**OLABISI ONABANJO UNIVERSITY**

College of Engineering & Environmental Studies,

Faculty of Engineering

Ibogun Campus.

**MECHANICAL ENGINEERING DEPARTMENT**



**STRENGTH OF MATERIALS**

**LABORATORY MANUAL**

**MEG 204**

**200 LEVEL**

**NAMES…………………………………………………………………………………..**

**MATRIC. NO. :……………………………… LEVEL: ………………………………**

**DEPT.: ………………………………………. GROUP NO: …………………………**

**COURSE:……………………………………. CODE: ………………………………..**

**DATE:…………………SESSION:………………SIGNATURE…………………….**

**EXPERIMENT -1**

**TITLE: DEFLECTION OF BEAMS EXPERIMENT**

1. **Introduction**

A beam design is not complete until the amount of deflections has been determined for the specified load.

Failure to control the beam deflection within proper limits in building constructions is frequently reflected by the cracks development in plastered walls and ceilings. Beam in many machines must deflect, just like the right amount for gears and other part to make proper contacts. In innumerable instance, the requirements for a beam involved a given load carrying capacity with a specified maximum deflection. The deflection of a beam depends upon the stiffness of the materials and the dimensions of the beam as well as upon the applied loads and supports.

The deformation of a beam is most easily expressed in terms of deflection of the beam from its original unloaded position. The deflection is measured from the original neutral surface of the deformed beam the configuration assumed by the deformed neutral surface is known as the elastic curve of the beam. Figure 1 represents the beam in its original state and figure 2 represents the beam in the deformed configuration it has assumed under the action of the load. The displacement Y is defined as the deflection of the beam, usually it will be necessary to determine the deflection Y on every value of X along the beam. This relation may be written in the form of an equation, which is frequently called the equation of the deflection curve (or elastic curve) of the beam.

The knowledge of beam deflection is essential to the designer; for example, in many building codes, the maximum allowance deflection of a beam is known to exceed 1/3000 of the length of the beam. Components of aircraft are usually designed so that deflections do not exceed some pre assigned value, or else the aerodynamic characteristics may be altered.

For common method for calculating beam deflection for fibred stressed are available. They are:

1. The double integration method.
2. The area-moment method.
3. The super position method, and
4. An energy method.

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Figure 1.1: Simply supported Beam Figure 1.2: Beam Deflection

* 1. **OBJECTIVES**

**The objectives of this experiment are:**

1. Determine the deflection of beam under the action of a concentrated load.
2. Determine the value of young’s modulus, E of the beam
3. Compare the experimental results of the deflection with the theoretical values.
4. Determine the value of young Modulus E, from a vibration cantilever.

**1.20 THEORY 1**

The differential equation of the deflection curve of the bent beam is given by

Where E = Young’s Modulus of elasticity of the beam.

I = second moment of area of the beam cross section about the neutral axis.

M = the bending moment at a distance X from one end of the beam

Y = the deflection of the beam.

**1.21 THEORY II**

Theoretical investigation shows that the full relationship between the periodic time, to the vibrating length L and the mass M attached to the free end of a cantilever is given by,

Where b = breath of the beam

d = thickness of the beam

**1.22 PROCEDURE**

Put a load of mass 1000g on the load hanger placed at the midpoint of the beam. Read and record the deflection of the beam on the dial gauge mounted at the point of loading. Repeat the procedure for a load of mass.

M = 2, 4, 6 …………………….. Up to 10kg.

Tabulate your results.

Note: record your readings on the table below and request that the laboratory instructor in charge endorses it, without which your readings and reports are invalid.

**RESULTS AND CALCULATION**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S/N | MASS M (KG) | DISTANCE  value x (cm) | DEFLECTION  value y (mm) |  |
|  |  |  |  |  |
|  |  |  |  |  |

Length of the beam (rod) = mm

Beam breath = mm

Beam thickness = mm

EXERCISES:

(1) Plot a graph of deflection(y) against the load (w).

(2) Determine the slope of your graph.

Use your slope to determine the value of young’s modulus E

(3) Plot a graph of deflection of the load (w) against deflection (y).

(4) Determine the slope of your graph.

(5) Compare your slope with 1(b) above.

(6) Determine the beam deflection when you apply the load of

(i) 6.5kg (ii) 10.5kg (iii) 12.5kg (iv) 15.0kg (v) 19kg

(7) A beam 6m long, simply supported at its end, is carrying a part load of 50kN at its centre. The moment of inertia of the beam (i.e. I) is given as equal to 78 X 104 mm4. If E for the material of the beam is 2.1 X 105 N/mm2.

Calculate: Deflection at the centre of the beam, and Slope at the support.

(8) Define: (i) stiffness of a steel, (ii) Resilience of steel.

EXPERIMENT -2

**TITLE: BEAM DEFLECTION TEST ON MID STEEL**

**OBJECTIVE:**

To determine the extreme fibre stresses, deflection and modulus of elasticity, E of the material in flexure with a central point loading on simply supported beam.

**Apparatus**: Beam deflection apparatus, square or rectangular section beam, dial test indicator with support stand, steel-rule and micro-meter.

Diagram:

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**L**

Figure 2.1: Simply Supported Beam

**PROCEDURE:**

(i) The cross section of the beam is measured using micro meter and steel rule. (ii) Simply support the beam over a suitable span and position the dial test indicator.

(iii) Apply a point load of 10N to the beam at its midpoint and record the deflection as given by the dial test indicator.

(iv) The experiment is repeated four more times, by increasing the load by (20N, 30N, 40N and 50N) and the deflection are recorded.

