# Dach+: Connections according to EN 1995

This documentation contains additional information about our roof program Dach+

## Table of contents



## Basic documentation - overview

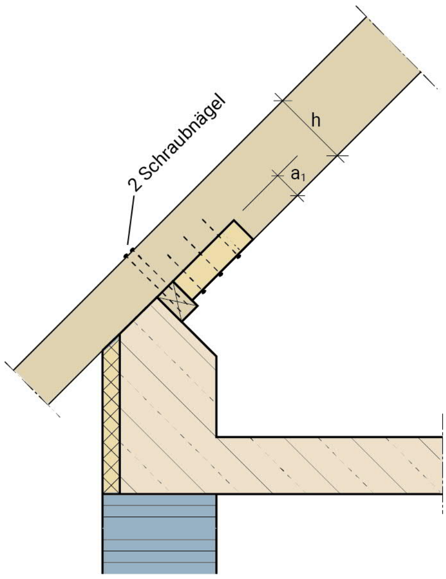
In addition to the individual program Manuals, you will find basic explanations of how to use the programs on our homepage www.frilo.eu/en/ in the download area (Manuals).

Tip: To go back - e.g. after a link to another chapter/document - in the PDF use the key combination *"ALT"* + *"Left direction key"*.

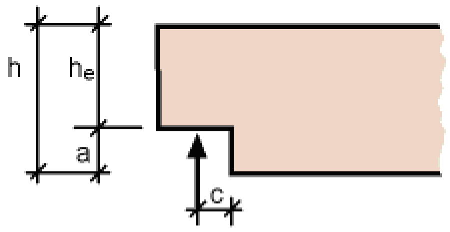
# Base points

## Notch

After selecting a cut depth a1, the shear stress and the sill pressure are verified. If the shear stress verification cannot be adhered to, the shear force to be absorbed is also output for the reinforcement.




### Geometric boundary conditions




The notch is calculated according to EN 1995-1-1:2008/2014, 6.5.

The bare EN does not specify any boundary conditions for notches; the determination is made in the respective NAs.

#### ÖNorm B 1995:2010

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ ÖNorm B 1995-1-1, 6.6.7, Eq.(16)

If equation EN 1995-1-1, (6.60) cannot be met, then reinforcement must be made.

#### ÖNorm B 1995:2014

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ ÖNorm B 1995-1-1, NCI to 6.5.2, Eq.(NA.6.63 E1 and E2)

If equation EN 1995-1-1, (6.60) cannot be met, then reinforcement must be made.

#### DIN EN 1995:2010, 2013

DIN EN 1995-1-1:2010 does not contain any boundary conditions for the geometry. Since the NA is based on DIN 1052:2008, its boundary conditions are checked:

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ DIN 1052:2008, 11.2

In the case of reinforced beam notches or with short or very short load durations or with beams notched at the top, the conditions mentioned do not have to be adhered to.

Beam notches in service class 3 must always be reinforced!

## UNI EN 1995:2010, NTC EN 1995:2008

UNI EN 1995-1-1 and NTC EN 1995, like the bare EN 1995-1-1, do not contain any boundary conditions for the geometry. The values analogous to DIN 1052:2008 are therefore adopted as a sensible assumption:

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ DIN 1052:2008, 11.2

In the case of reinforced beam notches or with short or very short load durations or with beams notched at the top, the conditions mentioned do not have to be adhered to.

Beam notches in service class 3 must always be reinforced!

## NA to BS EN 1995:2008

NA to BS EN 1995-1-1, like the bare EN 1995-1-1, does not contain any boundary conditions for the geometry. The values analogous to DIN 1052:2008 are therefore adopted as a sensible assumption:

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ DIN 1052:2008, 11.2

In the case of reinforced beam notches or with short or very short load durations or with beams notched at the top, the conditions mentioned do not have to be adhered to.

Beam notches in service class 3 must always be reinforced!

# Verifications

## Shear stress verification

The existing shear stress in the remaining cross-section is:

$\tau_{vorh} = 1{,}5 \frac{V_d}{b \cdot h_{ef}}$ EN 1995-1-1, Eq. (6.60)

In EN 1995-1-1, 6-1-7(2), the standard recommends using an effective width $b_{ef} = k_{cr} \cdot b$ Eq. (6.13a) when checking shear to take cracks into account.

We consider this recommendation to be useful for the very sensitive notching verification and therefore calculate in Eq. (6.60) with the effective width according to Eq. (6.13).

In EN 1995-1-1/A2:2014, equation (6.60) is also corrected to:

$\tau_{vorh} = 1{,}5 \frac{V_d}{b_{ef} \cdot h_{ef}}$ EN 1995-1-1/A2:2014 (6.60)

The permissible shear stress is calculated as:

$\tau_{zul} = k_V \cdot f_{V,d}$ EN 1995-1-1, Eq. (6.60)

The following applies to beams notched at the top: $k_V = 1$ EN 1995-1-1, Eq. (6.61)

the following applies to beams notched at the bottom:

$$k_V = \min \begin{cases} 1 \\ \dfrac{k_n \cdot \left(1 + \dfrac{1{,}1 \cdot i^{1{,}5}}{\sqrt{h}}\right)}{\sqrt{h} \cdot \left(\sqrt{\alpha \cdot (1-\alpha)} + 0{,}8 \cdot \dfrac{c}{h} \cdot \sqrt{\dfrac{1}{\alpha} - \alpha^2}\right)} \end{cases} \quad \text{with } \alpha = \frac{h_e}{h}$$

EN 1995-1-1, Eq. (6.62)

The coefficient $k_n$ is: EN 1995-1-1, Eq. (6.63)

| | |
|---|---|
| 5 | for solid and laminated timber |
| 6,5 | for glued laminated timber |
| 4,5 | for laminated veneer lumber |

## Verification according to ÖNorm B 1995-1-1:2010,2014

ÖNorm B 1995-1-1:2010 and 2014 carry out the calculation according to EN 1995-1-1:2008, 6.5.2.

## Verification according to DIN EN 1995-1-1:2010,2013

The verification is carried out analogously to EN 1995-1-1:2008. 6.5.2.

