AIRCRAFT STRUCTURES LABORATORY

DEPARTMENT OF AEROSPACE ENGINEERING

Subject Code:		**AEC3105**
Regulations	**:**	**2017**
Class	**:**	**V Semester**
Branch	**:**	**Aeronautical Engineering**

LAB MANUAL

HOD/AERO **Lab In charge**

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AIRCRAFT STRUCTUTRES LAB SYLLABUS

1. Determination of Young's Modulus for the given material (statically determinate beam) and verify Maxwell's reciprocal theorem for the same using extensometers

2. Determination of Young's Modulus for the given material (statically indeterminate beam) and verify Maxwell's reciprocal theorem for the same using extensometers.

3. Determination of critical load for a column (South well – plot).

4. Unsymmetrical bending of beams

5. Determination of Shear center for Closed and Open Section.

6. Constant Strength Beam

7. Beam with combined loading.

8. Calibration of photo-elastic material and determination of Stresses in circular discs and beams.

9. Vibrations of beams

10. Wagner's beam.

EXPERIMENT NO. 1

Determination of Young's Modulus for the given material (statically determinate beam) and verify Maxwell's reciprocal theorem for the same using extensometers

Aim:

To determine the Young‟s modulus of a given mild steel Beam

Apparatus:

- Beam test set up
- Weights 500 Gms – 2 No.„s
- Loading hooks – 1 No.
- Mild steel bar
- Measuring tape
- Dial gauge – 1 No.

Formula:

The formula for young's modulus from the deflection of a rectangular beam which is simply supported is given by

$E = (m \times g \times l^3)/(48 \times I \times y)$

Where,

I = moment of inertia of the beam

g = acceleration due to gravity = 9.81m/sec2

y = deflection of the beam

m = mass of the load applied

l = distance between the two supports

PROCEDURE:

- The beam is placed on the frame where both ends are simply supported.
- The longitudinal and the cross-sectional dimensions of the beam are noted.
- The mid-point of the beam is marked and the loading hook should be placed there at the centre.
- Now the dial gauge is mounted exactly on the middle of the loading hook.
- The load is applied on the loading hook and the corresponding deflection is noted down.

- Now these values are substituted in the theoretical formula given and the Young's modulus of the material is found.

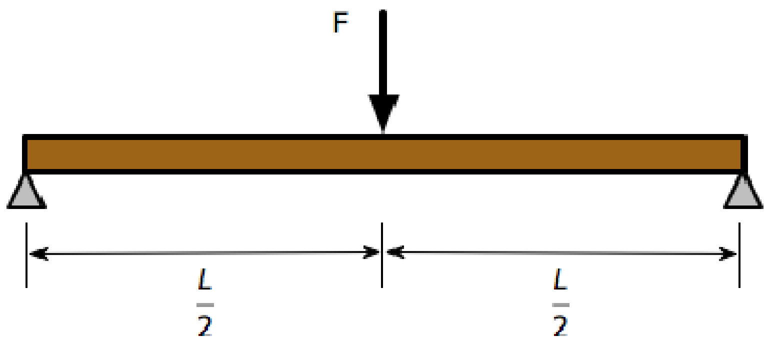


Fig: simply supported beam with load at centre.

Tabular column:

S. No	Weight (kgs)	Deflection (div)	Deflection (mm)	Young's Modulus

Precautions:

- Take the readings without parallax error.
- While doing the experiment, see that no external loads are acting on the table or frame.

Result:

The Young‟s modulus of given material is found and is of value ____________

VERIFICATION OF MAXWELL'S RECIPROCAL THEOREM

THEORY:

The following are the three versions of Maxwell's reciprocal theorem

1. The deflection at point B due to load at point A is equal to the deflection at point A due to load at point B.

2. The slope at point B due to unit moment at point A is equal to the slope at the point A due to unit moment at point B.

3. The slope at point B due to unit load at point A is equal to the slope at point A due to unit load at point B

Procedure:

- Place the beam on the simply supported edges.
- Measure the length of the beam with the measuring tape
- Mark two points A & B which are equidistant from the supports.
- At first the loading hook is mounted at point A and the dial gauge is mounted at point B, now the load is applied at A and corresponding deflections are noted down.
- Repeat the same procedure by changing three positions of the dial gauge and the loading hook.

Tabular column:

1. When load is applied at point A

S. No	Load applied (gms)	Deflection (div)	Deflection (mm)

2. When load is applied at point B

S. No	Load applied (gms)	Deflection (div)	Deflection (mm)

Precautions:

- Make sure that dial gauge tip is in touch with the beam.
- The dial gauge needle should be adjusted to zero before taking the readings.
- Take the readings without parallax error.

RESULTS:

Hence Maxwell’s reciprocal theorem is verified.

