NOTHING BEATS A GREAT TEMPLATE

Preface

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

Guidelines of use
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All templates are linked to various databases by TAB()- or SEL() functions. For instructional purposes these links are displayed in this document, but can also be hidden when printing.

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Beside its functions for documentation, VCmaster offers an intuitive concept enabling engineers to carry out calculations. The input of mathematic formulas can be executed in natural notation directly in the document itself. The software significantly supports the reuse of structural calculations and documents. VCmaster simplifies modifications and adjustments and automates standard tasks. Collaboration with work-groups or with other offices and clients is uncomplicated as well. As a result, processing time and costs can be considerably reduced.

System Requirements
VCmaster 2016 or newer

Development and Copyrights
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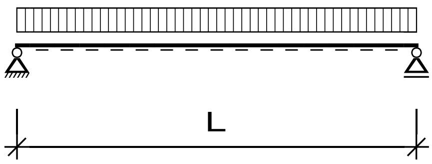
Contents

Chapter 1: Beams

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= $1.35 * G_k + 1.50 * Q_k$ = 7.95 kN

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

Material properties:

Timber T	=	Softwood
Strength class C_T	=	C24
Service class C_S	=	2
Duration class C_D	=	medium-term
Partial factor γ_M =		1.30
$f_{m,k}$	=	24.00 N/mm²
k_{mod}	=	0.80

Ultimate moment of resistance

Depth factor k_h = MAX(1.0 ; MIN($(150/h)^{0.2}$; 1.3)) = 1.00

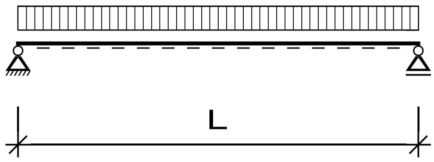
Bending strength $f_{m,d}$ = $k_{mod} * k_h * \frac{f_{m,k}}{\gamma_M} = 0.80 * 1.00 * \frac{24.00}{1.30}$ = 14.77 N/mm²

Modulus W_{yy} = $\frac{b * h^2}{6} = \frac{100.0 * 150.0^2}{6}$ = 375000.0 mm³

M_{ult} = $f_{m,d} * W_{yy}$ = 14770*0.000375 = 5.54 kNm

$\frac{M_d}{M_{ult}} = \frac{3.98}{5.54}$ = **0.72 ≤ 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		= Softwood
Strength class C_T		= C24
E		= 11000.00 N/mm²
A =	$b * h$	= $15.00*10^3$ mm²
I =	$\frac{b * h^3}{12}$	= $28.13*10^6$ mm⁴

Instantaneous Deflection

For dead load:

$$M = \frac{G_k * L}{8} = 1.00 \text{ kNm}$$

$$w_{inst,G} = \frac{5 * G_k * L^3}{384 * E * I} + \frac{19.2 * M * 10^6}{E * A} = 5.50 \text{ mm}$$

For imposed load:

$$M = \frac{Q_k * L}{8} = 1.75 \text{ kNm}$$

$$w_{inst,Q} = \frac{5 * Q_k * L^3}{384 * E * I} + \frac{19.2 * M * 10^6}{E * A} = 9.63 \text{ mm}$$

Total instantaneous deflection:

$$w_{inst} = w_{inst,G} + w_{inst,Q} = 5.50 + 9.63 = 15.13 \text{ mm}$$

Final deflection

Catagory	=	B: office areas
ψ_2	=	0.30
Service class C_S	=	2
k_{def}	=	0.80

$w_{fin,G} = w_{inst,G} * (1 + k_{def}) = 5.50 * (1 + 0.80) = 9.90$ mm

$w_{fin,Q} = w_{inst,Q} * (1 + \psi_2 * k_{def}) = 9.63 * (1 + 0.30 * 0.80) = 11.94$ mm