The coefficient kv may be determined as follows according to DIN EN 1995-1-1:2010/2013, NCI to 6.5.2:

For $c<h_e$ $k_v = \left(\frac{h}{h_e}\right) \cdot \left[1 - \frac{(h-h_e)\cdot c}{h \cdot h_e}\right]$, otherwise $k_v=1$

## Verification according to UNI EN 1995-1-1:2010, NTC EN 1995-1-1:2008

UNI EN 1995-1-1 and NTC EN 1995 carry out the calculation according to EN 1995-1-1:2008, 6.5.2.

## Verification according to NA to BS EN 1995-1-1:2008

NA to BS EN 1995-1-1:2008 carries out the calculation according to EN 1995-1-1:2008, 6.5.2.

### Sill pressure

The shear force $V_d$ is transmitted directly to the base, the axial force $N_d$ via the sill.

The verification of the transverse compressive stress on the support is carried out for:

$\sigma_{c,90,d,Schwelle} = \frac{N_d}{a_1 \cdot l_A}$ and $\sigma_{c,0,d,Sparren} = \frac{N_d}{a_1 \cdot b_{Sp}}$

$\frac{\sigma_{c,90,d}}{k_{c,90} \cdot f_{c,90,d}} \leq 1$ EN 1995-1-1, 6.1.5 (6.3) and $\frac{\sigma_{c,0,d}}{f_{c,0,d}} \leq 1$ EN 1995-1-1, 6.1.4 (6.2)

The value $k_{c90}$ must be specified by the user.

For $l_A$ 3 cm may be added to the rafter width on each side (EN 1995:2010,2014, 6.1.5(1))

## Verification according to ÖNorm B 1995-1-1:2010

Takes over the verification according to EN 1995-1-1.

## Verification according to ÖNorm B 1995-1-1:2014

Takes over the verification according to EN 1995-1-1, but allows a $k_{c,90}$ > 1,75 if the addition of $l_A$ is omitted. (NCI to 6.1.5(2)).

## Verification according to DIN EN 1995-1-1:2010, 2013

Takes over the verification according to EN 1995-1-1.

## Verification according to UNI EN 1995-1-1:2010, NTC EN 1995-1-1:2008

UNI EN 1995-1-1 and NTC EN 1995 take over the verification according to EN 1995-1-1.

## Verification according to NA to BS EN 1995-1-1:2008

NA to BS EN 1995-1-1:2008 takes over verification according to EN 1995-1-1.

### Reinforcement

If the shear stress verification cannot be complied with, the notch needs to be reinforced:

There is no regulation for reinforcements in EN 1995-1-1.

The determination is therefore carried out analogously to DIN 1052:2008:

$$F_{t,90,d} = (\text{erf } Z_{Verst}) = 1{,}3 \cdot V_d \cdot \left[3(1-\alpha)^2 - 2(1-\alpha)^3\right] \text{ with } \alpha = \frac{h_e}{h}$$ DIN 1052:2008, Eq.(162)

## Verification according to ÖNorm B 1995-1-1:2010

Does not contain its own regulation and therefore carries out the determination according to bare EN (or DIN 1052:2008).

## Verification according to ÖNorm B 1995-1-1:2014

The tensile force to be absorbed is:

$$F_{t,90,d} = 1{,}3 \cdot V_d \cdot \left[1 - 3\alpha^2 + 2\alpha^3\right] \text{ with } \alpha = \frac{h_e}{h}$$ ÖNorm B 1995-1-1 (NA.Eq.11)

## Verification according to DIN EN 1995-1-1:2010, 2013

The tensile force to be absorbed is:

$$F_{t,90,d} = (\text{erf } Z_{Verst}) = 1{,}3 \cdot V_d \cdot \left[3(1-\alpha)^2 - 2(1-\alpha)^3\right] \text{ with } \alpha = \frac{h_e}{h}$$ DIN EN 1995-1-1, (NA.75), or (NA.77)

## Verification according to DIN EN 1995-1-1:2010, 2013

Takes over the verification according to EN 1995-1-1.

## Verification according to UNI EN 1995-1-1:2010, NTC EN 1995-1-1:2008

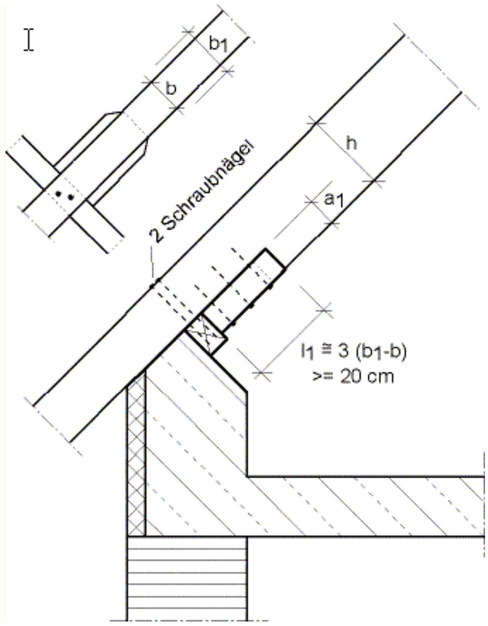
Does not contain its own regulation and therefore carries out the determination according to bare EN (or DIN 1052:2008).

## Verification according to NA to BS EN 1995-1-1:2008

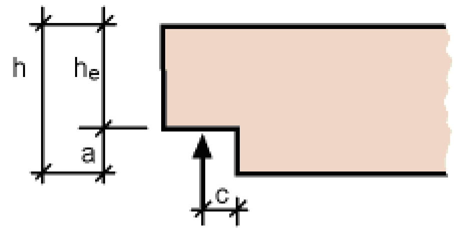
Does not contain its own regulation and therefore carries out the determination according to bare EN (or DIN 1052:2008).

## Nailed cleat

For a given cut depth a1, the program determines the required cleat width b1 and cleat length l1.
The shear stress verification for the notch is carried out.




### Geometric boundary conditions




The notch is calculated according to EN 1995-1-1:2008/2014, 6.5.
The bare EN does not specify any boundary conditions for notches; the determination is made in the respective NAs.

### ÖNorm B 1995:2010

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ ÖNorm B 1995-1-1, 6.6.7, Eq.(16)

If equation EN 1995-1-1, (6.60) cannot be met, then reinforcement must be made.

