EUROCODE 5, part 1-1
Components and assemblies
Structural detailing and control

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Components

- Glued thin-webbed beams
- Glued thin-flanged beams
- Mechanically jointed beams
- Mechanically jointed and glued columns

Components – Glued thin-webbed beams

Axial stresses in the flanges:

– **Design stresses of extreme fibres:**

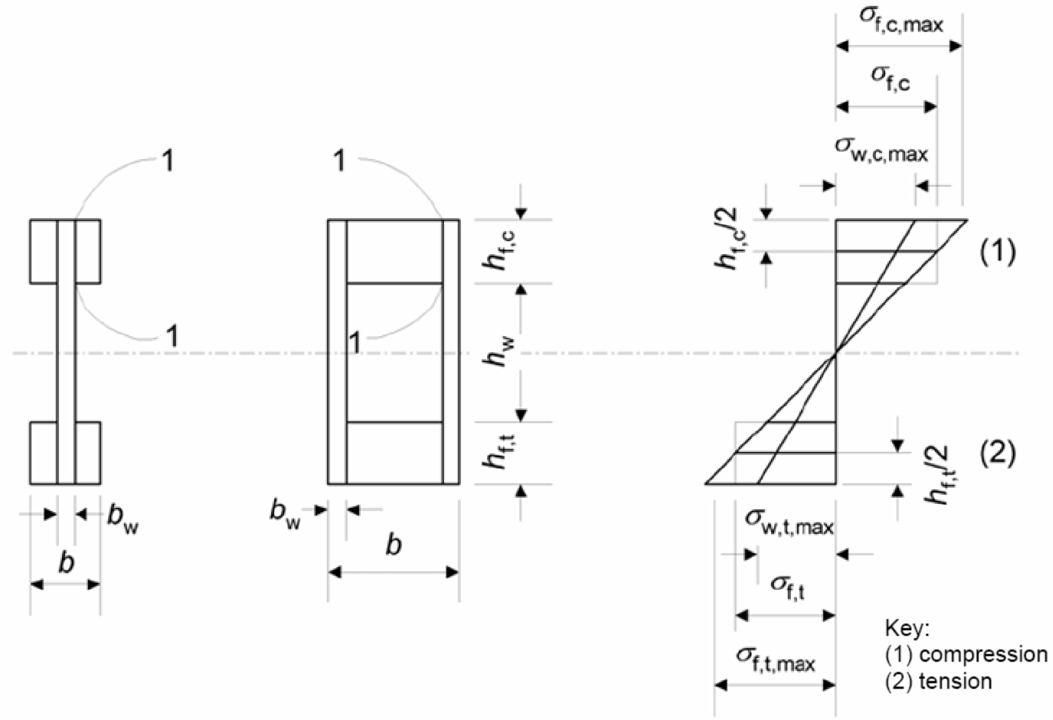
$$\sigma_{f,c,max,d} \leq f_{m,d}$$

$$\sigma_{f,t,max,d} \leq f_{m,d}$$

– **Design stresses of the mean flange:**

$$\sigma_{f,c,d} \leq k_c f_{c,0,d}$$

$$\sigma_{f,t,d} \leq f_{t,0,d}$$



Axial stresses in the webs:

$$\sigma_{w,c,d} \leq f_{c,w,d}$$

$$\sigma_{w,t,d} \leq f_{t,w,d}$$

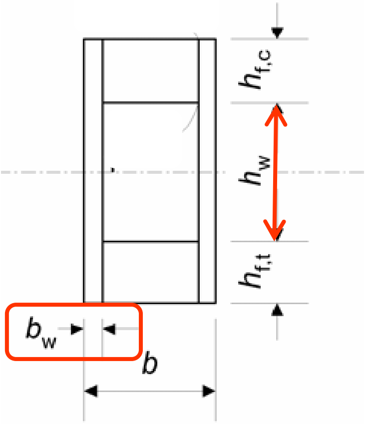
Components – Glued thin-webbed beams

Buckling analysis:

$$h_w \leq 70\, b_w$$

Design shear force acting on each web:

$$F_{v,w,Ed} \leq \begin{cases} b_w h_w \left(1+\dfrac{0{,}5(h_{f,t}+h_{f,c})}{h_w}\right) f_{v,0,d} & \text{for } h_w \leq 35 b_w \\ 35\, b_w^2 \left(1+\dfrac{0{,}5(h_{f,t}+h_{f,c})}{h_w}\right) f_{v,0,d} & \text{for } 35 b_w \leq h_w \leq 70 b_w \end{cases}$$



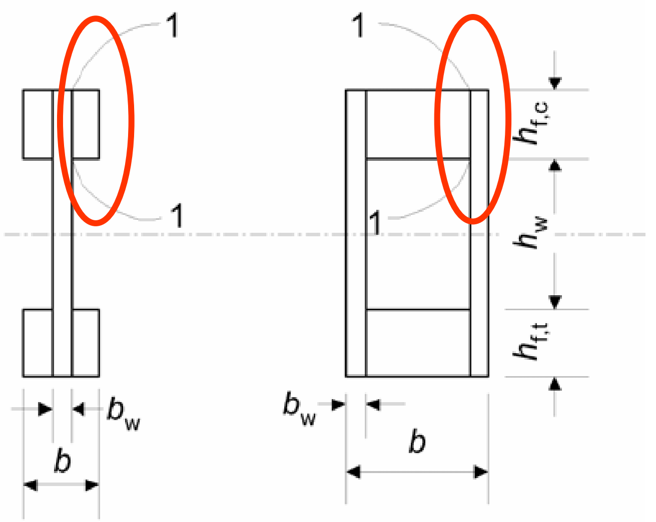
For webs of wood-based panels, should be verified for secction 1-1 that:

Design shear stress at section 1-1:

$$\tau_{mean,d} \leq \begin{cases} f_{v,90,d} & \text{for } h_f \leq 4\, b_{ef} \\ f_{v,90,d} \left(\dfrac{4 b_{ef}}{h_f}\right)^{0,8} & \text{for } h_f > 4\, b_{ef} \end{cases}$$

where:

$$b_{ef} = \begin{cases} b_w & \text{for boxed beams} \\ b_w / 2 & \text{for I-beams} \end{cases}$$



