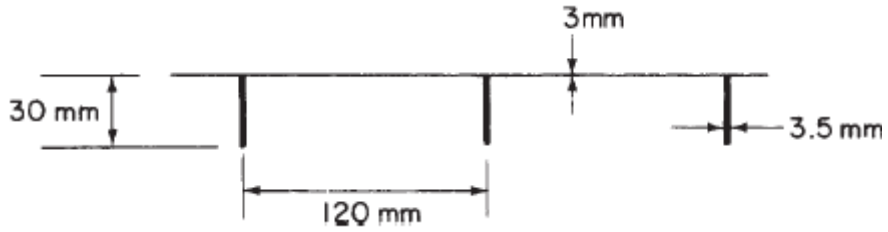
MECÂNICA DE ESTRUTURAS AEROESPACIAIS

Problems of practical classes of the chapter

Example 9.4

Part of a compression panel of internal construction is shown in figure below.



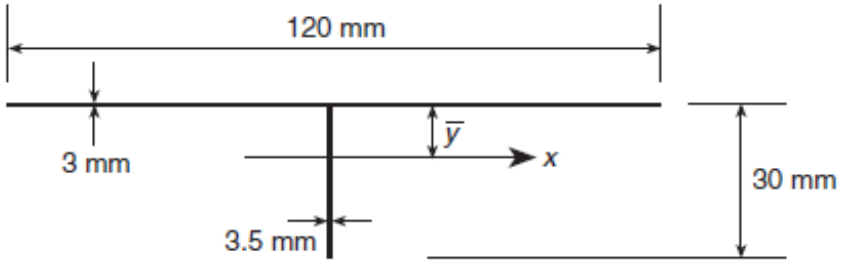
The equivalent pin-centre length of the panel is 500 mm. The material has a Young's modulus of 70 000 N/mm^2. Taking coefficients of 3.62 for buckling of a plate with simply supported sides and of 0.385 with one side simply supported and one free, determine the load per mm width of panel when initial buckling may be expected (treating the material as thin for calculating section constants).

Ans. 613.8 N/mm

Solution

(a) Consider, initially, the buckling of the panel as a pin-ended column.

For a section comprising a width of sheet and associated stiffener as shown in Figure below.



$A = 120 \times 3 + 30 \times 3.5 = 465\ mm^2$

Also

$465y' = 30 \times 3.5 \times 15 + 120 \times 3 \times 1.5$

i.e. $y' = 4{,}5\ mm$

Then

$$I_x = 120 \times 3 \times 4.5^2 + \frac{120 \times 3^3}{12} + \frac{3.5 \times 4.5^3}{3} + \frac{3.5 \times 25.5^3}{3}$$

i.e.

$$I_x = 27\,011\,\text{mm}^4$$

Hence

$$r = \sqrt{\frac{27\,011}{465}} = 7.62\,\text{mm}$$

From

$$\sigma_{CR} = \frac{\pi^2 \times 70\,000}{(500/7.62)^2}$$

i.e.

$$\sigma_{CR} = 160.5\,\text{N/mm}^2$$

From the equivalent skin thickness is

$$\bar{t} = \frac{30 \times 3.5}{120} + 3 = 3.875\,\text{mm}$$

Overall buckling of the panel will occur when

$$N_{x,CR} = \sigma_{CR}\bar{t} = 160.5 \times 3.875 = 621.9\,\text{N/mm}$$

Buckling of the sheet will occur when

$$\sigma_{CR} = 3.62E\left(\frac{t}{b}\right)^2 = 3.62 \times 70\,000\left(\frac{3}{120}\right)^2$$

i.e.

$$\sigma_{CR} = 158.4\,\text{N/mm}^2$$

Hence

$$N_{x,CR} = 158.4 \times 3.875 = 613.8\,\text{N/mm}$$

Buckling of the stiffener will occur when

$$\sigma_{CR} = 0.385E\left(\frac{t}{b}\right)^2 = 0.385 \times 70\,000\left(\frac{3.5}{30}\right)^2$$

i.e.

$$\sigma_{CR} = 366.8\,\text{N/mm}^2$$

whence

$$N_{x,\mathrm{CR}} = 366.8 \times 3.875 = 1421.4\,\mathrm{N/mm}$$

By comparison all results (overall buckling, buckling of thin plate and buckling of the stiffener) onset of buckling will occur when

$$N_{x,\mathrm{CR}} = 613.8\,\mathrm{N/mm}$$