NRI INSTITUTE OF INFORMATION SCIENCE & TECHNOLOGY BHOPAL

DEPARTMENT OF CIVIL ENGINEERING

LAB MANUAL

STRUCTURAL ANALYSIS-I LAB

NIIST BHOPAL		NRI INSTITUTE OF INFORMATION SCIENCE & TECHNOLOGY DEPARTMENT : CIVIL ENGINEERING	FORM NO	NIIST/A/10
BRANCH	CIVIL	**LIST OF EXPERIMENTS**	REV. NO	0
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SUBJECT / CODE: STRUCTURAL ANALYSIS- I / CE403

SNO	LIST OF EXPERIMENTS
1	To verify Maxwell- Bett's Law.
2	To determine the flexural rigidity of the beam and verify it theoretically
3	To determine the deflection of a pin jointed truss and to verify the results theoretically and graphically.
4	To verify strain in an externally loaded beam with the help of a strain gauge indicator and to verify theoretically
5	To study behaviour of different types of columns and find Euler's buckling load for each case
6	To study two hinged arch for the horizontal displacement of the roller end for a given system of loading and to compare the same with those obtained analytically.
7	To study the behaviour of a portal frame under different end conditions.
8	To find the value of flexural rigidity (EI) for a given beam and compare it with theoretical value
9	To determine the deflection of a pin connected truss analytically &graphically and verify the same experimentally
10	To verify the Muller Breslau theorem by using Begg's deformator set

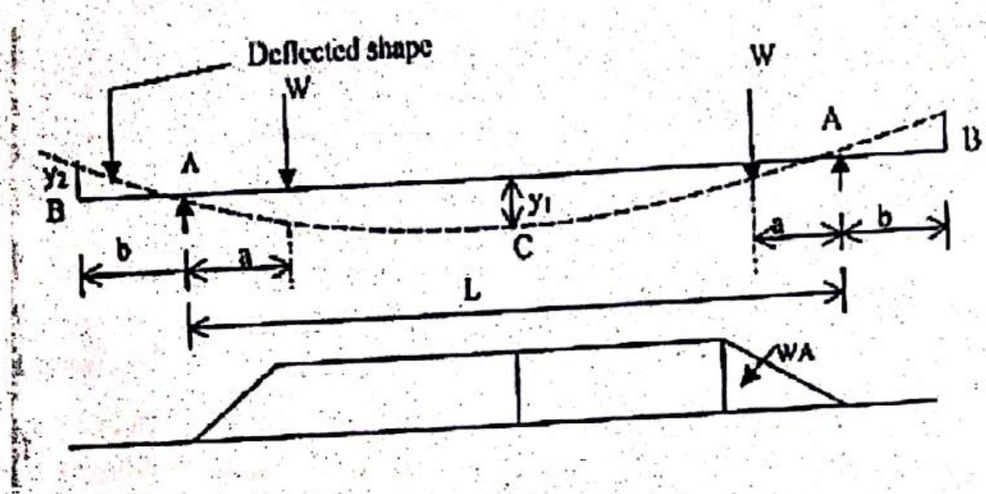
STRUCTURAL ANALYSIS -I

LO	LAB OUTCOMES
LO1	Knowledge of flexural property of materials ,deflection of beams and column,
LO2	Study of load, strain , stress, and buckling
LO3	Study of arch, portal frames, flexural rigidity,
LO4	Deformation of structures under various loads

Experiment no.1

Aim: - To verify the moment area theorem regarding the slopes and deflections of the beam.

Apparatus: - Moment of area theorem apparatus.



Theory : -

According to moment area theorem

1. The change of slope of the tangents of the elastic curve between any two points of the deflected beam is equal to the area of M/EI diagram between these two points.
2. The deflection of any point relative to tangent at any other point is equal to the moment of the area of the M/EI diagram between the two point at which the deflection is required.

Slope at B= Y2 / b

Since the tangent at C is horizontal due to symmetry,

Slope at B= shaded area / EI = 1 / EI [Wa2 / 2 + WA (L/2 – a)] Displacement at B with respect to tangent at C = (y1 + y2) = Moment of shaded area about B / EI

= 1 / EI [Wa2 / 2 (b+2/3a) + Wa(L/2 –a)(b+ a/2+L/2)]

Procedure: -

1. Measure a, b and L of the beam
2. Place the hangers at equal distance from the supports A and load them with equal loads.
3. Measure the deflection by dial gauges at the end B (y2) and at the center C (y1)
4. Repeat the above steps for different loads.

