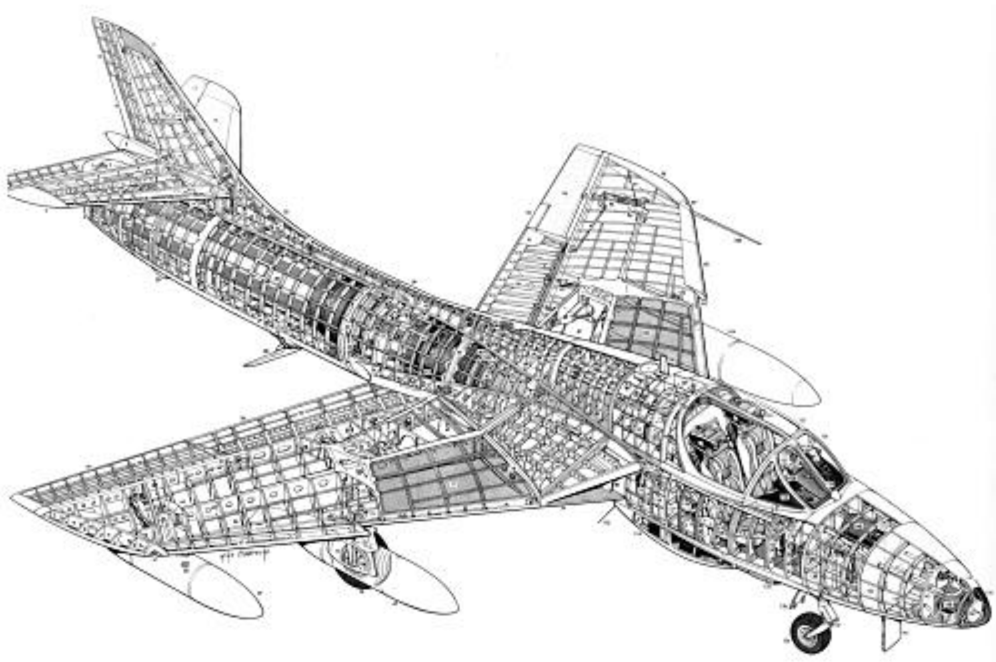
AE 2305 AIRCRAFT STRUCTURES LAB-II

R- 2008

RAJALAKSHMI ENGINEERING COLLEGE

THANDALAM

DEPARTMENT OF AERONAUTICAL ENGINEERING



LAB MANUAL

HOD/AERO
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LAB IN-CHARGE
(Mr.S.Aravindan)

LIST OF EXPERIMENTS

1. Determination of principal plane of an Unsymmetrical beam
2. Determination of Shear centre of channel section
3. Calibration of Photo- elastic materials
4. Determination of principal stress using plariscope
5. Determination of principal stress – Combined loading
6. Constant strength beam
7. Shear Centre of a closed section
8. Vibrations of beams
9. Wagner beam

EXP.NO:1 DETERMINATION OF PRINCIPAL PLANE OF AN UNSYMMETRICAL BEAM

AIM:

To determine the principal plane of the unsymmetrical Z-section beam and verify the result graphically.

APPARATUS REQUIRED:

1. Z-section beam set-up
2. Vernier caliper
3. Dial gauge
4. Weights

FORMULA USED:

EXPERIMENTAL:

$$1.\tan\theta_a = \frac{F_y}{F_x}$$

$$2.\tan\theta_b = \frac{d_y}{d_x}$$

Where,

1. θ_a - The angle of the plane of loading
2. θ_b - The angle of plane of Displacement
3. F_x - Force applied in x Direction
4. F_y - Force applied in y Direction
5. d_y - Displacement in y Direction
6. d_x - Displacement in x Direction

PROCEDURE:

1. Measure the length, breadth, thickness of the given unsymmetrical section and calculate the values of Ixx, Iyy and Ixy.

2. Draw the Mohr's circle for the given Ixx, Iyy and Ixy. Calculate the value of Φ from Mohr's circle.

3. In the given section, hang two weights Fy and Fx. Fix two dial gauges to measure vertical deflection in the top of the web at the extreme of the flange and to measure horizontal deflection in the middle of the web.

4. Keeping values of Fy constant and varying values of Fx, note values of dy and dx.From these values , calculate values of θ_A and θ_B

5. Plot the graph θ_A (y-axis) and θ_B (x-axis).Calculate the value of Φ from the graph.

6. Find the error percentage.

TABULATION:

S.NO	DIMENSION MEASURED	MSR mm	VSR	VSC mm	TOTAL READING mm
1 2 3	Thickness of section				
1 2 3	Breadth of the flange				
1 2 3	Length of the web				

S.NO	Fy Kg	Fx Kg	dy mm	dx mm	θ_A	θ_B	tan θ_A	tan θ_B
1								
2								
3								
4								
5								

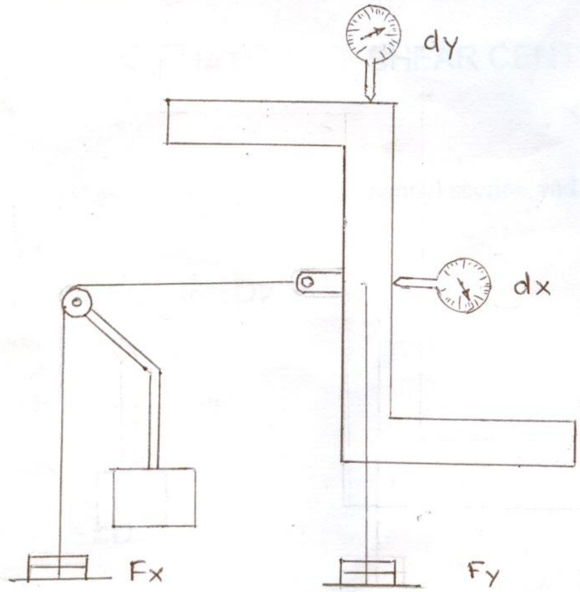
RESULT:

