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Authorised and notified according to Article 29 of the Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011

MEMBER OF EOTA

European Technical Assessment ETA-22/0235 of 2023/11/07

I General Part

Technical Assessment Body issuing the ETA and designated according to Article 29 of the Regulation (EU) No 305/2011: ETA-Danmark A/S

Trade name of the construction product:	WBS – Wood Building Screws, WBS VG –Wood Building Screws with Full Thread, CPS – Chipboard Screws, WBS TT – Wood Building Screws with Top Thread, WBS PB – Post Bracket Screws and TS – Terrace Screws
Product family to which the above construction product belongs:	Screws for use in timber constructions
Manufacturer:	DIN LING CORP. 114 12F, No. 79, ZHOUZI ST. TAIPEI 11493 TAIWAN R.O.C. www.din-ling.eu
Manufacturing plant:	DIN LING CORP.
This European Technical Assessment contains:	35 pages including 6 annexes which form an integral part of the document
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of:	European Assessment document (EAD) no. EAD 130118-01-0603 "Screws and threaded rods for use in timber constructions"
This version replaces:	The ETA with the same number issued on 2022-05-17

II SPECIFIC PART OF THE EUROPEAN TECHNICAL ASSESSMENT

1 Technical description of product

Technical description of the product
Din Ling WBS – Wood Building Screws, WBS VG – Full Threaded Wood Building Screws, CPS – Chipboard Screws, WBS TT – Wood Building Screws with Top Thread, WBS PB – Post Bracket Screws and TS – Terrace Screws are in the following referred to as Din Ling screws for general aspects and to the specific type for specific aspects.

Din Ling screws are screws to be used in timber structures. They shall be threaded over a part of the length or over the whole length. The screws shall be produced from carbon steel wire for nominal diameters between 3,0 mm and 12,0 mm and from stainless steel wire for nominal diameters of 4,0 mm to 5,0 mm. Where corrosion protection is required, the material or coating shall be declared in accordance with the relevant specification given in Annex A of EN 14592.

Geometry and Material
The nominal diameter (outer thread diameter), d, of Din Ling screw shall not be less than 3,0 mm and shall not be greater than 12,0 mm. The overall length of the screws, L, shall not be less than 16 mm and shall not be greater than 600 mm. Other dimensions are given in Annex A.

Screw types WBS, WBS VG, CPS, WBS TT and WBS PB are made from carbon steel and screw type TS is made from martensitic stainless steel 1.4006.

The ratio of inner thread diameter to outer thread diameter d_1/d ranges from 0,60 to 0, 71.

The screws are threaded over a minimum length L1 of $4 \cdot d$ (i.e. $L1 \geq 4 \cdot d$).

The screws covered by this ETA have a minimum bending angle, α, of $(45/d^{0,7} + 20)$ degrees.

2 Specification of the intended use in accordance with the applicable European Assessment Document (hereinafter EAD)

The screws are used for connections in load bearing timber structures between members of solid timber (softwood), glued laminated timber, cross-laminated timber, and laminated veneer lumber, similar glued members, wood-based panels or steel.

Steel plates and wood-based panels except solid wood panels, laminated veneer lumber and cross laminated timber shall only be located on the side of the screw head.

The following wood-based panels may be used:

- Laminated veneer lumber LVL of softwood according to EN 14374, arrangement of the screws only perpendicular to the plane of the veneers,
- Plywood according to EN 636 and EN 13986,
- Oriented Strand Board, OSB according to EN 300 and EN 13986,
- Particleboard according to EN 312 and EN 13986,
- Fibreboards according to EN 622-2, EN 622-3 and EN 13986,
- Cement-bonded particle boards according to EN 634-2 and EN 13986,
- Solid-wood panels according to EN 13353 and EN 13986.

Wood-based panels shall only be arranged on the side of the screw head.

Din Ling screws with an outer thread diameter of at least 6 mm may be used for the fixing of thermal insulation material on top of rafters or on wood-based members in vertical façades. Furthermore, Din Ling full threaded screws WBS are also used as tensile, compressive reinforcement perpendicular to the grain

The screws are driven into the wood-based member made of softwood without pre-drilling or in pre-drilled holes with a diameter not exceeding the inner thread diameter d_1. The screw holes in steel members shall be pre-drilled with an adequate diameter greater than the outer thread diameter.

If screws with an outer thread diameter d $\geq$ 8 mm are driven into the wood-based member without pre-drilling, the structural solid or glued laminated timber, laminated veneer lumber and similar glued members shall be from spruce, pine or fir.

In the case of fastening battens on thermal insulation material on top of rafters the screws shall be driven in the rafter through the battens and the thermal insulation material without pre-drilling in one sequence.

Countersunk head screws may be used with washers according to Annex A. After inserting the screws, the washers shall touch the surface of the wood-based member completely.

By fastening screws in wood-based members the head of the screws shall be flush with the surface of the wood based member. For pan head, wafer head, hex head or hex wafer head screws the underside of the head shall be flush with the surface of the wood-based member.

The screws are intended to be used in timber connections for which requirements for mechanical resistance and stability and safety in use in the sense of the Basic Works Requirements 1 and 4 of Regulation 305/2011 shall be fulfilled.

The design of the connections shall be based on the characteristic load-carrying capacities of the screws. The design capacities shall be derived from the characteristic capacities in accordance with Eurocode 5 or an appropriate national code. Regarding environmental conditions, national provisions at the building site shall apply considering the environmental conditions.

The screws are intended for use for connections subject to static or quasi static loading.

The screws are for use in timber structures subject to service classes 1, 2 and 3 of Eurocode 5. In service class 1 and 2 the corrosion protection is given according to EN1995-1-1, or by equivalent measures. In service class 3 the corrosion protection is given according to EN1995-1-1 or by stainless steel. Section 3.5 of this ETA contains the corrosion protection for Din Ling screws made from carbon steel and the material number of the stainless steel.

The scope of the screws regarding resistance to corrosion shall be defined according to national provisions that apply at the installation site considering environmental conditions.
The provisions made in this European Technical Assessment are based on an assumed intended working life of the screws of 50 years.

The indications given on the working life cannot be interpreted as a guarantee given by the producer or Assessment Body but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

3 Performance of the product and references to the methods used for its assessment

Characteristic	Assessment of characteristic

3.1 Mechanical resistance and stability*) (BWR1)

Tensile strength
Screws made of carbon steel

Characteristic value $f_{tens,k}$:

$d = 3,0$ mm:	2,5 kN
$d = 3,5$ mm:	4,0 kN
$d = 4,0$ mm:	5,0 kN
$d = 4,5$ mm:	5,5 kN
$d = 5,0$ mm:	7,5 kN
$d = 6,0$ mm:	9,5 kN
$d = 8,0$ mm:	19,0 kN
$d = 10,0$ mm:	25,0 kN
$d = 12,0$ mm:	42,0 kN

Screws made of stainless steel

$d = 4,0$ mm:	5,0 kN
$d = 4,5$ mm:	6,0 kN
$d = 5,0$ mm:	8,0 kN

Insertion moment

Ratio of the characteristic torsional strength to the mean insertion moment:
$f_{tor,k} / R_{tor,mean} \geq 1,5$

Torsional strength
Screws made of carbon steel

Characteristic value $f_{tor,k}$:

$d = 3,0$ mm:	1,6 Nm
$d = 3,5$ mm:	2,2 Nm
$d = 4,0$ mm:	3,3 Nm
$d = 4,5$ mm:	4,3 Nm
$d = 5,0$ mm:	5,8 Nm
$d = 6,0$ mm:	9,0 Nm
$d = 8,0$ mm:	24,0 Nm
$d = 10,0$ mm:	40,0 Nm
$d = 12,0$ mm:	68,0 Nm

Screws made of stainless steel

$d = 4,0$ mm:	3,3 Nm
$d = 4,5$ mm:	4,5 Nm
$d = 5,0$ mm:	6,1 Nm

3.2 Safety in case of fire (BWR2)

Reaction to fire

The screws are made from steel classified as Euroclass A1 in accordance with EN 13501-1 and Commission Delegated Regulation 2016/364

3.3 General aspects related to the performance of the product

The screws have been assessed as having satisfactory durability and serviceability when used in timber structures using the timber species described in Eurocode 5 and subject to the conditions defined by service classes 1, 2 and 3

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*) See additional information in section 3.4 – 3.6.

3.4 Mechanical resistance and stability

The load-carrying capacities for Din Ling Screws are applicable to the wood-based materials mentioned in paragraph 1 even though the term timber has been used in the following.

The characteristic lateral load-carrying capacities and the characteristic axial withdrawal capacities of Din Ling screws should be used for designs in accordance with Eurocode 5 or an appropriate national code.

Point side penetration length must be $\ell_{ef} \geq 4 \cdot d$, where d is the outer thread diameter of the screw. For the fixing of rafters, point side penetration must be at least 40 mm, $\ell_{ef} \geq 40$ mm.

European Technical Assessments for structural members or wood-based panels must be considered where applicable.

Lateral load-carrying capacity
The characteristic lateral load-carrying capacity of Din Ling screws shall be calculated according to EN 1995-1-1 (Eurocode 5) using the outer thread diameter d as the nominal diameter of the screw. The contribution from the rope effect may be considered.

The characteristic yield moment shall be assumed as:

d = 3,0 mm: $M_{y,k}$ = 1,6 Nm
d = 3,5 mm: $M_{y,k}$ = 2,3 Nm
d = 4,0 mm: $M_{y,k}$ = 3,3 Nm
d = 4,5 mm: $M_{y,k}$ = 4,3 Nm
d = 5,0 mm: $M_{y,k}$ = 5,5 Nm
d = 6,0 mm: $M_{y,k}$ = 9,5 Nm
d = 8,0 mm: $M_{y,k}$ = 20,0 Nm
d = 10,0 mm: $M_{y,k}$ = 36,0 Nm
d = 12,0 mm: $M_{y,k}$ = 58,0 Nm

Din Ling Screws TS made from stainless steel:
d = 4,0 mm: $M_{y,k}$ = 3,0 Nm
d = 4,5 mm: $M_{y,k}$ = 4,5 Nm
d = 5,0 mm: $M_{y,k}$ = 5,9 Nm

The embedding strength for screws in non-pre-drilled holes arranged at an angle between screw axis and grain direction, $30° \leq \alpha \leq 90°$ is:

$$f_{h,k} = \frac{0,082 \cdot \rho_k \cdot d^{-0,3}}{2,5 \cdot \cos^2 \alpha + \sin^2 \alpha} \qquad [\text{N/mm}^2]$$

and accordingly for screws in pre-drilled holes:

$$f_{h,k} = \frac{0,082 \cdot \rho_k \cdot (1 - 0,01 \cdot d)}{2,5 \cdot \cos^2 \alpha + \sin^2 \alpha} \qquad [\text{N/mm}^2]$$

Where
ρ_k characteristic timber density [kg/m³];
d   outer thread diameter [mm];
α angle between screw axis and grain direction;

The embedding strength for screws arranged parallel to the plane of cross laminated timber, independent of the angle between screw axis and grain direction, $0° \leq \alpha \leq 90°$, shall be calculated from:

$$f_{h,k} = 20 \cdot d^{-0,5} \qquad [\text{N/mm}^2]$$

unless otherwise specified in the technical specification (ETA or hEN) for the cross laminated timber.