Observation Table:-

Length of main span, L (cm) = Length of overhang on each side, a (cm) = Modulus of el

Sl . No.	Load at each Hanger (kg)	Central Deflection Y1 (cm)	Deflection at Free end y2 (cm)	Slope at B Y2 / b	Deflection at C= Deflection at B (y1)

Calculation:-

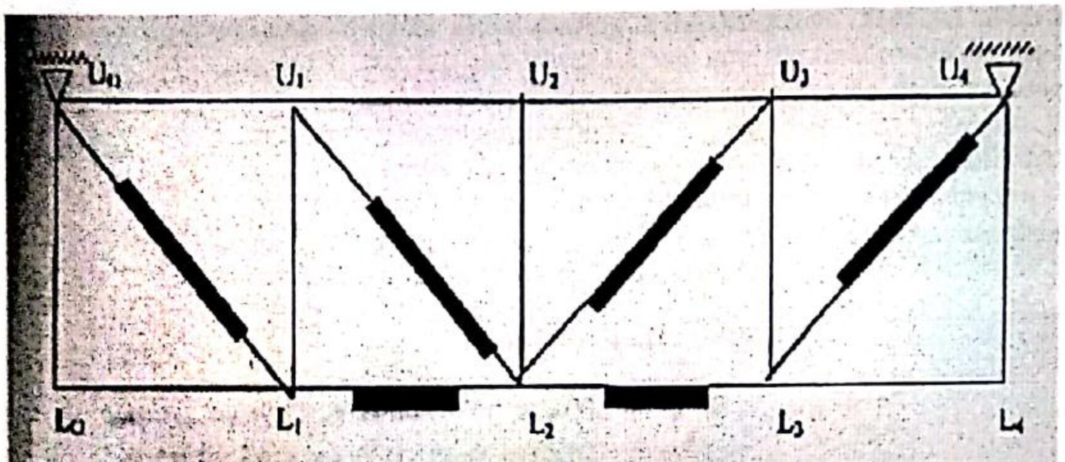
1. Calculate the slope at B as y2 / b (measured value).
2. Compute slope and deflection at B theoretically from B.M.D. and compare with experimental values.
3. Deflection at C = y1(measured value).
4. Deflection at C = Average calculated value

Result :- The slope and deflection obtained is close to the slope and deflection obtained by suing moment area method.

EXPERIMENT NO.2

Aim : - To determine the deflection of a pin connected truss analytically & graphically and verify the same experimentally.

Apparatus: - Truss Apparatus, Weight's, Hanger, Dial Gauge, Scale, Verniar caliper.



Truss Model

Theory :-The deflection of a node of a truss under a given loading is determined by: 0 = (TUL/AE)

Where, 0 = deflection at the node point.

T = Force in any member under the given loading.

U = Force in any member under a unit load applied at the point where the deflection is required. The unit load acts when the loading on the truss have been removed and acts in the same direction in which the deflection is required.

L = Length of any member.

A = Cross sectional area of any member.

E = Young's modulus of elasticity of the material of the member.

Here, (L/AE) is the property of the member, which is equal to its extension per unit load. It may be determined for each member separately by suspending a load from it and noting the extension.

Procedure: -

(1) Detach each spring from the member. Plot extension against load by suspending load from the spring and nothing the extension. From the graph, obtain the extension per unit load (stiffness).
(2) For initial position of the truss, load each node with 0.5 kg load to activate each member. Now place the dial gauges in position for measuring the deflections and note down the initial reading in the dial gauge .Also put additional load of 1kg, at L1, 2kg, L2, and 1kg at L3, and note the final reading in the dial gauges. The difference between the two readings will give the desired deflection at the nodal points. Central deflection y.
(3) Calculate the deflection for the three nodes L1, L2, and L3 from the formula given in Eq. (1) and compare the same with the experimental values obtained in step 3.
(4) Draw the Willot – Mohr diagram for deflection and compare the deflection so obtained experimentally and analytically.

Observation Table:-

Experimental Deflection Values

S.No.	Node Deflection	L1	L2	L3
1	Initial dial gauge reading (mm)			
2	Additional loads (kgs)			
3	Final dial gauge Reading (mm)			
4	Deflection (3) – (1) (mm)			

Sample Calculation: - Member =

L/AE = ...

