Preface

Content
Interactive design aids for timber elements in accordance to BS EN 1995

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Chapter 1: Beams

Check of a timber beam at the bending ULS

Data given:
Beam span $L = 4.00\,\text{m}$
Width $b = 100.0\,\text{mm}$
Depth $h = 150.0\,\text{mm}$

Loading
Dead load $G_k = 2.00\,\text{kN}$
Imposed load $Q_k = 3.50\,\text{kN}$
Ultimate load $F_d = 1.35 \times G_k + 1.50 \times Q_k = 7.95\,\text{kN}$
Moment $M_d = \frac{F_d \times L}{8} = \frac{7.95 \times 4.00}{8} = 3.98\,\text{kNm}$

Material properties:
Timber $T = \text{SEL(}EC5_BS/classes\text{}; type; \text{)} = \text{Softwood}$
Strength class $C_T = \text{C24}$
Service class $C_S = 2$
Duration class $C_D = \text{medium-term}$
Partial factor $\gamma_M = 1.30$

$f_{m,k} = 24.00\,\text{N/mm}^2$
$k_{\text{mod}} = 0.80$

Ultimate moment of resistance
Depth factor $k_h = \text{MAX}(1.0; \text{MIN}(150/h)^{0.2}; 1.3) = 1.00$
Bending strength $f_{m,d} = k_{\text{mod}} \times k_h \times f_{m,k} = 0.80 \times 1.00 \times \frac{24.00}{1.30} = 14.77\,\text{N/mm}^2$
Modulus $W_{yy} = \frac{b \times h^2}{6} = \frac{100.0 \times 150.0^2}{6} = 375000.0\,\text{mm}^3$
$M_{ult} = f_{m,d} \times W_{yy} = 14770 \times 0.000375 = 5.54\,\text{kNm}$
$\frac{M_d}{M_{ult}} = \frac{3.98}{5.54} = 0.72 \leq 1$
Check of a beam for deflection SLS

Data given:
Span L = 4.00 m
Width b = 100.0 mm
Depth h = 150.0 mm

Loading
Dead load $G_k =$ 2.0 kN
Imposed load $Q_k =$ 3.5 kN

Material and stiffness properties
Timber $T =$ SEL("EC5_BS/classes"; type; ) = Softwood
Strength class $C_T =$ C24
E = 11000.00 N/mm²

\[
A = b \times h = 15.00 \times 10^3 \text{ mm}^2
\]

\[
l = \frac{b \times h^3}{12} = 28.13 \times 10^6 \text{ mm}^4
\]

Instantaneous Deflection
For dead load:
\[
M = \frac{G_k \times L}{8} = 1.00 \text{ kNm}
\]
\[
w_{\text{inst,G}} = \frac{5 \times G_k \times L^3}{384 \times E \times l} + \frac{19.2 \times M \times 10^6}{E \times A} = 5.50 \text{ mm}
\]

For imposed load:
\[
M = \frac{Q_k \times L}{8} = 1.75 \text{ kNm}
\]
\[
w_{\text{inst,Q}} = \frac{5 \times Q_k \times L^3}{384 \times E \times l} + \frac{19.2 \times M \times 10^6}{E \times A} = 9.63 \text{ mm}
\]

Total instantaneous deflection:
\[
w_{\text{inst}} = w_{\text{inst,G}} + w_{\text{inst,Q}} = 5.50 + 9.63 = 15.13 \text{ mm}
\]
Final deflection

| Category | = B: office areas |
| ψ₂       | = 0.30 |
| Service class Cₛ | = 2 |
| kₜₚ | = 0.80 |

\[ w_{\text{fin,G}} = w_{\text{inst,G}} \times (1 + k_{\text{def}}) = 5.50 \times (1 + 0.80) \quad = 9.90 \text{ mm} \]

\[ w_{\text{fin,Q}} = w_{\text{inst,Q}} \times (1 + \psi_2 \times k_{\text{def}}) = 9.63 \times (1 + 0.30 \times 0.80) \quad = 11.94 \text{ mm} \]