Where
d   outer thread diameter [mm]

The embedding strength for screws in the wide face of cross laminated timber should be assumed as for solid timber based on the characteristic density of the outer layer. If relevant, the angle between force and grain direction of the outer layer should be taken into account.

The direction of the lateral force shall be perpendicular to the screw axis and parallel to the wide face of the cross laminated timber.

For laterally loaded screws, the rules for multiple fastener connections in EN 1995-1-1, 8.3.1.1 (8) shall be applied.

Bending angle
No performance assessed

Axial withdrawal capacity
The characteristic axial withdrawal capacity of Din Ling screws at an angle of $15° \leq \alpha \leq 90°$ to the grain in solid timber, glued laminated timber and cross-laminated timber members shall be calculated according to EN 1995-1-1 from:

$$F_{ax,\alpha,Rk} = n_{ef} \cdot k_{ax} \cdot f_{ax,k} \cdot d \cdot \ell_{ef} \cdot \left(\frac{\rho_k}{350}\right)^{0,8} \qquad [\text{N}]$$

Where
$F_{ax,\alpha,RK}$ characteristic withdrawal capacity of the screw at an angle α to the grain [N]
n_{ef} effective number of screws according to EN 1995-1-1
k_{ax} Factor, taking into account the angle α between screw axis and grain direction
k_{ax} = 1,0 for $45° \leq \alpha < 90°$

$k_{ax} = 0,3 + \dfrac{0,7 \cdot \alpha}{45}$ for $15° \leq \alpha < 45°$

$f_{ax,k}$ Characteristic withdrawal parameter
3 mm $\leq$ d $\leq$ 5 mm: $f_{ax,k}$ = 12 N/mm²

6 mm $\leq$ d $\leq$ 8 mm: $f_{ax,k}$ = 11 N/mm^2

d $\geq$ 10 mm: $f_{ax,k}$ = 10 N/mm^2

For screws TS

4 mm $\leq$ d $\leq$ 5 mm: $f_{ax,k}$ = 12 N/mm^2

d	outer thread diameter [mm]
ℓ_{ef}	Penetration length of the threaded part according to EN 1995-1-1 [mm]
α	Angle between grain and screw axis ($\alpha \geq$ 15°)
ρ_k	Characteristic density [kg/m³]

For screws arranged under an angle between screw axis and grain direction of less than 90°, the minimum threaded penetration length is:

$$\ell_{ef} \geq \min (4 \cdot d/\sin\alpha \; ; 20 \cdot d)$$

For screws penetrating more than one layer of cross laminated timber, the different layers may be considered proportionally.

The axial withdrawal capacity is limited by the head pull-through capacity and the tensile capacity of the screw.

For axially loaded screws in tension, where the external force is parallel to the screw axes, the rules in EN 1995-1-1, 8.7.2 (8) should be applied. If crossed pairs of screws are used in timber-to-timber connections, n is the number of crossed pairs of screws in a row.

The axial slip modulus K_{ser} of the threaded part of a screw for the serviceability limit state should be taken independent of angle α to the grain as:

$$K_{ser} = 25 \cdot d \cdot \ell_{ef} \text{ [N/mm]} \text{ for fasteners in softwood}$$

Where
d	outer thread diameter [mm]
ℓ_{ef}	penetration length in the timber member [mm]

Head pull-through capacity
The characteristic head pull-through capacity of Din Ling self-tapping screw shall be calculated according to EN 1995-1-1 from:

$$F_{ax,\alpha,Rk} = n_{ef} \cdot f_{head,k} \cdot d_h^2 \cdot \left(\frac{\rho_k}{350}\right)^{0,8} \quad \text{[N]}$$

where:
$F_{ax,\alpha,RK}$	Characteristic head pull-through capacity of the connection at an angle $\alpha \geq$ 30° to the grain [N]
n_{ef}	Effective number of screws according to EN 1995-1-1:2008
$f_{head,k}$	Characteristic head pull-through parameter [N/mm^2]
d_h	Diameter of the screw head or the washer [mm]. Outer diameter of heads or washers

d_h > 2,5 · d shall not be taken into account.

ρ_k Characteristic density [kg/m³], for wood-based panels ρ_k = 380 kg/m³

Characteristic head pull-through parameter for Din Ling screw in connections with timber and in connections with wood-based panels with thicknesses above 20 mm:
$f_{head,k}$ = 9,4 N/mm^2

Characteristic head pull-through parameter for screws in connections with wood-based panels with thicknesses between 12 mm and 20 mm:
$f_{head,k}$ = 8 N/mm^2

Screws in connections with wood-based panels with a thickness below 12 mm (minimum thickness of the wood-based panels of 1,2·d with d as outer thread diameter):
$f_{head,k}$ = 8 N/mm^2 limited to $F_{ax,Rk}$ = 400 N

The head diameter d_h shall be greater than 1,8·d_s, where d_s is the smooth shank or the wire diameter. Otherwise, the characteristic head pull-through capacity $F_{ax,\alpha,Rk}$ = 0.

The minimum thickness of wood-based panels according to the clause 3.6 must be observed.

In steel-to-timber connections the head pull-through capacity is not governing.

Tensile capacity
The characteristic tensile strength $f_{tens,k}$ is given in clause 3.1.

For screws used in combination with steel plates, the tear-off capacity of the screw head including a washer shall be greater than the tensile capacity of the screw.

Combined laterally and axially loaded screws
For connections subjected to a combination of axial and lateral load, the following expression should be satisfied:

$$\left(\frac{F_{ax,Ed}}{F_{ax,Rd}}\right)^2 + \left(\frac{F_{la,Ed}}{F_{la,Rd}}\right)^2 \leq 1$$

where
$F_{ax,Ed}$	axial design load of the screw
$F_{la,Ed}$	lateral design load of the screw
$F_{ax,Rd}$	design load-carrying capacity of an axially loaded screw
$F_{la,Rd}$	design load-carrying capacity of a laterally loaded screw

Mechanically jointed beams

Full threaded screws WBS VG may be used for connections in structural members which are composed of several parts in mechanically jointed beams or columns.

Compressive capacity

The design compressive capacity $F_{c,90,Rd}$ of full threaded screws WBS VG along the length embedded in timber with an angle between fastener axis and grain direction of $45° \leq \alpha \leq 90°$ is the minimum of the axial resistance against pushing-in and the buckling resistance:

$$F_{c,90,Rd} = \min\left\{F_{ax,Rd}; F_{ki,Rd}\right\}$$

$$F_{c,90,Rd} = \min\left\{f_{ax,d} \cdot d \cdot \ell_{ef} \cdot \left(\frac{\rho_k}{\rho_a}\right)^{0,8}; \frac{k_c \cdot N_{pl,k}}{\gamma_{M1}}\right\}$$

Where:

$$\kappa_c = \begin{cases} 1 & \text{for } \bar{\lambda}_k \leq 0,2 \\ \dfrac{1}{k + \sqrt{k^2 - \bar{\lambda}_k^2}} & \text{for } \bar{\lambda}_k > 0,2 \end{cases}$$

$$k = 0,5 \cdot \left[1 + 0,49 \cdot (\bar{\lambda}_k - 0,2) + \bar{\lambda}_k^2\right]$$

The relative slenderness ratio shall be calculated from:

$$\bar{\lambda}_k = \sqrt{\frac{N_{pl,k}}{N_{ki,k}}}$$

where

$$N_{pl,k} = \pi \cdot \frac{d_1^2}{4} \cdot f_{y,k} \qquad [N]$$

is the characteristic value for the axial capacity in case of plastic analysis referred to the inner thread cross-section.

Characteristic yield strength of screws from carbon steel:
$$f_{y,k} = 700 \qquad [N/mm^2]$$

Characteristic ideal elastic buckling load:
$$N_{ki,k} = \sqrt{c_h \cdot E_S \cdot I_S} \qquad [N]$$

Elastic foundation of the screw:
$$c_h = (0,19 + 0,012 \cdot d) \cdot \rho_k \cdot \left(\frac{\alpha}{180°} + 0,5\right) \qquad [N/mm^2]$$

Modulus of elasticity:
$$E_s = 210000 \qquad [N/mm^2]$$

Second moment of area:
$$I_S = \frac{\pi}{64} \cdot d_1^4 \qquad [mm^4]$$

$f_{ax,d}$ design value of the axial withdrawal parameter of the threaded part of the screw [N/mm²]

d_1 inner thread diameter   [mm]
     3,83 mm for WBS VG 6,0 mm
     5,28 mm for WBS VG 8,0 mm
     6,45 mm for WBS VG 10,0 mm

d outer thread diameter   [mm]
ℓ_{ef} penetration length of the threaded part   [mm]
α angle between screw axis and grain direction

ρ_k characteristic density   [kg/m³]

ρ_a associated density for $f_{ax,k}$ [kg/m³]

γ_{M1} partial factor according to EN 1993 or to the particular national annex

Compression reinforcement
See Annex D

Tensile reinforcement
See Annex E

Shear reinforcement
See Annex F

3.5 Aspects related to the performance of the product

Corrosion protection in service class 1
The Din Ling screws with diameters ≤ 4,0 mm are produced from carbon wire. Screws made from steel are electrogalvanised and yellow or blue chromated, brass plated, browned or nickel plated. The thickness of the zinc coating is minimum 5 μm. Alternatively, the screws can be coated with a minimum 4 μm zinc-nickel coating.

