$\sigma_{m,g,par} = 5.3\ N/mm^2$

K_3 (medium term) $= 1.25$

Purlins will be spaced at centres greater than 600 mm and therefore are not load sharing; hence K_8 factor does not apply.

Approximate Z_{xx} required

$$= \frac{M}{\sigma_{m,g,par} K_3} = \frac{2.98 \times 10^6}{5.3 \times 1.25} = 449\,811\ mm^3 = 450 \times 10^3\ mm^3$$

Maximum depth to breadth ratio to avoid lateral buckling is 5.

From Table 2.4:

For 75 mm × 200 mm sawn joists: $Z_{xx} = 500 \times 10^3\ mm^3$

For 63 mm × 225 mm sawn joists: $Z_{xx} = 532 \times 10^3\ mm^3$

For 75 mm × 225 mm sawn joists: $Z_{xx} = 633 \times 10^3\ mm^3$

Check with $K_7 = 1.032$:

$$\text{Final } Z_{xx} \text{ required} = \frac{450 \times 10^3}{1.032} = 436 \times 10^3\ mm^3$$

Deflection

Permissible $\delta_p = 0.003 \times \text{span} = 0.003 \times 2650 = 7.95\ mm$

Since purlins are not load sharing, E_{min} must be used when calculating the actual deflection.

$$\text{Actual } \delta_a = \delta_m + \delta_v = \frac{5}{384}\frac{WL^3}{EI} + \frac{19.2M}{AE}$$

$$\text{For } 75 \times 200\text{: } \delta_a = \frac{5}{384} \times \frac{9 \times 10^3 \times 2650^3}{5800 \times 50 \times 10^6} + \frac{19.2 \times 2.98 \times 10^6}{15 \times 10^3 \times 5800}$$

$$= 7.5 + 0.66 = 8.16\ mm > 7.95\ mm$$

$$\text{For } 63 \times 225\text{: } \delta_a = \frac{5}{384} \times \frac{9 \times 10^3 \times 2650^3}{5800 \times 59.8 \times 10^6} + \frac{19.2 \times 2.98 \times 10^6}{14.2 \times 10^3 \times 5800}$$

$$= 6.29 + 0.69 = 6.98\ mm < 7.95\ mm$$

$$\text{For } 75 \times 225\text{: } \delta_a = \frac{5}{384} \times \frac{9 \times 10^3 \times 2650^3}{5800 \times 71.2 \times 10^6} + \frac{19.2 \times 2.98 \times 10^6}{16.9 \times 10^3 \times 5800}$$

$$= 5.28 + 0.58 = 5.86\ mm < 7.95\ mm$$

Thus both 63 mm × 225 mm and 75 mm × 225 mm joists are adequate.

Shear unnotched

Maximum shear $F_v = 4.5\ kN = 4.5 \times 10^3\ N$

$r_g = 0.67\ N/mm^2$

$r_{adm} = r_g K_3 = 0.67 \times 1.25 = 0.84\ N/mm^2$

For 63 × 225: $r_a = \frac{3}{2} \times \frac{4.5 \times 10^3}{14.2 \times 10^3} = 0.48\ \text{N/mm}^2 < r_{adm}$

For 75 × 225: $r_a = \frac{3}{2} \times \frac{4.5 \times 10^3}{16.9 \times 10^3} = 0.4\ \text{N/mm}^2 < r_{adm}$

Both sections are therefore adequate.

Bearing

$F = 4.5 \times 10^3\ \text{N}$

Assume that the purlins will be supported on 100 mm blockwork and check the narrower choice of section:

$$\sigma_{c,a,perp} = \frac{F}{\text{bearing area}} = \frac{4.5 \times 10^3}{100 \times 63} = 0.71\ \text{N/mm}^2$$

$\sigma_{c,g,perp} = 2.2\ \text{N/mm}^2$, wane prohibited

$\sigma_{c,adm,perp} = \sigma_{c,g,perp} K_3 = 2.2 \times 1.25 = 2.75\ \text{N/mm}^2 > 0.71\ \text{N/mm}^2$

Both sections are adequate.

Conclusion

Use 63 mm × 225 mm or 75 mm × 225 mm SC3 redwood sawn purlins. The final choice may be determined by availability.

Example 2.4

Timber roof beams spaced on a grid of 1200 mm are required to span 7.2 m, supporting a total dead plus imposed load of 1.5 kN/m^2. What size of solid timber joist, having a grade bending stress of 5.3 N/mm^2 and a minimum E of 5800 N/mm^2, would be required?

Total UDL $= 1.5 \times 7.2 \times 1.2 = 12.96\ \text{kN}$

$$M = \frac{WL}{8} = \frac{12.96 \times 7.2}{8} = 11.66\ \text{kN m} = 11.66 \times 10^6\ \text{N mm}$$

K_3 (medium term) = 1.25; K_7 is unknown; K_8 load sharing factor is not applicable.

$$\text{Approximate } Z_{xx} \text{ required} = \frac{11.66 \times 10^6}{5.3 \times 1.25} = 1\,760\,000\ \text{mm}^3 = 1760 \times 10^3\ \text{mm}^3$$

$\delta_p = 0.003 \times \text{span} = 0.003 \times 7200 = 21.6\ \text{mm}$

Approximate I_{xx} required for δ_m

$$= \frac{5}{384} \frac{WL^3}{E\delta_p} = \frac{5}{384} \times \frac{12.96 \times 10^3 \times 7200^3}{5800 \times 21.6} = 502\,758\,620\ \text{mm}^4 = 503 \times 10^6\ \text{mm}^4$$

By reference to Table 2.4, only a 300 mm × 300 mm solid timber section would appear to be adequate. This however would not normally be considered to be a practical choice for a beam. The alternative is to use a stronger hardwood section, or one of the many proprietary timber beams available.