Analytical deflection:= FUL/AE

Result :-The theoretical and experimental deflection in various members is found same.

EXPERIMENT NO.3

Aim: - To verify clerk Maxwell's reciprocal theorem

Apparatus: - Clerk Maxwell's Reciprocal Theorem apparatus, Weight's, Hanger, Dial Gauge, Scale, Verniar caliper.

Theory : -

Maxwell theorem in its simplest form states that deflection of any point A of any elastic structure due to load P at any point B is same as the deflection of beam due to same load applied at A

It is, therefore easily derived that the deflection curve for a point in a structure is the same as the deflected curve of the structure when unit load is applied at the point for which the influence curve was obtained.

Procedure: -

i) Apply a load either at the centre of the simply supported span or at the free end of the beam, the deflected form can be obtained.

ii) Measure the height of the beam at certain distance by means of a dial gauge before and after loading and determine the deflection before and after at each point separately.

iii) Now move a load along the beam at certain distance and for each positions of the load, the deflection of the point was noted where the load was applied in step 1 .This deflection should be measured at each such point before and after the loading, separately.

iv) Plot the graph between deflection as ordinate and position of point on abssica the plot for graph drawn in step2 and 3 .These are the influence line ordinates for deflection of the beam.

Observation Table:-

Distance from the pinned end	Load at central point/ cantilever end		Deflection of various points (mm) 2-3	Load moving along beam		Deflection of various points (mm) 5-6
	Beam unloaded Dial gauge reading (mm)2	Beam loaded Dial gauge reading (mm)3	Beam unloaded Dial gauge reading (mm)5	Beam unloaded Dial gauge reading (mm)5	Beam loaded Dial gauge reading (mm)6	

Result : - The Maxwell reciprocal theorem is verified experimentally and analytically.

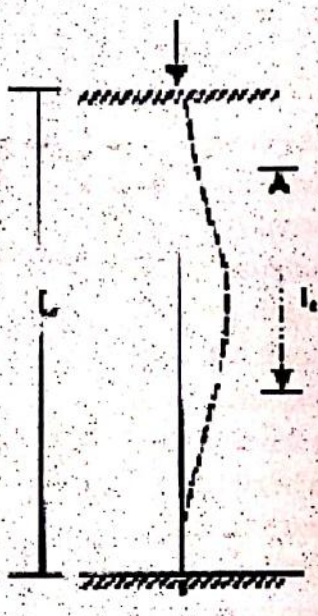
Precaution: - i) Apply the loads without anyjerk.

ii) Perform the experiment at a location, which is away from any
iii) Avoid external disturbance.
v) Ensure that the supports are rigid.

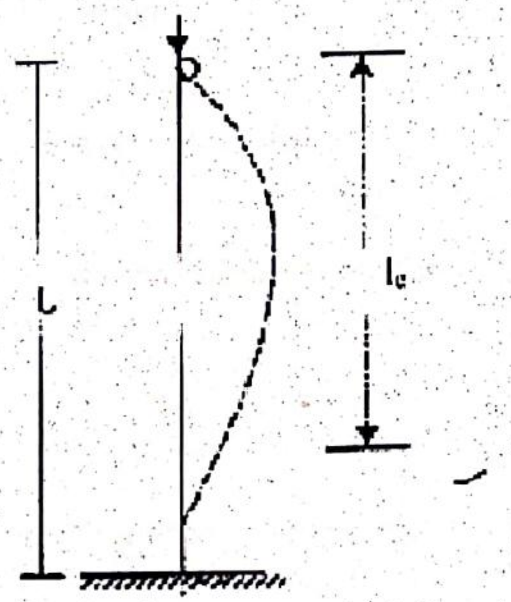
EXPERIMENT NO. 4

Aim: To study the behavior of struts and column with various end conditions.

Apparatus: model of struts and columns.

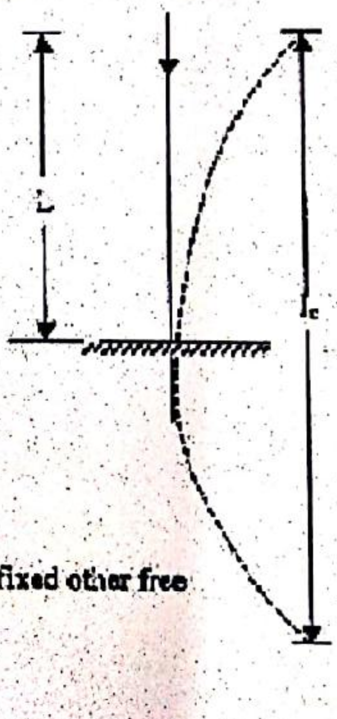


(i) Both ends fixed



(ii) One end fixed other pinned

(iii) Both ends pinned



(iv) One end fixed other free

Theory:

Struts – a bar or a member of a structure in any position other than vertical, subjected to an axial compressive load is called a strut.

