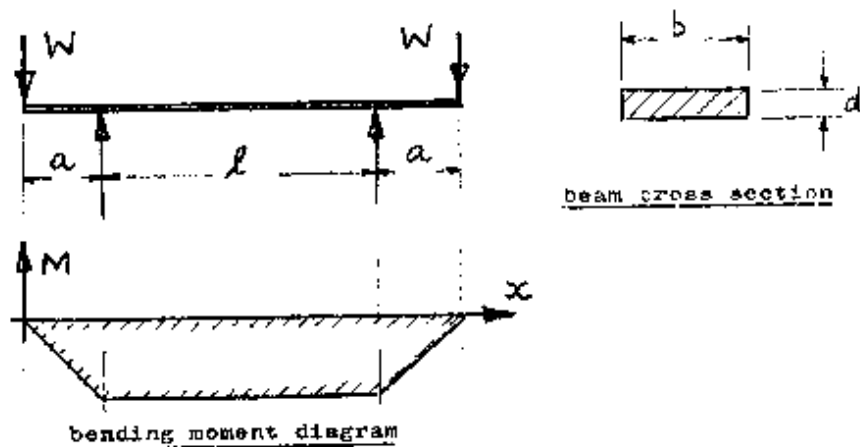
For this arrangement, it can be shown that the central deflection relative to the supports, i.e. maximum deflection between the supports:-

$$\Delta = \frac{Wl^3}{3EI}$$

where  $I = \frac{bd^3}{12}$

$\therefore$  beam compliance  $\frac{\Delta}{W} = \frac{4l^3}{Ebd^3}$

### Simply supported beam subjected to uniform bending moment



For this arrangement, it can be shown that the central deflection relative to the supports, i.e. maximum deflection between the supports:-

$$\Delta = \frac{Wal^2}{8EI}$$

$$\text{where } I = \frac{bd^3}{12}$$

$$\therefore \text{beam compliance } \frac{\Delta}{W} = \frac{3al^2}{2Ebd^3}$$

### **Set of Apparatus:**

Twist and Bend Test Machine MT 210.

### **Procedure:**

**Task 1:** To investigate the relationship between load, span, width, height and deflection of a beam, placed on two bear affected by a concentrated load at the center.



### **A: Investigate the relationship between load and deflection**

1. Set the bearers so that a span of 600 mm. is obtained. The interval between each groove on the shafts of the apparatus is 100 mm.
2. Place a test specimen with dimensions of 6 x 25 mm. on the bearers and mount the load device in the center of test specimen.
3. Set the testing device so that the top of the gauge is centered on the upper plane of the load device. Lower the gauge so that its small hand is at about 10 and set the gauge to zero by twisting its outer ring. Load with weights as shown in the table below and read off the deflection. One revolution of the large hand of the gauge corresponds to 1 mm. of deflection.

Load (N)	Deflection (mm)
5	
10	
15	
20	

4. Draw a graph of deflection vs. loading.

**B: Investigate relationship between span and deflection**

1. Employ a test specimen with dimensions of 6x25 mm and load with weight 10 N. Vary the span as indicated in the table and read off the deflection.

Span (mm)	Deflection (mm)
300	
400	
500	
600	

2. Draw a graph of deflection vs. span.

**C: Investigate the relationship between width and deflection of the test specimen.**

1. Set the bearers for a span of 500 mm. Employ the test specimens indicated in the table below, load with weight 5 N and read off the deflection.

Test Specimen Dimensions (mm)	Deflection (mm)
4 x 15	
4 x 20	
4 x 25	
4 x 30	

2. Draw a graph of width of the deflection vs. test specimen.

**D: Investigate the relationship between the height and deflection of the test specimen.**

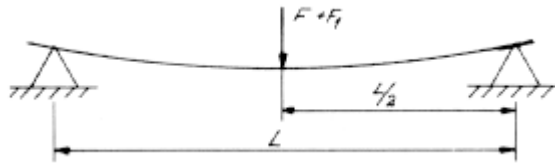
1. Set the bearers for a span of 500 mm. Employ the test specimens indicated in the table below, load with weight 5 N and read off the deflection.

Test Specimen Dimensions (mm)	Deflection (mm)
3 x 25	
4 x 25	
6 x 25	
8 x 25	

2. Draw a graph of height of the deflection vs. test specimen.

**Task 2: To ascertain the coefficient of elasticity for steel, brass, aluminum and wood.**

**E: Determine the coefficient of elasticity for steel, brass, aluminum and wood.**



Calculations:

Deflection formula for the load given above:

$$\delta = \frac{FL^3}{48EI} \qquad E = \frac{FL^3}{48I\delta}$$

A determination of the flexural stress yields:

$$\sigma_b = \frac{M_b}{W_b} \qquad M_b = (F + F_1) \frac{L}{4}$$

When rectangular it is:

$$I = \frac{bh^3}{12} \quad \text{and} \quad W_b = \frac{bh^2}{6}$$

When circular it is :

$$I = \frac{\pi d^4}{64} \quad \text{and} \quad W_b = \frac{\pi d^3}{32}$$

Where:

$\delta$ =	Deflection (mm.)	$E$ =	Coefficient of Elasticity
$L$ =	Span(mm.)	$I$ =	Inertia Factor
$M_b$ =	Moment of Flexure (Nmm)	$F_1$ =	Load occasioned by weight of Load Device (N)
$W_b$ =	Resistance to Flexure (mm <sup>3</sup> )	$F$ =	Load occasioned by additional weight (N)
$\sigma_b$ =	Flexural Stress (N/mm <sup>2</sup> )		

The span is set at 500 mm., and a circular test specimen of steel is employed. Mount load device and set the testing device. Load with weights as shown in Table below and read off the deflection. The test is repeated with test specimens of brass, aluminum and wood.

Calculate the coefficient of elasticity and flexural stress.

When  $E$  is calculated, the initial load caused by the load device has no significance since the gauge has been set at zero with the device in place. However, when calculating flexural stress,  $F_1$  is included.

Material	Load F (N)	Moment of Flexure $M_b$ (Nmm)	Flexural Stress	Deflection	Coefficient of Elasticity	
			$\sigma_b$ (N/mm <sup>2</sup> )	$\delta$ (mm)	E (N/mm <sup>2</sup> )	$E_{ave}$ (N/mm <sup>2</sup> )
Steel	5					
	10					
	15					
Brass	5					
	10					
	15					
Aluminum	5					
	10					
	15					
Wood	5					
	10					
	15					

**Questions:**

- Q. 1: Discuss the relationship observed for a, b, c & d and
- Q. 2: Compare the Coefficient of Elasticity obtained with the theoretical value for steel, brass, aluminum & wood. Discuss the result.
- Q. 3: Give two reasons why the tensile properties of most brittle materials are accessed by transverse bending tests and not ascertain by tensile tests.