### ÖNorm B 1995:2014

$\frac{h_e}{h} \geq 0{,}5$ und $\frac{c}{h} \leq 0{,}4$ ÖNorm B 1995-1-1, NCI zu 6.5.2, Gl.(NA.6.63 E1 und E2)

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ ÖNorm B 1995-1-1, NCI to 6.5.2, Gl.(NA.6.63 E1 and E2)

If equation EN 1995-1-1, (6.60) cannot be met, then reinforcement must be made.

### DIN EN 1995:2010, 2013

DIN EN 1995-1-1:2010 does not contain any boundary conditions for the geometry. Since the NA is based on DIN 1052:2008, its boundary conditions are verified:

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ DIN 1052:2008, 11.2

In the case of reinforced beam notches or with short or very short load durations or with beams notched at the top, the conditions mentioned do not have to be adhered to.

Beam notches in service class 3 must always be reinforced!

### UNI EN 1995:2010, NTC EN 1995:2008

UNI EN 1995-1-1 and NTC EN 1995, like the bare EN 1995-1-1, do not contain any boundary conditions for the geometry. The values analogous to DIN 1052:2008 are therefore adopted as a sensible assumption:

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ DIN 1052:2008, 11.2

In the case of reinforced beam notches or with short or very short load durations or with beams notched at the top, the conditions mentioned do not have to be adhered to.
Beam notches in service class 3 must always be reinforced!

## NA to BS EN 1995:2008

NA to BS EN 1995-1-1, like the bare EN 1995-1-1, does not contain any boundary conditions for the geometry. The values analogous to DIN 1052:2008 are therefore taken over as a sensible assumption:

$\frac{h_e}{h} \geq 0{,}5 \text{ and } \frac{c}{h} \leq 0{,}4$ DIN 1052:2008, 11.2

In the case of reinforced beam notches or with short or very short load durations or with beams notched at the top, the conditions mentioned do not have to be adhered to.

Beam notches in service class 3 must always be reinforced!

## Verifications

### Required cleat dimensions

The required cleat width can be determined from the area required to verify the sill pressure:

$$erf.A = \frac{F_{c,90,d}}{k_{c,90} \cdot f_{c,90,d}} \quad \text{and} \quad erf.b_1 = \frac{erf.A}{a_1}$$

According to EN 1995:2010,2014, 6.1.5, the required cleat length is:

$$erf.\,l_1 = 3 \cdot (b_1 - b)$$

### Shear stress verification

The available shear stress in the remaining cross-section is:

$\tau_{vorh} = 1{,}5 \frac{V_d}{b \cdot h_{ef}}$ EN 1995-1-1, Eq. (6.60)

In EN 1995-1-1, 6-1-7(2), the standard recommends using an effective width Eq. $b_{ef} = k_{cr} \cdot b$ Eq.(6.13a) when checking shear to take cracks into account.

In EN 1995-1-1, 6-1-7(2), the standard recommends using an effective width Eq. (6.13a) when checking shear to take cracks into account.

We consider this recommendation to be useful for the very sensitive notch verification and therefore calculate in Eq. (6.60) with the effective width according to Eq. (6.13).

In EN 1995-1-1/A2:2014, equation (6.60) is also corrected to:

$\tau_{vorh} = 1{,}5 \frac{V_d}{b_{ef} \cdot h_{ef}}$ EN 1995-1-1/A2:2014 (6.60)

The permissible shear stress is calculated as:

$\tau_{zul} = k_V \cdot f_{V,d}$ EN 1995-1-1, Eq. (6.60)

The following applies to beams notched at the top: $k_V = 1$ EN 1995-1-1, Eq. (6.61)

The following applies to beams notched at the bottom:

$$k_V = \min\begin{cases} 1 \\ \dfrac{k_n \cdot \left(1 + \dfrac{1{,}1 \cdot i^{1{,}5}}{\sqrt{h}}\right)}{\sqrt{h} \cdot \left(\sqrt{\alpha \cdot (1-\alpha)} + 0{,}8 \cdot \dfrac{c}{h} \cdot \sqrt{\dfrac{1}{\alpha} - \alpha^2}\right)} \end{cases} \quad \text{with } \alpha = \frac{h_e}{h}$$

EN 1995-1-1, Eq. (6.62)

The coefficient $k_n$ is: EN 1995-1-1, Eq. (6.63)

| | |
|---|---|
| 5 | for for solid and laminated timber |
| 6,5 | for glued laminated timber |
| 4,5 | for laminated veneer lumber |

## Verification according to ÖNorm B 1995-1-1:2010,2014

ÖNorm B 1995-1-1:2010 takes over the calculation according to EN 1995-1-1:2008, 6.5.2.

## Verification according to DIN EN 1995-1-1:2010,2013

The verification is carried out analogously to EN 1995-1-1:2008. 6.5.2.

The coefficient kv may be determined as follows according to DIN EN 1995-1-1:2010/2013, NCI to 6.5.2:

For $c<h_e$ $k_v = \left(\frac{h}{h_e}\right) \cdot \left[1 - \frac{(h-h_e)\cdot c}{h \cdot h_e}\right]$, otherwise $k_v=1$

## Verification according to UNI EN 1995-1-1:2010, NTC EN 1995-1-1:2008

UNI EN 1995-1-1 and NTC EN 1995 take over the calculation according to EN 1995-1-1:2008, 6.5.2.

## Verification according to NA to BS EN 1995-1-1:2008

NA to BS EN 1995-1-1:2008 takes over the calculation according to EN 1995-1-1:2008, 6.5.2.

### Verification of the rafter/cleat contact

Verification of pressure between rafters and cleat:

$$\sigma_{c,0,d,Sparren} = \sigma_{c,0,d,Knagge} = \frac{N_d}{a_1 \cdot b_{Sp}}$$

$\frac{\sigma_{c,0,d}}{f_{c,0,d}} \leq 1$ EN 1995-1-1, 6.1.4 (6.2)

### Verification of sill pressure

Verification of the sill pressure for the selected cleat dimensions.

$\sigma_{c,90,d,Schwelle} = \frac{N_d}{d_{Knagge} \cdot l_A}$ and $\sigma_{c,0,d,Knagge} = \frac{N_d}{d_{Knagge} \cdot b_{Knagge}}$

$\frac{\sigma_{c,90,d}}{k_{c,90} \cdot f_{c,90,d}} \leq 1$ EN 1995-1-1, 6.1.5 (6.3) and $\frac{\sigma_{c,0,d}}{f_{c,0,d}} \leq 1$ EN 1995-1-1, 6.1.4 (6.2)

For $l_A$ 3 cm may be added to the cleat width $b_1$ on each side (EN 1995:2010,2014, 6.1.5(1)).