1. Thus the principal plane of the unsymmetrical Z-section beam is inclined at an angle of

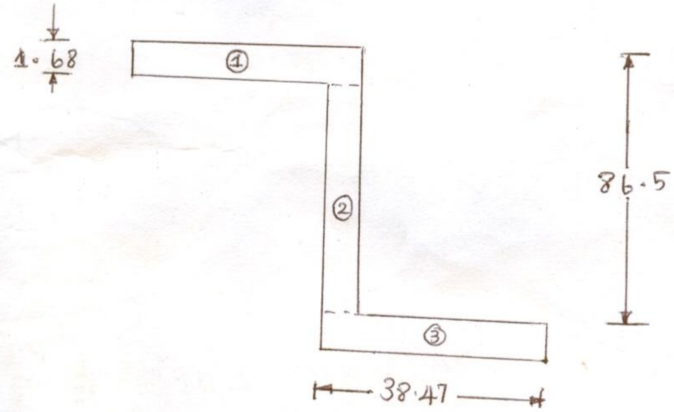
___________(Theoretically)
___________(Graphically)

2. The error percentage is ___________.

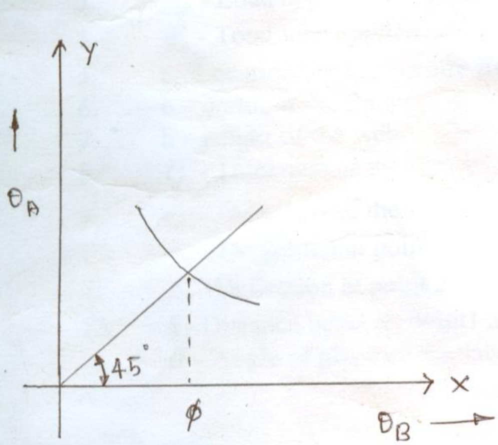
DETERMINATION OF PRINCIPLE PLANE OF UNSYMMETRIC BEAM



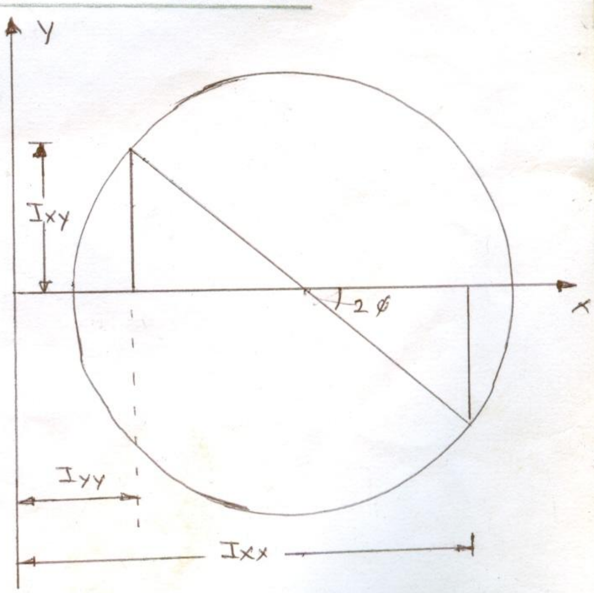
1. EXPERIMENTAL SET UP



2. DIMENSIONS OF THE SECTION (IN mm)



3. MODEL GRAPH



4. MOHR'S CIRCLE

EXP.NO:2 DETERMINATION OF SHEAR CENTRE OF CHANNEL SECTION

AIM:

To determine the shear centre of the given channel section and validate with theoretical values.

APPARATUS REQUIRED:

Channel section
Weight hanger
Dial gauge with magnetic stand
Weights
Vernier calipers

FORMULA USED:

EXPERIMENTAL:

$$e = \frac{AB}{2} \times \frac{W_a - W_b}{W_t}$$

$$\theta = \frac{\delta_1 - \delta_2}{d}$$

THEORETICAL:

$$e = \frac{3b^2 t_f}{6bt_f + ht_w}$$

Where,

1. AB- Distance between the 2 loads
2. W_a - Load applied at point A
3. W_b - Load applied at point B
4. W_t - Total load applied
5. e - Location of shear centre from the web
6. b – width of the flange
7. h – height of the web
8. t_f - Thickness of the flange
9. t_w - Thickness of the web
10. δ_1 - Deflection at point 1
11. δ_2 -Deflection at point 2
12. d - Distance between point1 and point2
13. θ - Angle of plane of displacement

PROCEDURE:

1. The given channel section consisting of two flanges and one web is first fixed in a particular position.

2. The dimensions of the flange are calculated so as to facilitate determination of shear centered.

3. The weight hanger is first placed arbitrarily along the plane on which the load is to be applied.

4. Since the section is symmetric with respect to axis, the shear centre lies along centroidal plane of section.

5.Since there will be deflections in the dial gauge installed on either side of the section, untie the loads applied at point A and B .Using the formula ,value of e is calculated.

6. The value of shear centre is independent of magnitude of applied load.

7. Plot the graph of θ Vs e.

8. The distance from the origin to the point where the curve crosses x-axis is given as distance of shear centre from origin.

