20.2 Idealization of a panel

Suppose that we wish to idealize the panel of Fig. 20.3(a) into a combination of direct stress carrying booms and shear stress only carrying skin as shown in Fig. 20.3(b). In Fig. 20.3(a) the direct stress carrying thickness t_D of the skin is equal to its actual thickness t while in Fig. 20.3(b) $t_D = 0$. Suppose also that the direct stress distribution in the actual panel varies linearly from an unknown value σ_1 to an unknown value σ_2.

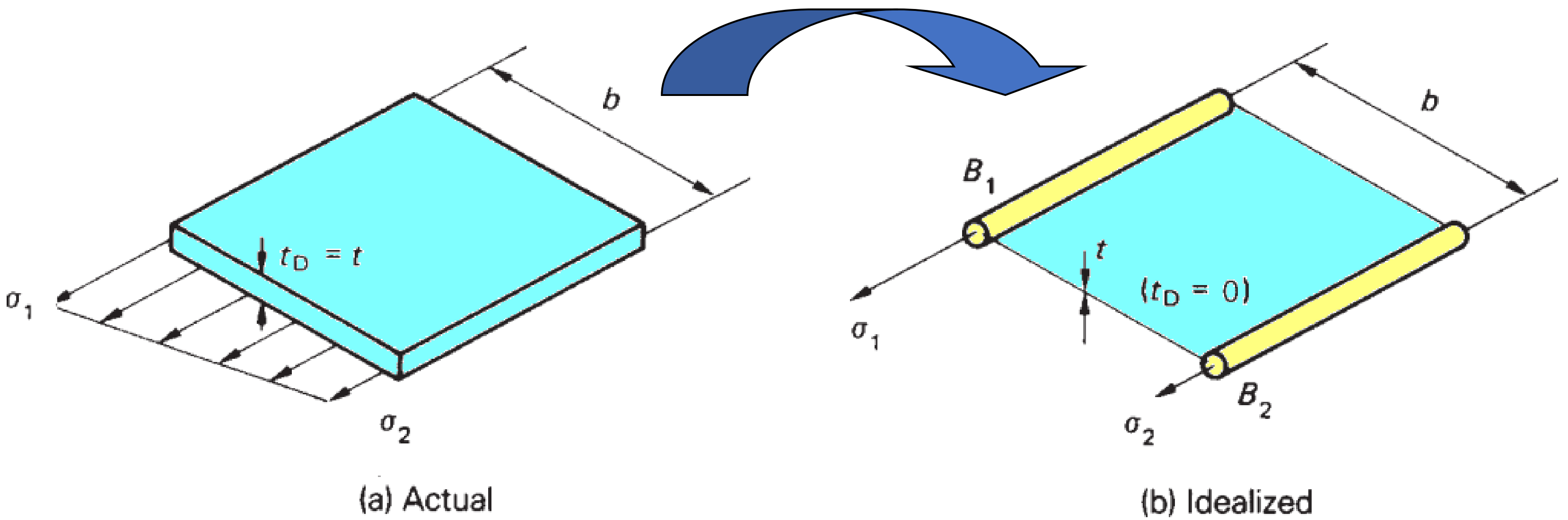

Fig. 20.3 Idealization of a panel.

Idealization of a panel

The analysis should predict the extremes of stress σ_1 and σ_2 although the distribution of direct stress is obviously lost. Since the loading producing the direct stresses in the actual and idealized panels must be the same, we can equate moments to obtain expressions for the boom areas B_1 and B_2.

