6. Putting the equations into a form more suitable for trial-and-error solution of $\bar{\sigma}$ (though (h)-(iii) may be solved directly):

$$\begin{aligned}
&\text{(h)-(i)} \quad \Theta\left[1+\eta \sec\tfrac{\pi}{2}\sqrt{\psi}\right] = 1 \\
&\text{-(ii)} \quad \Theta\left[1+\eta\left(\sec\tfrac{\pi}{2}\sqrt{\psi}-1\right).\,8/\pi^2\psi\right] = 1 \\
&\text{-(iii)} \quad \Theta\left[1+\eta/(1-\psi)\right] = 1
\end{aligned}$$

in which $\eta = 0.1$ or 1.0; $\Theta = \bar{\sigma}/\hat{\sigma}$; $\hat{\sigma} = S = 200$ MPa; $\psi = \bar{\sigma}/\sigma_c$; $\sigma_c = 150$ MPa

The $\bar{\sigma}$ which eventuate are:

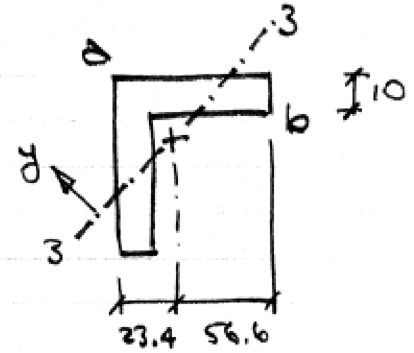
η	0.1			1.0		
(h)	(i)	(ii)	(iii)	(i)	(ii)	(iii)
$\bar{\sigma}$ MPa	121.7	124.6	125.0	66.7	69.3	69.7

The advantages of (h)(iii) in yielding a closed-form solution are evident. This equation is also the simplest though the least conservative of the three. One concludes from these results that the form of the imperfection is of much less significance than the magnitude. This is confirmed by the expansion of the equations, thus:

$$\sec\alpha = 1 + \tfrac{1}{2}\alpha^2 + \tfrac{5}{24}\alpha^4 + \tfrac{61}{720}\alpha^6 + \cdots$$

$$\begin{aligned}
&\text{(i)} \quad (1/\Theta - 1)/\eta = \sec\tfrac{\pi}{2}\sqrt{\psi} &&= 1 + 1.234\psi + 1.268\psi^2 + \cdots \\
&\text{(ii)} \quad\quad = \left(\sec\tfrac{\pi}{2}\sqrt{\psi}-1\right)8/\pi^2\psi &&= 1 + 1.028\psi + 1.032\psi^2 + \cdots \\
&\text{(iii)} \quad\quad = (1-\psi)^{-1} &&= 1 + \psi + \psi^2 + \cdots
\end{aligned}$$

7. Bending will occur about the axis for which I is a minimum – eg. the 3-3 axis shown :-



Properties of the section, from tables:-

$A = 1510$ mm² $\quad I_{min} = 36.3\times10^4$ mm⁴

$\therefore\ r = \sqrt{I/A} = 15.5$ mm

$\rho = L/r = 10^3/15.5 = 64.5$

$\therefore\ \sigma_c = E(\pi/\rho)^2 = 491$ MPa.

Given $\hat{e} = L/1000 = 1$ mm.

An estimate of $\hat{y}$ is necessary for determining η.

From sketch: $y_a = 23.4\sqrt{2} = 33.1$ mm

$y_b = 80/\sqrt{2} - 23.4\sqrt{2} + 10/\sqrt{2} = 30.6$ mm

(the latter value neglects rounding)

$\therefore\ \hat{y} = 33.1$ mm

So $\eta = \hat{e}\hat{y}/r^2 = 1\times33.1/15.5^2 = 0.138$

Use equation (2) – based on (h)-(iii) as being more direct than (h)-(i), viz :-

$$\bar{\sigma}^2 - \bar{\sigma}\left[S + (1+\eta)\sigma_c\right] + S\sigma_c = 0$$

$$\bar{\sigma}^2 - \bar{\sigma}\left[250 + 1.138\times491\right] + 250\times491 = 0$$

whence $\bar{\sigma} = nF/A = 202.5$ MPa

$\therefore\ F = 202.5\times1510/2 = \underline{153\text{ MPa}}$

contd . . .