Partial threaded screws can also be organic coated in various colours.

Corrosion protection in service class 1 and 2
The Din Ling screws with diameters > 4,0 mm are produced from carbon wire. Screws made from steel are electrogalvanised and yellow or blue chromated, brass plated, browned or nickel plated. The thickness of the zinc coating is minimum 5 μm. Alternatively, the screws can be coated with a minimum 4 μm zinc-nickel coating.

Partially threaded screws may also be organic coated in various colours.

Corrosion protection in service class 1, 2 and 3
Din Ling screws TS are made from steel no. 1.4006

3.6 General aspects related to the intended use of the product

The screws are manufactured in accordance with the provisions of the European Technical Assessment using

the automated manufacturing process and laid down in the technical documentation.

The installation shall be carried out in accordance with Eurocode 5 or an appropriate national code unless otherwise is defined in the following. Instructions from the manufacturer should be considered for installation.

The screws are used for connections in load bearing timber structures between members of solid timber (softwood), glued laminated timber (softwood), cross-laminated timber, laminated veneer lumber (softwood), similar glued members (softwood), wood-based panels or steel members.

The screws may be used for connections in load bearing timber structures with structural members according to an associated ETA, if according to the ETA of the structural member a connection in load bearing timber structures with screws according to an ETA is allowed.

Furthermore, the screws with diameters between 6 mm and 12 mm may also be used for the fixing of insulation on top of rafters or at vertical facades.

A minimum of two screws should be used for connections in load bearing timber structures.

The minimum penetration depth in structural members made of solid, glued or cross-laminated timber or laminated veneer lumber is:

$$\ell_{ef,req} = \min\left\{\frac{4 \cdot d}{\sin \alpha}; 20 \cdot d\right\}$$

Wood-based panels and steel plates should only be arranged on the side of the screw head. The minimum thickness of wood-based panels should be $1{,}2 \cdot d$. Furthermore, the minimum thickness for following wood-based panels should be:

- Plywood, Fibreboards: 6 mm
- Particleboards, OSB, Cement Particleboards: 8 mm
- Solid wood panels: 12 mm

For structural members according to ETA's the terms of the ETA's must be considered.

If screws with an outer thread diameter $d \geq 8$ mm are used in load bearing timber structures, the structural solid or glued laminated timber, laminated veneer lumber and similar glued members must be from spruce, pine or fir. This does not apply for screws in pre-drilled holes.

The minimum angle between the screw axis and the grain direction is $\alpha = 15°$.

Only the equipment prescribed by DIN LING CORP shall be used for driving the screws.
In connections with screws with countersunk head according to Annex A the head must be flush with the surface of the connected structural member. A deeper countersink is not allowed.

The screws shall be driven into the wood without pre-drilling or after pre-drilling with a diameter equal or less than the inner thread diameter.

The drill hole diameters are:

Outer thread diameter [mm]	Drill hole diameter [mm]
	Softwood
3,0	2,0
3,5	2,0
4,0	2,5
4,5	2,5
5,0	3,0
6,0	4,0
8,0	5,0
10,0	6,0
12,0	7,0

The hole diameter in steel members must be predrilled with a suitable diameter.

For structural timber members, minimum spacing and distances for screws are given in EN 1995-1-1 (Eurocode 5) clause 8.3.1.2 and table 8.2 as for nails in predrilled or non-predrilled holes, respectively. Here, the outer thread diameter d must be considered.

For Douglas fir members minimum spacing and distances parallel to the grain shall be increased by 50%.

Minimum distances from the unloaded edge perpendicular to the grain may be reduced to $3 \cdot d$, if the spacing parallel to the grain and the end distance is at least $25 \cdot d$.

Minimum thickness for predrilled structural members is t = 24 mm for screws with outer thread diameter d < 8 mm, t = 30 mm for screws with outer thread diameter d = 8 mm, t = 40 mm for screws with outer thread diameter d = 10 mm and t = 80 mm for screws with outer thread diameter d = 12 mm. These minimum thickness values generally apply for non-predrilled softwood members, if the spacing parallel to the grain and the end distance is at least $25 \cdot d$.

Cross laminated timber:

Unless specified otherwise in the technical specification (ETA or hEN) of cross laminated timber, minimum distances and spacing for screws in the wide face of cross laminated timber members with a minimum thickness $t = 10 \cdot d$ may be taken as (see Annex B):

Spacing a_1 parallel to the grain $\qquad a_1 = 4 \cdot d$
Spacing a_2 perpendicular to the grain $\qquad a_2 = 2{,}5 \cdot d$
Distance $a_{3,c}$ from centre of the screw-part in
timber to the unloaded end grain $\qquad a_{3,c} = 6 \cdot d$
Distance $a_{3,t}$ from centre of the screw-part in
timber to the loaded end grain $\qquad a_{3,t} = 6 \cdot d$
Distance $a_{4,c}$ from centre of the screw-part in
timber to the unloaded edge $\qquad a_{4,c} = 2{,}5 \cdot d$
Distance $a_{4,t}$ from centre of the screw-part in
timber to the loaded edge $\qquad a_{4,t} = 6 \cdot d$

Unless specified otherwise in the technical specification (ETA or hEN) of cross laminated timber, minimum distances and spacing for screws in the edge surface of cross laminated timber members with a minimum thickness $t = 10 \cdot d$ and a minimum penetration depth perpendicular to the edge surface of $10 \cdot d$ may be taken as (see Annex B):

Spacing a_1 parallel to the CLT plane $\qquad a_1 = 10 \cdot d$
Spacing a_2 perpendicular to the CLT plane $\qquad a_2 = 4 \cdot d$
Distance $a_{3,c}$ from centre of the screw-part in
timber to the unloaded end $\qquad a_{3,c} = 7 \cdot d$
Distance $a_{3,t}$ from centre of the screw-part in
timber to the loaded end $\qquad a_{3,t} = 12 \cdot d$
Distance $a_{4,c}$ from centre of the screw-part in
timber to the unloaded edge $\qquad a_{4,c} = 3 \cdot d$
Distance $a_{4,t}$ from centre of the screw-part in
timber to the loaded edge $\qquad a_{4,t} = 6 \cdot d$

Exclusively axially loaded screws

Minimum distances and spacing for inclined or crossed full threaded screws WBS $d = 6{,}0$ mm and $8{,}0$ mm in joist-to-header connections arranged under $45°$ to the joist's end grain surface with a minimum joist depth of $18 \cdot d$ may be taken as:

Distance $a_{1,CG}$ from centre of the screw-part in
timber to the unloaded joist end $\qquad a_{1,CG} = 8 \cdot d$
Distance $a_{2,CG}$ from centre of the screw-part in
timber to the unloaded joist edge $\qquad a_{2,CG} = 3 \cdot d$

For a crossed screw couple, the minimum spacing between the crossing screws is $a_2 = 1{,}5 \cdot d$.

4 Attestation and verification of constancy of performance (AVCP)

4.1 AVCP system

According to the decision 97/176/EC of the European Commission1, as amended, the system(s) of assessment and verification of constancy of performance (see Annex V to Regulation (EU) No 305/2011) is 3.

5 Technical details necessary for the implementation of the AVCP system, as foreseen in the applicable EAD

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited at ETA-Danmark prior to CE marking

Issued in Copenhagen on 2023-11-07 by

Thomas Bruun
Managing Director, ETA-Danmark

Annex A
Drawings and material specification of Din Ling screws

A.1 Chipboard Screw - CPS

Self-drilling screw with full or part thread, Carbon Steel
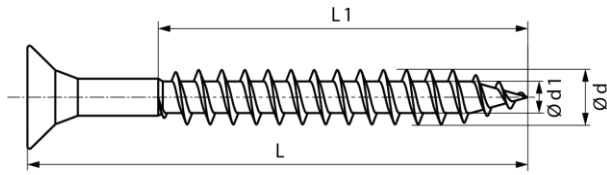
All dimensions and tolerances in mm.

Nominal diameter			3,0	3,5	4,0	4,5	5,0	6,0
d		min	2,75	3,30	3,75	4,25	4,75	5,80
		max	3,00	3,50	4,00	4,50	5,00	6,00
d1		min	1,70	2,00	2,25	2,45	2,70	3,40
		max	2,10	2,20	2,50	2,70	3,00	3,70
L		+1,0/-2,0	16 - 50	18 - 50	20 - 70	25 - 80	25 - 120	30 - 300
L1		+1,0/-2,0	12 - 46	14 - 44	16 - 64	18 - 74	20 - 75	24 - 75
dh	H1 - H3	min	5,60	6,60	7,50	8,50	9,50	11,50
		max	6,00	7,00	8,00	9,00	10,00	12,00
	H4	min	-	-	-	-	7,00	-
		max	-	-	-	-	7,40	-
dc	H4	min	-	-	-	-	4,60	-
		max	-	-	-	-	4,90	-

CPS Head Types

Countersunk H1	Raised CSK H2	Pan H3	Connector H4	- Under Head Construction: Rips or Pockets optional - Head Mark: optional - Recess: TX and PZ - H4 head shape only for steel-wood joints

CPS Point and Thread Types

- Point Options: sharp point, saw thread, Type 17, saw thread & Type 17
- Thread Cutting Line: optional
- Shank Rips: optional; obligatory for L ≥ 220mm

A.2 Wood Building Screw - WBS

Self-drilling with full or part thread, Carbon Steel
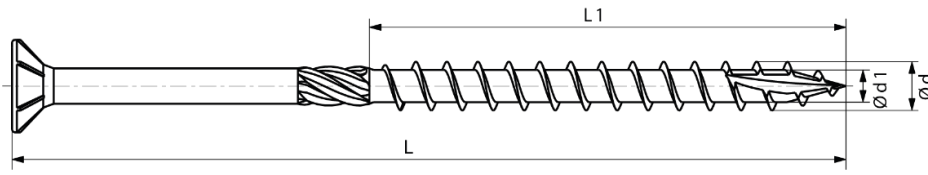
All dimensions and tolerances in mm.