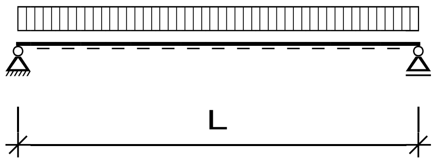
Total final deflection

$w_{fin} = w_{fin,G} + w_{fin,Q} = 9.90 + 11.94 = 21.8$ mm

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

$$\frac{w_{fin}}{w_{max}} = \frac{21.8}{26.7} = \mathbf{0.82 \leq 1}$$

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= $1.35 * G_k + 1.50 * Q_k$ = 7.95 kN

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

Material properties:

Timber T	=	Softwood
Strength class C_T	=	C24
Service class C_S	=	1
Duration class C_D	=	short-term
Partial factor γ_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 * factor	=	500.0 > h

The beam is not subject to lateral torsional buckling

Ultimate moment of resistance

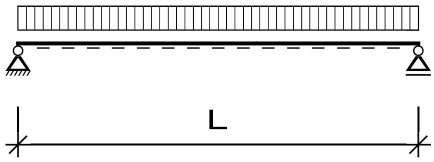
Depth factor k_h = MAX(1.0 ; MIN($(150/h)^{0.2}$; 1.3)) = 1.00

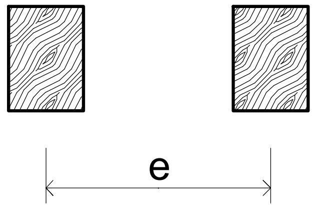
Bending strength $f_{m,d}$ = $k_{mod} * k_h * \frac{f_{m,k}}{\gamma_M} = 0.90 * 1.00 * \frac{24.00}{1.30}$ = 16.62 N/mm²

Modulus W_{yy} = $\frac{b * h^2}{6} = \frac{100.0 * 150.0^2}{6}$ = 375000.0 mm³

M_{ult} = $f_{m,d} * W_{yy}$ = 16620*0.000375 = 6.23 kNm

Check of a residential floor against the vibration criterion





Data given:

Span L =	4.00 m
Joist spacing e =	400.0 mm
Width b =	100.0 mm
Depth h =	150.0 mm

Loading

Timber T	=	Softwood
Strength class C_T	=	C24
ρ_{mean}	=	420.00 kg/m²

Mass of joist: $b * h * \rho_{mean} / e = 0.1 * 0.15 * 420.00 / 0.4$ = 15.8 kg/m²

Chipboard: 15.0 kg/m²

Plasterboard: 20.0 kg/m²

Total mass on floor m = <u>50.8 kg/m²</u>

EI value of one metre of floor

On joist I_1: $$\frac{b * h^3}{12} = \frac{100.0 * 150.0^3}{12} = 28.1*10^6 \text{ mm}^4$$

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

Modulus of elasticity E = 11000.0 N/mm²

EI = $I * E / 10^6$ = $0.77*10^6$ Nm²/m

First fundamental frequency f_1

$$f_1 = \frac{\pi}{2 * L^2} * \sqrt{\frac{EI}{m}} = \frac{3.14159}{2 * 4.00^2} * \sqrt{\frac{770000}{50.8}} = 12.09 \text{ Hz}$$

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

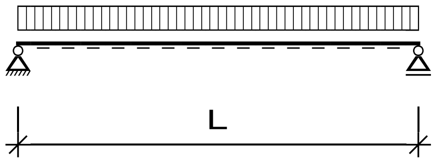
Deflection under 1-kN point load

$$w = \frac{399 * L^3}{48 * E * I_1} = \frac{399 * 4000^3}{48 * 11000.0 * 28100000} = 1.72 \text{ mm}$$

$$w_{lim} = \text{MIN}\left(\frac{16500}{L^{1.1}} ; 1.80\right) = 1.80 \text{ mm}$$