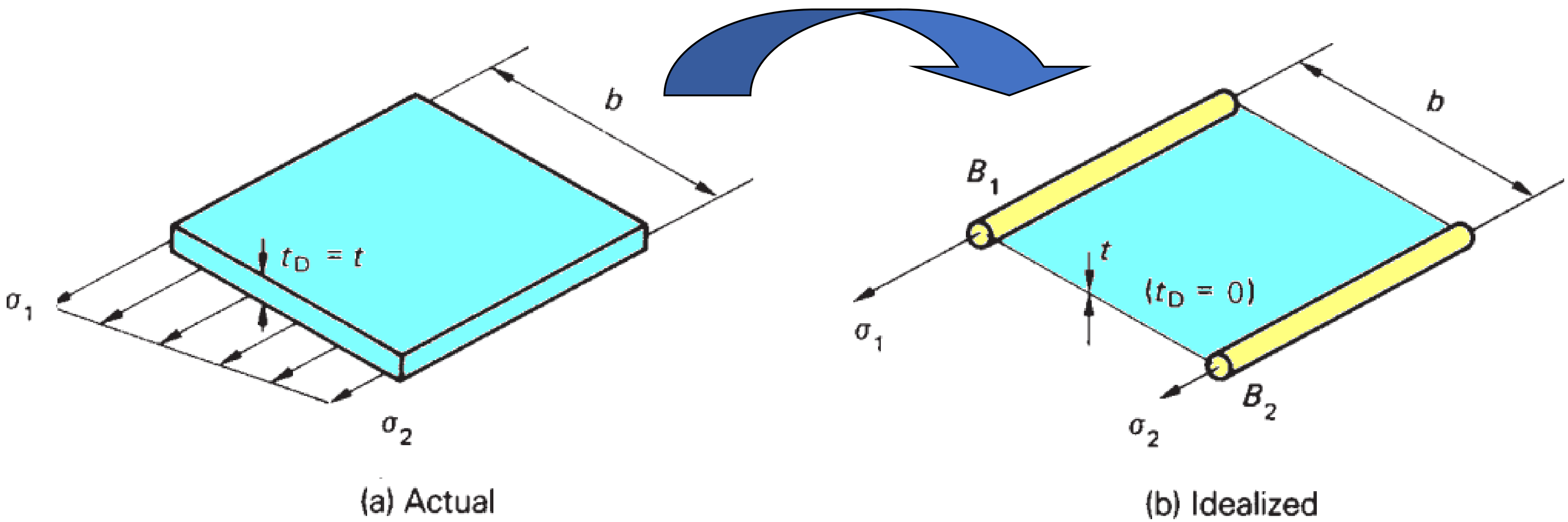

Fig. 20.3 Idealization of a panel.

Idealization of a panel

Taking moments about the right-hand edge of each panel

$$\sigma_2 t_D \frac{b^2}{2} + \frac{1}{2}(\sigma_1 - \sigma_2) t_D b \frac{2}{3} b = \sigma_1 B_1 b$$

$$B_1 = \frac{t_D b}{6}\left(2 + \frac{\sigma_2}{\sigma_1}\right) \tag{20.1}$$

Similarly

$$B_2 = \frac{t_D b}{6}\left(2 + \frac{\sigma_1}{\sigma_2}\right) \tag{20.2}$$

In Eqs (20.1) and (20.2) the ratio of σ_1 to σ_2, if not known, may frequently be assumed.

For axial load only $\sigma_1/\sigma_2 = 1$ **and** $B_1 = B_2 = t_D b/2$;
for a pure bending moment $\sigma_1/\sigma_2 = -1$ **and** $B_1 = B_2 = t_D b/6$.

Idealization of a panel

Example 20.1

Part of a wing section is in the form of the two-cell box shown in Fig. 20.4(a) in which the vertical spars are connected to the wing skin through angle sections all having a cross-sectional area of 300mm^2. Idealize the section into an arrangement of direct stress carrying booms and shear stress only carrying panels suitable for resisting bending moments in a vertical plane. Position the booms at the spar/skin junctions.

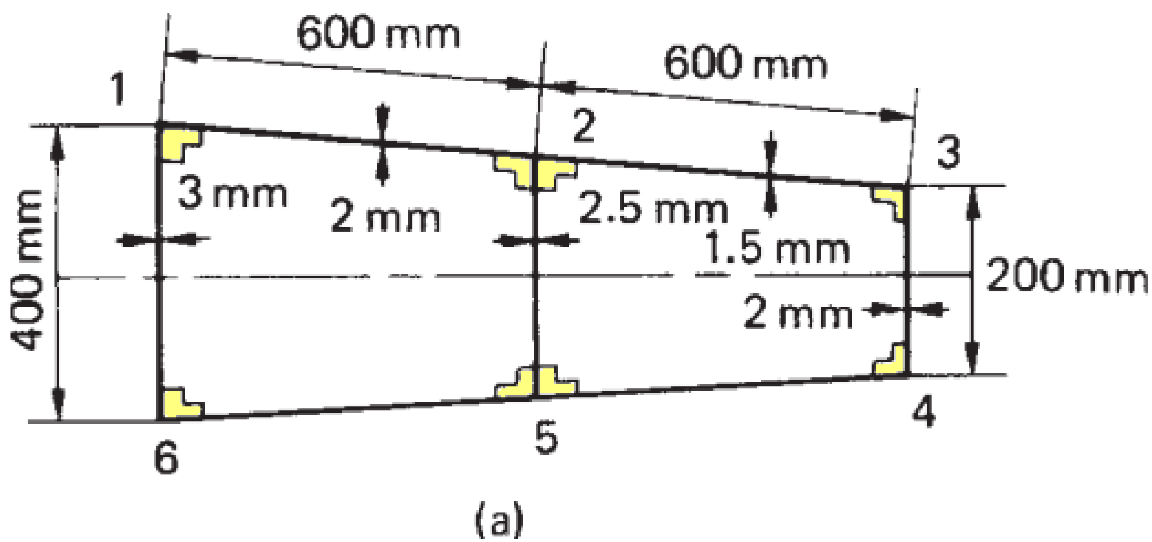

Fig. 20.4 Idealization of a wing section.