Eurocode 5 part 1-1 Section 9.1.1

Components – Glued thin-flanged beams

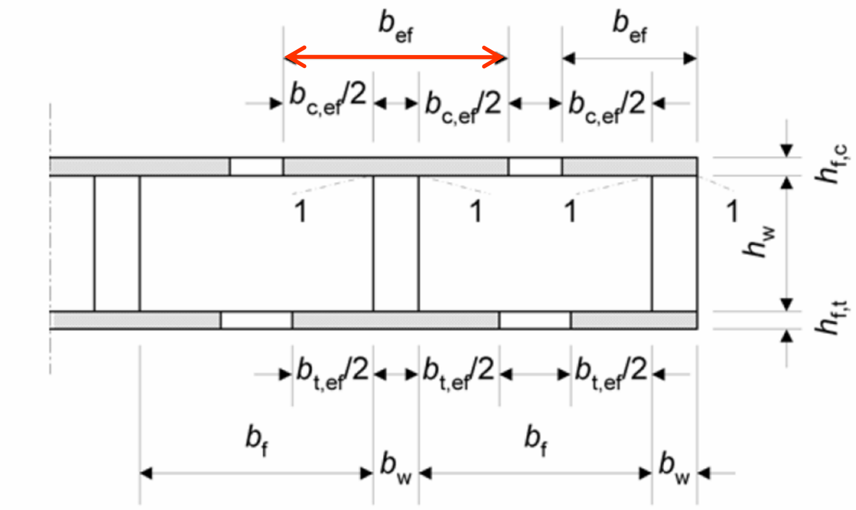
Effective flange widths b_{ef}:

– **I-beams:**

$$b_{ef} = b_{c,ef} + b_w \qquad (\text{or } b_{t,ef} + b_w)$$

– **U-beams:**

$$b_{ef} = 0{,}5b_{c,ef} + b_w \qquad (\text{or } 0{,}5b_{t,ef} + b_w)$$



Maximum effective flange widths due to the effects of shear lag and plate buckling:

Flange material	Shear lag	Plate buckling
Plywood, with grain direction in the outer plies:		
– Parallel to the webs	$0{,}1\ell$	$20h_f$
– Perpendicular to the webs	$0{,}1\ell$	$25h_f$
Oriented strand board	$0{,}15\ell$	$25h_f$
Particleboard or fibreboard with random fibre orientation	$0{,}2\ell$	$30h_f$

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Components – Glued thin-flanged beams

The axial stresses in the flanges, based on the relevant effective flange width, should satisfy the following expressions:

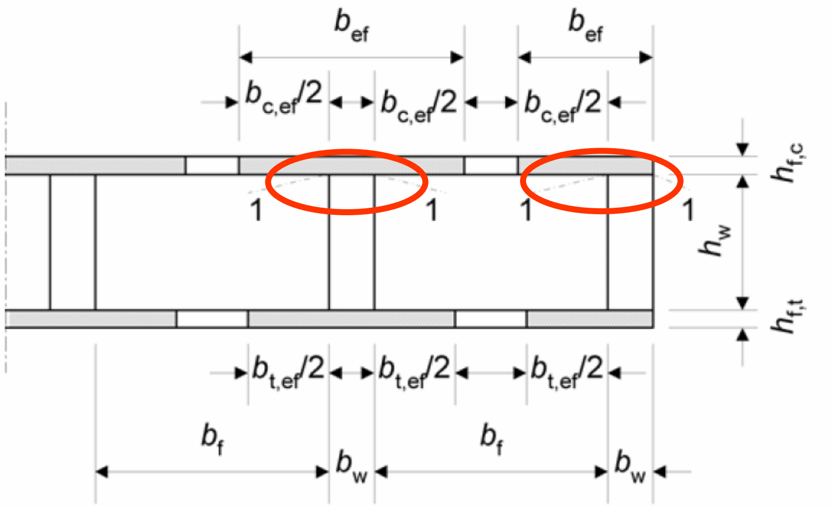
$$\sigma_{f,c,d} \leq f_{f,c,d}$$

$$\sigma_{f,t,d} \leq f_{f,t,d}$$

For webs of wood-based panels, it should , for sections 1-1 of an I-shaped cross-section be verified that:

Design shear stress at the section 1-1:

$$\tau_{mean,d} \leq \begin{cases} f_{v,90,d} & \text{for } b_w \leq 8h_f \\ f_{v,90,d}\left(\dfrac{8h_f}{b_w}\right)^{0,8} & \text{for } b_w > 8h_f \end{cases}$$



For U-shaped cross-section: $8h_f \rightarrow 4h_f$

Components – Mechanically jointed beams

If the spacing of the fasteners varies in the longitudinal direction, an effective spacing may be used:

$$s_{ef} = 0{,}75\, s_{min} + 0{,}25\, s_{max} \qquad s_{max}\ (\leq 4 s_{min})$$

A method for the calculation of the load-carrying capacity of mechanically jointed beams is given in Annex B:

Effective bending stiffness

$$(EI)_{ef} = \sum_{i=1}^{3} (E_i I_i + \gamma_i E_i A_i a_i^2)$$

and:

$$A_i = b_i h_i$$

$$I_i = \frac{b_i h_i^3}{12}$$

$$\gamma_2 = 1$$

$$\gamma_i = \left[1 + \pi^2 E_i A_i s_i / (K_i l^2)\right]^{-1} \qquad \text{for } i = 1 \text{ and } i = 3$$

$$a_2 = \frac{\gamma_1 E_1 A_1 (h_1 + h_2) - \gamma_3 E_3 A_3 (h_2 + h_3)}{2 \sum_{i=1}^{3} \gamma_i E_i A_i}$$