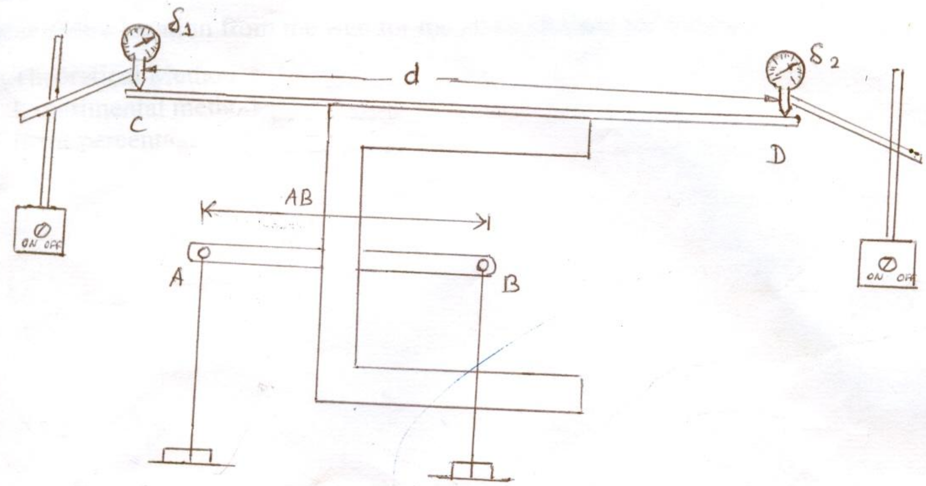
TABULATION:

S.NO	IMENSION IEASURED	MSR mm	VSR	VSC mm	TOTAL READING mm
1 2 3	Thickness of flange and web				
1 2 3	Breadth of the flange				
1 2 3	Height of the section				

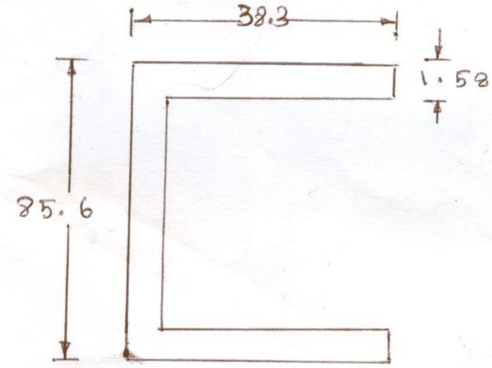
S.NO	Wa Kg	Wb Kg	Wt= Wa+Wb	δ1 mm	δ2 mm	θ =(δ1-δ2)/d	e=AB*(Wa-Wb)/2TWt
1							
2							
3							
4							

DETERMINATION OF SHEAR CENTRE OF CHENNEL SECTION

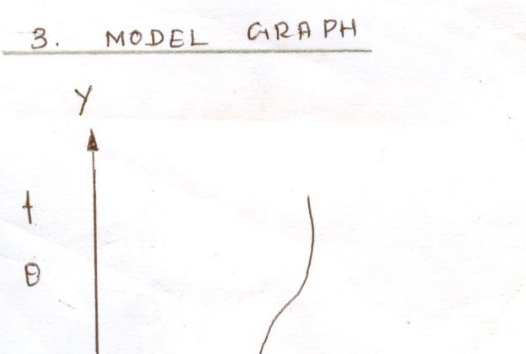
1. EXPERIMENTAL SETUP ·



2. DIMENSIONS OF THE BEAM (IN mm)



3. MODEL GRAPH



RESULT:

The shear centre location from the web for the given channel section by

a. Theoretical Method =__________
b. Experimental method=__________
c. Error percentage=______________

EXP.NO:3 CALIBRATION OF PHOTOELASTIC MATERIAL

AIM:

To calibrate the photoelastic material and to determine the value of the fringe of the material.

APPARATUS REQUIRED:

Circular disc (prepared out of photoelastic material)
12" diffused light polariscope
Universal loading frame
Weights

FORMULA:

$$f_\sigma = \frac{8p}{\pi DN}$$

$$P = \frac{WL}{X}$$

Where,

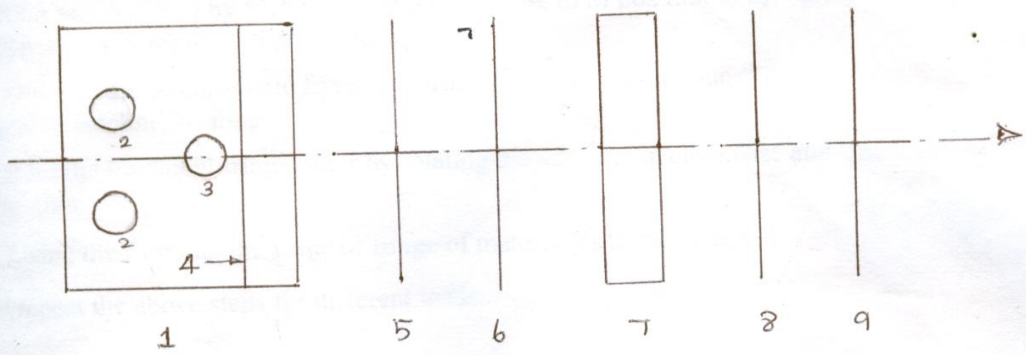
1. W - Applied load
2. P - load on the model
3. D – Diameter of the Disc
4. N – Fringe order
5. L – Distance between hinge point and the weight pan
6. X –Distance between the hinge point and the centre of the disc
7. f_σ - Material fringe value

PROCEDURE:

1. Place the model between the lever and the base.
2. The distance X and L must be initially measured and switch ON white light.
3. Change the polariscope to plane Polariscope (DARK FIELD ARRANGEMENT) by locking the two wave plate to D position in the spring loaded pin and apply the load on the model.
4. Keep the analyzer in '0' position and observe the isoclinic fringe pattern (DARK BRUSH LIKE).