Idealization of a panel

Solution

The idealized section is shown in Fig. 20.4(b) in which, from symmetry, $B_1 = B_6$, $B_2 = B_5$, $B_3 = B_4$. Since the section is required to resist bending moments in a vertical plane, the direct stress at any point in the actual wing section is directly proportional to its distance from the horizontal axis of symmetry. Further, the distribution of direct stress in all the panels will be linear so that either of Eqs (20.1) or (20.2) may be used.

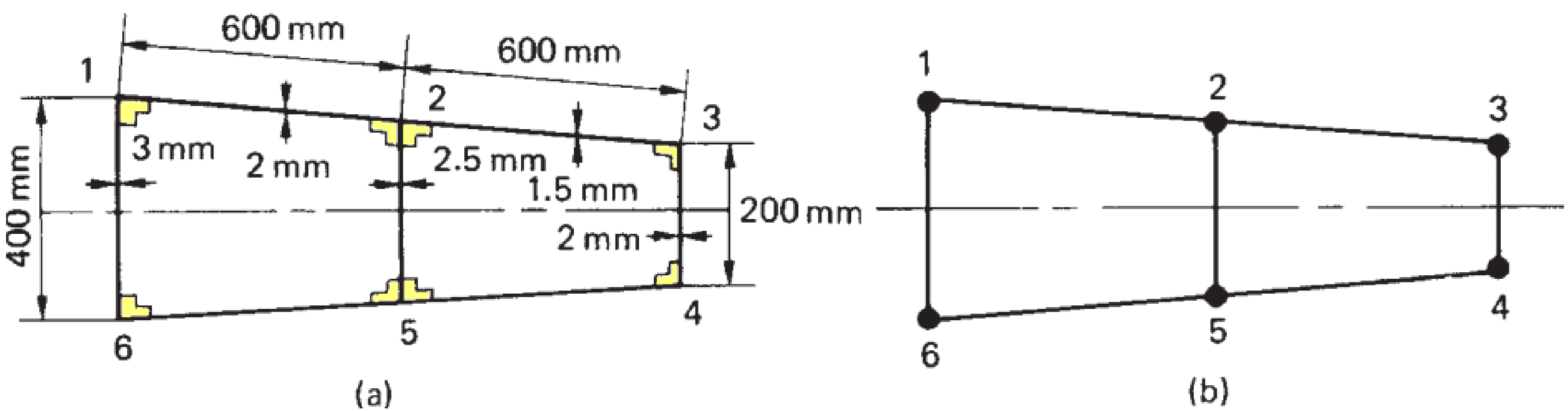

Fig. 20.4 Idealization of a wing section.

Idealization of a panel

$$B_1 = 300 + \frac{3.0 \times 400}{6}\left(2 + \frac{\sigma_6}{\sigma_1}\right) + \frac{2.0 \times 600}{6}\left(2 + \frac{\sigma_2}{\sigma_1}\right)$$

$$B_1 = 300 + \frac{3.0 \times 400}{6}(2 - 1) + \frac{2.0 \times 600}{6}\left(2 + \frac{150}{200}\right)$$