$$\frac{w}{w_{lim}} = \frac{1.72}{1.80} = \mathbf{0.96 \leq 1}$$

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:	$0.45*e*L = 0.45*0.6*4.00$	=	1.08 kN
Insulation:	$0.10*e*L = 0.10*0.6*4.00$	=	0.24 kN
Roof decking boards:	$0.30*e*L = 0.30*0.6*4.00$	=	0.72 kN
Timber firrings:	$0.01*e*L = 0.01*0.6*4.00$	=	0.02 kN
Suspended tile ceiling:	$0.15*e*L = 0.15*0.6*4.00$	=	0.36 kN
Assumed self weight:	$0.10*e*L = 0.10*0.6*4.00$	=	0.24 kN
		G_k =	**2.66 kN**
Snow load Q_k:	$0.60*e*L = 0.60*0.6*4.00$	=	1.44 kN
F_{SLS} =	$G_k + Q_k = 2.66 + 1.44$	=	4.10 kN
F_{ULS} =	$1.35*G_k + 1.50*Q_k = 1.35*2.66 + 1.50*1.44$	=	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 γ_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 =	$MAX(1.0 ; MIN((150/h)^{0.2} ; 1.3))$	=	1.00
k_{def}		=	0.60

Bending ULS

$M_d = \frac{F_{ULS} * L}{8} = \frac{5.75 * 4.00}{8}$ = 2.88 kNm

Bending strength $f_{m,d} = \frac{k_{sys} * k_{mod} * k_h * f_{m,k}}{\gamma_M} = \frac{1.10 * 0.90 * 1.00 * 24.00}{1.30}$ = 18.28 N/mm²

Modulus $W_{yy} = \frac{b * h^2}{6} = \frac{100.0 * 200.0^2}{6}$ = 666666.7 mm³

$M_{ult} = f_{m,d} * W_{yy} = 18280 * 0.0006666667$ = 12.19 kNm

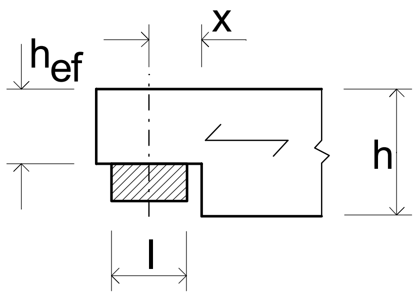
$\frac{M_d}{M_{ult}} = \frac{2.88}{12.19}$ = **0.24 ≤ 1**

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 * factor = 500.0 > h

The beam is not subject to lateral torsional buckling

Shear ULS



Data given

Depth h_{ef} = 100.0 mm
Distance x = 50.0 mm
Support l = 100.0 mm

Shear capacity

$V = \frac{F_{ULS}}{2} = \frac{5.75}{2}$ = 2.88 kN

$\alpha = \frac{h_{ef}}{h} = \frac{100.0}{200.0}$ = 0.50

$k_v = MIN\left(\frac{5}{\sqrt{h} * \left(\sqrt{\alpha * (1 - \alpha)} + 0.8 * \frac{x}{h} * \sqrt{\frac{1}{\alpha} - \alpha^2}\right)};1\right)$ = 0.462

Shear stress $\tau_d = \frac{1.5 * V}{b * h_{ef}} = \frac{1.5 * 2880}{100.0 * 100.0}$ = 0.43 N/mm²

Shear strength $f_{v,d} = \frac{k_{sys} * k_{mod} * k_v * f_{v,k}}{\gamma_M} = \frac{1.10 * 0.90 * 0.462 * 2.50}{1.30}$ = 0.88 N/mm²

$\frac{\tau_d}{f_{v,d}} = \frac{0.43}{0.88}$ = **0.49 ≤ 1**

Bearing ULS

$\sigma_{c,90,d} = \frac{V}{b*l} = \frac{2880}{100.0*100.0}$ = 0.29 N/mm²

$k_{c,90} = MAX(1 ; MIN(\left(2.38 - \frac{l}{250}\right)*\left(1 + \frac{h}{12*l}\right) ; 4))$ = 2.31

$f_{c,90,d} = \frac{k_{c,90}*k_{sys}*k_{mod}*f_{c,90,k}}{\gamma_M} = \frac{2.31*1.10*0.90*2.50}{1.30}$ = 4.40 N/mm²

$\frac{\sigma_{c,90,d}}{f_{c,90,d}} = \frac{0.29}{4.40}$ = **0.07 ≤ 1**

Deflection SLS

E = 11000.00 N/mm²

$A = b*h$ = $20.00*10^3$ mm²

$I = \frac{b*h^3}{12}$ = $66.67*10^6$ mm⁴

Instantaneous deflection for dead load:

$M = \frac{G_k*L}{8}$ = 1.33 kNm

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

Instantaneous deflection for imposed load:

$M = \frac{Q_k*L}{8}$ = 0.72 kNm

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

Total instantaneous deflection:

$w_{inst} = w_{inst,G} + w_{inst,Q} = 3.14 + 1.70$ = 4.84 mm

Final deflection

Catagory = Snow

ψ_2 = 0.00

k_{def} = 0.60

$w_{fin,G} = w_{inst,G}*(1 + k_{def}) = 3.14*(1 + 0.60)$ = 5.02 mm

$w_{fin,Q} = w_{inst,Q}*(1 + \psi_2*k_{def}) = 1.70*(1 + 0.00*0.60)$ = 1.70 mm

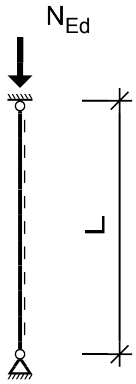
$w_{fin} = w_{fin,G} + w_{fin,Q} = 5.02 + 1.70$ = 6.7 mm

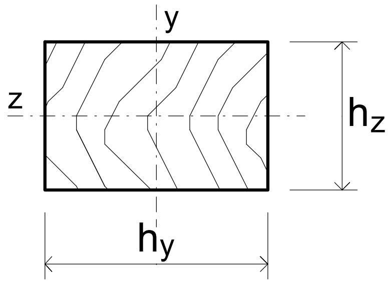
$w_{max} = \frac{L}{150} = \frac{4000}{150}$ = 26.7 mm

$\frac{w_{fin}}{w_{max}} = \frac{6.7}{26.7}$ = **0.25 ≤ 1**

Chapter 2: Columns

Axial load capacity of a timber post





Data given

Clear hight L = 3.50 m

Depth h_z = 100.0 mm

Depth h_y = 150.0 mm

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 N/mm²

$f_{c,0,k}$ = 21.00 N/mm²

k_{mod} = 0.80

Design compressive strength of timber:

$f_{c,0,d} = k_{mod} * f_{c,0,k} / \gamma_M = 0.80 * 21.00 / 1.30$ = 12.92 N/mm²

Calculations for buckling

Depth h = MIN(h_y ; h_z) = 100.00 mm

Radius of gyration $i = \frac{h}{\sqrt{12}} = \frac{100.00}{\sqrt{12}}$ = 28.87 mm

Slenderness ratio $\lambda = \frac{L}{i} = \frac{3500}{28.87}$ = 121.23

$\lambda_{rel} = \frac{\lambda}{\pi} * \sqrt{\frac{f_{c,0,k}}{E_{0,0,05}}} = \frac{121.23}{3.14159} * \sqrt{\frac{21.00}{7400.00}}$ = 2.06

β_c = IF(T ="Glulam" ; 0.1 ; 0.2) = 0.20

$k = 0.5 * (1 + \beta_c * (\lambda_{rel} - 0.3) + \lambda_{rel}^2)$ = 2.80

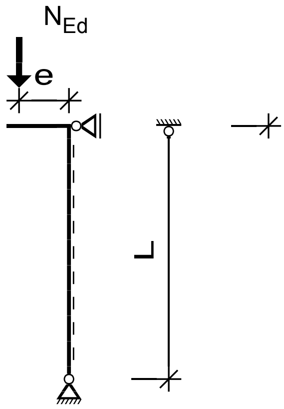
$k_c = \frac{1}{k + \sqrt{k^2 - \lambda_{rel}^2}} = \frac{1}{2.80 + \sqrt{2.80^2 - 2.06^2}}$ = 0.213

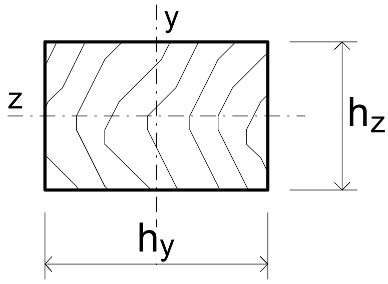
Ultimate axial load capacity

$k_{c,fc,0,d} = k_c * f_{c,0,d} = 0.213 * 12.92$ = 2.75 N/mm²

$N_{Ed,max} = k_{c,fc,0,d} * h_y * h_z / 10^3 = 2.75 * 150.0 * 100.0 / 10^3$ = **41.25 kN**