Total final deflection

\[ w_{\text{fin}} = w_{\text{fin,G}} + w_{\text{fin,Q}} = 9.90 + 11.94 \quad = 21.8 \text{ mm} \]

\[ w_{\text{max}} = \frac{L}{150} = \frac{4000}{150} \quad = 26.7 \text{ mm} \]

\[ \frac{w_{\text{fin}}}{w_{\text{max}}} = \frac{21.8}{26.7} = 0.82 \leq 1 \]
Check of a timber beam at the bending ULS

Data given:
- Beam span $L = 4.00$ m
- Width $b = 100.0$ mm
- Depth $h = 150.0$ mm

Loading
- Dead load $G_k = 2.00$ kN
- Imposed load $Q_k = 3.50$ kN

Ultimate load $F_d = 1.35 \times G_k + 1.50 \times Q_k = 7.95$ kN

Moment $M_d = \frac{F_d \times L}{8} = \frac{7.95 \times 4.00}{8} = 3.98$ kNm

Material properties:
- Timber $T = $ Softwood $C_{T}$
- Strength class $C_T = $ C24
- Service class $C_S = $ 1
- Duration class $C_D = $ short-term

Partial factor $\gamma_M = 1.30$

- $f_{m,k} = 24.00$ N/mm²
- $k_{mod} = 0.90$

Maximum depth-to-breadth ratio to avoid lateral torsional buckling (LTB)
- Limiting height/breadth ratio = 5:1
- Height/breadth ratio = $h/b = 1.5 : 1$
- Maximum height = $b \times \text{factor} = 500.0 > h$

The beam is not subject to lateral torsional buckling

Ultimate moment of resistance
- Depth factor $k_h = \text{MAX}(1.0 \text{; MIN}(150/h)^{0.2} ; 1.3)) = 1.00$
- Bending strength $f_{m,d} = k_{mod} \times k_h \times f_{m,k} \times \gamma_M = 0.90 \times 1.00 \times \frac{24.00}{1.30} = 16.62$ N/mm²
- Modulus $W_{yy} = \frac{b \times h^2}{6} = \frac{100.0 \times 150.0^2}{6} = 375000.0$ mm³
- $M_{ult} = f_{m,d} \times W_{yy} = 1662 \times 0.000375 = 6.23$ kNm
Check of a residential floor against the vibration criterion

Data given:
Span \( L = 4.00 \text{ m} \)
Joist spacing \( e = 400.0 \text{ mm} \)
Width \( b = 100.0 \text{ mm} \)
Depth \( h = 150.0 \text{ mm} \)

Loading
Timber \( T \)
Strength class \( C_T \)
\( \bar{\rho}_{\text{mean}} \)

Mass of joist:
\( b \cdot h \cdot \bar{\rho}_{\text{mean}} / e = 0.1 \cdot 0.15 \cdot 420.00 / 0.4 = 15.8 \text{ kg/m}^2 \)
Chipboard:
15.0 kg/m²
Plasterboard:
20.0 kg/m²

Total mass on floor \( m = 50.8 \text{ kg/m}^2 \)

EI value of one metre of floor
On joist \( I_1: \)
\( b \cdot h^3 / 12 = \frac{100.0 \cdot 150.0^3}{12} = 28.1 \cdot 10^6 \text{ mm}^4 \)

I value of metre with \( I = \)
\( \frac{I_1}{e} = \frac{28100000}{0.4} = 70.3 \cdot 10^6 \text{ mm}^4 \)

Modulus of elasticity \( E \)
\( E = 11000.0 \text{ N/mm}^2 \)

\( EI = I \cdot E / 10^6 = 0.77 \cdot 10^6 \text{Nm}^2/\text{m} \)

First fundamental frequency \( f_1 \)
\( f_1 = \frac{\pi}{2} \cdot 2 \cdot L \sqrt{\frac{EI}{m}} = \frac{3.14159}{2 \cdot 4.00^2 \cdot \sqrt{770000 \cdot 50.8}} = 12.09 \text{ Hz} \)

\( f_1 \) is more than 8 Hz, so a special investigation is not required

Deflection under 1-kN point load
\( w = \frac{399 \cdot L^3}{48 \cdot E \cdot I_1} = \frac{399 \cdot 4000^3}{48 \cdot 11000.0 \cdot 28100000} = 1.72 \text{ mm} \)