Eurocode 5 part 1-1 Section 9.1.3 Annex B

Components – Mechanically jointed beams

Annex B, EN 1995-1-1:2004

–Normal stresses

$$\sigma_i = \frac{\gamma_i\, E_i\, a_i\, M}{(E\,I)_{ef}}$$

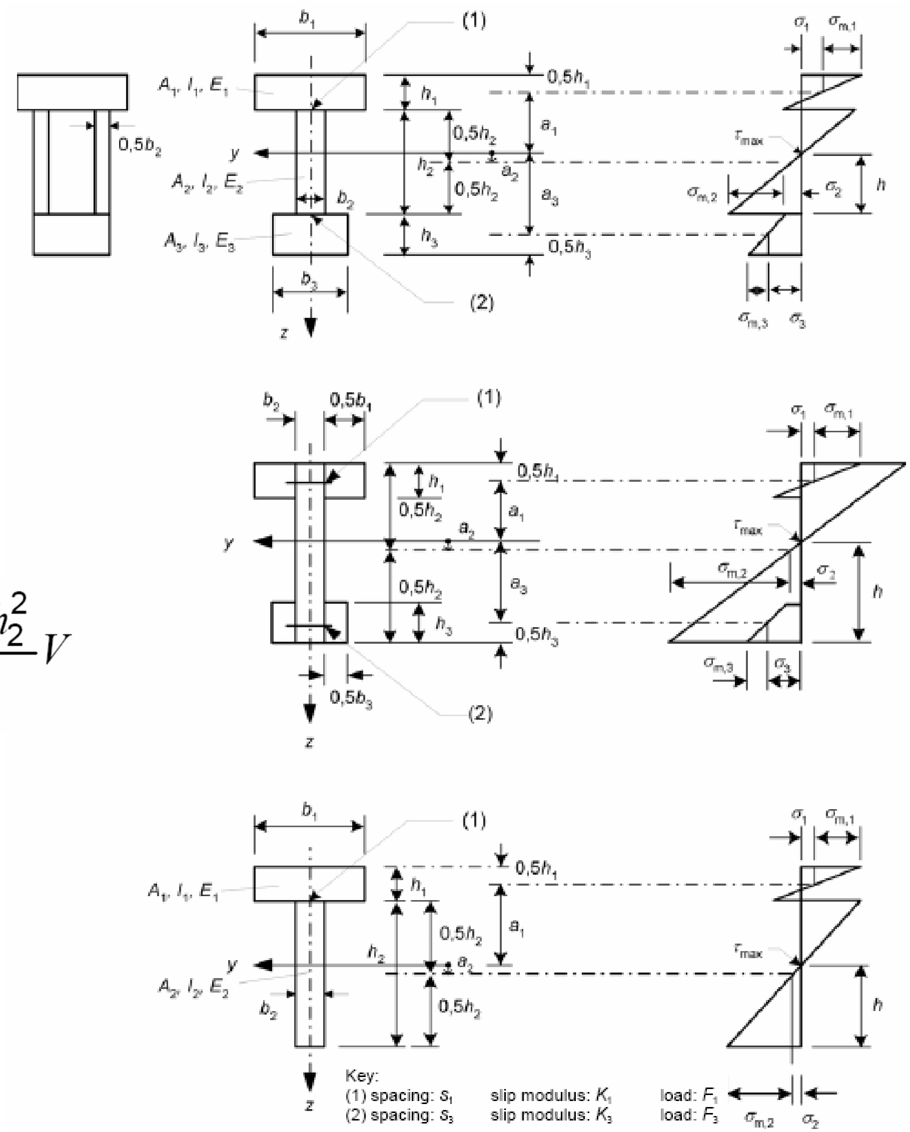
$$\sigma_{m,i} = \frac{0{,}5 E_i\, h_i\, M}{(E\,I)_{ef}}$$

–Maximum shear stress

$$\tau_{2,max} = \frac{\gamma_3\, E_3\, A_3\, a_3 \;+\; 0{,}5\, E_2\, b_2\, h_2^2}{b_2 (E\,I)_{ef}} V$$

–Fastener load

$$F_i = \frac{\gamma_i\, E_i\, A_i\, a_i\, s_i}{(E I)_{ef}} V$$



Eurocode 5 part 1-1 Section 9.1.3 Annex B

A method for the calculation of the load-carrying capacity of I- and box-columns, spaced columns and lattice columns is given in Annex C:

Mechanically jointed columns

–Effective slenderness ratio

$$\lambda_{ef} = \ell\sqrt{\frac{A_{tot}}{I_{ef}}} \qquad I_{ef} = \frac{(EI)_{ef}}{E_{mean}}$$

where $(EI)_{ef}$ is determined in accordance with Annex B

–Load on fasteners

$$V_d = \begin{cases} \dfrac{F_{c,d}}{120\,k_c} & \text{for } \lambda_{ef} < 30 \\[2ex] \dfrac{F_{c,d}\lambda_{ef}}{3600\,k_c} & \text{for } 30 \le \lambda_{ef} < 60 \\[2ex] \dfrac{F_{c,d}}{60\,k_c} & \text{for } 60 \le \lambda_{ef} \end{cases}$$

Assemblies

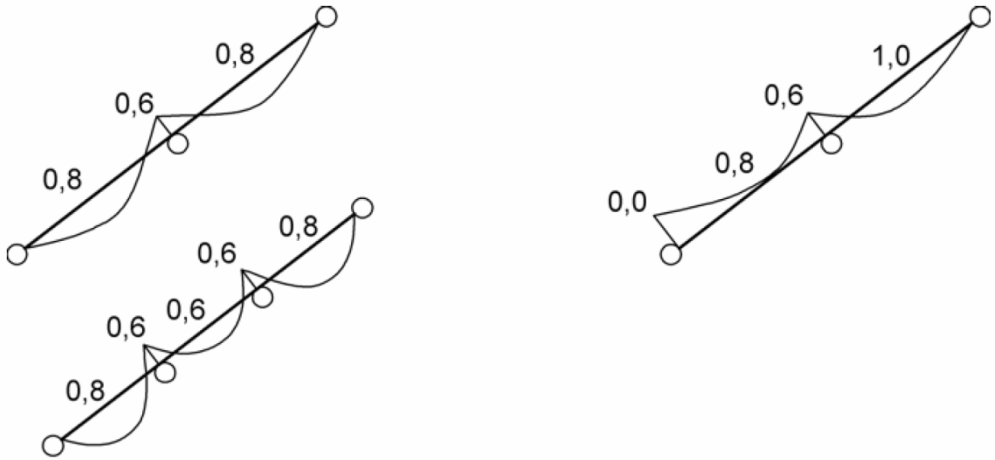
- Trusses
- Trusses with punched metal plate fasteners
- Roof and floor diaphragms
- Wall diaphragms
- Bracing