Nominal diameter			3,5	4,0	4,5	5,0	6,0	8,0	10,0	12,0
d		min	3,20	3,70	4,20	4,70	5,80	7,60	9,60	11,60
		max	3,50	4,00	4,50	5,00	6,20	8,25	10,25	12,30
d1		min	1,90	2,05	2,40	2,80	3,65	5,05	6,20	7,00
		max	2,10	2,50	2,90	3,30	4,00	5,50	6,70	7,50
L	[1] +1,0/-2,0 [2] +2,0/-2,0		20 - 70[1]	20 - 80[1]	20 - 80[1]	25 - 120[1]	40 - 300[2]	40 - 600[2]	80 - 600[2]	80 - 600[2]
L1	[3] +1,0/-3,0 [4] +1,5/-1,5		14 - 42[3]	16 - 49[3]	18 - 49[3]	20 - 74[3]	24 - 75[4]	32 - 150[4]	40 - 150[4]	50 - 150[4]
dh	H1	min	6,60	7,60	8,60	9,60	11,40	14,00	17,00	20,00
		max	7,00	8,00	9,00	10,00	13,20	15,00	19,00	21,50
	H2	min	-	-	-	-	14,50	20,50	23,50	27,50
		max	-	-	-	-	16,10	23,50	26,50	30,50
	H3	AF	-	-	-	-	10	12	15	17
	H4	min	-	-	-	-	14,50	19,40	23,00	27,50
		max	-	-	-	-	16,50	23,00	26,60	31,50
	H5	min	-	-	-	-	13,00	16,60	20,50	-
		max	-	-	-	-	13,80	17,40	21,50	-
	H6	min	-	-	-	-	13,50	17,00	20,00	-
		max	-	-	-	-	16,76	19,80	23,50	-

WBS Head Types

| Countersunk H1	Wafer H2	Hex H3	Hex Wafer H4	Pan H5	Flat H6

- Under Head Construction: Rips or Pockets optional
- Head Mark: optional
- Recess: TX

WBS Point and Thread Types

P1	P2	P3	P4	

- Point Options: sharp point, saw thread, Type 17, saw thread & Type 17
- Thread Cutting Line: optional
- Shank Rips: optional; obligatory L ≥ 220mm
- P4 for diameter 6, 8 and 10

A.3 Wood Building Screw Top Thread - WBS TT

Self-drilling with top thread, Carbon Steel
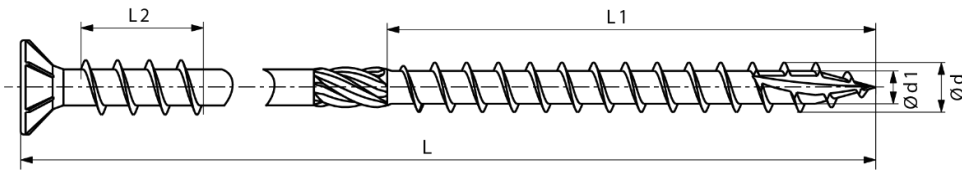
All dimensions and tolerances in mm.

Nominal diameter		8				8
d	min	8,30		H1	min	14,00
d	max	8,60		H1	max	15,00
d1	min	5,40		H2	min	20,50
d1	max	5,70		H2	max	23,50
L	+2,0/-2,0	160 - 600	dh	H3	AF	12,00
L1	min	80		H4	min	19,40
L1	min	80		H4	max	23,00
L2	min	59		H5	min	16,60
L2	min	59		H5	max	17,40
				H6	min	17,00
				H6	max	19,80

WBS TT Head Types

Countersunk H1	Wafer H2	Hex H3	Hex Wafer H4	Pan H5	Flat H6

- Under Head Construction: Rips or Pockets optional
- Head Mark: optional
- Recess: TX

WBS TT Point and Thread Types

P1	P2	P3	P4	- Point Options: sharp point, saw thread, Type 17, saw thread & Type 17 - Thread Cutting Line: optional - Shank Rips: optional; obligatory L ≥ 220mm

A.4 Wood Building Screw Post Brackets - WBS PB

Self-drilling with full or part thread, Carbon Steel
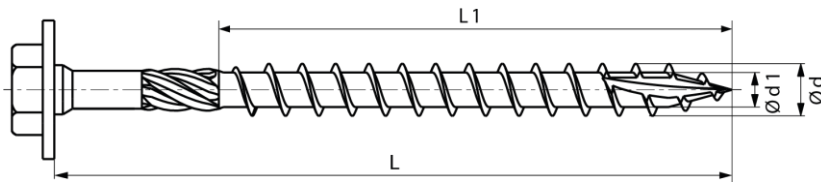
All dimensions and tolerances in mm.

Nominal diameter		8	10				8	10
d	min	7,60	9,60		H1	min	14,00	17,00
	max	8,25	10,25			max	15,00	19,00
d1	min	5,05	6,20		H2	min	20,50	23,50
	max	5,50	6,70			max	23,50	26,50
L	+2,0/-2,0	40 - 60	50 - 60	dh	H4	min	19,40	23,00
						max	23,00	26,60
L1	+1,5/-1,5	32 - 52	40 - 52		H5	min	16,60	20,50
						max	17,40	21,50
AF	H3	12,00	15,00		H6	min	17,00	20,00
						max	19,80	23,50

WBS PB Head Types

Countersunk H1	Wafer H2	Hex H3	Hex Wafer H4	Pan H5	Flat H6

Under Head Construction: Rips or Pockets optional

Head Mark: optional

Recess: TX

WBS PB Point and Thread Types

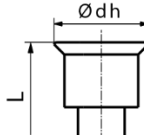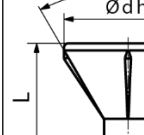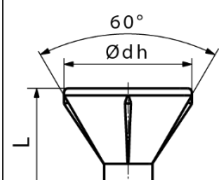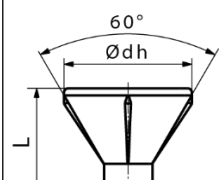| P1	P2	P3	P4	- Point Options: sharp point, saw thread, Type 17, saw thread & Type 17 - Thread Cutting Line: optional - Shank Rips: obligatory

A.5 Wood Building Screw Full Thread - WBS VG

Self-drilling with full thread, Carbon Steel
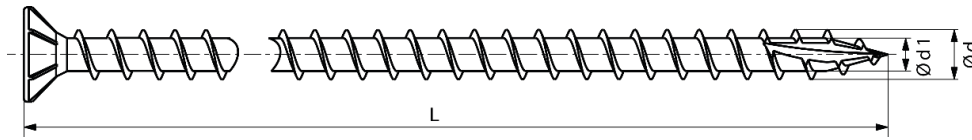
All dimensions and tolerances in mm.

Nominal diameter			6,0	8,0	10,0
d		min	5,80	7,60	9,60
		max	6,20	8,25	10,25
d1		min	3,65	5,05	6,20
		max	4,00	5,50	6,70
L		+2,0/-2,0	40 - 300	40 - 600	80 - 600
dh	H1	min	11,40	14,00	17,00
		max	13,20	15,00	19,00
	H2	min	14,50	20,50	23,50
		max	16,10	23,50	26,50
	H3	min	13,50	17,00	20,00
		max	16,76	19,80	23,50
	H4	min	14,50	19,40	23,00
		max	16,50	23,00	26,60
	H5	min	7,00	10,00	12,00
		max	8,00	11,00	13,00

WBS VG Head Types

Countersunk H1	Wafer H2	Flat H3	Hex H4	Hex Wafer H5	Cylinder H6

- Under Head Construction: Rips or Pockets optional
- Head Mark: optional
- Recess: TX

WBS VG Point and Thread Types

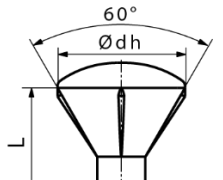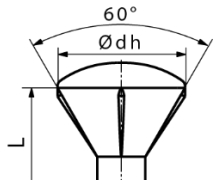| P1	P2	P3	P4	- Point Options: sharp point, saw thread, Type 17, saw thread & Type 17 - Thread Cutting Line: optional

A.6 Terrace Screw - TS

Self-drilling with full or part thread, Stainless Steel
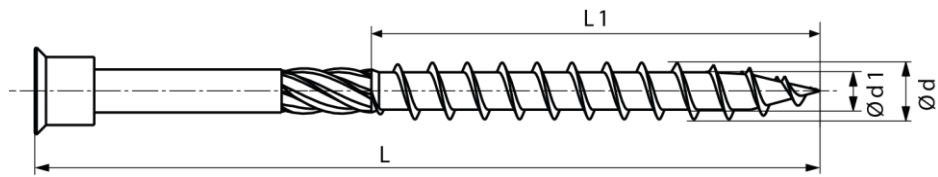
All dimensions and tolerances in mm.

Nominal diameter (d)			4,0	4,5	5,0
d		min	3,90	4,30	4,70
		max	4,10	4,60	5,10
d1		min	2,40	2,60	3,00
		max	2,60	2,80	3,45
L		+1,0/-1,0	30 - 140	30 - 140	30 - 140
L1		+1,0/-1,0	18 - 70	18 - 70	18 - 70
dh	H1	min	5,50	6,00	6,70
		max	6,50	8,00	8,70
	H2 + H3	min	6,60	7,50	8,50
		max	7,00	8,00	9,00

TS Head Types

Cylinder H1	Trim H2	Raised Trim H3	- Under Head Construction: Rips or Pockets optional
			- Head Mark: optional
			- Recess: TX

TS Point and Thread Types

- Point Options: sharp, saw thread, Type 17, saw thread & Type 17
- Thread Cutting Line: optional
- Shank Rips: obligatory