\( w_{\text{lim}} = \frac{16500}{L_{1.1}} ; 1.80 \)

\( w \)
\( w_{\text{lim}} \)
\( 1.72 \)
\( 1.80 \)

\( 0.96 \leq 1 \)
Design of a timber joist at ULS and SLS

Data given:
- Span L = 4.00 m
- Joist spacing e = 600.0 mm
- Width b = 100.0 mm
- Depth h = 200.0 mm

Load on one joist
- Asphalt: \(0.45 \times e \times L = 0.45 \times 0.6 \times 4.00\) = 1.08 kN
- Insulation: \(0.10 \times e \times L = 0.10 \times 0.6 \times 4.00\) = 0.24 kN
- Roof decking boards: \(0.30 \times e \times L = 0.30 \times 0.6 \times 4.00\) = 0.72 kN
- Timber firrings: \(0.01 \times e \times L = 0.01 \times 0.6 \times 4.00\) = 0.02 kN
- Suspended tile ceiling: \(0.15 \times e \times L = 0.15 \times 0.6 \times 4.00\) = 0.36 kN
- Assumed self weight: \(0.10 \times e \times L = 0.10 \times 0.6 \times 4.00\) = 0.24 kN

\(G_k = 2.66\) kN

Snow load \(Q_k\):
\(0.60 \times e \times L = 0.60 \times 0.6 \times 4.00\) = 1.44 kN

\(F_{SLS} = G_k + Q_k = 2.66 + 1.44\) = 4.10 kN

\(F_{ULS} = 1.35 \times G_k + 1.50 \times Q_k = 1.35 \times 2.66 + 1.50 \times 1.44\) = 5.75 kN

Timber properties and parameters
- Timber T = Softwood
- Strength class \(C_T\) = C24
- Service class \(C_S\) = 1
- Duration class \(C_D\) = short-term
- Partial factor \(\gamma_M\) = 1.30

- \(f_{m,k}\) = 24.00 N/mm²
- \(f_{c,90,k}\) = 2.50 N/mm²
- \(f_{v,k}\) = 2.50 N/mm²
- \(E\) = 11000.00 N/mm²

- \(k_{sys}\) = 1.10
- \(k_{mod}\) = 0.90
- \(k_h = \text{MAX}(1.0; \text{MIN}(150/h^{0.2}; 1.3))\) = 1.00
- \(k_{def}\) = 0.60
Bending ULS

\[ M_d = \frac{F_{ULS} \times L}{8} = \frac{5.75 \times 4.00}{8} = 2.88 \text{kNm} \]

Bending strength

\[ f_{m,d} = \frac{k_{sys} \times k_{mod} \times k_h \times f_{m,k}}{\gamma_M} = \frac{1.10 \times 0.90 \times 1.00 \times 24.00}{1.30} = 18.28 \text{N/mm}^2 \]

Modulus

\[ W_{yy} = \frac{b \times h^2}{6} = \frac{100.0 \times 200.0^2}{6} = 666666.7 \text{mm}^3 \]

Ultimate moment

\[ M_{ult} = f_{m,d} \times W_{yy} = 18280 \times 0.0006666667 = 12.19 \text{kNm} \]

\[ \frac{M_d}{M_{ult}} = \frac{2.88}{12.19} = 0.24 \leq 1 \]

Maximum depth-to-breadth ratio to avoid lateral torsional buckling (LTB)

Limiting height/breadth ratio = 5:1
Height/breadth ratio = h/b = 2.0 :1
Maximum height = b \times factor = 500.0 > h

The beam is not subject to lateral torsional buckling

Shear ULS

\[ \tau_d = \frac{0.43}{0.88} = 0.49 \leq 1 \]
Bearing ULS

\[
\sigma_{c,90,d} = \frac{V}{b \times l} = \frac{2880}{100.0 \times 100.0} = 0.29 \text{ N/mm}^2
\]

\[
k_{c,90} = \text{MAX}(1; \text{MIN}(\frac{2.38 \times \frac{l}{250}}{1 + \frac{h}{12 \times l}}; 4)) = 2.31
\]

\[
f_{c,90,d} = \frac{k_{c,90} \times k_{sys} \times k_{mod} \times f_{c,90,k}}{\gamma_M} = \frac{2.31 \times 1.10 \times 0.90 \times 2.50}{1.30} = 4.40 \text{ N/mm}^2
\]

\[
\frac{\sigma_{c,90,d}}{f_{c,90,d}} = \frac{0.29}{4.40} = 0.07 \leq 1
\]