CALIBRATION OF PHOTOELASTIC MATERIAL

DIFFUSED LIGHT POLARISCOPE



1. LIGHT HOUSE
2. WHITE LIGHT SOURCE
3. MONOCHROMATIC LIGHT SOURCE
4. DIFFUSING PLATE

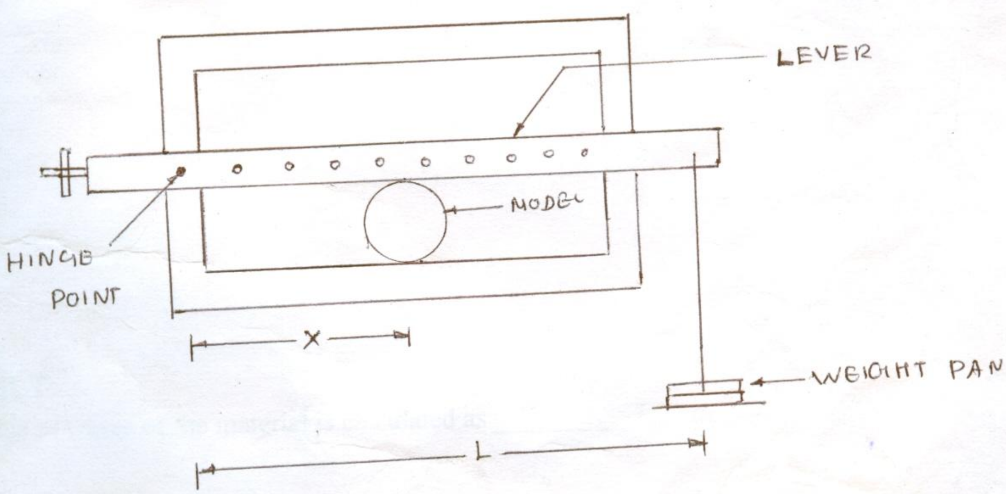
5. POLARIZER

6&8. WAVE PLATE

7. MODEL

9. ANALYZER

2. UNIVERSAL LOADING FRAME



X – DISTANCE FROM THE HINGE POINT TO THE CENTER OF THE MODEL

L – DISTANCE FROM THE HINGE POINT TO THE CENTER OF THE WEIGHT PAN

5. Now rotate the analyzer to some angles and make coincide isoclinic fringe to the point of interest on the dice. Note the angle as a isoclinic reading (if the point of interest is at center isoclinic reading is zero).

6. Change the polasicope to circular polariscope mode (WHITE FIELD ARRANGEMENT) by locking the two wave plate to M position in the spring loaded pin. Keep the analyzer in zero position.

7. Observe the isochromatic fringe pattern. Now rotate all the four plates to an angle equal to isoclinic reading.

8. Find the fractional fringe order by rotating the analyzer in clockwise and anticlockwise direction.

9. Using the formula, the value of fringe of material f_σ is calculated.

10.repeat the above steps for different loads.

TABULATION

S.NO	LOAD APPLIED W Kg	LOAD ON THE MODEL P=WX/L	FRACTIONAL FRINGE ORDER AT CENTRE	FRINGE VALUE……..	AVERAGE VALUE Kg/cm
1					
2					
3					

RESULT:

The value of fringe of the material is calculated as __________Kg/cm.

EXP.NO:4 DETERMINATION OF PRINCIPAL STRESSES USING POLARISCOPE

AIM:

To determine the maximum and minimum principal stresses at appoint in the given circular disc using polariscope.

APPARATUS REQUIRED:

12" diffused polariscope
Universal loading frame
Vernier caliper
Oblique incidence attachment
Weights

FORMULA:

$$\sigma_1 = \frac{f_\sigma}{h} \times (1.4 N_\alpha - N)$$

$$\sigma_2 = \frac{f_\sigma}{h} \times (1.4 N_\alpha - 2N)$$

Where,

1. Principle stress – σ_1, σ_2
2. f_σ - Material fringe value
3. N – Fringe order
4. N_α- Fringe order calculated using oblique incidence apparatus
5. h – Thickness of the model

PROCEDURE:

1. Refer the previous experiment and find the isoclinic reading and material fringe value for different loads.

2. Change the polasicope to circular polariscope mode (WHITE FIELD ARRANGEMENT) by locking the two wave plate to M position in the spring loaded pin. Keep the analyzer in zero position.

3. Now apply the known load and rotate the four plates to an angle equal to isoclinic reading for that load. Switch ON Monochromatic light.

5. Fix the Oblique incident attachment and rotate the prism to an angle equal to isoclinic reading for that load.

6. Observe the isochromatic fringe thro the flat and tapered face of the prism.

7. Rotate the analyzer and make the fringe to coincide with the point of interest (view thro flat face) And note the normal fringe order N.

8. Rotate the analyzer and make the fringe to coincide with the point of interest (view thro tapered face) and note the Oblique fringe order N_{α}.

9. Find principal stress using N and $N\alpha$

10. Repeat the above procedure for different loads.

TABULATION

S.NO	ISOCLINIC READING	PAN LOADING Kg	LOAD ON THE MODEL P=WX/L	FRACTIONAL FRINGE ORDER	FRINGE VALUE ….. Kg/cm	AVERAGE VALUE Kg/cm
1.						
2.						

S. NO	PAN LOADING Kg	ISOCLINIC READING	NORMAL FRINGE ORDER N	OBLIQUE FRINGE ORDER …….	PRINCIPAL STRESS σ1	PRINCIPAL STRESS σ2

RESULT:

The values of maximum and minimum principal stresses at a point in the given disc are

1) At load_________Kg
σ1=
σ2=

2) At load_________Kg
σ1=
σ2=

EXP.NO:5 DETERMINATION OF PRINCIPAL STRESS - COMBINED LOADING

AIM:

To determine the minimum and maximum principal stresses due to combined axial, bending and torsion loading.