$$B_1(=B_6) = 1050\,\text{mm}^2$$

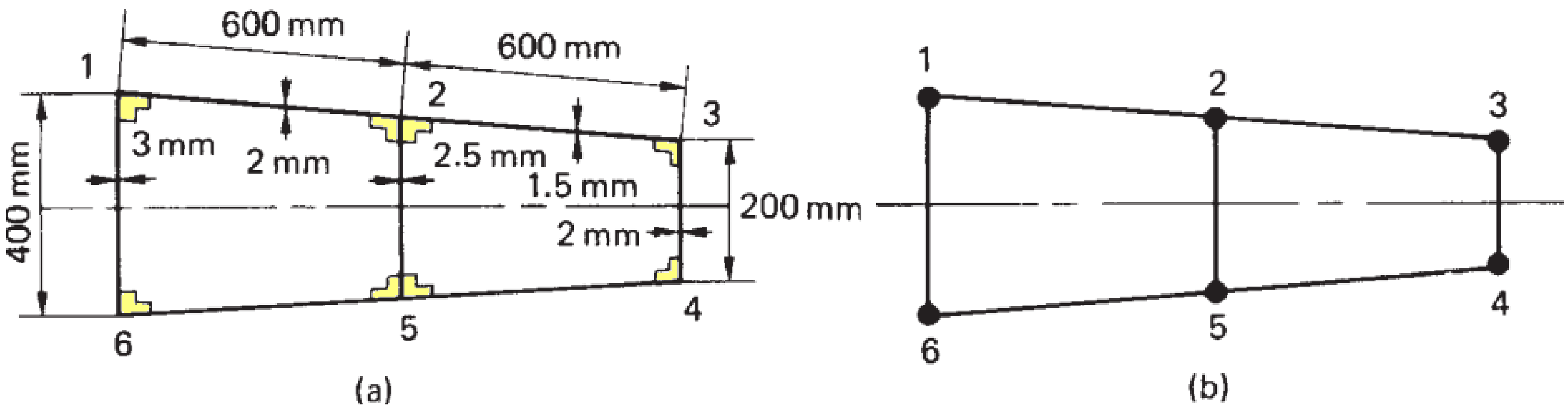

Fig. 20.4 Idealization of a wing section.

Idealization of a panel

$$B_2 = 2 \times 300 + \frac{2.0 \times 600}{6}\left(2 + \frac{\sigma_1}{\sigma_2}\right) + \frac{2.5 \times 300}{6}\left(2 + \frac{\sigma_5}{\sigma_2}\right) + \frac{1.5 \times 600}{6}\left(2 + \frac{\sigma_3}{\sigma_2}\right)$$

$$B_2 = 2 \times 300 + \frac{2.0 \times 600}{6}\left(2 + \frac{200}{150}\right) + \frac{2.5 \times 300}{6}(2 - 1) + \frac{1.5 \times 600}{6}\left(2 + \frac{100}{150}\right)$$

$$B_2 (= B_5) = 1791.7\,\text{mm}^2$$

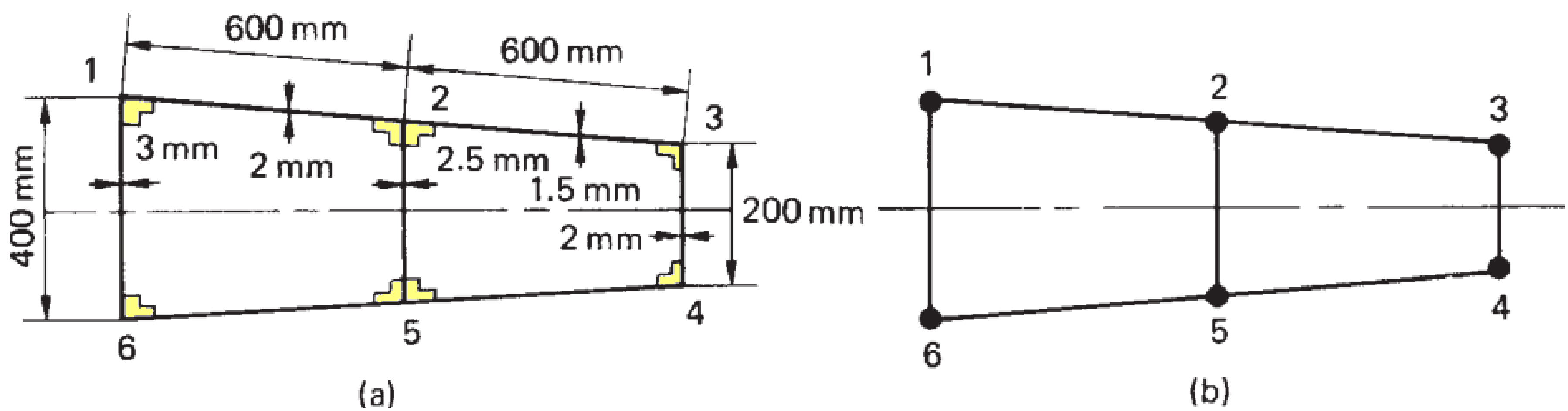

Fig. 20.4 Idealization of a wing section.