EXPERIMENT NO. 2

Determination of Young's Modulus for the given material (statically indeterminate beam) and verify Maxwell's reciprocal theorem for the same using extensometers

Aim:

To determine the Young‟s modulus of a given mild steel Beam

Apparatus:

- Beam test set up
- Weights 500 Gms – 2 No.„s
- Loading hooks – 1 No.
- Mild steel bar
- Measuring tape
- Dial gauge – 1 No.

Formula:

The formula for young's modulus from the deflection of a rectangular beam which is simply supported is given by

$E = (m \times g \times l^3)/(192 \times I \times y)$

Where,
I = moment of inertia of the beam
g = acceleration due to gravity = 9.81m/sec2
y = deflection of the beam
m = mass of the load applied
l = distance between the two supports

Procedure:

- The beam is placed on the frame where both ends are simply supported.
- The longitudinal and the cross-sectional dimensions of the beam are noted.
- The mid-point of the beam is marked and the loading hook should be placed there at the centre.
- Now the dial gauge is mounted exactly on the middle of the loading hook.
- The load is applied on the loading hook and the corresponding deflection is noted down.
- Now these values are substituted in the theoretical formula given and the Young's modulus of the material is found.

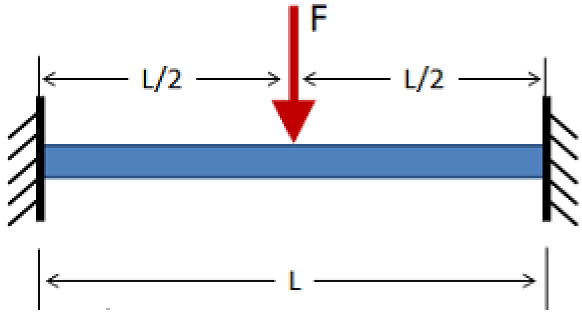


Fig: Fixed-fixed beam with load at centre.

Tabularcolumn:

S. No	Weight (kgs)	Deflection (div)	Deflection (mm)	Young's Modulus

Precautions:

- Take the readings without parallax error.
- While doing the experiment, see that no external loads are acting on the table or frame.

Result:

The Young‟s modulus of given material is found and is of value ___________

VERIFICATION OF MAXWELL'S RECIPROCAL THEOREM

Theory:

The following are the three versions of Maxwell's reciprocal theorem
1. The deflection at point B due to load at point A is equal to the deflection at point A due to load at point B.
2. The slope at point B due to unit moment at point A is equal to the slope at the point A due to unit moment at point B.
3. The slope at point B due to unit load at point A is equal to the slope at point A due to unit load at point B

PROCEDURE:

- Place the beam on the simply supported edges.
- Measure the length of the beam with the measuring tape

- Mark two points A & B which are equidistant from the supports.
- At first the loading hook is mounted at point A and the dial gauge is mounted at point B, now the load is applied at A and corresponding deflections are noted down.
- Repeat the same procedure by changing three positions of the dial gauge and the loading hook.

Tabularcolumn:

1. When load is applied at point A

S. No	Load applied (gms)	Deflection (div)	Deflection (mm)

2. When load is applied at point B

S. No	Load applied (gms)	Deflection (div)	Deflection (mm)

Precautions:

- Make sure that dial gauge tip is in touch with the beam.
- The dial gauge needle should be adjusted to zero before taking the readings.
- Take the readings without parallax error.

Results:

Hence Maxwell's reciprocal theorem is verified.

EXPERIMENT NO. 3

Determination of critical load for a column (South well – plot).

Aim:

To determine the critical load of a column using South well plot.

Apparatus Required:

- Column testing apparatus.
- Specimens.
- Dial gauge.
- Vernier calipers.
- Weights.

Buckling of a Perfect Column (Euler Buckling):

Consider the buckling of a column loaded by opposing axial loads as shown in Figure 1a. We can model this using an extension of Euler-Bernoulli beam theory. Using this theory, the transverse deformation, $w(x)$, of a beam is governed by the equation (1)

$$EI\frac{d^4w}{dx^4} + P\frac{d^2w}{dx^2} = q(x) \quad (1)$$

Where E and I are the elastic modulus and second moment of area, P is the axial compressive load and $q(x)$ is the distributed load. At first glance, this equation may not appear to be nonlinear, however, the second term $P\left(d^2w/dx^2\right)$ is, in fact, a nonlinear term. If we consider a beam that is only subject to a compressive load, with $q(x)=0$, then the governing equation can be rewritten as

$$\frac{d^4w}{dx^4} + k^2\frac{d^2w}{dx^2} = 0 \quad (2)$$

where $k^2 = P / EI$.

