Subject Code & Name**: 23AST205-Aerospace Structures**

TOPIC: **6. Neutral axis method Unsymmetrical section bending**

Unsymmetrical section bending Thin Walled Sections

Due to the thin nature of aircraft structures, the assumption can be made that stresses are constant through the thickness 't' of the skin. By saying this, the square and higher powers of 't' can be neglected from the computation of sectional properties.

To see this, look at a channel section:

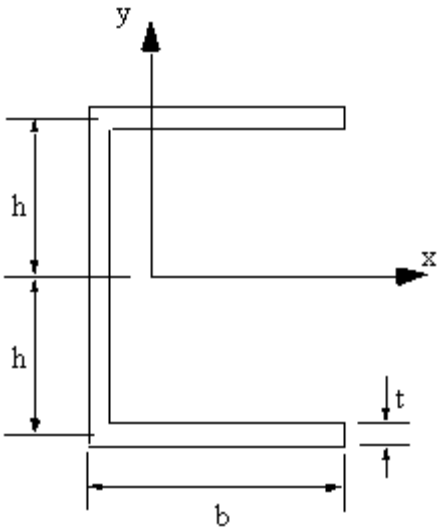

Figure : Thin-walled channel section.

1) Because the section is symmetrical about the x-axis, then $I_{xy} = 0$
2) The second moment of area I_{xx} is given by:

$$I_{xx} = 2\left(\frac{bt^3}{12} + bth^2\right) + \frac{t[2(h - t/2)]^3}{12}$$

Expanding the RHS, gives:

$$I_{xx} = 2\left(\frac{bt^3}{12} bth^3\right) + \frac{t}{12}\left[2^3\left(h^3 - 3h^2\frac{t}{2} + 3h\frac{t^2}{4} - \frac{t^3}{8}\right)\right]$$

by eliminating t^2 powers and higher it becomes:

$$I_{xx} = 2bth^2 + \frac{t(2h)^3}{12}$$

and similarly

$$I_{yy} = 2\frac{tb^3}{12} + 2tb\left(\frac{hb}{2b+2h}\right)^2 + 2ht\left(\frac{b^2}{2b+2h}\right)^2$$

This indicates that the sectional properties may be calculated as if the section was represented by a thin line, as shown in Figure 18, disregarding any t^2 or higher terms.

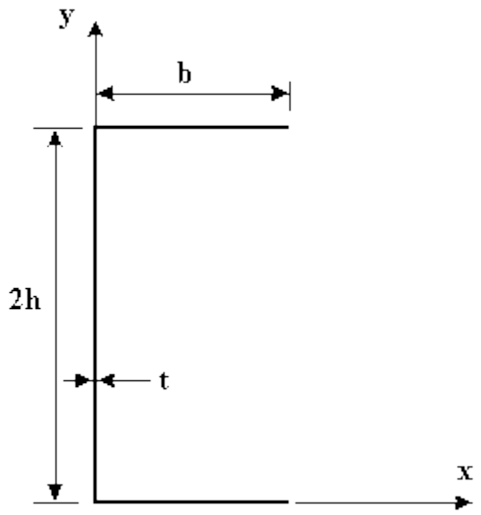

Figure : Approximation of channel section.

For this discrete thin walled section, the sectional properties would be found as follows:

1) Determine location of centroid

$$\bar{x} = \frac{2bt\frac{b}{2}}{2bt+2ht} = \frac{b^2}{2b+2h}$$
$$\bar{y} = \frac{bt(2h)+(2ht)h}{2bt+2ht} = h$$

2) Shift axis to centroid

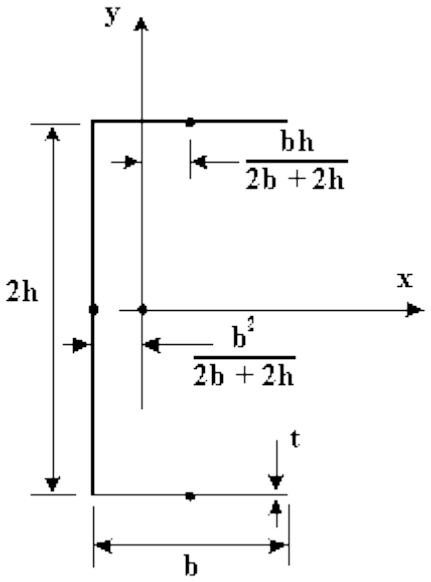

Figure : Axis at centroid

3) Determining moments of inertia

$$I_{xx} = \frac{t(2h)^3}{12} + 2bth^2$$

$$I_{yy} = \frac{2tb^3}{12} + 2bt\left[\frac{hb}{2b + 2h}\right] + 2ht\left[\frac{b^2}{2b + 2h}\right]$$

These results are exactly the same as for the section considering the skin material thickness and then disregarding all $t^2$and higher terms.

Since not all skin sections will lie parallel to either the x or y axis, the local moments or area for a section of skin at an angle θ with respect to the x-axis are given by the following equations.

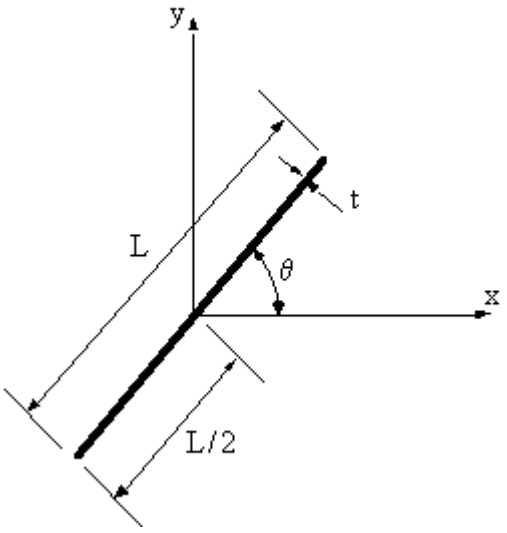

Figure : Thin skin section inclined at an angle θ wrt the x-axis

$$I_{xx} = \frac{L^3 t \sin^2(\theta)}{12} \quad , \quad I_{yy} = \frac{L^3 t \cos^2(\theta)}{12} \quad , \quad I_{xx} = \frac{L^3 t \sin(2\theta)}{24} \tag{3.12}$$