Assemblies – Trusses

All joints should be capable of transferring a force $F_{r,d}$ acting in any direction within the plane of the truss.

$$F_{\mathrm{r,d}} = 1{,}0 + 0{,}1L$$

L is the overall length of the truss



Moment diagrams and effective lengths in compression (a) No significant end moments (b) Significant end moments

Assemblies – Trusses with punched metal plate fasteners

- For fully triangulated trusses where a small concentrated force has a component perpendicular to the member of < 1,5kN, and where $\sigma_{c,d} < 0,4\, f_{c,d}$, and $\sigma_{t,d} < 0,4\, f_{t,d}$, then the requirements of EN 1995 6.2.3 and 6.2.4 may be replaced by

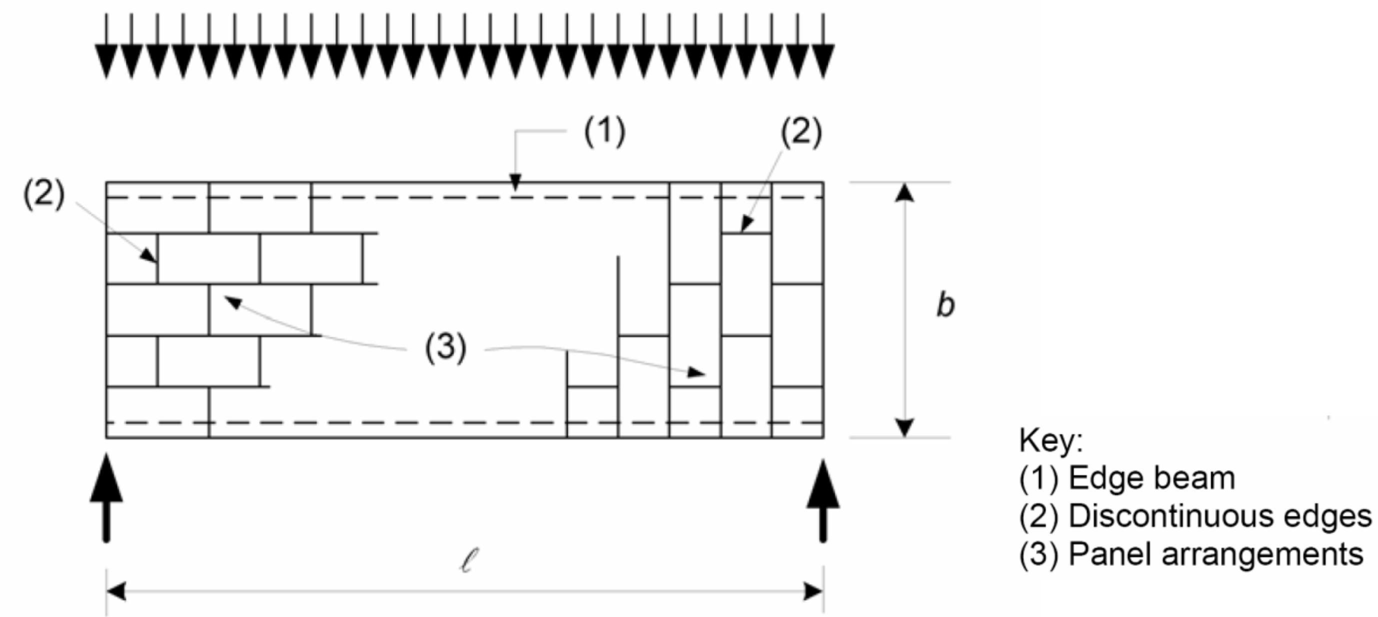
$$\sigma_{m,d} \leq 0,75 f_{m,d}$$

- Punched metal plate fasteners used in chord splices should cover at least 2/3 of the required member height.

- Trusses made with punched metal plate fasteners shall conform to the requirements of EN 14250

Assemblies – Roof and floor diaphragms

Simplified analysis of roof and floor diaphragms



For diaphragms with a uniformly distributed load the simplified method of analysis should be used provided that:

- the span l lies between 2b and 6b, where b is the diaphragm width
- the critical ultimate design condition is failure in the fasteners (and not in the panels);

