LAB REPORT

AE351

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

INSHU NAMDEV
(170308)

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

Theory: Principal axes of the moment of inertia are the two mutually perpendicular axes passing through the centroid of the given body such that its moment of inertia about one of them is a maximum whereas that about the other is minimum. Moreover, the product of inertia of the section with respect to these special axes is always zero. The thing of interest about the principal axes is that when loads are applied along these axes they produce deflection only along the direction of the applied force.
Due to the thin nature of aircraft structures, the assumption can be made that stresses are constant throughout the section.

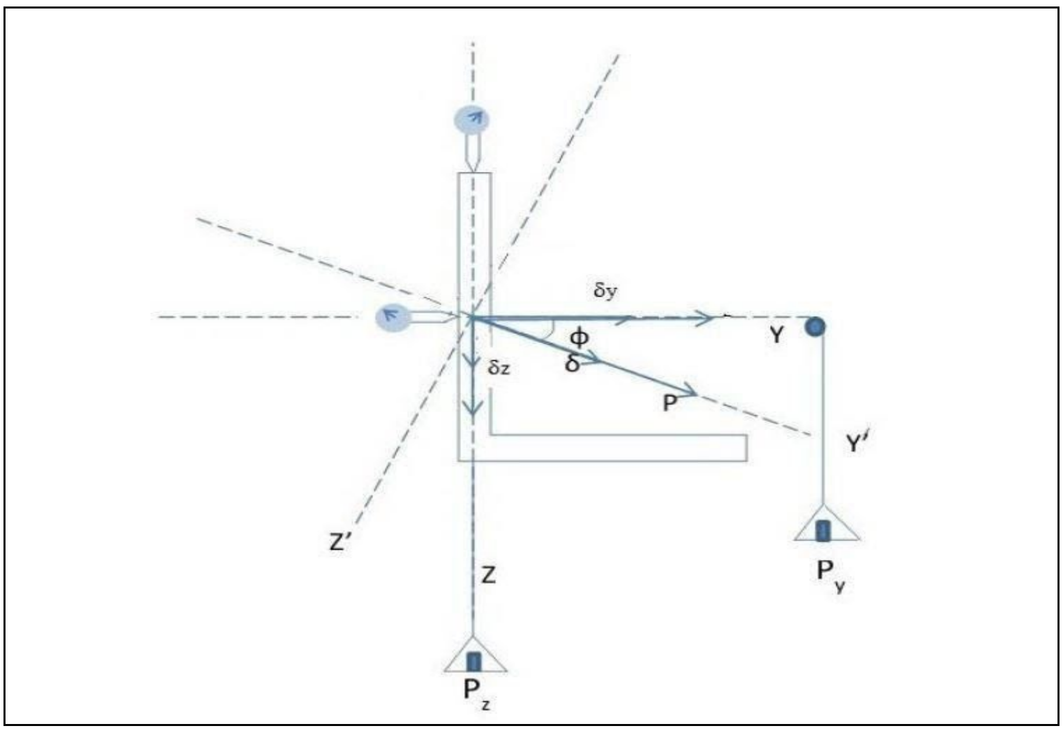


Figure 1: Experimental Setup

Here Y'Z' is the principal axes of the cross-section and YZ is our defined co-ordinate axes.

Theoretically, the orientation of the principal axes is given by,

$$\boldsymbol{tan2\Phi = \frac{-2I_{yz}}{I_{yy} - I_{zz}}}$$

Experimentally, the orientation of the principal axes is given by,

$$\tan \emptyset = \frac{P_z}{P_y} = \frac{\delta_z}{\delta_y}$$

Equipment:

- L-section beam
- Dial gauges to measure the deflections
- Digital Vernier caliper
- Weight carrying pans
- Weights (100gm, 200gm, 500gm)

Procedure:

- Measured the length and thickness of the web and flange of the L section and determined the values of I_{zz}, I_{yy} and I_{yz}.
- Adjusted the dial gauges to remove any zero error.
- Fixed the y-direction load P_y, and for some random z-direction load P_z, note the beam deflections δ_y and δ_z.
- Increased the loads in each of the pan and calculated the ratios of loads and the ratios of deflections produced.