## Verification according to ÖNorm B 1995-1-1:2010

Takes over the verification according to EN 1995-1-1.

## Verification according to ÖNorm B 1995-1-1:2014

Takes over the verification according to EN 1995-1-1, but allows a $k_{c,90}$ > 1,75 if the addition of $l_A$ is omitted. (NCI at 6.1.5(2)).

## Verification according to DIN EN 1995-1-1:2010, 2013

Takes over the verification according to EN 1995-1-1.

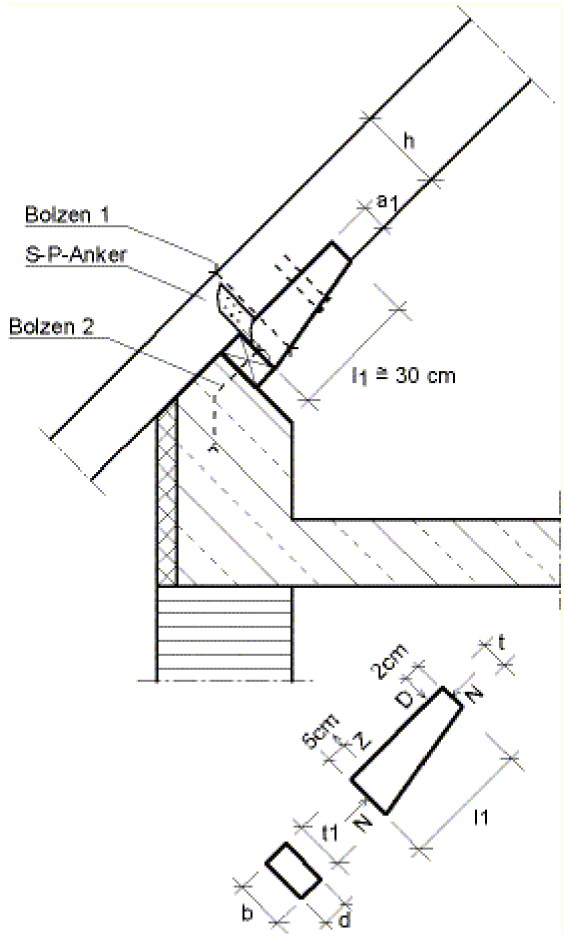
## Verification according to UNI EN 1995-1-1:2010, NTC EN 1995-1-1:2008

UNI EN 1995-1-1 and NTC EN 1995 take over the verification according to EN 1995-1-1.

## Verification according to NA to BS EN 1995-1-1:2008

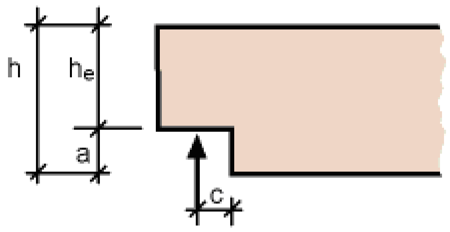
NA to BS EN 1995-1-1:2008 takes over the verification according to EN 1995-1-1.

# Cleat with bolts




For the cleat connected with bolts, the required cleat depths t and t1 as well as the required bolt diameter are determined.

## Geometric boundary conditions




The notch is calculated according to EN 1995-1-1:2008/2014, 6.5.

The bare EN does not specify any boundary conditions for notches; the determination is made in the respective NAs.

### ÖNorm B 1995:2010

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ ÖNorm B 1995-1-1, 6.6.7, Eq.(16)

If equation EN 1995-1-1, (6.60) cannot be met, then reinforcement must be made.

### ÖNorm B 1995:2014

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ ÖNorm B 1995-1-1, NCI to 6.5.2, Eq. (NA.6.63 E1 and E2)

If equation EN 1995-1-1, (6.60) cannot be met, then reinforcement must be made.

### DIN EN 1995:2010, 2013

DIN EN 1995-1-1:2010 does not contain any boundary conditions for the geometry. Since the NA is based on DIN 1052:2008, its boundary conditions are verified:

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ DIN 1052:2008, 11.2

In the case of reinforced beam notches or with short or very short load durations or with beams notched at the top, the conditions mentioned do not have to be adhered to.

Beam notches in service class 3 must always be reinforced!

## UNI EN 1995:2010, NTC EN 1995:2008

UNI EN 1995-1-1 and NTC EN 1995, like the bare EN 1995-1-1, do not contain any boundary conditions for the geometry. The values analogous to DIN 1052:2008 are therefore adopted as a sensible assumption:

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ DIN 1052:2008, 11.2

In the case of reinforced beam notches or with short or very short load durations or with beams notched at the top, the conditions mentioned do not have to be adhered to.

Beam notches in service class 3 must always be reinforced!

## NA to BS EN 1995:2008

NA to BS EN 1995-1-1, like the bare EN 1995-1-1, does not contain any boundary conditions for the geometry. The values analogous to DIN 1052:2008 are therefore adopted as a sensible assumption:

$\frac{h_e}{h} \geq 0{,}5$ and $\frac{c}{h} \leq 0{,}4$ DIN 1052:2008, 11.2

In the case of reinforced beam notches or with short or very short load durations or with beams notched at the top, the conditions mentioned do not have to be adhered to.

Beam notches in service class 3 must always be reinforced!

# Verifications

### Required cleat dimensions

The required cleat depth req.t can be determined as follows:

$$\text{erf.A} = \frac{F_{c,0,d}}{f_{c,0,d}} \quad \text{and} \quad \text{erf.t} = \frac{\text{erf.A}}{b}$$

The required cleat depth req.t1 can be determined as follows:

$$\text{erf.A}_1 = \frac{F_{c,90,d}}{k_{c,90} \cdot f_{c,90,d}} \quad \text{and} \quad \text{erf.t}_1 = \frac{\text{erf.A}_1}{l_A}$$

For $l_A$, 3 cm may be added to the cleat width $b_1$ on each side (EN 1995:2010,2014, 6.1.5(1)).