Eurocode 5 part 1-1 Section 9.2.3

Assemblies – Wall diaphrams

Simplified analysis of wall diaphragms – Method A

Design racking load-carrying capacity

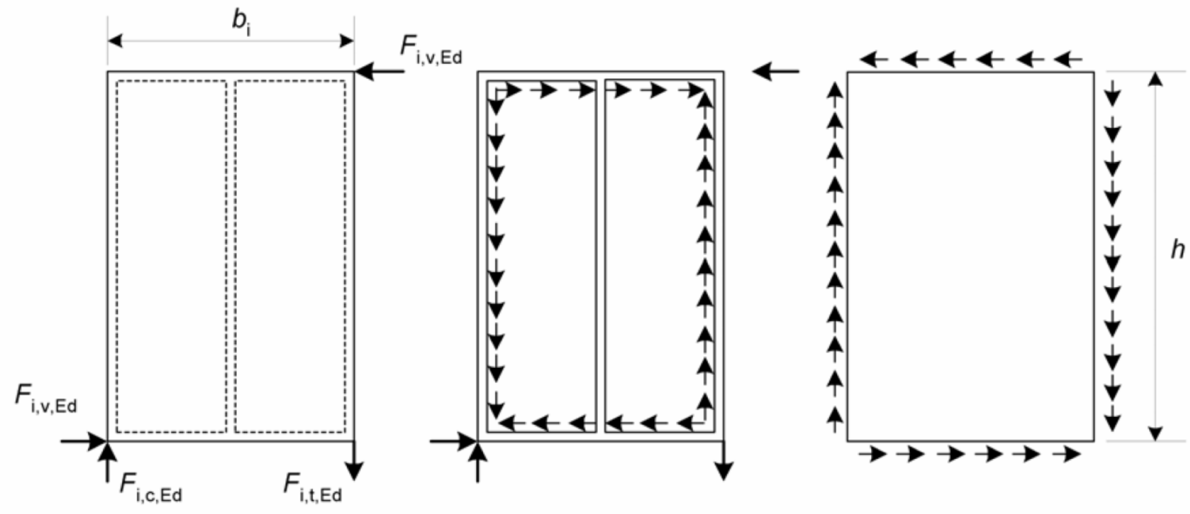
$$F_{v,Rd} = \sum F_{i,v,Rd}$$

$$F_{i,v,Rd} = \frac{F_{f,Rd}\, b_i\, c_i}{s}$$

$F_{f,Rd}$ is the lateral design capacity of an individual fastener

External forces

$$F_{i,c,Ed} = F_{i,t,Ed} = \frac{F_{i,v,Ed}\, h}{b_i}$$



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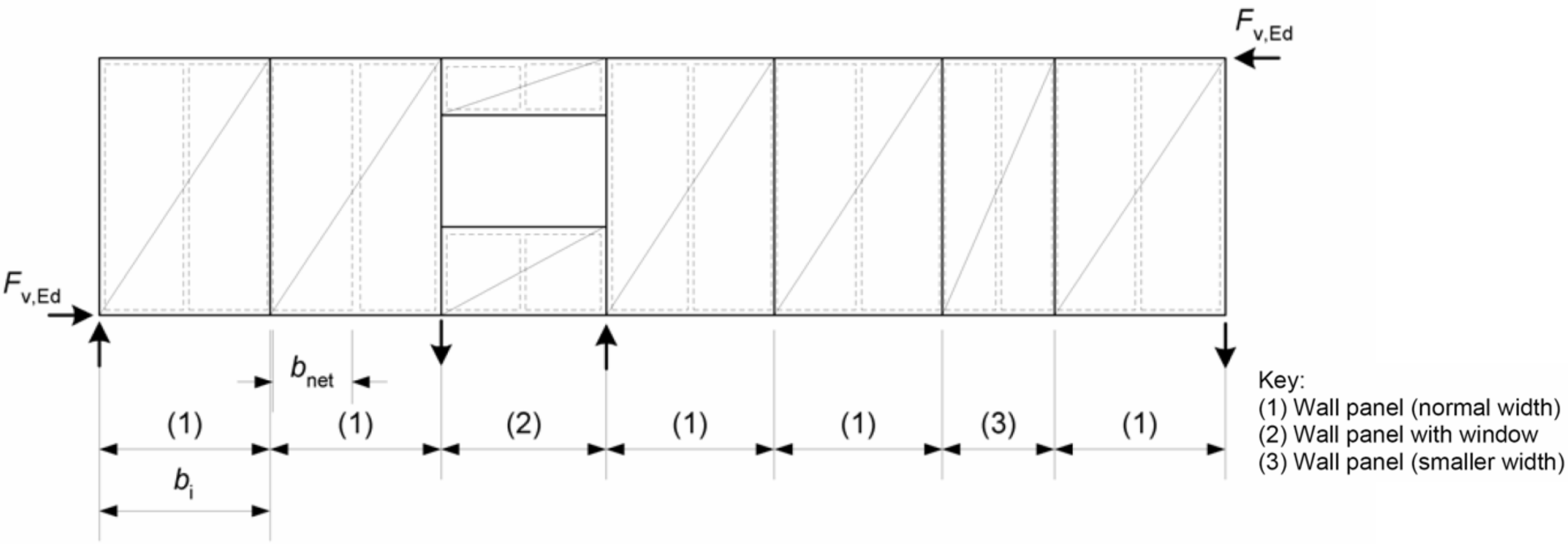
Assemblies – Wall diaphrams

Simplified analysis of wall diaphragms – Method A

The external forces which arise in wall panels containing door or window openings and in wall panels of smaller width, can similarly be transmitted to the construction situated above or below.



Shear buckling of the sheet may be disregarded, provided that

$$\frac{b_{net}}{t} \leq 100$$

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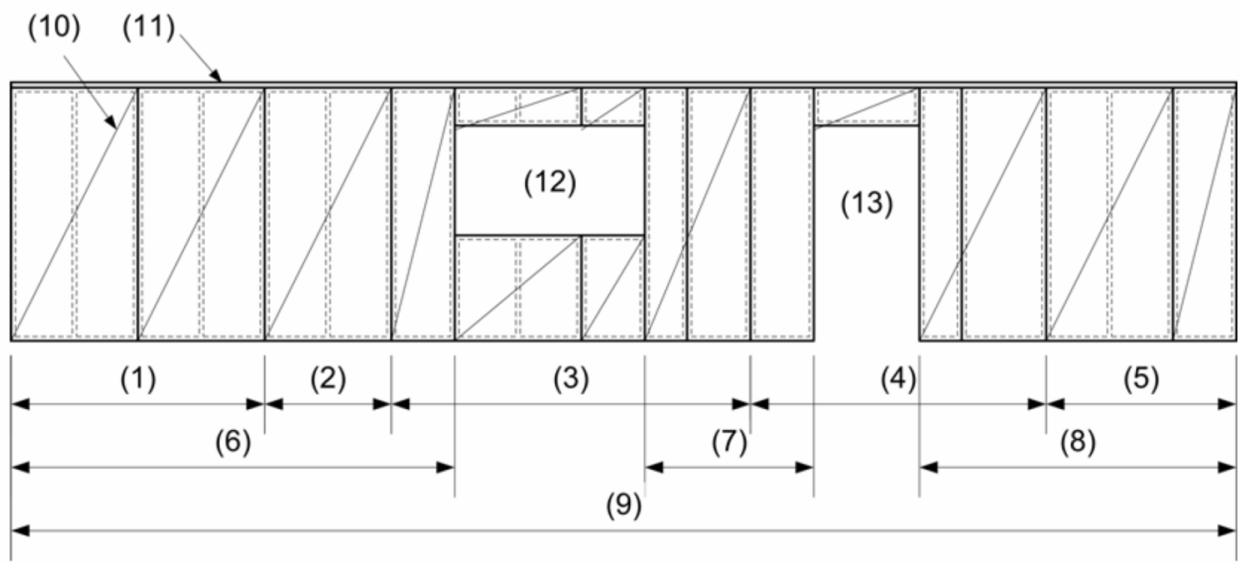
Assemblies – Wall diaphrams