A.7 Washer

Carbon Steel

WSH1   WSH2

All dimensions and tolerances in mm.
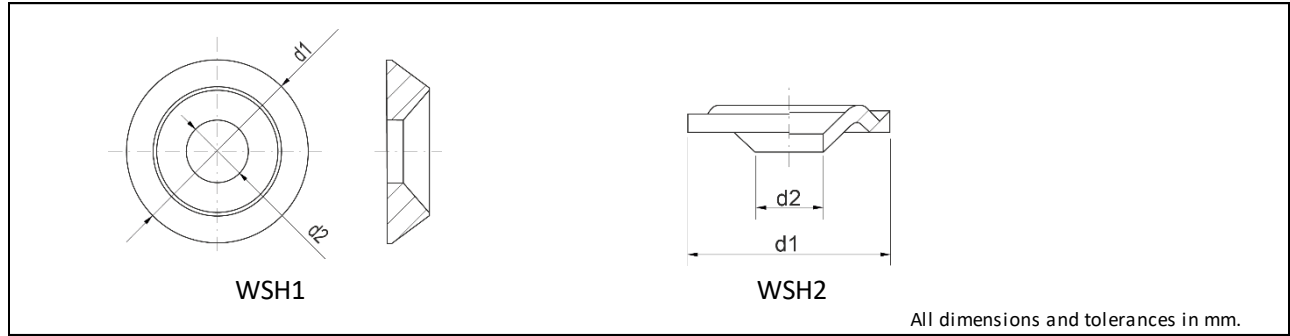
Nominal diameter (d)			6	8	10	12
WSH1	d1	min	19,20	24,70	31,70	-
		max	19,80	25,30	32,30	-
	d2	min	7,70	8,20	10,70	-
		max	8,30	8,80	11,30	-
WSH2	d1	min	21,50	27,50	32,50	41,50
		max	22,50	28,50	33,50	42,50
	d2	min	6,00	8,00	10,00	12,00
		max	7,00	9,00	11,00	13,00

Annex B
Minimum distances and spacing

Axially loaded screws - Single configuration
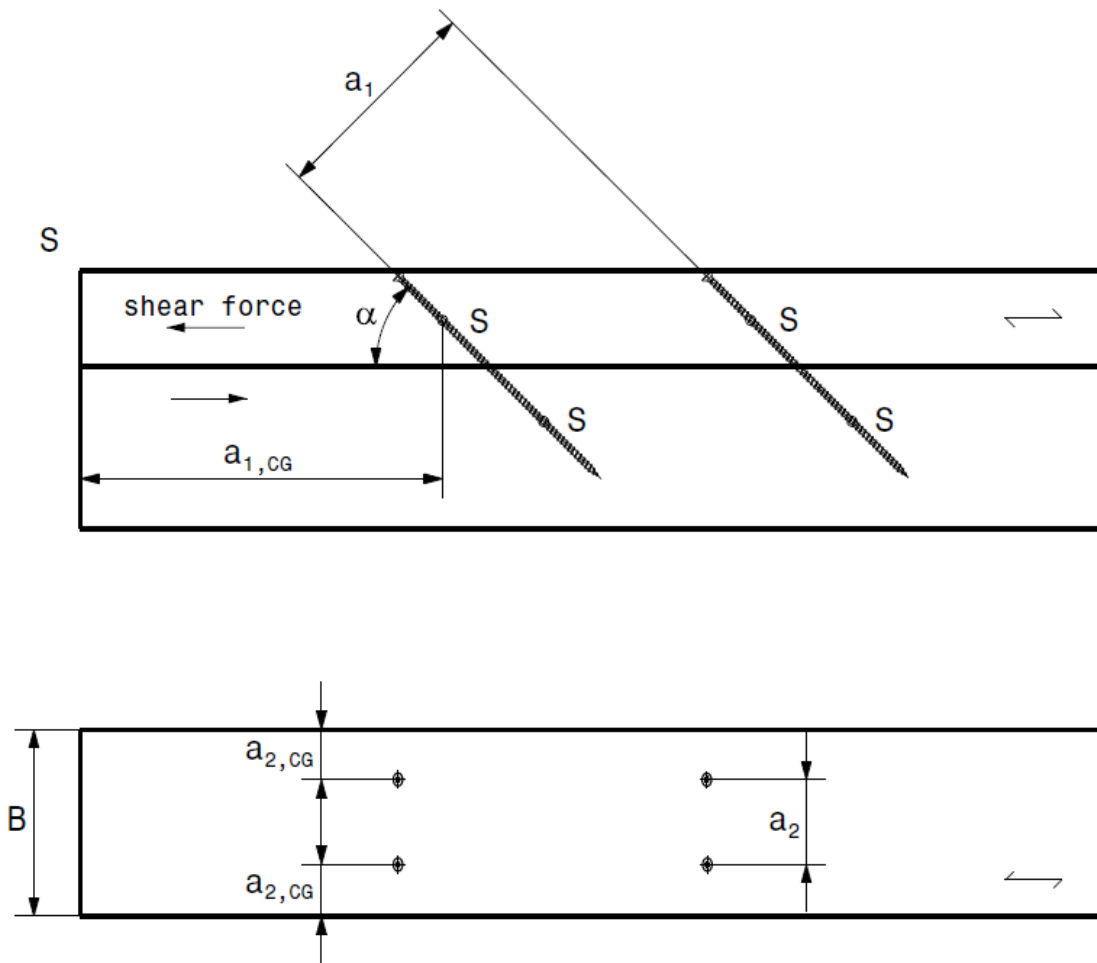
S = centroid of the part of the screw in the timber

$a_1 \geq 7 \cdot d$
$a_2 \geq 5 \cdot d$
$a_{1,CG} \geq 10 \cdot d$
$a_{2,CG} \geq 4 \cdot d$

Minimum distances and spacing see also 3.6
Minimum timber thickness t = 12 · d, see also 3.6

Axially loaded screws - Crosswise configuration
Use example of WBS VG screws
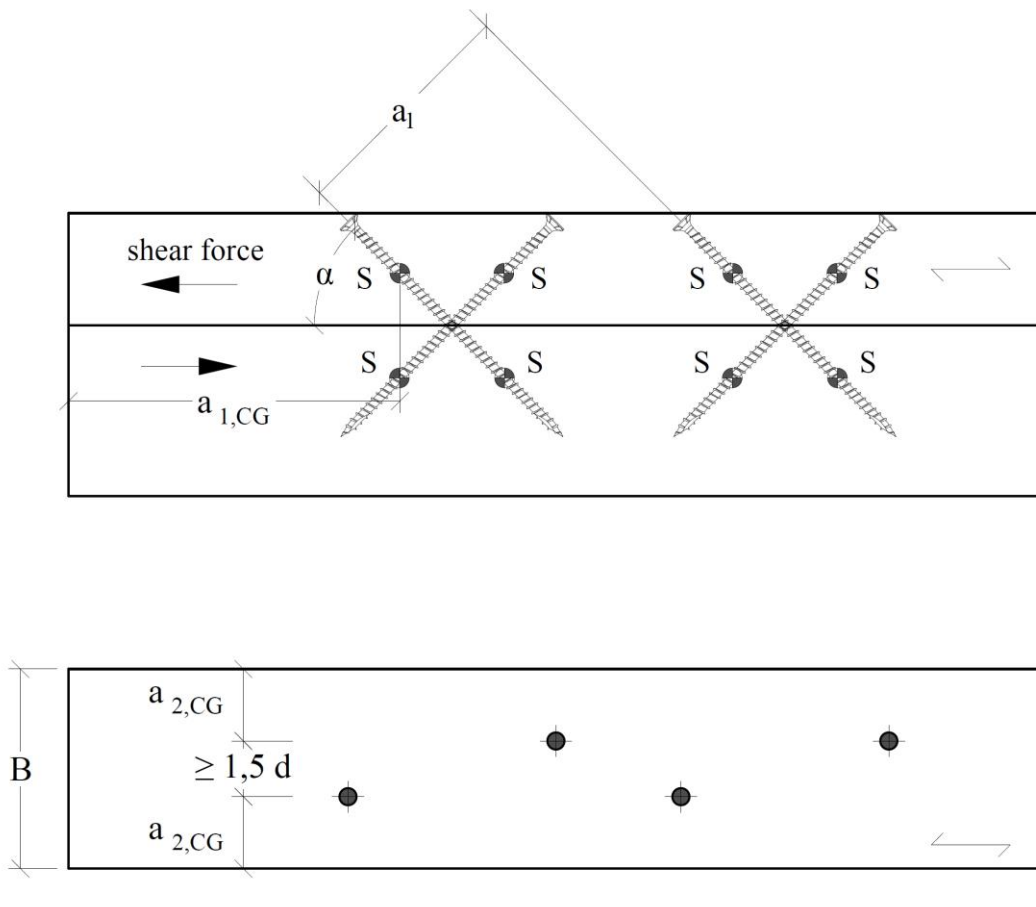
S = centroid of the part of the screw in the timber

$a_1 \geq 7 \cdot d$
$a_2 \geq 5 \cdot d$
$a_{1,CG} \geq 10 \cdot d$
$a_{2,CG} \geq 4 \cdot d$

Minimum distances and spacing see also 3.6
Minimum timber thickness $t = 12 \cdot d$, see also 3.6

Axially or laterally loaded screws in the plane or edge surface of cross laminated timber