Deflection SLS

\[
E = 11000.00 \text{ N/mm}^2
\]

\[
A = b \times h = 20.00 \times 10^3 \text{ mm}^2
\]

\[
l = \frac{b \times h^3}{12} = 66.67 \times 10^6 \text{ mm}^4
\]

Instantaneous deflection for dead load:

\[
M = \frac{G_k \times L}{8}
\]

\[
w_{\text{inst},G} = \frac{5 \times G_k \times L^3}{384 \times E \times I} + \frac{19.2 \times M \times 10^6}{E \times A} = 3.14 \text{ mm}
\]

Instantaneous deflection for imposed load:

\[
M = \frac{Q_k \times L}{8}
\]

\[
w_{\text{inst},Q} = \frac{5 \times Q_k \times L^3}{384 \times E \times I} + \frac{19.2 \times M \times 10^6}{E \times A} = 1.70 \text{ mm}
\]

Total instantaneous deflection:

\[
w_{\text{inst}} = w_{\text{inst},G} + w_{\text{inst},Q} = 3.14 + 1.70 = 4.84 \text{ mm}
\]

Final deflection

Category = Snow

\[
\psi_2 = 0.00
\]

\[
k_{\text{def}} = 0.60
\]

\[
w_{\text{fin},G} = w_{\text{inst},G} \times (1 + k_{\text{def}}) = 3.14 \times (1 + 0.60) = 5.02 \text{ mm}
\]

\[
w_{\text{fin},Q} = w_{\text{inst},Q} \times (1 + \psi_2 \times k_{\text{def}}) = 1.70 \times (1 + 0.00 \times 0.60) = 1.70 \text{ mm}
\]

\[
w_{\text{fin}} = w_{\text{fin},G} + w_{\text{fin},Q} = 5.02 + 1.70 = 6.7 \text{ mm}
\]

\[
w_{\text{max}} = \frac{L}{150} = \frac{4000}{150} = 26.7 \text{ mm}
\]

\[
\frac{w_{\text{fin}}}{w_{\text{max}}} = \frac{6.7}{26.7} = 0.25 \leq 1
\]
Chapter 2: Columns

Axial load capacity of a timber post

\[ N_{Ed} \]

\[ L \]

\[ h_y \]

\[ h_z \]

Data given

Clear height \( L = 3.50 \) m
Depth \( h_z = 100.0 \) mm
Depth \( h_y = 150.0 \) mm

Timber properties and parameters

- Timber \( T = \) SEL("EC5_BS/classes"; type; ) = Softwood
- Strength class \( C_T = \) C24
- Service class \( C_S = 2\)
- Duration class \( C_D = \) medium-term

- \( E_{0,0.05} = 7400.00 \) N/mm²
- \( f_{c,0,k} = 21.00 \) N/mm²
- \( k_{mod} = 0.80\)

Design compressive strength of timber:

\[ f_{c,0,d} = k_{mod} \frac{f_{c,0,k}}{?M} = 0.80 \times 21.00 / 1.30 = 12.92 \text{ N/mm}^2 \]

Calculations for buckling

- Depth \( h = \text{MIN}(h_y; h_z) = 100.00 \text{ mm}\)
- Radius of gyration \( i = \frac{h}{\sqrt{12}} = 28.87 \text{ mm}\)
- Slenderness ratio \( \lambda = \frac{L}{i} = \frac{3500}{28.87} = 121.23 \)

- \( \lambda_{rel} = \frac{\lambda}{\pi} \sqrt{\frac{f_{c,0,k}}{E_{0,0.05}}} = \frac{121.23}{3.14159} \times \frac{21.00}{7400.00} = 2.06 \)
- \( \beta_c = 0.20\)
- \( k = 0.5 \times (1 + \beta_c \times (\lambda_{rel}^{-0.3} + \lambda_{rel}^{-2})) = 2.80\)
- \( k_c = \frac{1}{k + \sqrt{k^2 - \lambda_{rel}^2}} = \frac{1}{2.80 + \sqrt{2.80^2 - 2.06^2}} = 0.213\)