Note that the governing equation (2) is now an Eigen problem. Using simply supported boundary conditions for the ends of the beam, we find the Eigen values of (2) are given by equation (3).

$$kL_n = n\pi \text{ for } n=1,2,3,\ldots \quad (3)$$

Rearranging this expression gives the following equation for the loads corresponding to these Eigen values

$$P_n = n^2\frac{\pi^2 EI}{L^2} \quad (4)$$

We are most interested in the lowest load for which the beam becomes unstable, i.e., the critical load. This corresponds to the case with n = 1, i.e.,

$$P_{cr} = \frac{\pi^2 EI}{L^2} \quad (5)$$

The critical load based on this theory is often referred to as the Euler buckling load. Using this load, we can compute the axial stress in the beam when it buckles

$$\sigma_{cr} = \frac{P_{cr}}{A} = \frac{\pi^2 EI}{L^2 A} \tag{6}$$

Where *'A' is* cross-sectional area of the beam. This critical stress is often written in terms of the radius of gyration (R_g) of the column about its weak axis, which is defined as $R_g = \sqrt{\frac{I}{A}}$. With this definition, the critical buckling load stress and strain from this theory are given by

$$\sigma_{cr} = \left(\frac{\pi R_g}{L}\right)^2 E$$

$$\varepsilon_{cr} = \left(\frac{\pi R_g}{L}\right)^2 \tag{7}$$

Buckling of an Imperfect Column and the Southwell Plot:

The model of Euler buckling is flawed. In particular, the beam is not perfectly straight and the axial compressive load is not applied through the center of the beam. As a result, the beam does not suddenly buckle at P_{cr} but more gradually buckles in a direction determined by the imperfections in the beam. Such an imperfect beam is shown in Figure 1b. Even though these imperfections can be quite small, they can have a large effect on the response of the structure. This is called imperfection sensitivity.

A more sophisticated analysis that takes into account an initial imperfection of the beam, where the imperfection causes an initial displacement with the form $a_1 \sin(\pi x/L)$, results in the following expression for the transverse deflection of the beam at its mid-point ($x=L/2$) as a function of the Euler buckling load.

$$\delta = \frac{P a_1}{P_{cr} - P} \tag{8}$$

This relationship forms the basis of the **Southwell plot**. Rearranging this relationship, one can create an expression for the deflection normalized by the load, i.e.,

$$\frac{\delta}{P} = \frac{\delta}{P_{cr}} + \frac{a_1}{P_{cr}} \tag{9}$$

A Southwell plot consists of a series of measurements plotted on a graph of δ/P versus δ. The slope of a linear fit to the data then provides P_{cr} and the y-intercept provides a measure of the initial displacement magnitude (see Figure 2).

PROCEDURE:

1. The ends of the given column specimens are carefully prepared to provide knife-edge supports.
2. The specimen is then mounted on the column testing apparatus.
3. The columns are should be placed with the longitudinal axis aligned vertically. At the mid-point of the given column, a dial gauge is placed.

4. Loads are then gradually applied. The values of applied compressive load and corresponding mid-point deflections are recorded.
5. For each column specimen, a plot of δ / P versus δ is obtained. This is called the Southwell plot, which should be a straight line. The inverse of the slope of this line indicate the value of the critical load, Pcr of the given hinged – hinged column.

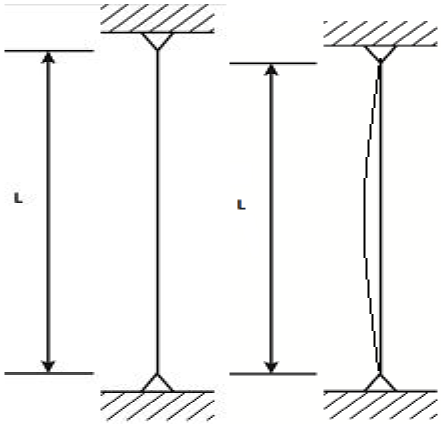


Figure 1**(a)** Euler-Bernoulli beam subject to a compressive load, *P***(b)**Imperfect Euler beam with initial curvature.

Tabular column:

S.No	P	δ	δ / P
1			
2			
3 . . 10			

Data Reduction:

1. Using a Southwell plot for each of the columns, determine the column's buckling load and buckling (axial) stress.
2. Calculate the theoretical buckling load and stress for each column based on beam theory.

L =
b =
d =
I = $bd^3/12$
P = $(\pi^2 EI)/ L^2$
$P_{cr.theortical}$ =

$P_{cr.exp}$ =

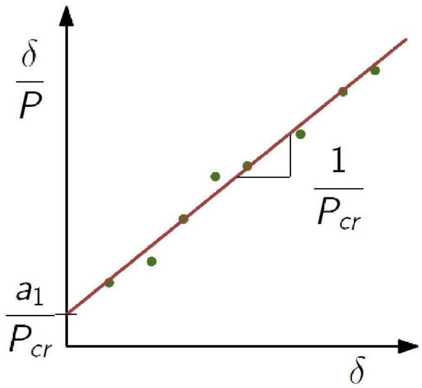


Figure 2:Southwell plots for determining the critical load:

Results :

1. Table of measured displacement for each of the applied (measured) axial loads for long column.
2. Southwell plots for the columns.

EXPERIMENT NO. 4

UNSYMMETRICAL BENDING OF BEAMS

Aim:

To determine the principal axes of an unsymmetrical section.