**THEORY**:

The bending moment equation is expressed as:

Where, M = Maximum Bending Moment (N/m2)

E = Maximum fibre stress (N/m2)

ԑ = Modulus of Elasticity (N/m2)

For bending Moment of a beam:

F = 2nd moment of area of section m4

The maximum slope of the beam,

The maximum deflection, =

For a simply supported beam with a point central load.

**Table 2.1: RESULT**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S/N | Load | Deflection | Fibre stress | Resisting moment |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**Exercises**

1. Plot the graph of load against deflection.
2. Calculate the fibre stress and resisting moment.
3. Calculate the slope and use the slope to get modulus of elasticity.
4. Give reason why the beam was bent.
5. Does the material obey Hooke’s law?
6. Suggest precautions for this experiment.

**EXPERIMENT – 3**

**TITLE: COMPRESSION AND EXTENSION OF SPRINGS**

**OBJECTIVES:-** To determine

1. The relationship between load and deflection
2. The relationship between load and compression
3. The modulus of Rigidity (G) for the spring materials.

**THEORY**

**L**

**5**

**6**

**7**

**8**

Figure 3.1: Diagram of spring with load

Consider the closely coiled helical spring which is made of a wire coiled in the form of a helix intended for tensile or compressive load as shown in the diagram. Stresses are set up due to the bending and direct shear, most importantly the torsion.

For a steadily applied load,

Work done (w.d) = Force (p) x distance (D)

= Average load x Deformation

Torque (T) = force (p) X Radius (d/2)

The tension theory equation is

Total active length of the wire

L = Length of one coil x No of active coils = 𝝅D x n

N = No of active coil

θ = Angular deflection of the wire when acted upon by the torque T.

Axial deflection of the spring:

From the tension theory:

Where J = Polar moment of inertia of the spring wire =

D = diameter of the spring wire

G = Modulus of Rigidity of the material of spring wire

θ =

Substitute for the value of θ,

**PROCEDURE**

Fix the specified spring into the anger of apparatus. Check the free movement of the spring by applying the load.

Attach the load and read the value of the vertical position of the vertical position of the Vernier rule Xo as a datum (Reference).

Increase the load steadily by 2 kg, record new value of Vernier reading.

Determine the deflection(s) obtained.

Repeat with 2kg increment up to 10kg

Measure (i) The spring coil diameter (D)

(ii) The wire diameter (d)

(iii) The number of the free turns (N)

Results and calculations =……mm

Initial Vernier value (Xo) Lθ = .….mm

Coil diameter (d) = …..mm

Wire diameter (d) = ……mm

No of free turn (N) or active coil (n) = 32

Modulus of Rigidity (G) = 80KN/mm2

Table 3.1: Results for extension

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S/N | Mass (kg) | Force P (N) | Vernier reading L (x) (mm) | Extension (e) (mm) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

Table 3.2: Results for compression

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| S/N | Mass (kg) | Force P (N) | Vernier reading L (x) (mm) | Deflection (e) (mm) |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

**EXERCISES:** The following exercises are for both tables.

1 (a) Plot a graph of force (p) against extension (e)

(b) Determine the slope of the graph and calculate the Modulus of rigidity (G).

2 (a) Plot a graph of mass (m) against deflection (e)

(b) Determine the slope of the graph

3 (a) Compare the value obtained from G in 1 (b) above with the value obtained from any other reference.

(b) Comment on any discrepancy and suggest the reason.

4. A solid steel shaft has to transmit 75k W at 200rpm. Taking allowable shear stress as 70N/mm2 Find the suitable diameter for the shaft, if the maximum torque transmitted at each revolution exceed the mean by 30%.

5. A close coiled helical spring of 10cm mean diameter is made up of 1cm diameter rod and has 20 turns. The spring carries an axial load of 200N. determine the shearing stress. Taking the value of Modulus of rigidity as 8.4 X 104 N/mm2. Determine the deflection when carrying this load. Also, calculate the stiffness of the spring and the frequency of free vibration for a mass hanging from it.

**EXPERIMENT -4**

**Title:**Torsion

**Objectives:** To observe the relationship between torque and angular deflection of a specimen subject to torsional loading and to determine the modulus of rigidity of the shaft material.

**Apparatus**: Torsion apparatus, specimen, micrometer screw gauge or vernier

caliper, meter rule, hanger and masses.

**Procedure:**

1. The specimen is set by introducing it through the hole on the fixed end of the apparatus and pushing it further into the other at the moving end and screwed tight using the provided grub screw.
2. The deflection gauge is at position which is about three – quarter of the length of the specimen measured from the fixed end.
3. The effective length of the specimen is measured.
4. A suitable load is applied e.g. 1kg to the hanger and the deflection on the deflection gauge is noted.
5. The load is increased by 1kg up to the minimum available size (depending on the strength of the shaft) each time recording the corresponding total value of θ.
6. The result gotten is tabulated as follows:

Effective length of shaft L,

Diameter of shaft D,

Radius of torsion pulley ‘a’.

Table 4.1: Table of results

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | Deflection gauge | | Dial gauge | |  |
| S/N | Load mass (m/kg) | Torque T/Mga/N | Angular Deflection е (Degree) | Angular Deflection in Radian | Angular Deflection е in degree | Angular Deflection in Radian | Mean (Radian) |
| 1  2  3  4  5 |  |  |  |  |  |  |  |

**EXERCISES**

1. Derive the appropriate equation of torsion of circular shaft for data analysis.
2. Plot graphs for torque T vertically against deflection O and obtain the slopes
3. Calculate the modulus of rigidity of the specimen
4. Comment on the accuracy of measurements and calculations.
5. Comment on the values of modulus of rigidity of the specimen.
6. Suggest precautions you will take if you were to perform the experiment.

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