## Verification according to ÖNorm B 1995-1-1:2010

Takes over the verification according to EN 1995-1-1.

## Verification according to ÖNorm B 1995-1-1:2014

Takes over the verification according to EN 1995-1-1, but allows a $k_{c,90}$ > 1,75 if the addition of $l_A$ is omitted. (NCI to 6.1.5(2)).

## Verification according to DIN EN 1995-1-1:2010, 2013

Takes over the verification according to EN 1995-1-1.

## Verification according to UNI EN 1995-1-1:2010, NTC EN 1995-1-1:2008

UNI EN 1995-1-1 and NTC EN 1995 take over the verification according to EN 1995-1-1.

## Verification according to NA to BS EN 1995-1-1:2008

NA to BS EN 1995-1-1:2008 takes over the verification according to EN 1995-1-1.

### Required bolt 1 washer

The offset of the axial forces on surfaces A and A1 results in a moment which is absorbed by the force pair Z and D.

$$Z = \frac{F_{c,0,d} \cdot \frac{t_1 - t}{2}}{l_1 - 7} \quad \text{(see sketch)}$$

$$erf.A_{Scheibe} = \frac{Z}{k_{c,90} \cdot f_{c,90,d}}$$

The required bolt diameter $d_1$ can also be derived from the required area of the washer. (Additional table of washers/bolts).

### Required sill dimensions.

If the base sill is stored directly on an eaves base, the required width b and height d of the base sill are calculated:

req. b = req. $t_1$

$$erf.A = \frac{V_d}{k_{c,90} \cdot f_{c,90,d}} \quad \text{and} \quad erf.d = \frac{erf.A}{t_1}$$

### Verification of bolts 2

The base sill is connected to the eaves base by bolts. The bolts are verified for shearing or embedding according to EN 1995-1-1:2008,2014, 8.2.2 (DIN 1052:2004, G.2 (Johansen method)).

$$R_{d,Bolzen} = R_{d,nach8.2} \cdot \frac{e}{a}$$

e = rafter spacing

a = distance between bolts 2

or as the required absorbable force per bolt:

$$V_{d,erf,Bolzen} = \frac{V_{d,vorh}}{\frac{e}{a}}$$

# Purlin connections

## Birdsmouth joint

### Verifications

#### Verification of support pressure

Verification of the support pressure for the selected birdsmouth joint depth tv (purlin).

$$\sigma_{c,90,d} = \frac{V_d}{l_A \cdot \frac{t_v}{\sin\alpha}}$$

$$\frac{\sigma_{c,90,d}}{k_{c,90} \cdot f_{c,90,d}} \leq 1 \text{ EN 1995-1-1, 6.1.5 (6.3)}$$

For $l_A$, 3 cm may be added to the rafter width b on each side (EN 1995:2010,2014, 6.1.5(1)).

Verification of the support pressure for the selected birdsmouth joint depth tv (birdsmouth joint).

$$\sigma_{c,\alpha,d} = \frac{V_d}{b \cdot \frac{t_v}{\sin\alpha}}$$

$$\frac{\sigma_{c,\alpha,d}}{\left(\frac{f_{c,0,d}}{\frac{f_{c,0,d}}{k_{c,90} \cdot f_{c,90,d}} \cdot \sin^2\alpha + \cos^2\alpha}\right)} \leq 1 \text{ EN 1995-1-1, 6.2.2 (6.16)}$$

#### Verification according to ÖNorm B 1995-1-1:2010

Takes over the verification according to EN 1995-1-1.

#### Verification according to ÖNorm B 1995-1-1:2014

Takes over the verification according to EN 1995-1-1, but allows a $k_{c,90}$ > 1,75 if the addition of $l_A$ is omitted. (NCI at 6.1.5(2)).

#### Verification according to DIN EN 1995-1-1:2010, 2013

Takes over the verification according to EN 1995-1-1.

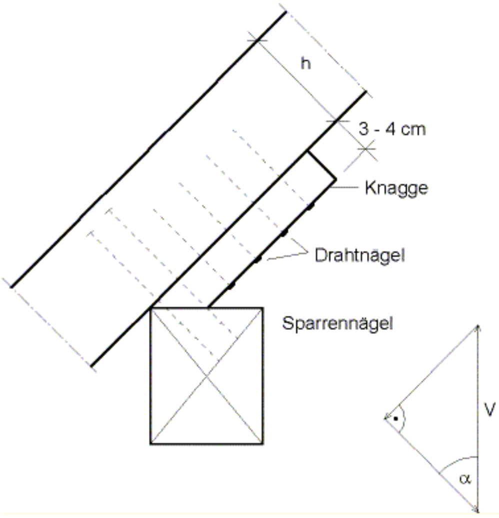
#### Verification according to UNI EN 1995-1-1:2010, NTC EN 1995-1-1:2008

UNI EN 1995-1-1 and NTC EN 1995 take over the verification according to EN 1995-1-1.

#### Verification according to NA to BS EN 1995-1-1:2008

NA to BS EN 1995-1-1:2008 takes over the verification according to EN 1995-1-1.

# Nailed cleat




## Verifications

### Required cleat width

The required support area can be determined using the following criteria:

$$erf.A_{90} = \frac{V_d}{k_{c,90} \cdot f_{c,90,d}} \quad \text{and} \quad erf.l_A = \frac{erf.A_{90}}{b_1} \quad \text{with} \quad b_1 = \frac{d_{Knagge}}{\sin\alpha}$$

For $l_A$, 3 cm may be added to the required width on each side (EN 1995:2010,2014, 6.1.5(1)).

$$erf.A_{\alpha} = \frac{V_d}{k_{c,\alpha} \cdot f_{c,\alpha,d}} \quad \text{and} \quad erf.b = \frac{erf.A_{\alpha}}{b_1}$$

## Verification according to ÖNorm B 1995-1-1:2010

Takes over the verification according to EN 1995-1-1.

## Verification according to ÖNorm B 1995-1-1:2014

Takes over the verification according to EN 1995-1-1, but allows a $k_{c,90}$ > 1,75 if the addition of $l_A$ is omitted. (NCI at 6.1.5(2)).

## Verification according to DIN EN 1995-1-1:2010, 2013

Takes over the verification according to EN 1995-1-1.