Apparatus Required:

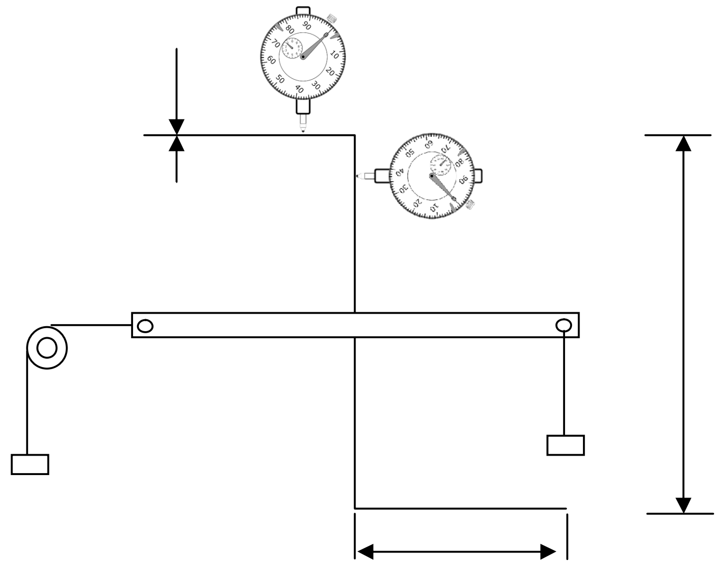
- A thin uniform cantilever Z section as shown in figure.
- Two dial gauges.
- Two hooks
- A string and pulley arrangement
- A steel support structure to mount the Z section as cantilever.

Procedure:

1. Mount two dial gauges on the tip section to measure the horizontal and vertical deflections of a point on it.
2. Apply the vertical load W_V
3. Read u and v, the horizontal and vertical deflections respectively at the chosen point.
4. Increase the load W_H in steps of about 300 gm (for the first case 100 gm + 200 gm hook) from zero to a maximum of about 3 Kg, noting down in each case the values of u and v. Repeat the procedure and check for consistency for measurements.
5. Plot the graphs (u/v) vs (W_H / W_V) and find the intersection of this curve with a straight line through the origin at 45º.
6. Calculate the inclination of one of the axes to the web as $\theta = \tan^{-1} (W_V / W_H)$.
7. Calculate the inclination θ using the formula $\tan 2\theta = 2I_{XY} / (I_{YY} – I_{XX})$.

Tabular column:

S.No	W_H	u	v	W_H / W_V	u/v
1					
2					
3					
4					
5					
6					
7					
8					
9					



CALCULATION:

W_V =

θ_{exp} = $\tan^{-1}(W_V / W_H)$.

b =

h =

t =

I_{XX} =

I_{XY} =

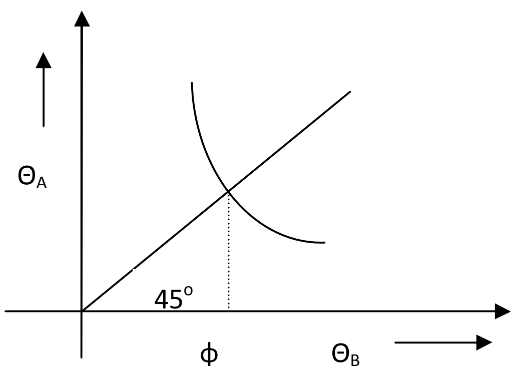
I_{YY} =

tan 2θ = $2I_{XY} / (I_{YY} - I_{XX})$

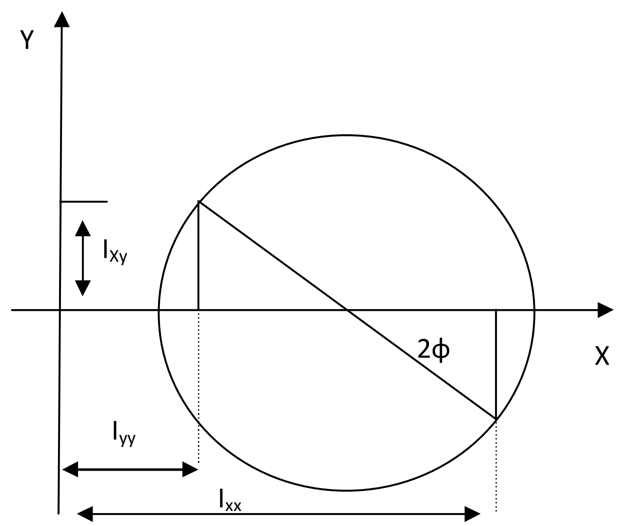
θ theoretical =

Graph:

θ_A vs θ_B



Model graph



Mohr's circle

Result:

Therefore, the unsymmetrical bending of beam is calculated and proved the value of 'θ' is approximately same experimentally and theoretically.