Column – a bar or a member of a structure inclined at 90^0 to the horizontal and carrying an axial compressive load is called a column.

Procedure:

End condition – a loaded column and struts can have only one of the following four end condition -:

(a) Both end hinged or pin jointed –
In this case the end of the column cannot have any lateral displacement but can take slope when the column buckle on loading as shown in figure..

(b) Both end fixed –
In this case both ends are rigidly fixed. The end cannot have any lateral displacement and also cannot take slope as shown in figure..

(c) On end fixed and other hinged-
In this case one end of the column and struts is hinged and the other end is fixed. The fixed end can neither more laterally nor it take any slope but the hinged end can take slope when the column is loaded as shown in figure..

(d) One end fixed and other free-
In this case one end is secured both in position and direction and the other end is free to take any position and slope as shown in figure..

EXPERIMENT NO.5

Aim: To find out the elastic properties of a beam.

Apparatus: - Strain gauge Indicator, weights, hanger, scale, verniar caliper.

Formula: - $f = \frac{M y}{I}$

Theory : - When a beam is loaded with some external loading, moment & shear force are set up at each strain. The bending moment at a section tends to deflect the beam & internal stresses tend to resist its bending. This internal resistance is known as bending stresses.

Following are the assumptions in theory of simple bending.

1. The material of beam is perfectly homogeneous and isotropic (i.e. have same elastic properties in all directions.)
2. The beam material is stressed to its elastic limits and thus follows Hook's law.
3. The transverse section which are plane before bending remains plane after bending also.
4. The value of young's modulus of elasticity 'E' is same in tension and compression.

The bending stress at any section can be obtained by

beam equation. $f = (M/I)\, y$

Where, M= moment at considered section.

f = extreme fiber stresses at considered section.

I = Moment of inertia at that section.

y= Extreme fiber distance from neutral axis.

f_{max} = maximum stress at the farthest fiber i.e. at ymax from neutral axis.

Digital strain indicator is used to measure the strain in static condition. It incorporates basic bridge balancing network, internal dummy arms, an amplifier and a digital display to indicate strain value.

Strain can be calculated analytically at the section by using Hook's law. Distrainindicator is used to measure the extreme fiber at particular section. It basically incorporates basic bridge balancing network, internal dummy arms, amplifier & digital display to indicate strain value.

Two -Arm Bridge requires two strain gauge and will display the strain value two times of actual. Four -Arm Bridge requires four strain gauge and will display the strain value four times of actual.

Procedure: -

i) Mount the beam with hanger, at the desired position and strain gauges, over it supports properly and connect the strain gauges to the digital indicator as per the circuit diagram.

ii) Connect the digital indicator to 230(+/- 10%) colts 50 Hz single phase A.C. power supply and switch 'ON' the apparatus.
iii) Select the two/four arm bridge as required and balance the bridge to display a '000' reading.
iv) Push the 'GF READ' switch and adjust the gauge factor to that of the strain gauge used (generally 2.00)
v) Apply load on the hanger increasingly and note the corresponding strain value.

Observation: - 1) Width of the beam model, B (cm) =

2) Depth of the beam model, D (cm) =
3) Span of the beam, L (cm) =
4) Moment of inertia of beam, I =
$Y_{max} = D/2$ =

5) Modulus of elasticity of beam material, E =

Observation Table:-

S.No	Load applied on the hanger P (kg)	Moment at the mid span section (kg cm) = PL/4	$f_{max} = (M/I)\ Y_{max}$	Theoretical Strain $\emptyset$ = f max	Observed strain on the display
1					
2					
3					
4					
5					

Sample Calculation: - For reading No. ....

Load applied on the hanger P (kg)

Moment at the mid span section (kg

cm) = PL/4 $f_{max=}{}^{(M/I)}Y_{max}$

Theoretical Strain Ø

= f max E Observed

strain on the display

Result : - From observation table, it is seen that, the theoretical and observed value of strain is same.