

Department of
Civil Engineering

LAB MANUAL
Structural Analysis-1 LAB

B.Tech– IV Semester



KCT College OF ENGG AND TECH.

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1	To Study behavior of column and struts with different end conditions.
2	Experiment of two hinge arch
3	To determine the flexural rigidity of a given beam
4	To determine the deflection of a pin connected truss analytically & graphically and verify the same experimentally.
5	To verify clerk Maxwell's reciprocal theorem

EXPERIMENT NO. 1

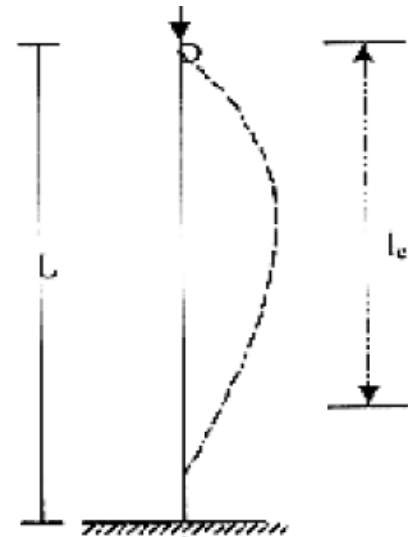
Aim: - To study behavior of different types of columns and find Euler's buckling load for each case.

Apparatus: - Column Buckling Apparatus, Weights, Hanger, Dial Gauge, Scale, Vernier caliper.

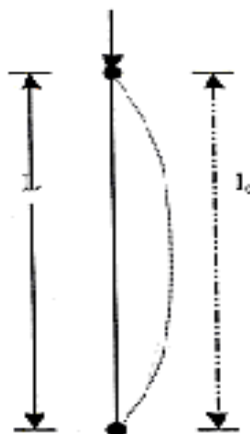
Diagram:-



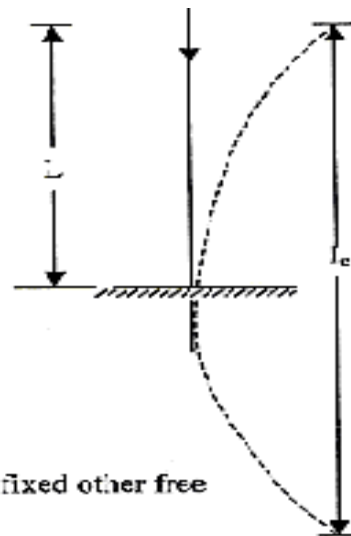
(i) Both ends fixed



(ii) One end fixed other pinned



(iii) Both ends pinned



(iv) One end fixed other free

Theory :-If compressive load is applied on a column, the member may fail either by crushing or by buckling depending on its material, cross section and length. If member is considerably long in comparison to its lateral dimensions it will fail by buckling. If a member shows signs of buckling the member leads to failure with small increase in load. The load at which the member just buckles is called as crushing load. The buckling load, as given by Euler, can be found by using following expression.

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$$P = \pi^2 EI$$

$$l_e^2$$

Where,

E = Modulus of Elasticity

= 2×10^5 N/mm² for steel

I = Least moment of inertia of column section

Le = Effective length of column

Depending on support conditions, four cases may arise. The effective length for each of which are given as:

1. Both ends are fixed $l_e = L/2$
2. One end is fixed and other is pinned $l_e = L/\sqrt{2}$
3. Both ends are pinned $l_e = L$
4. One end is fixed and other is free $l_e = 2L$

Procedure: -

- i) Pin a graph paper on the wooden board behind the column.
- ii) Apply the load at the top of columns increasing gradually. At certain stage of loading the columns shows abnormal deflections and gives the buckling load.
- iii) Note the buckling load for each of the four columns.
- iv) Trace the deflected shapes of the columns over the paper. Mark the points of change of curvature of the curves and measure the effective or equivalent length for each case separately.
- v) Calculate the theoretical effective lengths and thus buckling loads by the expressions given above and compare them with the observed values.

Observation: -

- 1) Width of strip (mm) b =
- 2) Thickness of strip (mm) t =
- 3) Length of strip (mm) L =
- 4) Least moment of inertia

$$I = bt^3$$

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Observation Table:-

Sr. No	End condition	Euler's Buckling load		Effective Length (mm)	
		Theoretical	Observed	Theoretical	Observed
1	Both ends fixed				
2	One end fixed and other pinned				
3	Both ends pinned				
4	One end fixed and other free.				