Simplified analysis of wall diaphragms – Method B

Construction of walls and panels to meet the requirements of the simplified analysis



Key:
(1) Wall panel 1
(2) Wall panel 2
(3) Wall panel 3
(4) Wall panel 4
(5) Wall panel 5
(6) Wall 1
(7) Wall 2
(8) Wall 3
(9) Wall assembly
(10) Sheet
(11) Head binder
(12) Window
(13) Door

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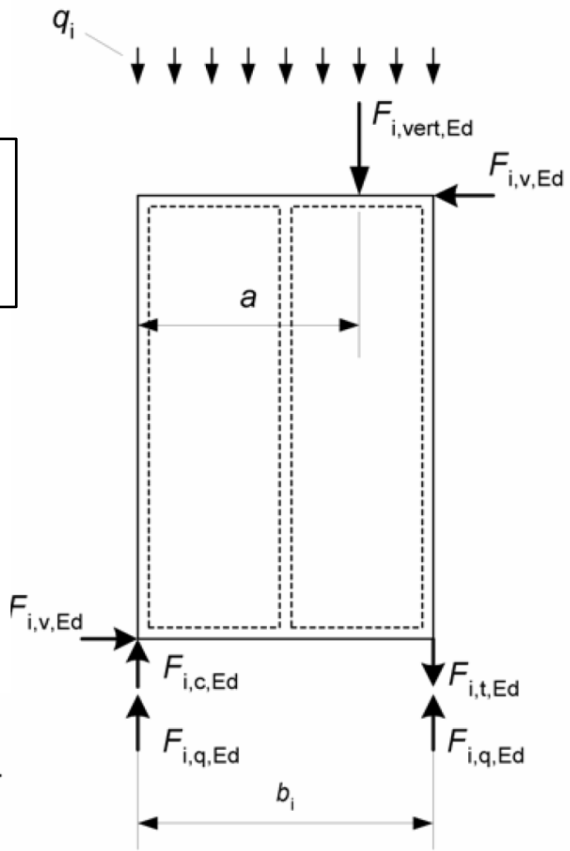
Assemblies – Wall diaphrams

Simplified analysis of wall diaphragms – Method B

Design ranking strength of the wall assembly:

$$F_{\mathrm{v,Rd}} = \sum F_{\mathrm{i,v,Rd}} \qquad F_{\mathrm{i,v,Rd}} = \frac{F_{\mathrm{f,Rd}}\, b_{\mathrm{i}}}{s_0} k_{\mathrm{d}}\, k_{\mathrm{i,q}}\, k_{\mathrm{s}}\, k_{\mathrm{n}}$$



and:

$$k_{\mathrm{i,q}} = 1 + \left(0{,}083\, q_{\mathrm{i}} - 0{,}0008\, q_{\mathrm{i}}^2\right)\left(\frac{2{,}4}{b_{\mathrm{i}}}\right)^{0{,}4}$$

$$k_{\mathrm{n}} = \begin{cases} 1{,}0 \\ \dfrac{F_{\mathrm{i,v,Rd,max}} + 0{,}5\, F_{\mathrm{i,v,Rd,min}}}{F_{\mathrm{i,v,Rd,max}}} \end{cases}$$

$$k_{\mathrm{d}} = \begin{cases} \dfrac{b_{\mathrm{i}}}{h} & \text{for } \dfrac{b_{\mathrm{i}}}{h} \le 1{,}0 \\ \left(\dfrac{b_{\mathrm{i}}}{h}\right)^{0{,}4} & \text{for } \dfrac{b_{\mathrm{i}}}{h} > 1{,}0 \text{ and } b_{\mathrm{i}} \le 4{,}8 \text{ m} \\ \left(\dfrac{4{,}8}{h}\right)^{0{,}4} & \text{for } \dfrac{b_{\mathrm{i}}}{h} > 1{,}0 \text{ and } b_{\mathrm{i}} > 4{,}8 \text{ m} \end{cases}$$

$$k_{\mathrm{s}} = \frac{1}{0{,}86\, \dfrac{s}{s_0} + 0{,}57}$$

$$s_0 = \frac{9700\, d}{\rho_{\mathrm{k}}}$$

$$q_{\mathrm{i}} = \frac{2\, a\, F_{\mathrm{i,vert,Ed}}}{b_{\mathrm{i}}^2}$$

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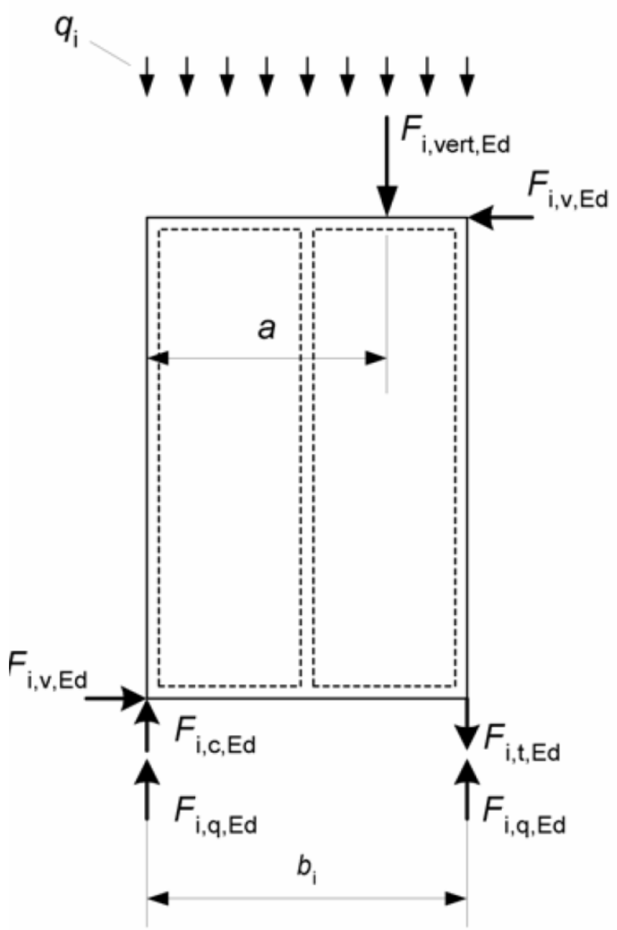
Assemblies – Wall diaphrams