Ultimate axial load capacity

\[ k_{c,fc,0,d} = k_c \times f_{c,0,d} = 0.213 \times 12.92 = 2.75 \text{ N/mm}^2 \]

\[ N_{Ed,max} = k_{c,fc,0,d} \times h_y \times h_z / 10^3 = 2.75 \times 150.0 \times 100.0 / 10^3 = 41.25 \text{ kN} \]
Axial load capacity of a timber post

Data given

Clear height $L = 3.00 \text{ m}$
Depth $h_y = 150.00 \text{ mm}$
Eccentricity $e_y = 50.00 \text{ mm}$
Depth $h_z = 100.00 \text{ mm}$
Eccentricity $e_z = 0.00 \text{ mm}$

Loading

Vertical load $N_{Ed} = 40.00 \text{ kN}$
Bending Moment $M_z = N_{Ed} \cdot e_z = 40.00 \cdot 0.00 = 0.00 \text{ kNm}$
Bending Moment $M_y = N_{Ed} \cdot e_y = 40.00 \cdot 0.05 = 2.00 \text{ kNm}$

Timber properties and parameters

Timber $T$ = Softwood
Strength class $C_T$ = C24
Service class $C_S$ = 2
Duration class $C_D$ = medium-term

$E_{0,0,05} = 7400.00 \text{ N/mm}^2$
Partial factor $\gamma_M =$ 1.3

$f_{m,k} = 24.00 \text{ N/mm}^2$
$f_{c,0,k} = 21.00 \text{ N/mm}^2$
$k_{mod} = 0.80$

Design compressive strength of timber:
$f_{c,0,d} = \frac{k_{mod} \cdot f_{c,0,k}}{\gamma_M} = \frac{0.80 \cdot 21.00}{1.30} = 12.92 \text{ N/mm}^2$

Design bending strength of timber:
Depth factor $k_h =$ MAX( 1.0 ; MIN( $(150/h_y)^{0.2} ; 1.3)$ ) = 1.000
$f_{m,y,d} = \frac{k_{mod} \cdot k_h \cdot f_{m,k}}{\gamma_M} = \frac{0.80 \cdot 1.000 \cdot 24.00}{1.30} = 14.77 \text{ N/mm}^2$

Depth factor $k_h =$ MAX( 1.0 ; MIN( $(150/h_z)^{0.2} ; 1.3)$ ) = 1.084
$f_{m,z,d} = \frac{k_{mod} \cdot k_h \cdot f_{m,k}}{\gamma_M} = \frac{0.80 \cdot 1.084 \cdot 24.00}{1.30} = 16.01 \text{ N/mm}^2$
Design bending and compressive stresses

Design compressive stress $\sigma_{c,0,d} = \frac{N_{Ed}}{h_y \cdot h_z} = \frac{40000}{150.0 \cdot 100.0} = 2.67$ N/mm²

Elastic section modulus $W_{yy} = \frac{h_z \cdot h_y}{6} = \frac{100.0 \cdot 150.0}{6} = 375.00 \cdot 10^3$ mm³

Design bending stress $\sigma_{m,y,d} = \frac{M_y}{W_{yy}} = \frac{200000}{375000} = 5.33$ N/mm²

Elastic section modulus $W_{zz} = \frac{h_z \cdot h_y}{6} = \frac{100.0^2 \cdot 150.0}{6} = 250.00 \cdot 10^3$ mm³

Design bending stress $\sigma_{m,z,d} = \frac{M_z}{W_{zz}} = \frac{0.00}{250000} = 0.00$ N/mm²

Calculations for buckling about z-z axis

Radius of gyration $i = \frac{h_z}{\sqrt{12}} = \frac{100.0}{\sqrt{12}} = 28.87$ mm