## Verification according to UNI EN 1995-1-1:2010, NTC EN 1995-1-1:2008

UNI EN 1995-1-1 and NTC EN 1995 take over the verification according to EN 1995-1-1.

## Verification according to NA to BS EN 1995-1-1:2008

NA to BS EN 1995-1-1:2008 takes over the verification according to EN 1995-1-1.

### Verification of support pressure

Verification of the support pressure for the selected cleat dimensions.

$$\sigma_{c,90,d} = \frac{F_{c,90,d}}{l_A \cdot a_1}$$

$$\frac{\sigma_{c,90,d}}{k_{c,90} \cdot f_{c,90,d}} \leq 1 \quad \text{EN 1995-1-1, 6.1.5 (6.3)}$$

For $l_A$, 3 cm may be added to the cleat width b1 on each side (EN 1995:2010,2014, 6.1.5(1)).

## Verification according to ÖNorm B 1995-1-1:2010

Takes over the verification according to EN 1995-1-1.

## Verification according to ÖNorm B 1995-1-1:2014

Takes over the verification according to EN 1995-1-1, but allows a $k_{c,90}$ > 1,75 if the addition of $l_A$ is omitted. (NCI at 6.1.5(2)).

## Verification according to DIN EN 1995-1-1:2010, 2013

Takes over the verification according to EN 1995-1-1.

## Verification according to UNI EN 1995-1-1:2010, NTC EN 1995-1-1:2008

UNI EN 1995-1-1 and NTC EN 1995 take over the verification according to EN 1995-1-1.

## Verification according to NA to BS EN 1995-1-1:2008

NA to BS EN 1995-1-1:2008 takes over the verification according to EN 1995-1-1.

### Required number of nails

For a given nail diameter, the permissible nail stress for a single-cut timber-timber connection is determined according to EN 1995-1-1:2008,2014, 8.2.2 using the Johansen theory.

The req. number of nails then results from the comparison of the force to be absorbed with the permissible one. The arrangement and any resulting reductions will NOT be taken into account. The required value is only the static required value, not the geometric one!

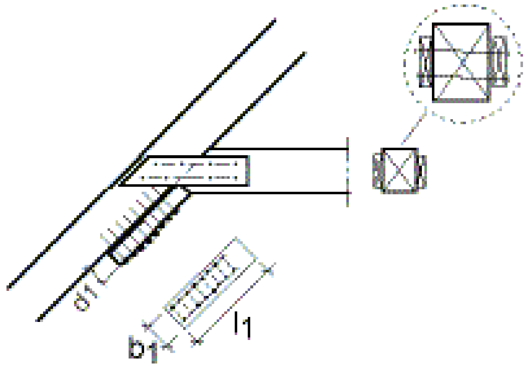
$$\text{erf.n} = \frac{V_d \cdot \sin\alpha}{R_d}$$

# Collar beam connections

## One-part CB with nailed cleat

### Geometric boundary conditions

cal $b_1 = \min(b_{cleat}; b_{CB})$




### Verifications

The force is transmitted via contact pressure in the pressure surfaces between the CB and rafters, or CB and cleat. The resulting connecting force is broken down into both components orthogonally to the pressure surfaces. The pressure verifications of both contact members are carried out.

The following verifications are provided for the specified cleat dimensions.

### Verifications in the pressure area of the rafter-collar beam:

$$D_1 = Res_d \cdot \sin\phi$$

with $Res_d$ = resultant of the CB

$\varphi$ = angle between resultant and rafter axis.

The length $l_A$ of the contact surface is:

$$l'_A = \frac{d_{KB}}{\sin\alpha} \quad \text{and} \quad l_A = l'_A - \frac{d_{Knagge}}{\tan\alpha}$$

Rafters: $\sigma_{c,90,d} = \dfrac{D_1}{(l_A + 6cm) \cdot b_{Sparren}}$

Collar beam: force-fiber-angle $\beta = 90 - \alpha$ $\quad \sigma_{c,\beta,d} = \dfrac{D_1}{(l_A + 3cm \cdot \cos(\beta)) \cdot b_{KB}}$

### Verification in the pressure area of the collar beam cleat

$$D_2 = Res_d \cdot \cos\phi$$

Cleat: $\sigma_{c,0,d} = \dfrac{D_2}{d_{Knagge} \cdot b_{Knagge}}$

Collar beam: force-fiber-angle $\beta = \alpha$ $\quad \sigma_{c,\beta,d} = \dfrac{D_2}{(d_{Knagge} + 3cm \cdot \cos(\beta)) \cdot b_{KB}}$

### Required number of nails

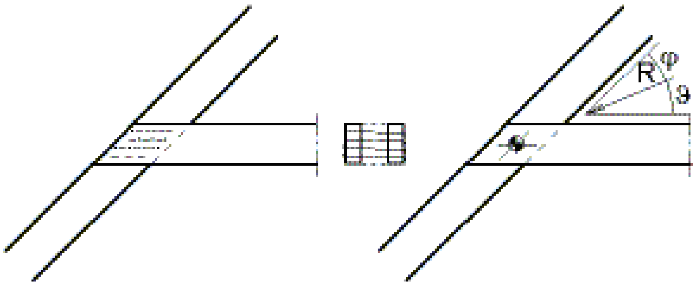
The program calculates the statically required number of nails for a given nail diameter. The geometric arrangement and any reductions are NOT taken into account!

The absorbable force of a nail is determined according to EN 1995-1-1:2008,2014, 8.2.2 for a single-cut timber-timber connection and compared to the existing longitudinal force of the nail:

$$erf.n = \frac{Res_d \cdot \cos\varphi}{R_{d,Nagel}}$$

# Two-part collar beam nailed

## Required number of nails



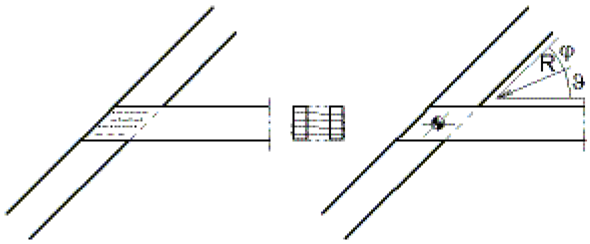

The program calculates the statically required number of nails for a given nail diameter. The geometric arrangement and any reductions are NOT taken into account!