Sample Calculation: - End condition: Both ends fixed

$$\text{Euler's buckling load.} = P = \frac{\pi^2 EI}{l_e^2}$$

Effective Length (mm) = .

Result :-The theoretical and experimental Euler's buckling load for each case is found nearly same.

EXPERIMENT NO. 2

Aim: - 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.

Apparatus: - Two Hinged Arch Apparatus, Weight's, Hanger, Dial Gauge, Scale, Verniar Caliper.

Formula: - $H = \frac{5WL}{8r} (a - 2a^3 + a^4)$

8r

Where,

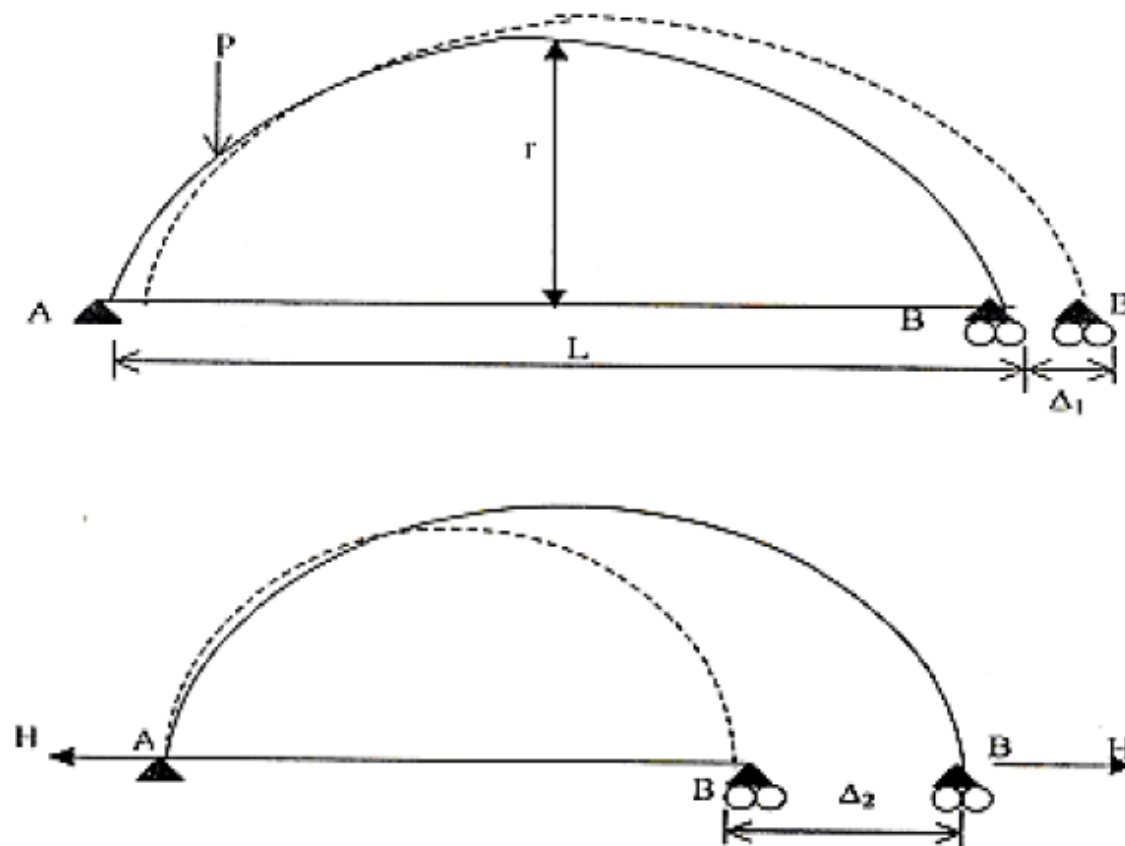
W= Weight applied at end support.

L= Span of two hinged arch.

r= rise of two hinged arch.

a = dial gauge reading.