Slenderness ratio $\lambda = \frac{L}{i} = \frac{3000}{28.87} = 103.91$

$\lambda_{rel} = \frac{\lambda \cdot f_{c,0,k}}{\pi \cdot E_{0,0.05}} = \frac{103.91 \cdot 21.00}{3.14159 \cdot 7400.00} = 1.76$

$\beta_c = \text{IF( T ="Glulam" ; 0.1 ; 0.2 )} = 0.20$

$k = 0.5 \cdot (1 + \beta_c \cdot (\lambda_{rel} - 0.3) + \lambda_{rel}^2) = 2.19$

$k_c = \frac{k + \sqrt{k^2 - \lambda_{rel}^2}}{1} = \frac{2.19 + \sqrt{2.19^2 - 1.76^2}}{1} = 0.286$

$\sigma_{c,0,d} + 0.7 \cdot \sigma_{m,y,d} + \sigma_{m,z,d} = \frac{2.67}{0.286 \cdot 12.92} + 0.7 \cdot 14.77 + 0.00 = 0.98 \leq 1$

Calculations for buckling about y-y axis

Radius of gyration $i = \frac{h_y}{\sqrt{12}} = \frac{150.0}{\sqrt{12}} = 43.30$ mm

Slenderness ratio $\lambda = \frac{L}{i} = \frac{3000}{43.30} = 69.28$

$\lambda_{rel} = \frac{\lambda \cdot f_{c,0,k}}{\pi \cdot E_{0,0.05}} = \frac{69.28 \cdot 21.00}{3.14159 \cdot 7400.00} = 1.17$

$k = 0.5 \cdot (1 + \beta_c \cdot (\lambda_{rel} - 0.3) + \lambda_{rel}^2) = 1.27$

$k_c = \frac{k + \sqrt{k^2 - \lambda_{rel}^2}}{1} = \frac{1.27 + \sqrt{1.27^2 - 1.17^2}}{1} = 0.567$

$\sigma_{c,0,d} + 0.7 \cdot \sigma_{m,y,d} + \sigma_{m,z,d} = \frac{2.67}{0.567 \cdot 12.92} + 0.7 \cdot 14.77 + 0.00 = 0.73 \leq 1$
Chapter 3: Supports

Compression perpendicular to the grain at end bearing

Data given
Width b = 100.0 mm
Depth h = 150.0 mm
Support l = 100.0 mm

Material properties:
Timber T = Softwood
Strength class C_T = C24
Bearing strength f_{c,90,k} = 2.50 N/mm²
Service class C_S = 2
Duration class C_D = medium-term
Partial factor \( \gamma_M \) = 1.30

\[ f_{m,k} = 24.00 \text{ N/mm}^2 \]
\[ k_{\text{mod}} = 0.80 \]
\[ f_{c,90,d} = k_{\text{mod}} \frac{f_{c,90,k}}{\gamma_M} = 0.80 \times \frac{2.50}{1.30} = 1.54 \text{ N/mm}^2 \]

At end bearing
\[ h = 150.0 \]
\[ \frac{3}{3} = 50.0 > a \]
\[ k_{c,90} = \text{MAX}(1; \text{MIN}(\frac{2.38}{250} \times (1 + \frac{h}{12 \times l}; 4)) = 2.23 \]
\[ \sigma_{c,90,d} = k_{c,90} f_{c,90,d} = 2.23 \times 1.54 = 3.43 \text{ N/mm}^2 \]

Ultimate capacity of bearing at ULS
\[ F_{\text{MAX}} = \sigma_{c,90,d} b l = 0.343 \times 10.0 \times 10.0 = 34.3 \text{ kN} \]
Compression perpendicular to the grain at internal bearing

![Diagram of compression perpendicular to the grain at internal bearing]

Data given
- Width \( b = 100.0 \text{ mm} \)
- Depth \( h = 200.0 \text{ mm} \)
- Support \( l = 100.0 \text{ mm} \)

Material properties:
- Timber \( T \)
  - Strength class \( C_T \) = Softwood
  - Bearing strength \( f_{c,90,k} \) = 2.50 N/mm²
- Service class \( C_S \) = 2
- Duration class \( C_D \) = medium-term
- Partial factor \( \gamma_M \) = 1.30
- Modulus of elasticity \( f_{m,k} \) = 24.00 N/mm²
- Modulus of elasticity \( k_{mod} \) = 0.80
- Partial factor \( \gamma_M \) = 1.30