Measurements:

1. Dimensions of web and Flange.

S No.	L_1 (mm)	d_1 (mm)	L_2 (mm)	d_2 (mm)
1	24.17	3.15	24.32	3.11
2	24.11	3.29	24.20	3.19
3	24.10	3.14	24.45	3.18
4	24.03	3.05	24.74	3.08
AVERAGE	**24.10**	**3.16**	**24.43**	**3.14**

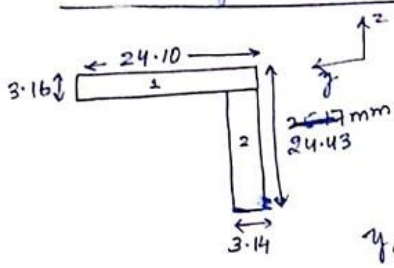
2. Experimental reading

P_Y(N)	P_Z(N)	δ_Y(mm)	δ_Z(mm)	P_Y/P_Z	δ_Y/δ_Z
5	5	13	15	1	0.866
5.98	5	16	17	1.196	0.942
6.47	5	19	16	1.294	1.188

5.98	6.47	19	17	0.924	1.117
5.49	5.98	15	20	0.918	0.75
10	10	28	33	1	0.848
11.47	10.98	35	34	1.045	1.0294

Calculations:

Moment of Inertia calculation:-



centroid	y	z	area
Sec 1	12.05	-1.58	76.15
Sec 2	1.57	-12.22	76.71

$y_{cg} = \frac{y_1 A_1 + y_2 \times A_2}{A_1 + A_2} = 6.79\text{ mm}$

$z_{cg} = \frac{z_1 A_1 + z_2 A_2}{A_1 + A_2} = -6.919\text{ mm} = -6.92\text{ mm}$

$d_1 = 3.16;\ d_2 = 3.14;\ L_1 = 24.10;\ L_2 = 24.43\ (\text{mm})$

$\rightarrow I_{yy} = \left(\frac{d_1^3 * (L_1)}{12}\right) + (z_1 - z_{cg})^2 * A_1 + \frac{d_2 * (L_2 - d_1)^3}{12} + [(z_2 - z_{cg})^2 * A_2)$

$= 63.37 + 2170.64 + 2517.97 + 2155.6 = 8807.577\text{ mm}^4$

$\rightarrow I_{zz} = \left(\frac{d_1 * L_1^3}{12}\right) + (y_1 - y_{cg})^2 * A_1 + \frac{d_2^3 * (L_2 - d_1)}{12} + [(y_2 - y_{cg})^2 * A_2]$

$= 3039.5 + 2106.8 + 54.87 + 2090.2 = 8091.39$

$\rightarrow I_{yz} = [(z_1 - z_{cg}) * (y_1 - y_{cg}) * A_1] + [(z_2 - z_{cg}) * (y_2 - y_{cg}) * A_2)]$

$= +2138.93 + (+2122.26)$

$= +4261.19\text{ mm}^4$

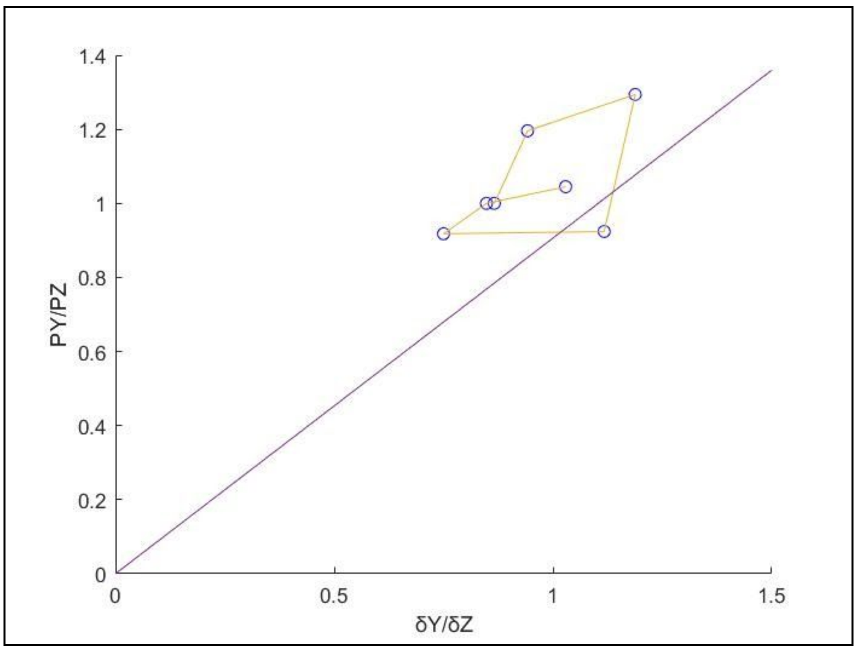
$\tan 2\phi = \frac{-2 I_{yz}}{I_{yy} - I_{zz}} = \cancel{22.25}\ -11.43$

$2\phi = \tan^{-1}(11.43) = -84.99$

$\phi = \frac{84.99}{2} = -42.499 \approx -42.5^\circ$

Conclusion:

Hence we have determined the principal axis theoretically as well as experimentally.
Theoretical: 45°
Experimental: 42.5°
B0th the results are almost similar. The small error might be attributed to the nonuniformity of the beam, errors in dial gauge, inaccurate weights.



PRECAUTIONS :

- Calibrate the dial gauge before taking the readings.
- Make sure the experimental setup is not disturbed while taking readings.
- Make sure the pans are not oscillating.