EXPERIMENT NO. 5

Determination of Shear center for Closed and Open Section.

a. Shear center for Open Section

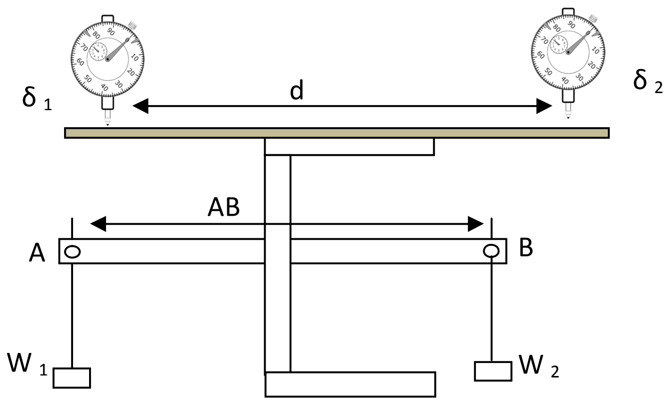
Aim:

To determine the shear center open section 'C'.

ApparatusRequired:

- A thin uniform cantilever beam of 'C' – section as shown in the figure. At the free end extension pieces are attached on either side of the web to facilitate vertical loading.
- Two dial gauges are mounted firmly on this section, a known distance apart over the top flange. This enables the determination of the twist, if any experienced by the section.
- A steel support structure to mount the channel section as cantilever.
- Two loading hooks each weighing about 0.2 kg.

Experimental setup:



Procedure:

1. Mount two dial gauges on the flange at a known distance apart at the free end of the beam.
2. Place a two kilograms load at left side hook and note the dial gauge readings
3. Remove one load from left end and place on right end, note the dial gauge readings.
4. Transfer carefully all the load pieces and finally the hook one by one to the other hook noting each time the dial gauge readings. Calculate the distance 'e' of the line of action from the web thus:

   $$(AB/2)\ (W_a - W_b) / W_v = e$$

5. For every load case calculate the algebraic difference between the dial gauge readings as the measure of the angle of twist θ suffered by the section.

6. Plot θ against e and obtain the meeting point of the curve (a straight line in this case) with the e-axis (i.e., θ, the twist of the section is zero for this location of the resultant vertical load). This determines the shear center.

Calculation:

Dimensions of the beam and the section :
Length of the beam (L) :
Height of the web (h) :
Width of the flange (b) :
Thickness of the sheet (t) :
Distance between the two hook stations :
Theoretical location of the shear center (e) : $= 3b^2 t_f / [6bt_f + ht_w]$
Vertical load $W_v = (W_a + W_b)$

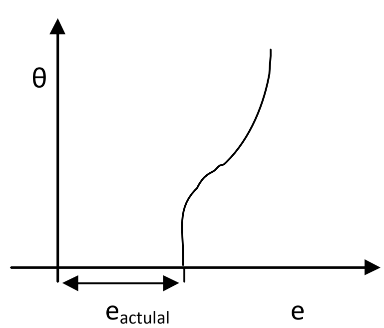
Tabular Column:

S.No	W_a	W_b	Dial gauge readings d1 d2	(d1-d2)	$e = (AB/2)(W_a - W_b)/W_v$
1					
2					
3 . . 11					

H =
B =
$e_{theory} = 3b / [6+(h/b)]=$

Graph:

θ vs e_{exp}



Model Graph

From the graph,
e_{exp} = when (d1 – d2) = 0

Result:

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

a. Theory ________ b. Experiment ________ C. Error ___________

PRECAUTION:

1. For the section supplied there are limits on the maximum value of obtain acceptable experimental results. Beyond these the section could undergo excessive permanent deformation and damage the beam forever. Do not therefore exceed the suggested values for the loads.

2. The dial gauges must be mounted firmly. Every time before taking the reading tap the set up (not the gauges) gently several times until the reading pointers on the gauges settle down and do not shift any further. This shift happens due to both backlash and slippages at the points of contact between the dial gauges and the sheet surfaces and can induce errors if not taken care of. Repeat the experiments with identical settings several times to ensure consistency in the readings.

b. Shear Centre for CLOSED SECTION

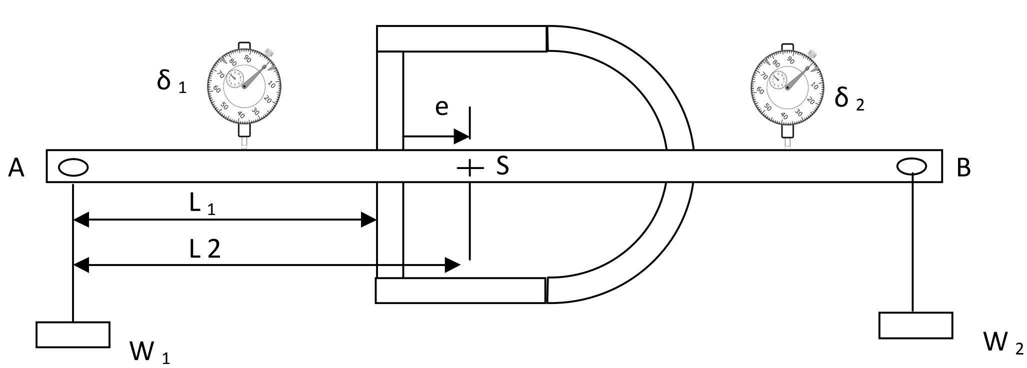
Aim:

To determine the shear center of a closed sections.