Definition of spacing, end and edge distances in the plane surface unless otherwise specified in the technical specification (ETA or hEN) for the cross laminated timber:
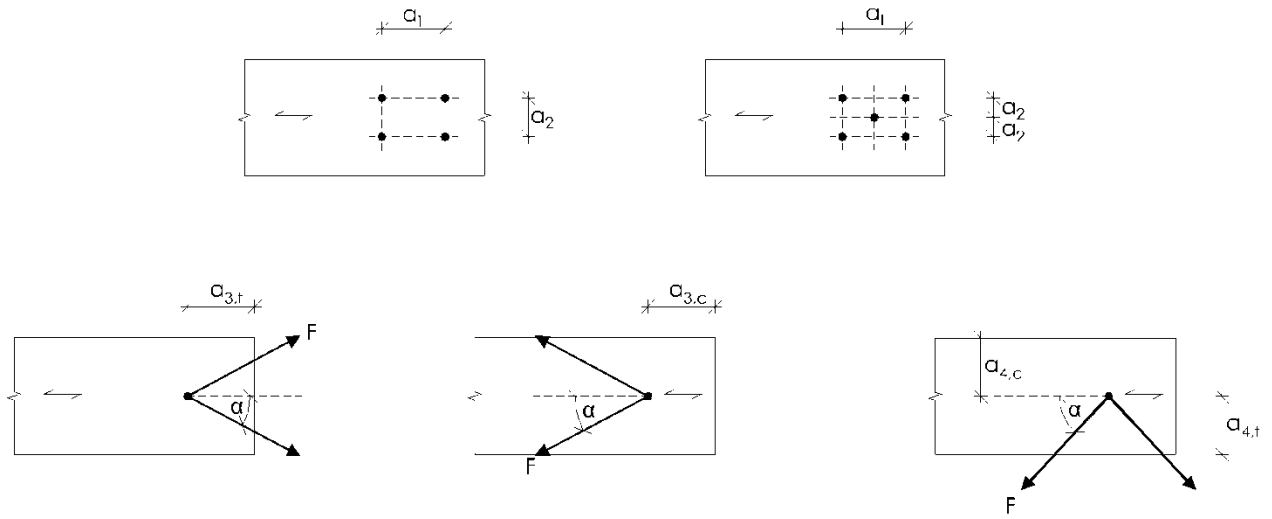
Definition of spacing, end and edge distances in the edge surface unless otherwise specified in the technical specification (ETA or hEN) for the cross laminated timber:
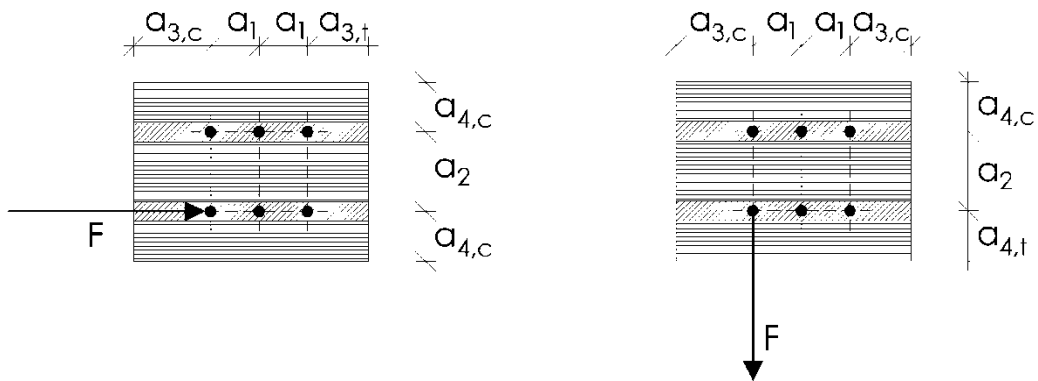
For screws in the edge surface, a_1 and a_3 are parallel to the CLT plane face, a_2 and a_4 perpendicular to CLT plane face.

Table B1: Minimum spacing, end and edge distances of screws in the plane or edge surfaces of cross laminated timber

	a_1	$a_{3,t}$	$a_{3,c}$	a_2	$a_{4,t}$	$a_{4,c}$
Plane surface (see Figure 1)	$4 \cdot d$	$6 \cdot d$	$6 \cdot d$	$2,5 \cdot d$	$6 \cdot d$	$2,5 \cdot d$
Edge surface (see Figure 2)	$10 \cdot d$	$12 \cdot d$	$7 \cdot d$	$4 \cdot d$	$6 \cdot d$	$3 \cdot d$

Annex C
Thermal insulation material on top of rafters

Din Ling self-tapping screw with an outer thread diameter of at least 6 mm may be used for the fixing of thermal insulation material on top of rafters.

The thickness of the insulation shall not exceed 300 mm. The rafter insulation must be placed on top of solid timber or glued laminated timber rafters or cross-laminated timber members and be fixed by battens arranged parallel to the rafters or by wood-based panels on top of the insulation layer. The insulation of vertical facades is also covered by the rules given here.

Screws must be screwed in the rafter through the battens or panels and the insulation without pre-drilling in one sequence.

The angle α between the screw axis and the grain direction of the rafter should be between 30° and 90°.

The rafter consists of solid timber (softwood) according to EN 338, glued laminated timber according to EN 14081, cross-laminated timber, or laminated veneer lumber according to EN 14374 or to ETA or similar glued members according to ETA.

The battens must be from solid timber (softwood) according to EN 338:2003-04. The minimum thickness t and the minimum width b of the battens is given as follows:

Screws $d \leq 8{,}0$ mm: $b_{min} = 50$ mm $\qquad t_{min} = 30$ mm
Screws $d = 10$ mm: $b_{min} = 60$ mm $\qquad t_{min} = 40$ mm
Screws $d = 12$ mm: $b_{min} = 100$ mm $\qquad t_{min} = 80$ mm

The insulation must comply with an hEN or ETA. The thermal insulation material shall be applicable as insulation on top of rafters according to national provisions that apply at the installation site.

Friction forces shall not be considered for the design of the characteristic axial capacity of the screws.

The anchorage of wind suction forces as well as the bending stresses of the battens or the boards, respectively, shall be considered in design. Additional screws perpendicular to the grain of the rafter (angle $\alpha = 90°$) may be arranged if necessary.

The maximum screw spacing is $e_S = 1{,}75$ m.

Thermal insulation material on rafters with parallel inclined screws and thermal insulation material in compression

Mechanical model

The system of rafter, thermal insulation on top of rafter and battens parallel to the rafter may be considered as a beam on elastic foundation. The batten represents the beam, and the thermal insulation on top of the rafter the elastic foundation. The minimum compression stress of the thermal insulation at 10 % deformation, measured according to EN 826[1], shall be $\sigma_{(10\%)} = 0,05$ N/mm². The batten is loaded perpendicular to the axis by point loads F_b. Further point loads F_s are from the shear load of the roof due to dead and snow load, which are transferred from the screw heads into the battens.
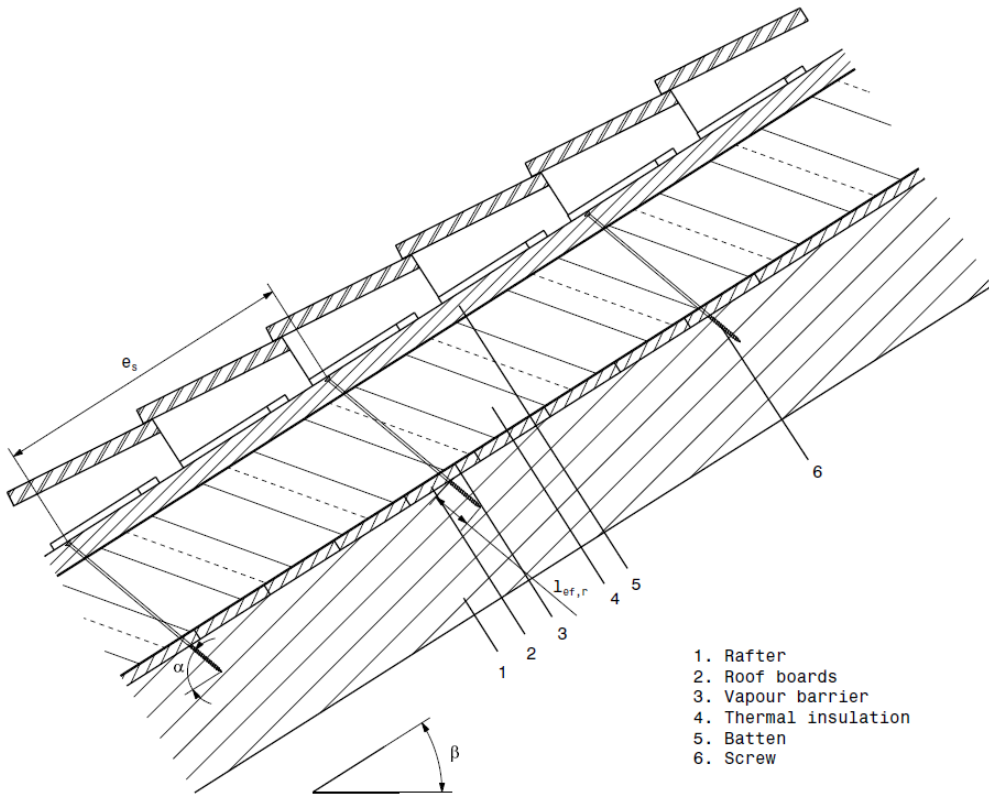
1. Rafter
2. Roof boards
3. Vapour barrier
4. Thermal insulation
5. Batten
6. Screw
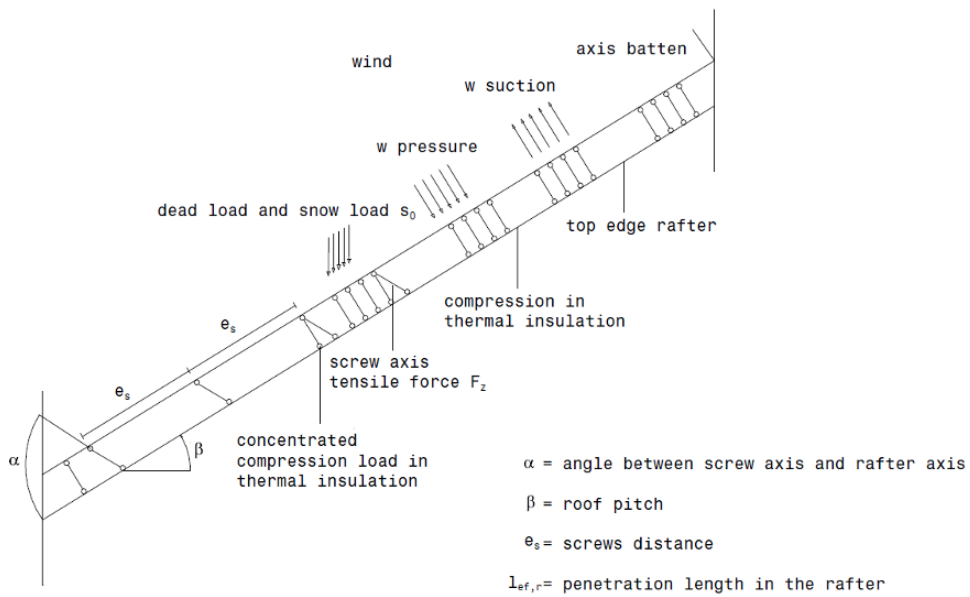
α = angle between screw axis and rafter axis

β = roof pitch

e_s = screws distance

$l_{ef,r}$ = penetration length in the rafter

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[1] EN 826   Thermal insulating products for building applications - Determination of compression behaviour

Design of the battens

The bending stresses are calculated as:

$$M = \frac{(F_b + F_s) \cdot \ell_{char}}{4}$$

Where

$$\ell_{char} = \sqrt[4]{\frac{4 \cdot EI}{w_{ef} \cdot K}}$$

ℓ_{char} = characteristic length

EI = bending stiffness of the batten

K = coefficient of subgrade

w_{ef} = effective width of the thermal insulation

F_b = Point loads perpendicular to the battens

F_s = Point loads perpendicular to the battens, load application in the area of the screw heads

The coefficient of subgrade K may be calculated from the modulus of elasticity E_{HI} and the thickness t_{HI} of the thermal insulation if the effective width w_{ef} of the thermal insulation under compression is known. Due to the load extension in the thermal insulation the effective width w_{ef} is greater than the width of the batten or rafter, respectively. For further calculations, the effective width w_{ef} of the thermal insulation may be determined according to:

$$w_{ef} = w + t_{HI}/2$$

where

w = minimum width of the batten or rafter, respectively

t_{HI} = thickness of the thermal insulation

$$K = \frac{E_{HI}}{t_{HI}}$$

The following condition shall be satisfied:

$$\frac{\sigma_{m,d}}{f_{m,d}} = \frac{M_d}{W \cdot f_{m,d}} \leq 1$$

For the calculation of the section modulus W the net cross section has to be considered.