External forces

$$F_{i,c,Ed} = F_{i,t,Ed} = \frac{F_{i,v,Ed}\ h}{b_i}$$



Shear buckling of the sheet may be disregarded, provided that

$$\frac{b_{net}}{t} \leq 100$$

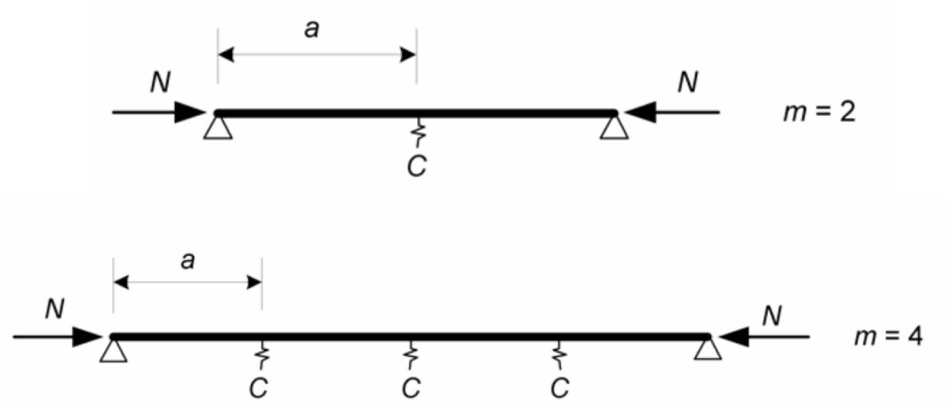
Eurocode 5 part 1-1 Section 9.2.4

Assemblies – Bracing

Single members in compression

Spring stiffness:

$$C = k_s \frac{N_d}{a}$$



Mean design compressive force:

$$N_d = (1 - k_{crit}) \frac{M_d}{h}$$

Design stabilizing force

$$F_d = \begin{cases} \dfrac{N_d}{k_{f,1}} & \text{for solid timber} \\ \dfrac{N_d}{k_{f,2}} & \text{for glued laminated timber and LVL} \end{cases}$$

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Assemblies – Bracing

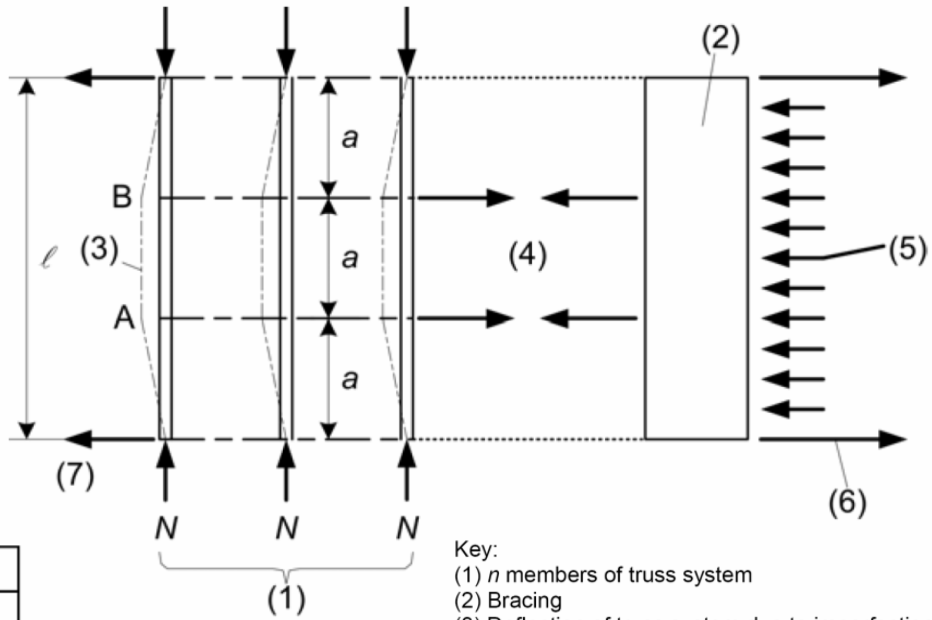
Bracing of beam or truss systems

Load per unit length:

$$q_d = k_\ell \frac{n N_d}{k_{f,3} \ell}$$

where:

$$k_\ell = \min \begin{cases} 1 \\ \sqrt{\dfrac{15}{\ell}} \end{cases}$$



Key:
(1) *n* members of truss system
(2) Bracing
(3) Deflection of truss system due to imperfections and second order effects
(4) Stabilizing forces
(5) External load on bracing
(6) Reaction forces of bracing due to external loads
(7) Reaction forces of truss system due to stabilizing forces

Modification factor	Range
k_s	4 to 1
$k_{f,1}$	50 to 80
$k_{f,2}$	80 to 100
$k_{f,3}$	30 to 80

Eurocode 5 part 1-1 Section 9.2.5

EN 1990 – 1.3 „Assumptions“

(2) The general assumptions of EN 1990 are:

the choice of the structural system and the design of the structure is made by appropriately qualified and experienced personnel;

- execution is carried out by personnel having the appropriate skill and experience;
- adequate supervision and quality control is provided in design offices and during execution of the work, i.e. factories, plants, and on site;
- the construction materials and products are use as specified in EN 1990 or in EN 1992 to EN 1999 or in the relevant execution standards, or reference material or product specifications;

EN 1990 – 1.3 „Assumptions“

The general assumptions of EN 1990 are: (continued)

- **the structure will be adequately maintained;**
- **the structure will be used in accordance with the design assumptions.**

NOTE: There may be cases when the above assumptions need to be supplemented.