The absorbable force of a nail is determined according to EN 1995-1-1:2008,2014, 8.2.2 for a single-cut timber-timber connection and compared to the existing resultant. The force-fiber angle of the resultant is taken into account.

$R_{d,Nail} = \min(R_{d,\varphi,Nail}\ ,\ R_{d,\vartheta,Nail})$

$$erf.n = \frac{Res_d}{R_{d,Nagel}}$$

# Two-part collar beam doweled




## Required number of connector joints

The program calculates the statically required number of dowels for a given dowel type and diameter. The geometric arrangement and any reductions are NOT taken into account!

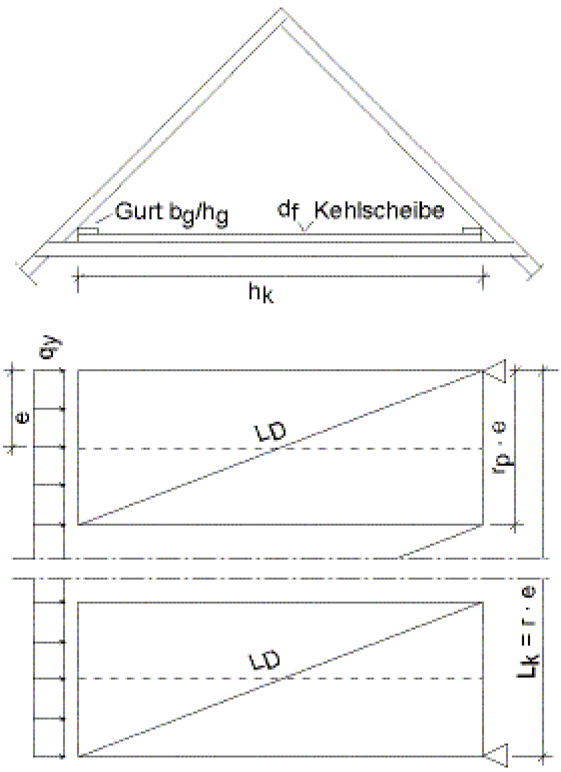
The absorbable force of a fastener unit is determined according to EN 1995-1-1:2008,2014, 8.2.2 for a single-cut timber-timber connection and compared to the existing resultant. The force-fiber angle of the resultant is taken into account.

$R_{d,DowBB} = \min(R_{d,\varphi}\ ,\ R_{d,\vartheta})$

$$erf.n = \frac{Res_d}{R_{d,DübBB}}$$

# Bracings

## Valley plate with slabs lying transversely




Because of the lack of shear flow all around, the valley plate cannot be calculated like a timber panel according to EN 1995-1-1, 9.2.3 (DIN 1052:2008, 10.6). The valley plate is treated according to the truss analogy, the side planks act as belts, the slab as a substitute diagonal.

### Action effect and internal forces

On the one hand, the planking is subjected to vertical action effect:

$$q_z = (g_k + p_k) \cdot e \cdot 1{,}0 \left[\frac{kN}{m}\right]$$

Only a 1 m wide strip is considered, i.e $q_k' \cdot 1{,}0$ with $q_k' = (g_k + p_k) \cdot e$

It also serves to stiffen the horizontal loads:

$$q_y = \frac{H_{KB,li} + H_{KB,re}}{e} \left[\frac{kN}{m}\right]$$

The following internal forces result:

Vertical action effect (uniaxial between the collar beams)

$\max V_z = 0{,}625 \cdot q_z \cdot e\,[kN]$

(unfavorable if applicable as a 2-span beam)

$\max M_y = q_z \cdot \frac{e^2}{8}\,[kNm]$

Horizontal action effect

$\max V_y = \frac{1}{2} \cdot q_y \cdot L\,[kN]$

$\max M_z = q_y \cdot \frac{L^2}{8}\,[kNm]$

## Stress verification

The tensile force is decisive for the belt plank:

$F_{t,Gurt} = \frac{\max M_z}{h_k}[kN]$ It is verified: $\frac{\sigma_{t,y,d}}{f_{t,y,d}} \leq 1$ (EN 1995-1-1, 6.1.2)

The vertical loading results in a bending stress for the valley plate $\sigma_{m,y} = \frac{\max.M_y}{W_y} =$

$$\sigma_{m,y} = \frac{\max.M_y \cdot 6}{d_{Platte}^2}\left[\frac{kN}{cm^2}\right].$$

According to the truss model of [footnote], an equivalent diagonal with the length results

$L_D = \sqrt{(r_p \cdot e)^2 + h_k^2}\,[cm]$ und der Fläche $A_D = \frac{3}{16} \cdot d_f \cdot \frac{L_D^3}{r_p \cdot e \cdot h_k}\left[cm^2\right]$

The horizontal action effect results in tensile stress $\sigma_{t,y} = \frac{\max V_y \cdot \frac{h_k}{L_D}}{A_D}\left[\frac{kN}{cm^2}\right]$

The valley plate is verified for $\frac{\sigma_{t,y,d}}{f_{t,y,d}} + \frac{\sigma_{m,y,d}}{f_{m,y,d}} \leq 1$ (EN 1995-1-1, 6.2.3).

## Deformation verifications

The deformation in the plane of the plate should be less than L/1000.

The bending stiffness of the panel is approximately equal to that of the replacement truss:

$$I_z = 2 \cdot b_{Gurt} \cdot h_{Gurt} \cdot \left(\frac{h_k}{2}\right)^2 \left[cm^4\right]$$

It follows:

$w_y = \frac{5}{384} \cdot \frac{q_y \cdot l^4}{E_{0,mean,Scheibe} \cdot I_z}$ or $w_y = \frac{1}{9{,}6} \cdot \frac{\max M_z \cdot l^2}{E_{0,mean,Scheibe} \cdot I_z}[cm]$

## Connections with 1-cut nailing

Connection of valley plate to collar beam:

$$\text{erf.R}_d = H_{KB,li} + H_{KB,re}\,[\text{kN}] \quad \text{or} \quad \text{erf.n} = \frac{\text{erf.R}_d}{R_{d,1Nagel}} \quad \text{or} \quad \text{erf.n} = \frac{H_{KB,li} + H_{KB,re}}{R_{d,1Nagel}}$$