At internal bearing
\[
k_{c,90} = \text{MAX} \left( 1 ; \text{MIN} \left( \left( 2.38 \frac{l}{250} \right)^{\left( 1 + \frac{h}{6l} \right)} ; 4 \right) \right) = 2.64
\]
\[
\sigma_{c,90,d} = k_{c,90} \times f_{c,90,d} = 2.64 \times 1.54 = 4.07 \text{ N/mm}^2
\]

Ultimate capacity of bearing at ULS
\[
F_{\text{MAX}} = \sigma_{c,90,d} \times b \times l = 4.07 \times 10.0 \times 10.0 = 40.7 \text{ kN}
\]
Shear capacity at a support

Data given
Width \( b = 100.0 \) mm  
Depth \( h = 150.0 \) mm  
Support \( l = 100.0 \) mm

Material properties:
- Timber \( T \) = Softwood
- Strength class \( C_T \) = C24
- Shear strength \( f_{v,k} \) = 2.50 N/mm²
- Service class \( C_S \) = medium-term
- Duration class \( C_D \) = medium-term
- Partial factor \( \gamma_M \) = 1.30

\[
f_{v,d} = k_{\text{mod}} \frac{f_{v,k}}{\gamma_M} = \frac{0.80 \times 2.50}{1.30} = 1.54 \text{ N/mm}^2
\]

Shear capacity
\[
V_{\text{max}} = \frac{f_{v,d} \times b \times h}{1.5} = \frac{0.154 \times 10.0 \times 15.0}{1.5} = 15.40 \text{ kN}
\]
Shear capacity at a support notched at the bottom

Data given
- Width \(b\) = 100.0 mm
- Depth \(h\) = 200.0 mm
- Depth \(h_{ef}\) = 120.0 mm
- Distance \(x\) = 75.0 mm
- Support \(l\) = 100.0 mm

Material properties:
- Timber \(T\) = SEL("EC5_BS/classes"; type; ) = Softwood
- Strength class \(C_T\) = C24
- Shear strength \(f_{v,k}\) = 2.50 N/mm²
- Service class \(C_S\) = 2
- Duration class \(C_D\) = medium-term
- Partial factor \(\gamma_M\) = 1.30
- \(k_{mod}\) = 0.80
- \(f_{v,d} = k_{mod} \cdot \frac{f_{v,k}}{\gamma_M} = \frac{2.50}{1.30} = 1.54 \text{ N/mm}^2\)

Shear capacity

\[
\alpha = \frac{h_{ef}}{h} = \frac{120.0}{200.0} = 0.60
\]

\[
k_v = \text{MIN}\left(\frac{5}{\sqrt{h\left(\sqrt{\alpha^*(1-\alpha)} + 0.8*\frac{x}{h}\sqrt{\frac{1}{\alpha^2}}\right)}, 1)\right) = 0.425
\]

\[
V_{max} = \left(\frac{k_v \cdot f_{v,d} \cdot b \cdot h_{ef}}{1.5}\right) = \left(\frac{0.425 \cdot 0.154 \cdot 10.0 \cdot 12.0}{1.5}\right) = 5.24 \text{ kN}
\]
Shear capacity at a support notched at the top

Data given
- Width $b = 100.0$ mm
- Depth $h_{ef} = 120.0$ mm
- Support $l = 100.0$ mm

Material properties:
- Timber $T$ = Softwood
- Strength class $C_T$ = C24
- Shear strength $f_{v,k} = 2.50$ N/mm²
- Service class $C_S$ = 2
- Duration class $C_D$ = medium-term
- Partial factor $\gamma_M = 1.30$

$$k_{mod} = 0.80$$

$$f_{v,d} = k_{mod} \frac{f_{v,k}}{\gamma_M} = 0.80 \times \frac{2.50}{1.30} = 1.54 \text{ N/mm}^2$$

Shear capacity

$$V_{max} = \frac{f_{v,d} \times b \times h_{ef}}{1.5} = \frac{0.154 \times 10.0 \times 12.0}{1.5} = 12.32 \text{ kN}$$