Diagram:-



Theory :-The two hinged arch is a statically indeterminate structure of the first degree. The horizontal thrust is the redundant reaction and is obtained by the use of strain energy methods. Two hinged arch is made determinate by treating it as a simply supported curved beam and horizontal thrust as a redundant reaction. The arch spreads out under external load. Horizontal thrust is the redundant reaction is obtained by the use of strain energy method.

Procedure: -

- i) Fix the dial gauge to measure the movement of the roller end of the model and keep the lever out of contact.
- ii) Place a load of 0.5kg on the central hanger of the arch to remove any slackness and taking this as the initial position, set the reading on the dial gauge to zero. Structural Analysis Laboratory
- iii) Now add 1 kg weights to the hanger and tabulated the horizontal movement of the roller end with increase in the load in steps of 1 kg. Take the reading up to 5 kg load. Dial gauge reading should be noted at the time of unloading also.
- iv) Plot a graph between the load and displacement (Theoretical and Experimental) compare. Theoretical values should be computed by using horizontal displacement formula.
- v) Now move the lever in contact with 200gm hanger on ratio 4/1 position with a 1kg load on the first hanger. Set the initial reading of the dial gauge to zero.
- vi) Place additional 5 kg load on the first hanger without shock and observe the dial gauge reading.
- vii) Restore the dial gauge reading to zero by adding loads to the lever hanger, say the load is w kg.
- viii) The experimental values of the influence line ordinate at the first hanger position shall be $4w$
- ix) Repeat the steps 5 to 8 for all other hanger loading positions and tabulate. Plot the influence line ordinates.
- x) Compare the experimental values with those obtained theoretically by using equation. (5).

Observation Table:-

Table: - 1
Horizontal displacement

Sr.No.	Central load (kg)	0.0	1.0	2.0	3.0	4.0	5.0	6.0
	Observed horizontal Displacement (mm)							
	Calculated horizontal Displacement Eq. (4)							

Sample Calculation: - Central load (kg) =.....

Observed horizontal Displacement (mm). =

Calculated horizontal Displacement = $H = \frac{5WL}{8r} (a - 2a^3 + a^4)$

8r

=.....

Result :-The observed and horizontal displacement is nearly same.

Precaution : - Apply the loads without jerk.

: - Perform the experiment away from vibration and other disturbances.

EXPERIMENT NO. 3

Aim: - To find the value of flexural rigidity (EI) for a given beam and compare it with theoretical value.

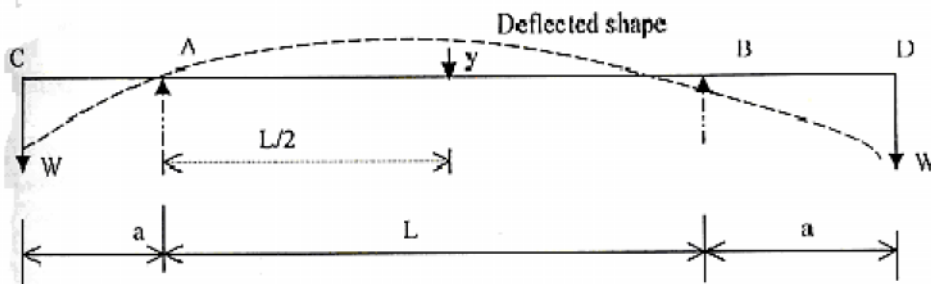
Apparatus: - Elastic Properties of deflected beam, weight's, hanger, dial gauge, scale, and Verniar caliper.

Formula: - (1) Central upward deflection, $y = w.a.L^2 / 8y$ (1)

(2): $EI = w.a. L^2 / 8y$ (2)

(3) Also it is known that EI for beam = $E \times bd^3 / 12$ (3)

Diagram:-



Theory :-For the beam with two equal overhangs and subjected to two concentrated loads W each at free ends, maximum deflection y at the centre is given by central upward deflection.

Central upward deflection, $y = w.a.L^2 / 8EI$

Where,

a = length of overhang on each side

W = load applied at the free ends

L = main span

E = modulus of elasticity of the material of the beam

I = moment of inertia of cross section of the beam

$EI = w.a. L^2 / 8y$

It is known that, EI for beam = $E \times bd^3 / 12$

Where, b = width of beam

d = depth of beam

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Procedure: -

- i) Find b and d of the beam and calculate the theoretical value of EI by Eq. (3).
- ii) Measure the main span and overhang span of the beam with a scale.
- iii) By applying equal loads at the free end of the overhang beam, find the central deflection y .
- iv) Repeat the above steps for different loads.