APPARATUS REQUIRED:

Combined loading beam set up
Digital strain indicator Weights
Vernier caliper

FORMULA:

$$\sigma_{1,2} = \frac{\sigma_x}{2} \pm \sqrt{\left(\left(\frac{\sigma_x}{2}\right)^2 + \tau_{xy}^2\right)}$$

$$\sigma_x = E\varepsilon_a + E\varepsilon_b$$

$$\tau_{xy} = \cancel{E\varepsilon_t}\ G.\varepsilon_t$$

Where,

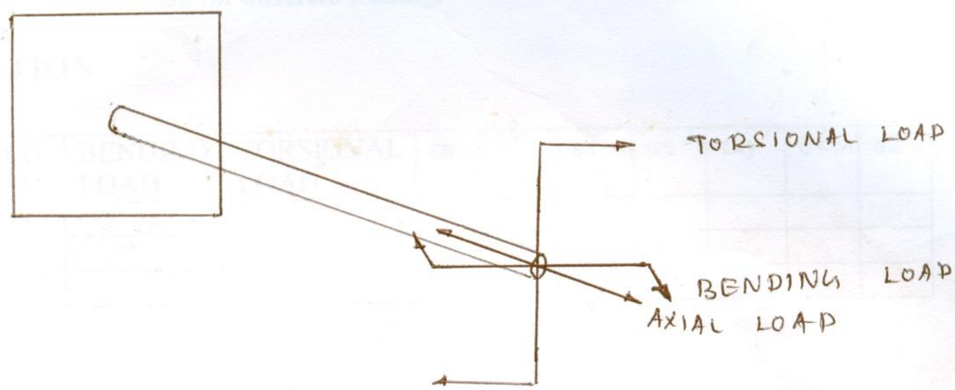
1. τ_{xy} - Shear stress in the beam
2. σ_x - Normal stress in the beam
3. E - Young's Modulus
4. ε_a - Strain measured in the axial direction
5. ε_b - Strain measured in the plane of bending
6. ε_t - Strain measured in the plane of torsion

PROCEDURE:

1. Connect the strain gauge (used for axial strain) to the channel one as quarter Wave Bridge in the digital strain indicator .
2. Connect the strain gauges (used for bending strain) to the channel two as half Wave Bridge in the digital strain indicator .
3. Connect the strain gauges (used for torsion shear strain) to the channel three as half Wave Bridge in the digital strain indicator .
4. Now set the gauge factor and gauge resistance in the digital strain indicator .
5. Select the channel one and change the bridge selector to quarter Wave Bridge.
6. Use the course and fine knob and set the reading to zero.
7. Select the channel two and change the bridge selector to half Wave Bridge.
8. Use only fine knob and set the reading to zero.
9. Select the channel three and change the bridge selector to half Wave Bridge
10. Use only fine knob and set the reading to zero.
11. Now apply load in axial, bending and torsion direction.

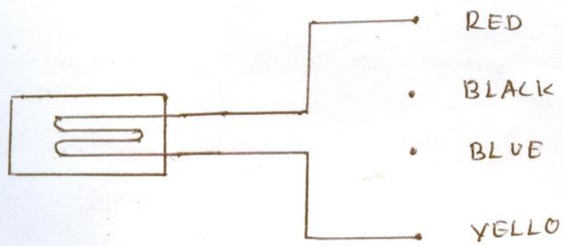
DETERMINATION OF PRINCIPAL STRESSES . DUE TO COMBINED LOADING

1. EXPERIMENTAL SETUP

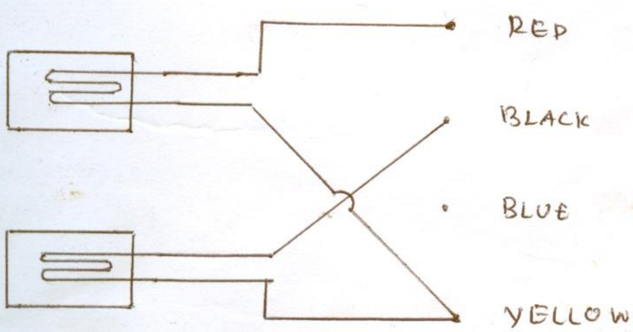


2. WIRE CONNECTIONS

QUATER WAVE



HALF WAVE



12. Select the channel one and quarter wave bridge note the axial strain (ε_a).

13. Select the channel two and Halfwave Bridge note the bending strain (ε_b)
14. Select the channel three and half wave bridge note the torsion shear strain (ε_t)
15. Find the principal strain using the formula.
16. Repeat above procedure for different loading.

TABULATION

S.NO	AXIAL LOAD	BENDING LOAD	TORSIONAL LOAD	εa	εb	εT	σx	τxy	σ1	σ2
1										
2										
3										

RESULT:

Thus the principal stress due to combined axial, bending and torsion loading are calculated.

EX.NO.6 CONSTANT STRENGTH BEAM

AIM:

To verify the constant strength property of the tapered beam using strain gauge and digital strain indicator.

APPARATUS REQUIRED:

Tapered beam set up
Digital strain indicator
Weight
Vernier caliper

FORMULA:

$$\sigma_{\max} = \frac{6Px}{b_x \times d^2}$$

$$b_x = \frac{x}{l} \times b_{\max}$$

$$\sigma_{\max} = E\varepsilon$$

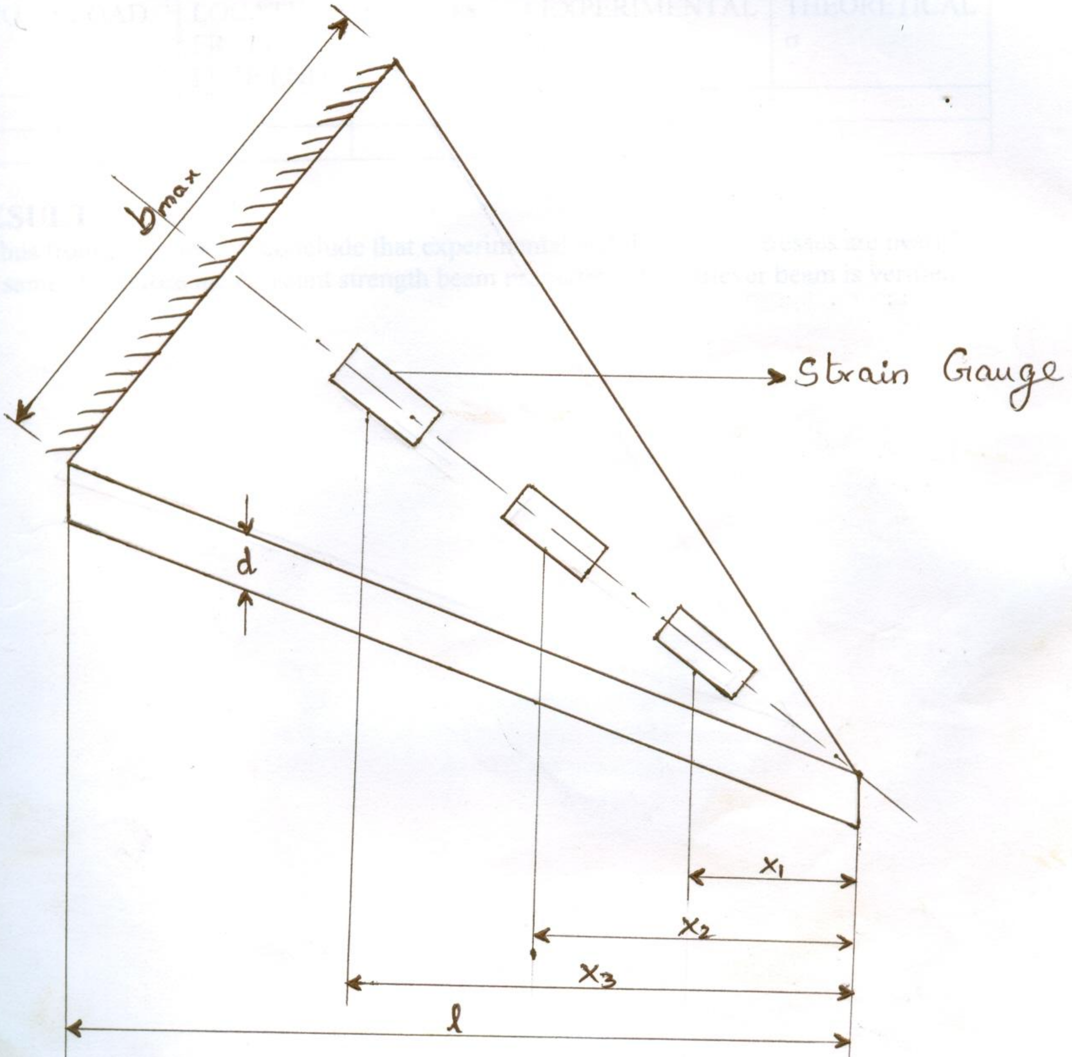
Where,

1. P – Applied load
2. X – Distance from the free end to a point where strain gauge pasted
3. b_x – Breadth of the beam where strain gauge pasted
4. d – Depth or thickness of the beam
5. l – Length of the beam
6. $b_{\max}$ – Maximum breadth of the beam
7. $\sigma_{\max}$ - Stress at a distance x
8. ε - Strain measured at a distance x

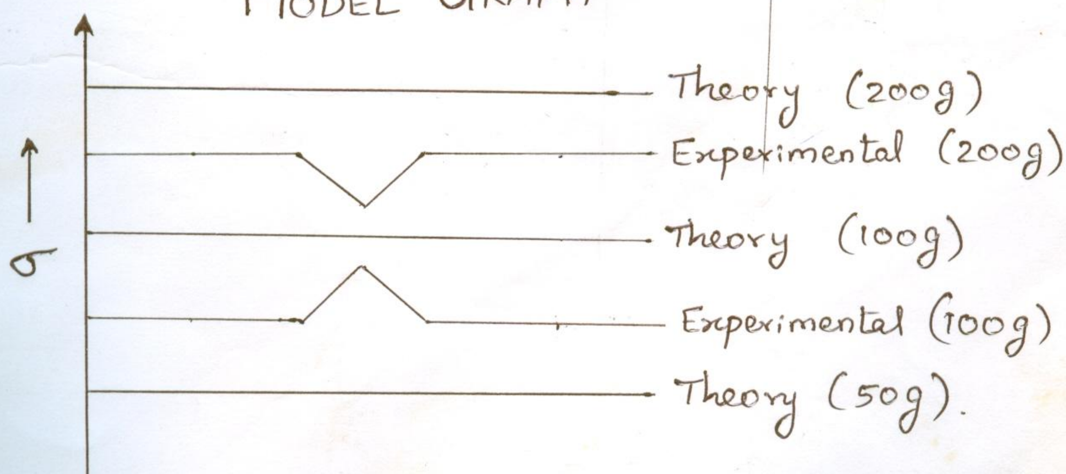
PROCEDURE:

1. In the cantilever beam, the strain is to be measured at three various points.
2. Connect the three points to channel 1, 2, 3 of the digital strain indicator respectively.
3. In digital strain indicator, quarter wave is set.
4. Channel 1, 2, 3 is brought to zero by using fine tuner.
5. Now load the beam with 100 gm weight and note down the strains at the three points.
6. Now add loads in steps of 100 gm and find the strains.
7. Using the formula find the theoretical and experimental stress.
8. Plot a graph between σ and x and verify the result.

CONSTANT STRENGTH BEAM



MODEL GRAPH



TABULATION

S.NO	LOAD	LOCATION FROM FREE END	bx	εx	EXPERIMENTAL σ	THEORETICAL σ

RESULT:

Thus from the graph we conclude that experimental and theoretical stresses are nearly the same. Therefore the constant strength beam properties of cantilever beam is verified.

EX: NO: 7 SHEAR CENTRE OF A CLOSED SECTION

AIM:

To determine the shear centre of a closed section.