Apparatus Required:

- A thin uniform cantilever beam of D – section as shown in the figure. At the free end extension pieces are attached on either side of the web to facilitate vertical loading.
- Two dial gauges are mounted firmly on this section, a known distance apart over the top flange. This enables the determination of the twist, if any experienced by the section.
- A steel support structure to mount the channel section as cantilever.
- Two loading hooks each weighing about 0.2 kg.

Experimental setup:



Procedure:

1. Mount two dial gauges on the flange at a known distance apart at the free end of the beam (see fig.). Set the dial gauge readings to zero.
2. Place a total of say two kilograms load at A (loading hook and nine load pieces will make up this). Note the dial gauge readings (normally hooks also weigh a 200 grams each).
3. Now remove one load piece from the hook at A and place another hook at B. this means that the total vertical load on this section remains two kilogram. Record the dial gauge readings.
4. Transfer carefully all the load pieces and finally the hook one by one to the other hook noting each time the dial gauge readings. This procedure ensures that while the magnitude of the resultant vertical force remains the same its line of action shifts by a known amount along AB every time a load piece is shifted. Calculate the distance e (see fig.) of the line of action from the web thus:
   $e = (AB/2)\ (W_a\ - W_b)/W_v$
5. For every load case calculate the algebraic difference between the dial gauge readings as the measure of the angle of twist θ suffered by the section.
6. Plot θ against e and obtain the meeting point of the curve (a straight line in this case) with the e-axis (i.e. θ, the twist of the section is zero for this location of the resultant vertical load). This determines the shear center.

Though a nominal value of two kilograms for the total load is suggested it can be less. In that event the number of readings taken will reduce proportionately.

Tabular column

S.NO.	W_a	W_b	Dial gauge readings d1 d2	(d1- d2)	$e = AB(W_a\ - W_b)/2W_v$
1					
2					
3 11					

Dimensions of the beam and the section :
Length of the beam (L) :
Height of the web (h) :
Thickness of the sheet (t) :

Distance between the two hook station (AB) :

Vertical load $W_{v} = (W_a + W_b)$

Graph:

Plot e versus (d1-d2) curve and determine where this meets the e axis and locate the shear center.

RESULT:

The shear center obtained experimentally is compared with the theoretical value.

PRECAUTION:

1. For the section supplied there are limits on the maximum value of obtain acceptable experimental results. Beyond these the section could undergo excessive permanent deformation and damage the beam forever. Do not therefore exceed the suggested values for the loads.
2. The dial gauges must be mounted firmly. Every time before taking the reading tap the set up (not the gauges) gently several times until the reading pointers on the gauges settle down and do not shift any further. This shift happens due to both backlash and slippages at the points of contact between the dial gauges and the sheet surfaces and can induce errors if not taken care of. Repeat the experiments with identical settings several times to ensure consistency in the readings.

EXPERIMENT NO. 6

Constant Strength Beam

AIM:

To determine the stress at various locations along the length of a constant strength beam to show that they are equal and compare with theoretical values.

APPARATUS REQUIRED:

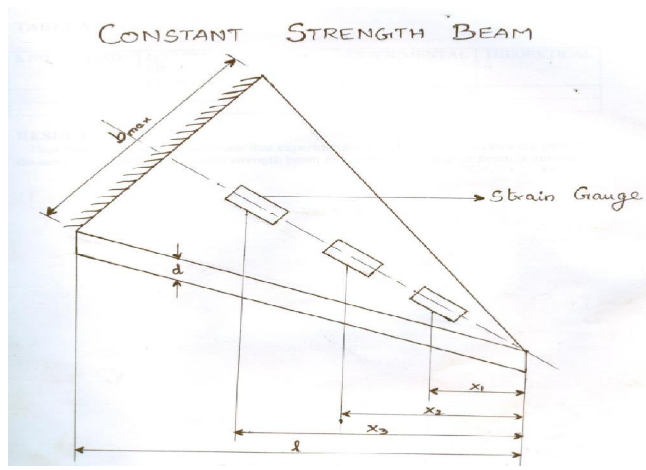
Tapered beam setup, Digital Strain indicator, weights, vernier calliper

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. σ_{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.