Valley plate on abutment:

$$\text{erf.R}_d = \text{max.V}_y \quad \text{or} \quad \text{erf.n} = \frac{\text{erf.R}_d}{R_{d,1Nagel}} \quad \text{r} \quad \text{erf.n} = \frac{\text{max.V}_y}{R_{d,1Nagel}}$$

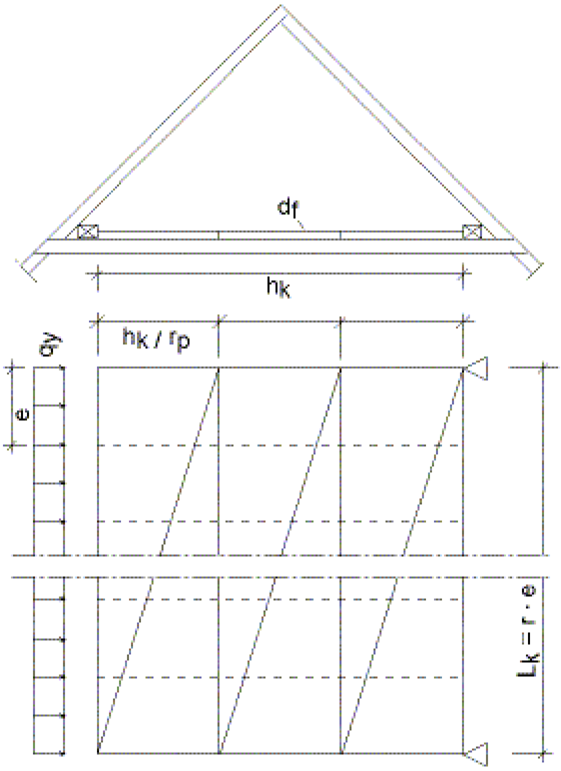
Belt plank on valley plate:

$$\text{erf.R}_d = \text{max.V}_y \quad \text{or} \quad \text{erf.n} = \frac{\text{erf.R}_d}{R_{d,1Nagel}} \quad \text{or} \quad \text{erf.n} = \frac{\text{max.V}_y}{R_{d,1Nagel}}$$

At the slab joint (the 1st joint at a distance of rp*e is the most unfavorable)

$$\text{erf.R}_d = \text{max.V}_y - q_y \cdot (r_p \cdot e)\,[\text{kN}] \quad \text{or} \quad \text{erf.n} = \frac{\text{erf.R}_d}{R_{d,1Nagel}} \quad \text{or} \quad \text{erf.n} = \frac{\text{max.V}_y - q_y \cdot (r_p \cdot e)}{R_{d,1Nagel}}$$

## Valley plate with slabs lying lengthwise




The calculation is carried out according to EN 1995-1-1.

The horizontal forces are transmitted from the collar beams directly into the plates - there are no load-bearing belt beams. The valley plate is simply calculated like a beam subjected to two-axis bending, in the vertical direction with supports at a distance of e, and horizontally at a distance of $L_K$.

The horizontal actions must be transferred to the abutments of the slabs.

### Action effect and internal forces

On the one hand, the planking is used as a slab:

$$q_z = (g_k + p_k) \cdot e \cdot 1{,}0 \left[\frac{kN}{m}\right]$$

Only a 1m wide strip is considered, i.e $q_k^{'} \cdot 1{,}0$ mit $q_k^{'} = (g_k + p_k) \cdot e$

It also serves to stiffen the horizontal loads:

$$q_y = \frac{H_{KB,li} + H_{KB,re}}{e} \left[\frac{kN}{m}\right]$$

The following internal forces result:

Vertical action effect (stressed uniaxially in the direction of the fibers)

$$\max V_z = 0{,}625 \cdot q_z \cdot e [kN]$$

(unfavorable if used as a 2-span beam)

$$\max M_y = q_z \cdot \frac{e^2}{10} [kNm]$$

Horizontal action effect

$$\max V_y = \frac{1}{2} \cdot q_y \cdot L [kN]$$

$$\max M_z = q_y \cdot \frac{L^2}{8} [kNm]$$

## Stress verifications

The vertical action effect results in a bending stress around the y-axis:

$$\sigma_{m,y} = \frac{max.M_y}{W_y} \quad = \quad \sigma_{m,y} = \frac{max.M_y \cdot 6}{d^2_{Platte}} \left[\frac{kN}{cm^2}\right]$$

The horizontal action effect results in a bending stress around the z-axis:

$$\sigma_{m,z} = \frac{max.M_z}{W_z} \quad = \quad \sigma_{m,z} = \frac{max.M_z \cdot 6}{r_p \cdot d_{Platte} \cdot h^2_{Platte}} \left[\frac{kN}{cm^2}\right]$$

The verification follows from the superposition of the two stresses:

$$\frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}} \leq 1 \quad \text{(EN 1995-1-1, 6.2.3)}$$

## Deformation verifications

The deformation in the plane of the plate should be less than L/1000.

The bending stiffness of the valley plate in the y-direction is:

$$I_z = n_{Platten} \cdot \frac{d_{Platte} \cdot \left(h_{Platte}\right)^3}{12} \left[cm^4\right]$$

It follows:

$$w_y = \frac{5}{384} \cdot \frac{q_y \cdot l^4}{E_{0,mean,Scheibe} \cdot I_z} + \frac{max.M_z}{G \cdot A} \quad \text{or} \quad w_y = \frac{1}{9,6} \cdot \frac{max M_z \cdot l^2}{E_{0,mean,Scheibe} \cdot I_z} [cm]$$

## Connections with 1-cut nailing

The collar beam must transmit its H-force to the slab, ie.

$$erf.R_d = \frac{H_{KB,li} + H_{KB,re}}{n_p} [kN] \quad \text{or} \quad erf.n = \frac{erf.R_d}{R_{d,1Nagel}} \quad \text{or} \quad erf.n = \frac{H_{KB,li} + H_{KB,re}}{n_p \cdot R_{d,1Nagel}}$$

The plate supports must be connected for max.Vy/nslab:

$$erf.R_d = \frac{max.V_y}{n_p} [kN] \quad \text{or} \quad erf.n = \frac{erf.R_d}{R_{d,1Nagel}} \quad \text{or} \quad erf.n = \frac{max.V_y}{n_p \cdot R_{d,1Nagel}}$$