APPARATUS REQUIRED:

Closed section beam
Dial gauge
Weights
Load
Vernier caliper

FORMULA:

$$l_1 = \frac{P_1}{P_2} \times (l - l_1)$$

$$e = l_1 - l_2$$

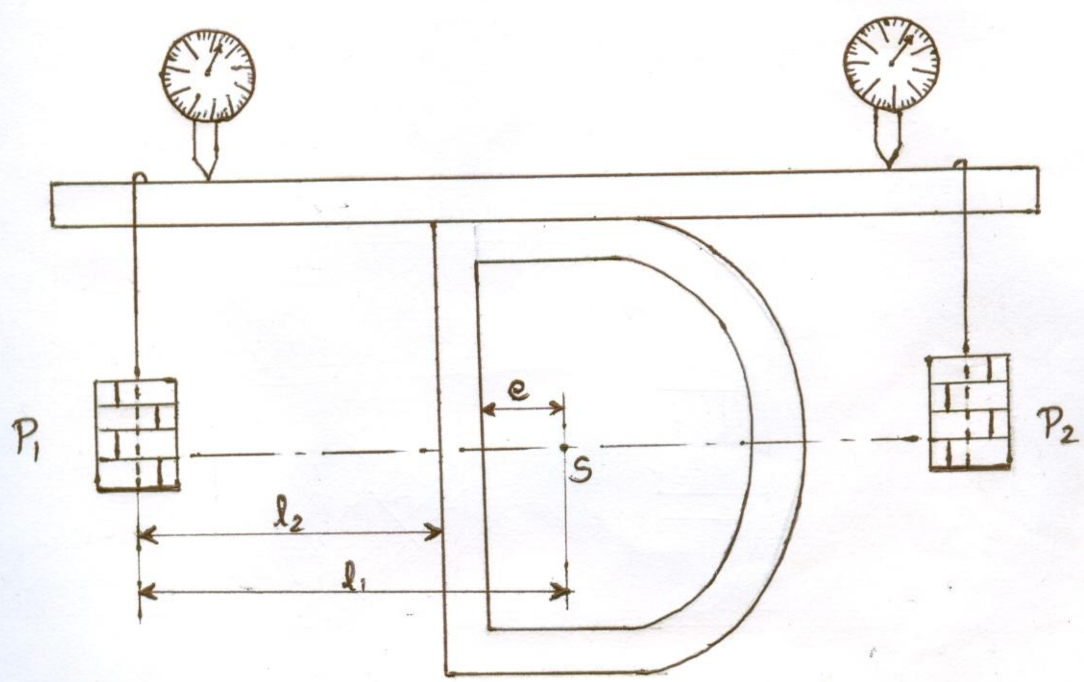
Where,

1. P_1 – Load applied at point 1
2. P_2 – Load applied at point 2
3. l_1 – Distance of the shear center from point 1
4. l_2 - Distance of the shear center from vertical web
5. l – Distance between the 2 loads

PROCEDRE:

1. Set the apparatus by properly by placing the two dial gauges on the closed section.
2. Now apply the load on P1 pan say 500 gm and then load the weights on P2 pan such that the two dial gauges show the same reading.
3. Now repeat the above procedure for increasing loads say 1000 gm, 1500 gm, etc.
4. Now calculate L1 by using the formula and then find shear centre by using the formula.

SHEAR CENTRE OF A CLOSED SYSTEM



$$e = l_1 - l_2$$

TABULATION

S.No	P1 gm	P2 gm	L1 cm

RESULT:

Thus the shear centre of the closed section is found.

The location of the shear center from the vertical web_______cm

Pyromatic Vibrating Table

Aim:

To determine transmissibility of forced vibrations and to analyze all types of Vibrations with its frequency and amplitude

Description:

Vibration:

When elastic bodies such as a spring, a beam and a shaft are displaced from the equilibrium position by the application of external forces, and when released, they execute a Vibrating Motion.

This is due to the reason that when a body is displaced, the internal forces in the form of elastic or strain energy are present in the body. At release, these forces bring the body to its original position

Time Period:

It is the time interval after which the motion is repeated itself. The period of vibration is usually expressed in seconds

Cycle:

It is the motion completed during one time period

Frequency:

It is the number of cycles described in one second.

Types:

Free/Natural Vibration:

When no external force acts on a body, after giving it an initial displacement then the body is said to be under free or natural vibrations. The frequency of this free Vibrations is called as Free/Natural Frequency

Force Vibration:

When the body vibrates under the influence of external force, then the body is said to be under forced vibration

Damped Vibration:

When there is reduction in amplitude over every cycle of vibration, the motion is said to be damped vibration. This is due to the fact that a certain amount of energy possessed by the vibrating system is always dissipated in overcoming frictional resistances to the motion.

To study the natural frequency of spring mass system:

Transverse Vibration:

When the particles of the shaft or disc move approximately perpendicular to the axis of the shaft as shown in the fig 1, then the vibrations are known as Transverse Vibration

Technical Specifications:

Mass of the Beam = kg
Total length of the beam (L)= m
Mass of the Exciter (m) = kg
Exciter position from one trunion end (L1) =
Stiffness of the spring = _______ N /m

To study forced damped vibrations of spring mass

Procedure:

- Attach the vibrating recorder at suitable position with the penholder slightly pressing the paper
- Attach the damper unit to stud
- Start the exciter motor and set at required speed and start the recorder motor
- Now vibrations are recorded over the vibration recorder. Increase the speed and note the vibrations
- At the resonance speed, the amplitude of the vibrations may be recorded as merged over one another.
- Hold the system and cross the speed little more than the resonance speed
- Analyze the recorded frequency and amplitude for both damped and undamped forced vibrations

Nature of the graph with damper
Transmissibility:

Transmissibility is defined as the ratio

F_{TR}/F

Max. Force transmitted/max impressed force

This can be calculated by mounting the system on springs and providing dashpots mechanism, which is commonly known as damper
$F_{TR} = s * x_{max}$

(F_{TR} = Stiffness of elastic support * max amplitude of vibration)

$$F = m\,\omega^2\,r$$

m = mass of total beam
$\omega = (2\pi N)/60$
r = radius of Exciter disc

TRANSVERSE VIBRATION

BSPIL'S Apparatus for Transverse Vibration is rigid made from strong channel. A beam can be fixed between two-trunion bearings. Weights are applied uniformly or concentrated.