EXPERIMENT NO. 7

Combined Loading

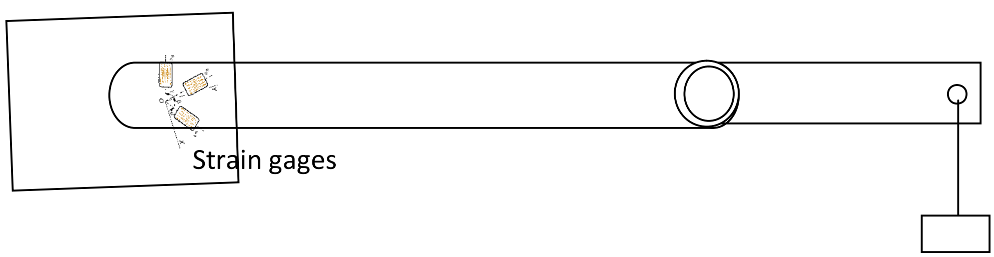
Aim:

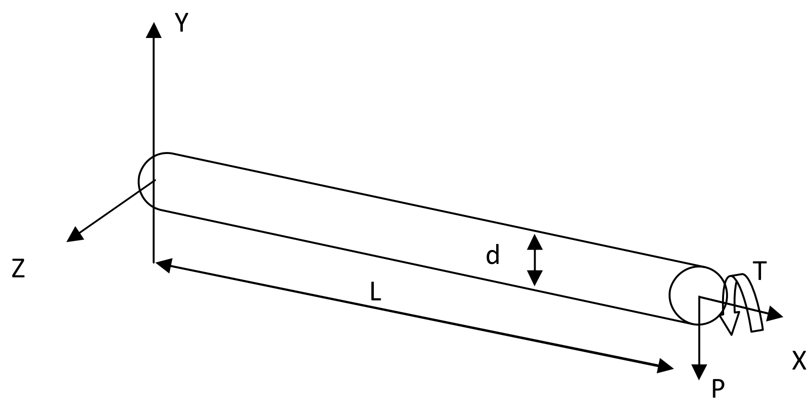
To determine the principle stresses and principle planed of a hollow circular shaft due to combined loading.

Apparatus Required:

Hollow circular shaft fixed as a cantilever, weight hanger with slotted weights, strain gauges, connection wires, strain indicator and micrometer.

Experimental Setup:





Procedure:

Two strain gauges are fixed near the root of the tube fixed as a cantilever, one on the top fiber and other at the bottom to measure the bending strain. Another strain gauge is fixed at the same location on the neutral axis at 45° to measure the shear strain. Similarly three more strain gauges are fixed at the middle of the length to verify the result at various location of the tube. The strain gauges on the top and bottom of the tube are connected to half bridge circuit in the strain indicator to increase the circuit sensitivity, since the tension and compression get added up. The strain gauge 45° is connected to the quarter bridge of the strain indicator to measure the shear strain. The outside diameter of the tube is measured using Vernier calipers. Weights are added to the hook attached to the lever in steps of two kg and the strain gauge readings are noted from the strain indicator for each load. From the strains the bending stress, shear stresses are calculated and hence principal stresses and principal angle are calculated. These values are compared with theoretical values.

Note:

For half bridge the strain readings are multiplied by two and quarter Bridge by four to get the actual strains.

Tabular column:

S.No	Axial Loading	Bending Load	TorsionLoad	ε_a	ε_b	ε_T	σ_x	τ_{xy}	σ_1	σ_2
1										
2										
3										

YOUNG`S Modulus of the tube =
Outside diameter of the tube =
Thickness of the tube =
Length of the tube =
Strain gauge resistance =
Gauge factor =
Distance of the strain gauges near root from tip =
Distance of the strain gauges at the middle from tip =
Distance from the center of the tube to the center of the hook =
Weight of the hook

Result:

Principle stress due to axial, bending and torsion are calculated

EXPERIMENT NO. 8

Calibration of photo-elastic material and determination of Stresses in circular discs and beams.

AIM:

To calibrate the photo elastic material and to determine the value of the fringe constant of the material

APPARTUS REQUIRED:

Plane Polariscope Photo-elastic setup, Circular disc, Load cell

FORMULA:

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

Where,

1. P = load applied on the model
2. N = Fringe order
3. D = Diameter of the circular disc
4. f_σ = fringe constant

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).
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 the fringe constant of the material is calculates as _____

EXPERIMENT NO. 9

Vibrations of beams

AIM:

To estimate the fundamental frequencies of the given cantilever beam under the action of load.

APPARATUS:

Cantilever beam setup, Transducer, Analyzer or Data Acquisition System (DAS)

PROCEDURE:

1. The specimen is clamped to the cantilever beam fixture
2. Transducer is attached to the tip of the cantilever beam
3. Force excitation at different locations are exhibited
4. The fundamental frequency of the beam under vibration is sensed by the transducer and displayed in the data acquisition monitor

PRECAUTIONS:

1. Check the connection properly connected or not

2. Readings should be regular taken note.

3. See that the equipement is far from the other vibrating sources.

RESULT: The natural frequency of the beam is

EXPERIMENT NO. 10

WAGNER'S BEAM

AIM: The objective of this experiment is to determine the constant K of Wagner beam.