Structural detailing and control

- Materials
- Glued joints
- Connections with mechanical fasteners
- Assembly
- Transportation and erection
- Control
- Special rules for diaphragms
- Special rules for trusses with punched metal plate fasteners

Structural detailing and control - Materials

Preliminary remark:
according to the relevant material – standards; grading and classification.

- Straightness
- Climatic conditions
- Moisture content

Structural detailing and control - Glued joints / connections with mechanical fasteners

Glued joints

- Reliability and quality of joint
- Adhesive manufacturing
- Conditioning period

Connections with mechanical fasteners

- Nails
- Bolts and washers
- Dowels
- Screws

Eurocode 5 part 1-1 Section 10.3 / 10.4

Structural detailing and control - Connections with mechanical fasteners

General

–Wane, splits, knots or other defects shall be limited in the region of the connection

Nails

–Nails should be driven in at right angles to the grain
–Slant nailing should be carried out
–The diameter of pre-drilled holes should not exceed 0,8d

Bolts and washers

Requirements for diameters of bolts used with timber connectors

Type of connector EN 912	d_c	d minimum	d maximum
	mm	mm	mm
A1 – A6	≤ 130	12	24
A1, A4, A6	> 130	0,1 d_c	24
B		d_1-1	d_1

Eurocode 5 part 1-1 Section 10.4

Structural detailing and control - Connections with mechanical fasteners

Dowels

The minimum dowel diameter should be **6 mm**. The tolerances on the dowel diameter should be - 0/+0,1 mm. Pre-bored holes in the timber members should have a diameter not greater than the dowel.

Screws

- **Softwoods,** smooth shank diameter $d \leq 6$ mm, **pre-drilling** is **not** required.

- **Hardwoods** and for screws in softwoods with **a diameter d > 6 mm**, pre-drilling is required, with the following requirements:
  - The lead hole for the shank should have the same diameter as the shank and the same depth as the length of the shank
  - The lead hole for the threaded portion should have a diameter of approximately 70 % of the shank diameter.

- For timber densities greater than 500 kg/m3, the pre-drilling diameter should be determined by tests.

Eurocode 5 part 1-1 Section 10.4

Structural detailing and control – Assembly / Transportation and erection

Assembly

The structure should be assembled in such a way that over-stressing of its members or connections is avoided. Members which are warped, split or badly fitting at the joints should be replaced.

Transportation and erection

The over-stressing of members during storage, transportation or erection should be avoided.

If the structure is loaded or supported in a different manner during construction than in the finished building the temporary condition should be considered as a relevant load case including any possible dynamic actions.

In the case of structural framework, e.g. framed arches, portal frames, special care should be taken to avoid distortion during hoisting from the horizontal to the vertical position.

Eurocode 5 part 1-1 Section 10.5 / 10.6

Structural detailing and control – Control

It is assumed that a control plan comprises:

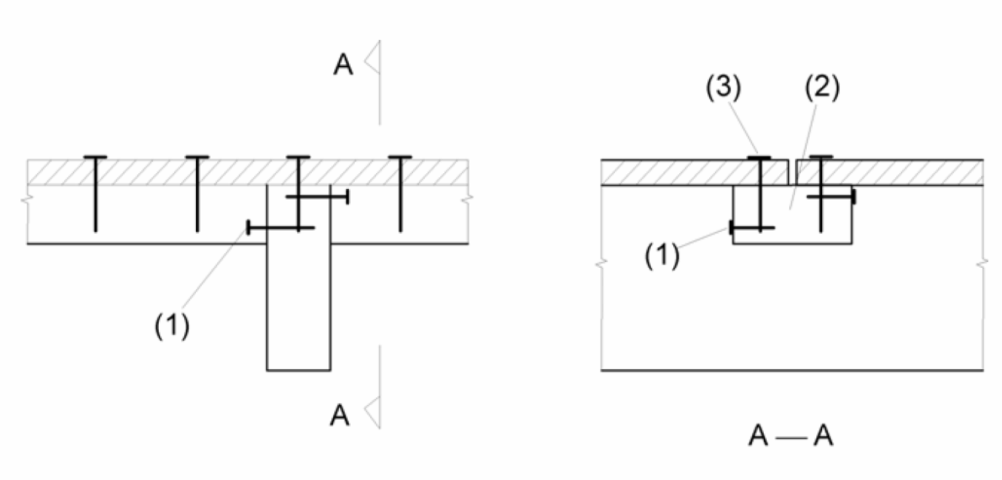
- production and workmanship control off and on site;
- control after completion of the structure

The control of the construction is assumed to include:

- preliminary tests
- checking of materials and their identification
- transport, site storage and handling of materials;
- checking of correct dimensions and geometry;
- checking of assembly and erection;
- checking of structural details
- final checking of the result of the production process, e.g. by visual inspection or proof loading.

Structural detailing and control - Special rules for diaphragm structures

Floor and roof diaphragms



Key:
(1) Batten slant nailed to joist or rafter
(2) Batten
(3) Sheathing nailed to batten

Wall diaphragms

Key:
(1) Maximum nail spacing 300 mm to intermediate studs
(2) Panel edge
(3) Maximum nail spacing 150 mm

Eurocode 5 part 1-1 Section 10.8

Structural detailing and control - Special rules for trusses with punched metal plate fasteners

Fabrication

Requirements for the fabrication of trusses are given in EN 14250

Erection

- Trusses should be checked for straightness and vertical alignment prior to fixing the permanent bracing
- When trusses are fabricated, the members should be free from distortion within the limits given in EN 14250
- The maximum bow in any truss member after erection should be limited. (10 to 50 mm)
- The maximum deviation of a truss from true vertical alignment after erection should be limited. (10 to 50 mm)

Eurocode 5 part 1-1 Section 10.9

Thank you very much for your kind attention

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