OBJECTIVE:

To study transverse Vibration of a beam subjected to Uniform load and concentrated load.

TEST SET UP:

It comprises following:
a. Main frame: made from channel, about 1.2 mt length
b. Trunion: 2 brackets of trunion bearing with slots to insert beam fitted at 1 mt apart
c. Weights: 1 kg, 250 gms*8 nos

PROCEDURE:

1. Ensure proper lubrication for bearings
2. Fit beam into both slots of trunion bearing and tighten and tighten them
3. Add weights, either concentrated at center or uniformly
4. Give a swing to the beam
5. Note down time required for 5 oscillations
6. Repeat experiment for different weights
7. And then change the position of the weights
8. Repeat the experiment
9. Find out the deflection for different weights

CALCULATIONS: (Free beam)

SL.NO	OSCILLATIONS	TIME TAKEN (T1)

Average (t1) =
Period T1 = t1/ no of Oscillation
=
Frequency of Vibration = 1/T1
Length of the beam (l) = 1000 mm
Breadth of the beam (d) = 25mm
Weight of the beam (w) = 1 kg
Frequency of the beam under its own weight = 5.623/ds
Where ds = 5/384 * wl 4 / E I
E = 2.7 * 10 5 N/sq.m m
I = ld3 / 12 m 4

Deflection for simply supported beam with a central point load = Wl3 / 48EI
Deflection for simply supported beam with uniformly distributed load = 5Wl4/384 EI
Deflection for simply supported beam with an eccentric point load W = Wa2 b2 / 3EIL

CANTILEVER BEAM SET-UP:

FORMULA:

Deflection (δ) for uniformly distributed load = $Wl^4 / 8EI$.

PROCEDURE:

1. Add weights at various points/nodes.
2. Give a swing to the beam.
3. Note down the time required for the required number of oscillations.
4. Substitute in the formula to determine the Deflection.

TORSIONAL VIBRATION(UNDAMPED) OF SINGLE ROTOR SHAFT SYSTEM

OBJECTIVE

To study the Torsional vibration (undamped) of single rotor system.

PROCEDURE

1. Fix the bracket at convenient position along the lower beam.
2. Grip one end of the shaft at the bracket by chuck.
3. Fix the rotor on the end of the shaft.
4. Twist the rotor through some angle and release.
5. Note down the time required for n of oscillations.
6. Repeat the procedure for different length of the shaft.
7. Make the following observations.

a) Shaft diameter = mm
b) Diameter of Disc = mm
c) Weight of the Disc = Kgf
d) Modulus of Rigidity = 0.8×10^6 kgf/sq.cm

OBSERVATION TABLE

S.No	Mass of Rotor (Kg)	Length of Shaft (m)	No. of oscillation	Time for n oscillation (sec)	Frequency

SPECIMEN CALCULATIONS

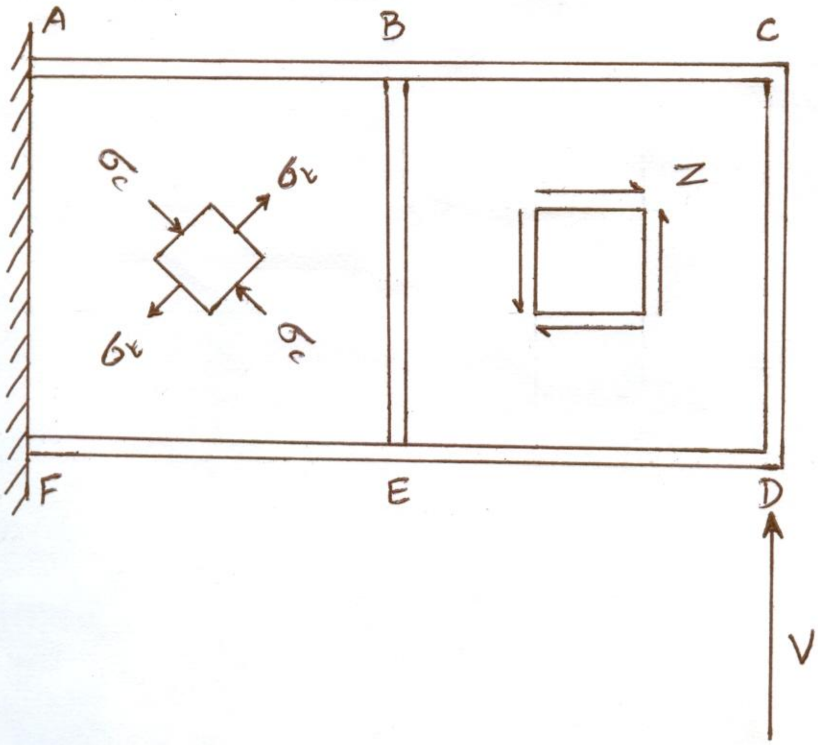
1) Determination of torsional stiffness: Kt?

$Kt = T/\theta = G \times Ip/L$
L = Length of shaft
Ip = polar M.I of shaft $= \pi d^4/32$
d = Shaft Diameter
G = Modulus of Rigidity of shaft 0.8×10^6 Kgf/sq.cm

2) Determine ωn Experimental

ωn = No. of oscillations/Time for n oscillations = c/sec

WAGNER BEAM - TENSION FIELD BEAM



AC, DF - Flanges.

CD, BE - Vertical Stiffeners.

Thumbs.db