Structural Eurocodes

EN 1995 Design of Timber Structures

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EN 1995-1-1 Design of Timber Structures – General – Common Rules and Rules for Buildings

Limit state design

Timber Properties IS-EN 338: 2003 Table 1. Values are fifth percentile characteristic values derived from tests of five minutes duration. Values for tension and bending relate to sections of depth 150 mm.

W_y, W_z: Elastic modulus

Table 2.1 Load-duration classes

Permanent (> 10 years)	self weight
Long-term (6 months – 10 years)	storage loading
Medium-term (1 week – 6 months)	imposed floor loading
Short-term (< 1 week)	snow; maintenance
Instantaneous	wind

Clause 2.3.1.3 Service Classes

		mc	rh
1	Internal	< 12%	< 65%
2	Cold roofs, external walls	12% - 20%	< 85%
3	External (fully exposed)	> 20%	

Table 2.3 $\gamma_M = 1.3$ (partial factor of safety for a material property for solid timber)

Service class	Permanent	Long-term	Medium-term	Short-term	Instantaneous
1	0.6	0.7	0.8	0.9	1.1
2	0.6	0.7	0.8	0.9	1.1

Table 3.1 k_{mod} (solid timber)

k_{mod}: Modification factor for load duration and moisture content

When loads are, for example, a combination of Permanent and Medium term, use k_{mod} for Medium term. However, depending on magnitude of loads, it may be necessary to consider Permanent load alone with k_{mod} for Permanent. (3.1.3 (2))

Table 3.2
k_{def}: deformation factor
$k_{def} = 0.6$ (Service class 1); $k_{def} = 0.8$ (Service class 2)

Clause 2.4.1(1) $X_d = k_{mod} (X_k/\gamma_M)$
X_d: characteristic value of strength property
X_k: design value of strength property

Clause 2.4.3(1) $R_d = k_{mod} (R_k/\gamma_M)$
R_d: characteristic value of resistance (load carrying capacity)
R_k: design value of resistance (load carrying capacity)

f: strength property   σ: applied stress

3.2 (3): Depth factor
$k_h = \min \{(150/h)^{0.2}, 1.3\}$ when h < 150 mm
k_h is applied to $f_{m,k}$ and $f_{t,0,k}$

Clause 6.6 $k_{sys} = 1.1$ (load sharing)

2.2.3 Serviceability limit states
(2) Mean values of moduli
(5) $u_{fin,G} = u_{inst,G} (1+ k_{def})$ $u_{fin,Q} = u_{inst,Q} (1+ \psi_{2,1} k_{def})$
$\psi_{2,1}$: EC0 Table NA2 *(= 0.3 for residential, office)*
k_{def} makes an allowance for creep
(u: deformation)

Clause 6.1.5 Compression perpendicular to the grain
$\sigma_{c,90,d} \le k_{c,90} f_{c,90,d}$
$(f_{c,90,d} = f_{c,90,k} * k_{mod} * k_{sys} / \gamma_M)$
$\sigma_{c,90,d} = F_{c,90,d}/A_{ef}$
(Effective bearing length = actual bearing length + max. 30 mm on both sides)
Clause 6.1.5 (4) $k_{c,90} = 1.5$ (solid timber)

Clause 6.1.6 Bending about one axis

$\sigma_{m,y,d} \leq f_{m,y,d}$ (= $f_{m,y,k}$ * k_{mod} * k_{sys} * k_{crit} * k_h/ γ_M) (Eq 6.11 when $\sigma_{m,z,d} = 0$)

k_m: factor that makes allowance for re-distribution of bending stresses in a section (= 0.7 for solid timber)

Clause 6.1.7 (1) Shear

$\tau_d \leq f_{v,d}$ (= $f_{y,k}$ * k_{mod} * k_{sys} / γ_M)

(2) $b_{ef} = k_{cr} * b$

$k_{cr} = 0.67$ for solid timber (to account for cracking of flexural members)

Concentrated shear force within depth of member from face of support can be ignored.

6.5.2 (2) Member with notch vertical notch at edge of support; solid timber

$\tau_d = 1.5V/bh_{ef} \leq k_v f_{v,d}$

$$k_v = \text{Min.} \quad \frac{k_n\left(1+\frac{1.1i^{1.5}}{\sqrt{h}}\right)}{\sqrt{h}\left(\sqrt{\alpha(1-\alpha)}+0,8\frac{x}{h}\sqrt{\frac{1}{\alpha}-\alpha^2}\right)} \quad , 1.0$$

Vertical notch at edge of support; solid timber

For 50 mm deep notch in 225 mm joist (length = 50 mm):

$k_v = 0.593$

For 25 mm deep notch in 225 mm joist (length = 50 mm):

$k_v = 0.799$

BS values: k = 0.78, 0.89

Table 7.2 Limiting deflection

(w_{inst}: *l*/300 - *l*/500)

(w_{fin}: *l*/150 - *l*/300)

($w_{net,fin}$: *l*/250 - *l*/350)

6.3.3 (5) Lateral stability: $k_{crit} = 1.0$ when compression edge is held in place and torsional rotation at supports is prevented.