Idealization of a panel

$$B_3 = 300 + \frac{1.5 \times 600}{6}\left(2 + \frac{\sigma_2}{\sigma_3}\right) + \frac{2.0 \times 200}{6}\left(2 + \frac{\sigma_4}{\sigma_3}\right)$$

$$B_3 = 300 + \frac{1.5 \times 600}{6}\left(2 + \frac{150}{100}\right) + \frac{2.0 \times 200}{6}(2 - 1)$$

$$B_3(= B_4) = 891.7\,\mathrm{mm}^2$$

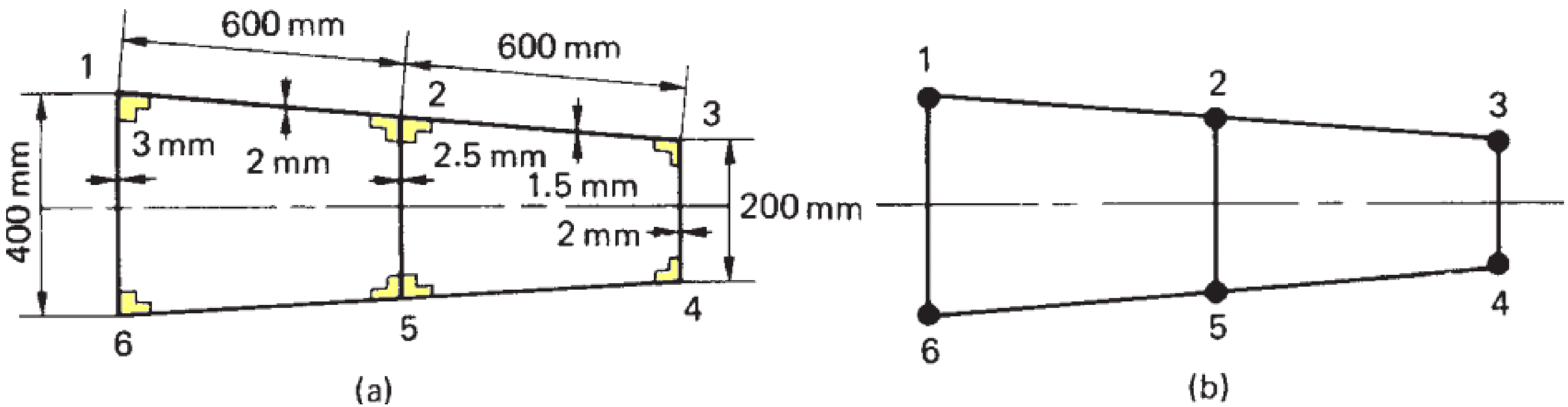

Fig. 20.4 Idealization of a wing section.

Idealization of a panel

Generally, in any idealization, different loading conditions require different idealizations of the same structure.

In Example 20.1, the loading is applied in a vertical plane. If, however, the loading had been applied in a horizontal plane, the assumed stress distribution in the panels of the section would have been different, resulting in different values of boom area.

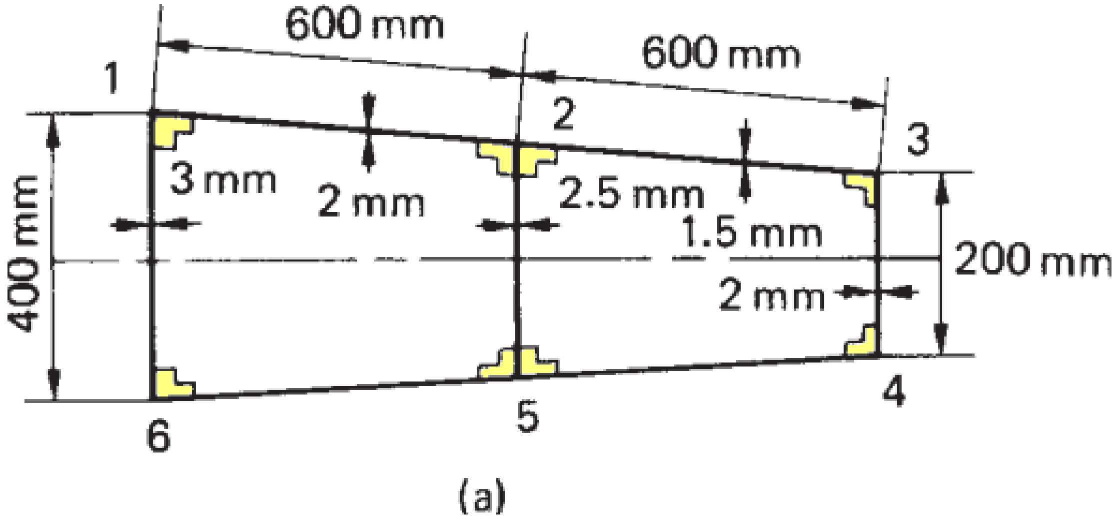

Fig. 20.4 Idealization of a wing section.