APPARATUS: 1. Wagner's beam setup

THEORY:

In this analysis of wing beams of airplanes the designer is faced with several problems which, in general are present in Aeronautical engineering structural design.

The Aeronautical engineering Endeavour's to make the web sheet of all beams thickness enough so that the web will not buckle before the design load is reacted on the structure.

Buckling in a case of failure and the shearing stress causing buckling determines the allowable shear that can be applied. The critical buckling shear stress is given by

$$\tau_{cr} = \frac{\pi^2 E}{12(1-m^2)}\{\frac{t}{b}\}^2 \sigma_{cr} = \frac{k\pi^2 E}{12(1-\vartheta^2)}\{\frac{t}{b}\}^2$$

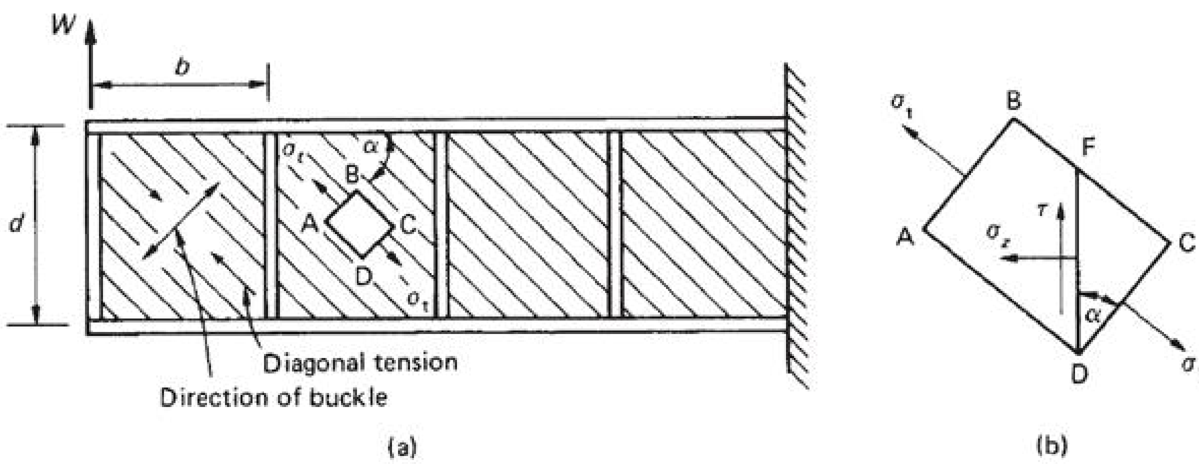


Fig. 1 Diagonal tension field beam.

The basic assumption of this theory is that total shear force in the web can be divided into a shear in the sheet and the shear force carried by diagonal tension.

$$k = (1 - \frac{\tau_{cr}}{\tau})^n$$

If the sheet is very thin, buckling stress given by equation is extremely low and in the interest of making, efficient use of all available material. The aircraft engineer raises the question as too much additional shear can be carried by such a buckled plate before.

- Some portion of the shear has a total stress equal to the yield point of the material. Thus giving rise to permanent deformation or
- The ultimate strength is reached.

OBSERVATIONS:

The thickness of plate :

Distance between the webs :

Distance between the supports :

Channel ï 1 ï red - white

Channel ï 2 ï blue - black

Channel – 3 – yellow – green

The Wagner beam constant for a given Wagner is beam to be positive value,

$$\sigma_x = \left(\frac{E}{1-\vartheta 2}\right)(\epsilon_x + \vartheta_{xy})$$

$$\sigma_y = \left(\frac{E}{1-\vartheta 2}\right)(\epsilon_y + \vartheta_{xy})$$

$$C_{xy} = \frac{E}{2(1+\vartheta)}\vartheta_{xy}$$

$$\sigma_1 = \frac{\sigma_x - \sigma_y}{2} + \frac{1}{2}\sqrt{\sigma_x - \sigma_y^2} + 4C_{xy}^2$$

$$\sigma_1 = \frac{\sigma_x - \sigma_y}{2} - \frac{1}{2}\sqrt{\sigma_x - \sigma_y^2} + 4C_{xy}^2$$

To find the Euler's critical buckling shear stress

$$\tau_{cr} = \frac{\pi^2 E}{12(1-m^2)}\{\frac{t}{b}\}^2$$

To find the shear buckling co-efficient K

$$k = (1 - \frac{\tau_{cr}}{\tau})^n$$

N=1 for linear materials

Where,

$$c = \frac{F}{bt(A)}$$

Shear load/ Area (thickness of plate * width of plate)

TABLE OF READING:

SL.No	Load in kg	ε_A	ε_C	ε_B	σ_x Mpa	σ_y Mpa	C_{xy} Mpa	σ_1 Mpa	σ_2 Mpa

Result:

Thus the constant K of Wagner beam is calculated