Axial load capacity of a timber post





Data given

Clear hight L =	3.00 m		
Depth h_y =	150.0 mm		
Eccentricity e_y =	50.00 mm		
Depth h_z =	100.0 mm		
Eccentricity e_z =	0.00 mm		

Loading

Vertical load N_{Ed} =	40.00 kN		
Bending Moment M_z =	$N_{Ed} * e_z$ = 40.00 * 0.00	=	0.00 kNm
Bending Moment M_y =	$N_{Ed} * e_y$ = 40.00 * 0.05	=	2.00 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 N/mm²
Partial factor γ_M =			1.30
$f_{m,k}$		=	24.00 N/mm²
$f_{c,0,k}$		=	21.00 N/mm²
k_{mod}		=	0.80

Design compressive strength of timber:

$f_{c,0,d}$ =	$k_{mod} * f_{c,0,k} / \gamma_M$ = 0.80 * 21.00 / 1.30	=	12.92 N/mm²

Design bending strength of timber:

Depth factor k_h =	MAX(1.0 ; MIN($(150/h_y)^{0.2}$; 1.3))	=	1.000
$f_{m,y,d}$ =	$k_{mod} * k_h * f_{m,k} / \gamma_M$ = 0.80 * 1.000 * 24.00 / 1.30	=	14.77 N/mm²
Depth factor k_h =	MAX(1.0 ; MIN($(150/h_z)^{0.2}$; 1.3))	=	1.084
$f_{m,z,d}$ =	$k_{mod} * k_h * f_{m,k} / \gamma_M$ = 0.80 * 1.084 * 24.00 / 1.30	=	16.01 N/mm²

Design bending and compressive stresses

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

Elastic section modulus $W_{yy} = \frac{h_z * h_y^2}{6} = \frac{100.0 * 150.0^2}{6}$ = $375.00*10^3$ mm³

Design bending stress $\sigma_{m,y,d} = \frac{M_y}{W_{yy}} = \frac{2000000}{375000}$ = 5.33 N/mm²

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

$\lambda_{rel} = \frac{\lambda}{\pi} * \sqrt{\frac{f_{c,0,k}}{E_{0,0,05}}} = \frac{103.91}{3.14159} * \sqrt{\frac{21.00}{7400.00}}$ = 1.76

β_c = IF(T ="Glulam" ; 0.1 ; 0.2) = 0.20

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

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

$\frac{\sigma_{c,0,d}}{k_c * f_{c,0,d}} + 0.7 * \frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \frac{2.67}{0.286 * 12.92} + 0.7 * \frac{5.33}{14.77} + \frac{0.00}{16.01}$ = **0.98 ≤ 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

$\lambda_{rel} = \frac{\lambda}{\pi} * \sqrt{\frac{f_{c,0,k}}{E_{0,0,05}}} = \frac{69.28}{3.14159} * \sqrt{\frac{21.00}{7400.00}}$ = 1.17

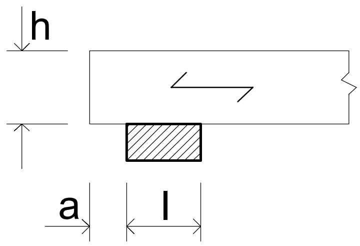
k = $0.5 * (1 + \beta_c * (\lambda_{rel} - 0.3) + \lambda_{rel}^2)$ = 1.27

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

$\frac{\sigma_{c,0,d}}{k_c * f_{c,0,d}} + \frac{\sigma_{m,y,d}}{f_{m,y,d}} + 0.7 * \frac{\sigma_{m,z,d}}{f_{m,z,d}} = \frac{2.67}{0.567 * 12.92} + \frac{5.33}{14.77} + 0.7 * \frac{0.00}{16.01}$ = **0.73 ≤ 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 γ_M = 1.30