Observation: - 1) Length of main span, L (cm) =

2) Length of overhang on each side, a (cm) =

3) Width of beam, b (cm) =

4) Depth of beam, d (cm) =

5) Modulus of elasticity, E (kg/cm^2) = 2×10^6

Observation Table:-

Sr. No.	Equal loads at the two ends (kg)	Dial gauge reading at the midspan of beam (cm)	EI from Eq. (3)	EI from Eq (2)

Calculation: - Average values of EI from observation =cm⁴

Average values of EI from calculation =cm⁴

Result :-Flexural rigidity (EI) is found same theoretically and experimentally.

Precaution : - Measure the center deflection y very accurately.

Ensure that the beam is devoid of initial curvature.

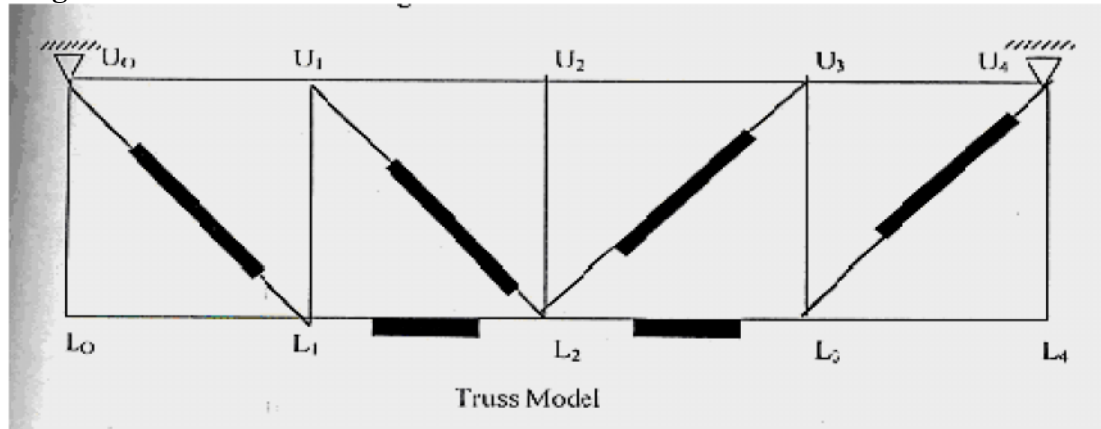
Loading should be within the elastic limit of the materials

EXPERIMENT NO. 4

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.

Diagram:-



Theory :-The deflection of a node of a truss under a given loading is determined by:

$$\delta = \Sigma (TUL/AE)$$

Where, δ = 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: -

i) Detach each spring from the member. Plot extension against load by suspending load from the spring and noting the extension. From the graph, obtain the extension per unit load (stiffness).

ii) 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 gauges.

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iii) 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.

iv) 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.

v) 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 =.....

$L/AE = \dots\dots\dots$

Analytical deflection:= FUL/AE

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

Precaution : - i) Apply the loads without any jerk.

ii) Measure the deflection to the nearest of a millimeter.

iii) Perform the experiment at a location, which is away from any

iv) external disturbance.

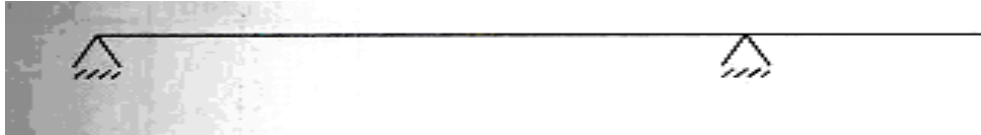
v) Ensure that the supports are rigid.

EXPERIMENT NO. 5

Aim: - To verify Clerk Maxwell's reciprocal theorem

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

Diagram:-



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 step1. 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 abscissa the plot for graph drawn in step2 and 3. These are the influence line ordinates for deflection of the beam.

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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 any jerk.

ii) Perform the experiment at a location, which is away from any

iii) Avoid external disturbance.

v) Ensure that the supports are rigid.