The shear stresses shall be calculated according to:

$$V = \frac{(F_b + F_s)}{2}$$

The following condition shall be satisfied:

$$\frac{\tau_d}{f_{v,d}} = \frac{1{,}5 \cdot V_d}{A \cdot f_{v,d}} \leq 1$$

For the calculation of the cross section area the net cross section has to be considered.

Design of the thermal insulation

The compressive stresses in the thermal insulation shall be calculated according to:

$$\sigma = \frac{1{,}5 \cdot F_b + F_s}{2 \cdot \ell_{char} \cdot w}$$

The design value of the compressive stress shall not be greater than 110 % of the compressive stress at 10 % deformation calculated according to EN 826.

Design of the screws

The screws are loaded predominantly axially. The axial tension force in the screw may be calculated from the shear loads of the roof R_s:

$$T_S = \frac{R_S}{\cos \alpha}$$

The load-carrying capacity of axially loaded screws is the minimum design value of the axial withdrawal capacity of the threaded part of the screw, the head pull-through capacity of the screw and the tensile capacity of the screw.

To limit the deformation of the screw head for Thermal insulation material thicknesses over 200 mm or with compressive strength below 0,12 N/mm², respectively, the axial withdrawal capacity of the screws shall be reduced by the factors k_1 and k_2:

$$F_{ax,\alpha,Rd} = \min\left\{k_{ax} \cdot f_{ax,d} \cdot d \cdot \ell_{ef} \cdot k_1 \cdot k_2 \cdot \left(\frac{\rho_k}{350}\right)^{0.8}; f_{head,d} \cdot d_h^2 \cdot \left(\frac{\rho_k}{350}\right)^{0.8}; f_{tens,d}\right\} \text{ for WBS and CPS}$$
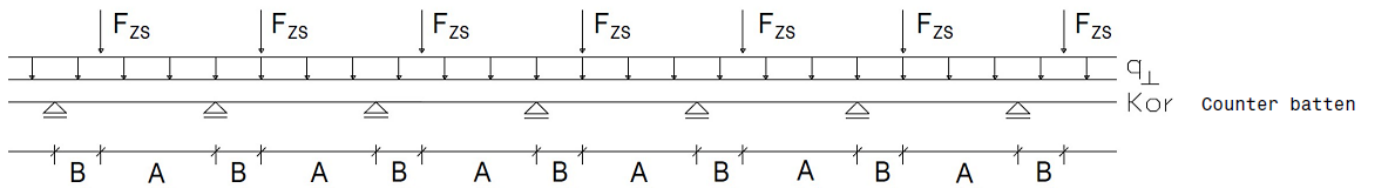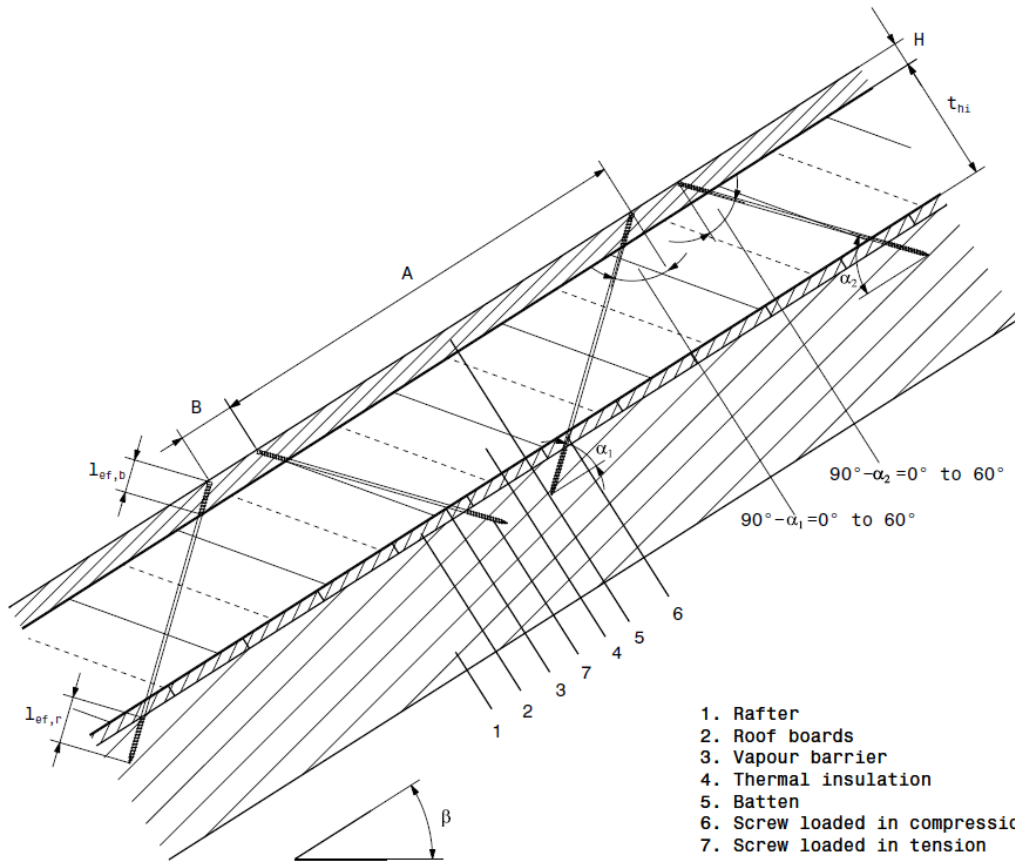
$$F_{ax,\alpha,Rd} = \min\left\{\begin{array}{l} k_{ax} \cdot f_{ax,d} \cdot d \cdot \ell_{ef} \cdot k_1 \cdot k_2 \cdot \left(\frac{\rho_k}{350}\right)^{0,8} \\ \max\{f_{head,d} \cdot d_h^2; \ k_{ax} \cdot f_{ax,d} \cdot d \cdot \ell_{ef}\} \cdot \left(\frac{\rho_k}{350}\right)^{0,8} \\ f_{tens,d} \end{array}\right\} \text{ for WBS TT and WBS VG}$$

Where:

$f_{ax,d}$	design value of the axial withdrawal parameter of the threaded part of the screw
k_{ax}	Factor, taking into account the angle α between screw axis and grain direction
	$k_{ax} = 1,0$ for $45° \leq \alpha < 90°$
	$k_{ax} = 0,3 + \dfrac{0,7 \cdot \alpha}{45}$ for $15° \leq \alpha < 45°$
ℓ_{ef}	Point side penetration length of the threaded part of the screw in the batten or rafter, for rafters $l_{ef} \geq 40$ mm
α	Angle between grain and screw axis ($\alpha \geq 30°$)
ρ_k	characteristic density of the wood-based member [kg/m³]
$f_{head,d}$	design value of the head pull-through capacity of the screw
d_h	head diameter
$f_{tens,d}$	design tensile capacity of the screw
k_1	min $\{1; 200/t_{HI}\}$
k_2	min $\{1; \sigma_{10\%}/0,12\}$
t_{HI}	thickness of the heat insulation [mm]
$\sigma_{10\%}$	compressive stress of the heat insulation under 10 % deformation [N/mm²]

If k_1 and k_2 are considered, the deflection of the battens does not need to be considered. Alternatively to the battens, panels with a minimum thickness of 22 mm from plywood according to EN 636, particle board according to EN 312, oriented strand board according to EN 300 or European Technical Approval and solid wood panels according to EN 13353 or cross laminated timber may be used.

Thermal insulation material on rafters with alternatively inclined screws WBS VG or WBS TT and thermal insulation material without compression

$90° - \alpha_2 = 0°$ to $60°$

$90° - \alpha_1 = 0°$ to $60°$

1. Rafter
2. Roof boards
3. Vapour barrier
4. Thermal insulation
5. Batten
6. Screw loaded in compression
7. Screw loaded in tension

Mechanical model

Depending on the screw spacing and the arrangement of tensile and compressive screws with different inclinations the battens are loaded by significant bending moments. The bending moments are derived based on the following assumptions:

- The tensile and compressive loads in the screws are determined based on equilibrium conditions from the actions parallel and perpendicular to the roof plane.
  These actions are constant line loads $q_\perp$ and $q_{||}$.
- The screws act as hinged columns supported 10 mm within the batten or rafter, respectively. The effective column length consequently equals the length of the screw between batten and rafter plus 20 mm.
- The batten is considered as a continuous beam with a constant span $\ell = A + B$. The battens or boards, respectively, must have sufficient strength and stiffness.
- The compressive screws constitute the supports of the continuous beam while the tensile screws transfer concentrated loads perpendicular to the batten axis.

The screws are predominantly loaded in withdrawal or compression, respectively. The screw's normal forces are determined based on the loads parallel and perpendicular to the roof plane:

Compressive screw: $$F_{c,Ed} = (A+B) \cdot \left(-\frac{q_{II} \cdot \sin\alpha_2 + q_\perp \cdot \cos\alpha_2}{\sin(\alpha_1 + \alpha_2)} \right)$$

Tensile screw:
$$F_{t,Ed} = (A+B) \cdot \left(\frac{q_{II} \cdot \sin\alpha_1 - q_\perp \cdot \cos\alpha_1}{\sin(\alpha_1 + \alpha_2)} \right)$$

The bending moments in the batten follow from the constant line load $q_\perp$ and the load components perpendicular to the batten from the tensile screws. The span of the continuous beam is $(A + B)$. The load component perpendicular to the batten from the tensile screw is:

$$F_{ZS,Ed} = (A+B) \cdot \left(\frac{q_{II} \cdot \sin\alpha_1 \cdot \sin\alpha_2 - q_\perp \cdot \cos\alpha_1 \cdot \sin\alpha_2}{\sin(\alpha_1 + \alpha_2)} \right)$$

where:

q_{II}	constant line load parallel to batten
$q_\perp$	constant line load perpendicular to batten
α_1	angle between compressive screw axis and grain direction
α_2	angle between tensile screw axis and grain direction

A positive value for F_{ZS} means a load towards the rafter, a negative value a load away from the rafter.