$f_{m,k}$ = 24.00 N/mm²
k_{mod} = 0.80

$$f_{c,90,d} = k_{mod} * \frac{f_{c,90,k}}{\gamma_M} = 0.80 * \frac{2.50}{1.30} = 1.54 \text{ N/mm}^2$$

At end bearing

$$\frac{h}{3} = \frac{150.0}{3} = 50.0 > a$$

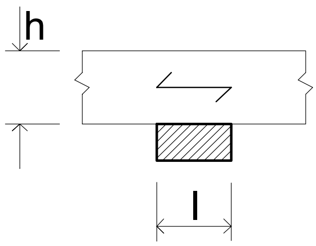
$$k_{c,90} = MAX\left(1 ; MIN\left(\left(2.38 - \frac{l}{250}\right) * \left(1 + \frac{h}{12 * l}\right) ; 4\right)\right) = 2.23$$

$$\sigma_{c,90,d} = k_{c,90} * f_{c,90,d} = 2.23 * 1.54 = 3.43 \text{ N/mm}^2$$

Ultimate capacity of bearing at ULS

$$F_{MAX} = \sigma_{c,90,d} * b * l = 0.343 * 10.0 * 10.0 = \mathbf{34.3\ kN}$$

Compression perpendicular to the grain at internal bearing



Data given

Width b = 100.0 mm
Depth h = 200.0 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 γ_M =		1.30
$f_{m,k}$	=	24.00 N/mm²
k_{mod}	=	0.80

$$f_{c,90,d} = k_{mod} * \frac{f_{c,90,k}}{\gamma_M} = 0.80 * \frac{2.50}{1.30} = 1.54 \text{ N/mm}^2$$

At internal bearing

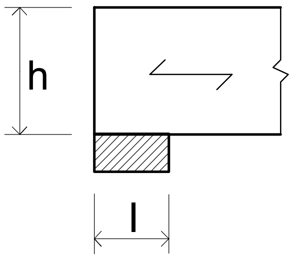
$$k_{c,90} = \text{MAX}\left(1 \; ; \; \text{MIN}\left(\left(2.38 - \frac{l}{250}\right) * \left(1 + \frac{h}{6 * l}\right) ; 4\right)\right) = 2.64$$

$$\sigma_{c,90,d} = k_{c,90} * f_{c,90,d} = 2.64 * 1.54 = 4.07 \text{ N/mm}^2$$

Ultimate capacity of bearing at ULS

$$F_{MAX} = \sigma_{c,90,d} * b * l = 0.407 * 10.0 * 10.0 = \mathbf{40.7\ kN}$$

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	= 2
Duration class C_D	= medium-term
Partial factor γ_M =	1.30

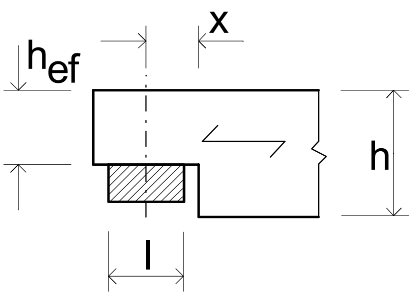
k_{mod} = 0.80

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

Shear capacity

$$V_{max} = \frac{f_{v,d} * b * h}{1.5} = \frac{0.154 * 10.0 * 15.0}{1.5} = 15.40 \text{ kN}$$

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	=	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 γ_M = 1.30

k_{mod} = 0.80

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

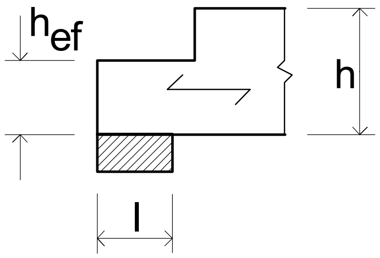
Shear capacity

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

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

$$V_{max} = \frac{k_v * f_{v,d} * b * h_{ef}}{1.5} = \frac{0.425 * 0.154 * 10.0 * 12.0}{1.5} = \mathbf{5.24\ kN}$$

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 γ_M =		1.30
k_{mod}	=	0.80

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

Shear capacity

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