6.2.4 Combined bending and axial compression

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + \frac{\sigma_{m,y,d}}{f_{m,y,d}} + k_m \frac{\sigma_{m,z,d}}{f_{m,z,d}} \leq 1 \qquad 6.19$$

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + k_m \frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}} \leq 1 \qquad 6.20$$

$$\left(\frac{\sigma_{c,0,d}}{f_{c,0,d}}\right)^2 + \frac{\sigma_{m,y,d}}{f_{m,y,d}} \leq 1 \qquad \text{when } \sigma_{m,z,d} = 0$$

$k_m = 0.7$ for solid timber of rectangular section

6.3 Stability of members
6.3.2 Columns subjected to either compression or combined compression and bending

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$$\lambda_{rel,y} = \frac{\lambda_y}{\pi}\sqrt{\frac{f_{c,0,k}}{E_{0.05}}} \qquad 6.21$$

$$\lambda_{rel,z} = \frac{\lambda_z}{\pi}\sqrt{\frac{f_{c,0,k}}{E_{0.05}}} \qquad 6.22$$

If $\lambda_{rel,y}$ and $\lambda_{rel,z} \leq 0.3$, stability is not an issue; Eq's 6.19 and 6.20 to be satisfied

$$\frac{\sigma_{c,0,d}}{k_{c,y} f_{c,0,d}} + \frac{\sigma_{m,y,d}}{f_{m,y,d}} + k_m \frac{\sigma_{m,z,d}}{f_{m,z,d}} \leq 1 \qquad 6.23$$

$$\frac{\sigma_{c,0,d}}{k_{c,z} f_{c,0,d}} + k_m \frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}} \leq 1 \qquad 6.24$$

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$$k_{c,y} = \frac{1}{k_y + \sqrt{k_y^2 - \lambda_{rel,y}^2}} \qquad 6.25$$

$$k_{c,z} = \frac{1}{k_z + \sqrt{k_z^2 - \lambda_{rel,z}^2}} \qquad 6.26$$

$$k_y = 0.5(1 + \beta_c(\lambda_{rel,y} - 0.3) + \lambda_{rel,y}^2) \qquad 6.27$$

$$k_z = 0.5(1 + \beta_c(\lambda_{rel,z} - 0.3) + \lambda_{rel,z}^2) \qquad 6.28$$

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For stud bending about yy axis:

$$\frac{\sigma_{c,0,d}}{k_{c,y} f_{c,0,d}} + \frac{\sigma_{m,y,d}}{f_{m,y,d}} \leq 1$$

$$\frac{\sigma_{c,0,d}}{k_{c,z} f_{c,0,d}} + k_m \frac{\sigma_{m,y,d}}{f_{m,y,d}} \leq 1$$

6.3.3 Beams subjected to either bending or combined bending and compression and bending

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$$\sigma_{m,crit} = \frac{M_{y,crit}}{W_y} = \frac{\pi\sqrt{E_{0.05} I_z G_{0.05} I_{tor}}}{l_{ef} W_y} = \frac{0.78 b^2}{h l_{ef}} E_{0.05} \qquad 6.31,\ 6.32$$

$$\left(\frac{\sigma_{m,d}}{k_{crit} f_{m,d}}\right)^2 + \frac{\sigma_{c,d}}{k_{c,z} f_{c,0,d}} \leq 1 \qquad 6.35$$

$$\lambda_{rel,m} = \sqrt{\frac{f_{m,k}}{\sigma_{m,crit}}} \qquad 6.30$$

k_{crit}: 1 ($\lambda_{rel,m} \leq 0.75$)
1.56 – 0.75 $\lambda_{rel,m}$ ($0.75 < \lambda_{rel,m} \leq 1.4$)
1/ $\lambda_{rel,m}^2$ ($\lambda_{rel,m} > 1.4$) 6.34

7.3 Vibrations

(3) Modal damping ratio ζ (zeta) = 0.01 (→ 0.02)
Effect of vibrations depends on human sensitivity

If f < 8 Hz; more detailed analysis required – vibration acceleration is critical in terms of human sensitivity.
If f > 8 Hz; vibration velocity is critical in terms of human sensitivity.

Assessment therefore requires consideration of:
Natural frequency
Deflection due to a vertical static load (1 kN)
Velocity due to unit impulse (1 Ns)

7.3.3 Residential floors
(2) Fundamental frequency > 8 Hz

$$f_1 = \frac{\pi}{2l^2}\sqrt{\frac{(EI)_l}{m}} \qquad 7.5$$

$w/F \leq a$ mm/kN 7.3

UK National Annex:-
$w_{inst,Q} = (Fl^3/48EI_l)(k_{dist} * k_{amp})$ F = 1 kN
k_{amp} = 1.05 for simply supported timber joists (to account for shear deflection)
k_{dist} = max (0.3, k_{strut} * (0.38 – 0.08 * *ln* (14 * EI_b/s^4))
(to account for 'load sharing')
k_{strut} = .97 when strutting provided; otherwise 1

$$v \leq b^{(f_1\varsigma - 1)} \text{ m/(Ns}^2) \qquad 7.4$$

$$n_{40} = \left\{\left(\left(\frac{40}{f_1}\right)^2 - 1\right)\left(\frac{b}{l}\right)^4 \frac{(EI)_l}{(EI)_b}\right\}^{0.25} \qquad 7.7$$

$$v = \frac{4(0.4 + 0.6n_{40})}{mbl + 200} \qquad 7.6$$

(a, b: Figure 7.2)

UK NA Table 5:
a = 1.8 mm (l < 4000 mm); $16500/l^{1.1}$ mm (l > 4000 mm)
b = 180 – 60a (a ≤ 1); 160 – 40a (a > 1)

Section 8 Connections with metal fasteners

Clause 8.2 Lateral load-carrying capacity of metal dowel-type fasteners

8.3 Nailed connections – spacings, characteristic values etc.

8.5 Bolted connections - spacings, characteristic values etc.

Design tables provided in 'Manual for the design of timber building structures to Eurocode 5' (TRADA, IStructE)
This manual also provides useful information on Initial Design


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