Indian Institute Of Technology Kanpur

AE 351A
Experiments in Aerospace Engineering 2020-21
Semester II

Principal axes of a given cross-section in a thin walled beam

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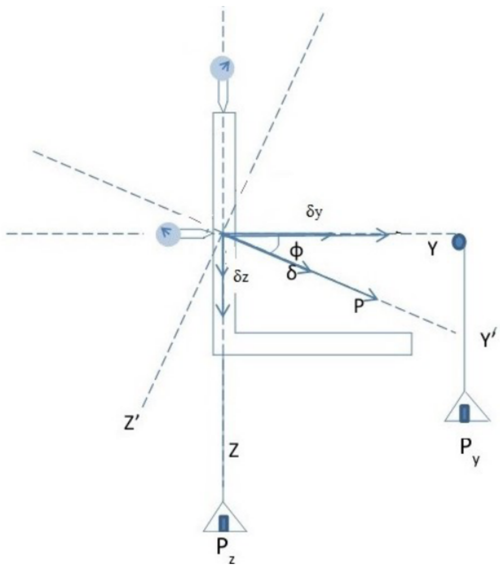
February 12, 2021

1 Objective

To determine the principal axes and the orientation of principal planes of an L section beam.

2 Introduction and Theory



3 Equipment's

- Aluminium alloy 6063 series beam
- Dial gage
- Strain gage
- Weights(1kg)
- Computer setup

4 Procedure and Measurement

- Measure the thickness of the web and flange of the L section. Also measure the length of the flange and the height of the web to determine the values of I_{zz}, I_{yy}, I_{yz}.
- Adjust the dial gauges to remove any zero error while supporting the pans with your hands to have the no load initial setup.

- Fix the y-direction load P_y , and for some random z-direction load P_z , note the beam deflections δ_y and δ_z.
- Increase the loads in each of the pan and calculate the ratio of loads and the ratio of deflections produced. They should be almost equal i.e., the difference between these two ratios should be very small.
- Repeat the steps above for different values of P_y and P_z .

L_1	d_1	L_2	d_2
24.8mm	3.09mm	22.08mm	3.18mm

Table 1: L shape beam specification

5 Results and Discussion

5.1 Sample Calculation

Calculation of second moment of area of the beam
with respect to reference frame
section-1 CG ($Y_1 = 12.4mm, Z_1 = -1.545mm$)
section-2 CG ($Y_2 = 1.59mm, Z_2 = -12.585mm$)
Area of section-1 $A_1 = 76.632mm^2$
Area of section-2 $A_2 = 70.2144mm^2$

$$Y_{cg} = \frac{Y_1 * A_1 + Y_2 * A_2}{A_1 + A_2} = 7.2312mm$$

$$Z_{cg} = \frac{Z_1 * A_1 + Z_2 * A_2}{A_1 + A_2} = -6.8237mm$$

$$I_{yy} = \frac{L_1 * d_1^3}{12} + A_1 * (Z_1 - Z_{cg})^2 + \frac{d_2 * (L_2 - d_1)^3}{12} + A_2 * (Z_2 - Z_{cg})^2$$

$$I_{yy} = (60.9741 + 2135.3256 + 1814.7665 + 2330.597)mm^4$$

$$I_{yy} = 6341.6631mm^4$$

$$I_{zz} = \frac{d_1 * L_1^3}{12} + A_1 * (Y_1 - Y_{cg})^2 + \frac{(L_2 - d_1) * d_2^3}{12} + A_2 * (Y_2 - Y_{cg})^2$$

$$I_{zz} = (3927.645 + 610.669 + 50.889 + 2234.4425)mm^4$$

$$I_{zz} = 6823.6467mm^4$$

$$I_{yz} = A_1 * (Y_1 * Z_1) + A_2 * (Y_2 * Z_2)$$

$$I_{yz} = 76.632 * (12.4 * (-1.545)) + 70.2144 * (1.59 * (-12.585))$$

$$I_{yz} = -2873.1165mm^4$$

Calculation of orientation of principal axis using moment of inertia

$$\tan 2\phi = \frac{-2I_{yz}}{I_{yy} - I_{zz}}$$

$$2\phi = -85.20535$$

$$\phi = -42.6026\,\deg$$

5.2 Data Presentation

No.	P_y	P_z	Δy	Δz	$\frac{P_y}{P_z}$	$\frac{\delta y}{\delta z}$
1	10	5	-38	-4	2.0	9.5
2	10	10	-26	-34	1.0	0.765
3	10	15	-10	-68	0.667	0.147
4	10	20	2	-101	0.5	-0.02
5	10	25	16	-131	0.4	-0.122

When load Pz is constant and load Py is varying

5.3 Discussion and Error Analysis

6 Conclusion

7 Appendix

No.	P_y	P_z	Δy	Δz	$\frac{P_y}{P_z}$	$\frac{\delta y}{\delta z}$
1	5	15	15	-80	0.333	-0.188
2	10	15	-9	-72	0.667	0.125
3	15	15	-38	-56	1.0	0.679
4	20	15	-64	-46	1.333	1.391