Design of the screws

The load-carrying capacity of the screws shall be calculated as follows:

Screws loaded in tension:

$$F_{ax,\alpha,Rd} = \min\left\{ k_{ax} \cdot f_{ax,d} \cdot d \cdot \ell_{ef,b} \cdot \left(\frac{\rho_{b,k}}{\rho_a} \right)^{0.8}; k_{ax} \cdot f_{ax,d} \cdot d \cdot \ell_{ef,r} \cdot \left(\frac{\rho_{r,k}}{\rho_a} \right)^{0.8}; f_{tens,d} \right\}$$

Screws loaded in compression:

$$F_{ax,\alpha,Rd} = \min\left\{ k_{ax} \cdot f_{ax,d} \cdot d \cdot \ell_{ef,b} \cdot \left(\frac{\rho_{b,k}}{\rho_a} \right)^{0.8}; k_{ax} \cdot f_{ax,d} \cdot d \cdot \ell_{ef,r} \cdot \left(\frac{\rho_{r,k}}{\rho_a} \right)^{0.8}; \frac{\kappa_c \cdot N_{pl,k}}{\gamma_{M1}} \right\}$$

where:

|	
$F_{ax,\alpha,Rd}$	design value of the load-carrying capacity of the screw [N]
$f_{ax,d}$	design value of the axial withdrawal parameter of the threaded part of the screw in the rafter or batten [N/mm²]
d	outer thread diameter of the screw [mm]
$\ell_{ef,b}$	penetration length of the threaded part of the screw in the batten including the head for tensile and excluding the head for compressive force [mm]
$\ell_{ef,r}$	penetration length of the threaded part of the screw in the rafter, $l_{ef} \geq 40$ mm [mm]
$\rho_{b,k}$	characteristic density of the batten [kg/m³]
$\rho_{r,k}$	characteristic density of the rafter [kg/m³]
α	angle α_1 or α_2 between screw axis and grain direction, $30° \leq \alpha_1 \leq 90°$, $30° \leq \alpha_2 \leq 90°$
$f_{tens,d}$	design value of the tensile capacity of the screw [N]
γ_{M1}, γ_{M2}	partial factor according to EN 1993 or to the particular national annex
$\kappa_c \cdot N_{pl,k}$	buckling capacity of the screw [N]
k_{ax}	see Section 3.4 axial withdrawal capacity [-]

Buckling capacity of the screw

Free screw length [mm]	WBS VG			WBS TT
	6,0 mm	8,0 mm	10,0 mm	8 mm
	$\kappa_c \cdot N_{pl,k}$ [kN]	$\kappa_c \cdot N_{pl,k}$ [kN]	$\kappa_c \cdot N_{pl,k}$ [kN]	$\kappa_c \cdot N_{pl,k}$ [kN]
≤ 100	1,24	4,06	8,27	6,42
120	0,94	3,14	6,53	5,03
140	0,74	2,49	5,25	4,02
160	0,59	2,02	4,29	3,28
180	0,49	1,67	3,57	2,72
200	0,41	1,41	3,01	2,29
220	0,34	1,20	2,58	1,95
240		1,03	2,22	1,69
260		0,90	1,95	1,47
280		0,79	1,71	1,29
300		0,70	1,52	1,14
320		0,62	1,35	1,02
340		0,56	1,21	0,92
360		0,50	1,10	0,83
380		0,45	0,99	0,75
400		0,41	0,91	0,68
420		0,38	0,83	0,62

where
free screw length = $t_{HI} / \sin \alpha$ [mm]   ($\alpha = \alpha_1$ or α_2)

Annex D
Compression reinforcement

WBS VG screws with diameters 6,0 mm, 8,0 mm or 10,0 mm may be used for reinforcement of timber members with compression stresses at an angle α to the grain of 45° < α < 90°. The compression force must be evenly distributed over all screws.
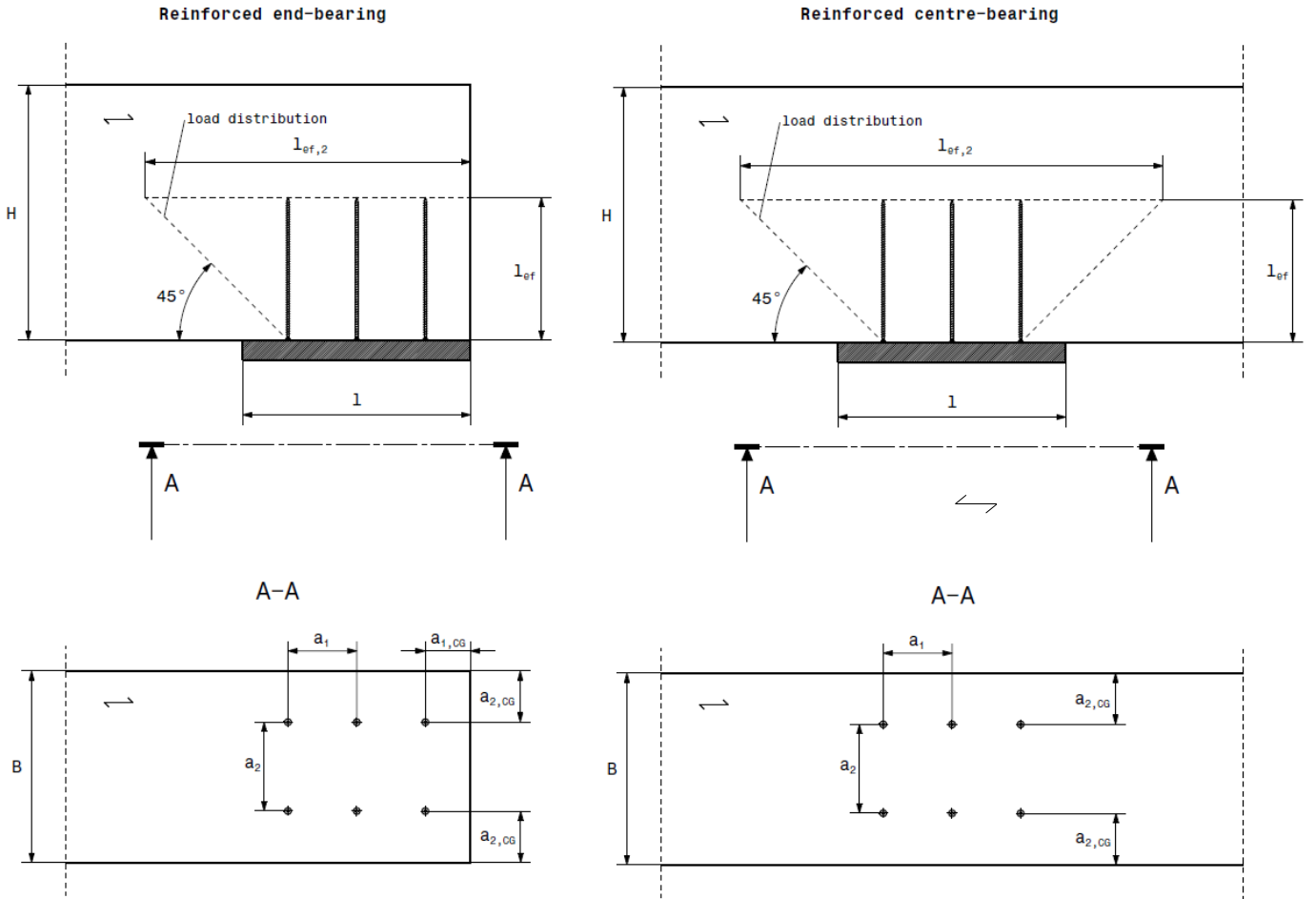
The design load-carrying capacity for a reinforced contact area with screws with a full thread at an angle α to the grain of 45° < α < 90° shall be calculated from:

$$F_{90,Rd} = \min \begin{cases} k_{c,90} \cdot B \cdot \ell_{ef,1} \cdot f_{c,90,d} + n \cdot F_{c,90,Rd} \\ B \cdot \ell_{ef,2} \cdot f_{c,90,d} \end{cases}$$

Where:

$F_{90,Rd}$	design load-carrying capacity of reinforced contact area [N]
$k_{c,90}$	factor for compression perpendicular to the grain according to EN 1995-1-1, 6.1.5
B	bearing width [mm]
H	component height [mm]
$\ell_{ef,1}$	effective length of contact area according to EN 1995-1-1, 6.1.5 [mm]
$f_{c,90,d}$	design compressive strength perpendicular to the grain [N/mm²]
n	number of reinforcement fasteners, $n = n_0 \cdot n_{90}$
n_0	number of reinforcement fasteners arranged in a row parallel to the grain
n_{90}	number of reinforcement fasteners arranged in a row perpendicular to the grain
$\ell_{ef,2}$	effective distribution length in the plane of the fastener tips [mm]
$\ell_{ef,2}$	$= 2 \cdot \ell_{ef} + (n_0 - 1) \cdot a_1$ for reinforced centre-bearings
$\ell_{ef,2}$	$= \ell_{ef} + (n_0 - 1) \cdot a_1 + \min (\ell_{ef}; a_{1,c})$ for reinforced end-bearings
ℓ_{ef}	point side penetration length [mm]
a_1	spacing parallel to grain [mm]
$a_{1,CG}$	end grain distance of the centre of the screw-part in timber [mm]
$F_{c,90,Rd}$	design compressive capacity [N]

An appropriate steel plate as intermediate layer between timber member and support has to be installed. The screws have to be driven into the timber member flush with the surface to provide both direct contact with the steel plate and direct contact between steel plate and timber. The screws must have a countersunk, pan or flat head.

Reinforcing screws for wood-based panels are not covered by this European Technical Assessment.

Annex E
Tensile reinforcement perpendicular to grain

Timber members loaded by a connection force perpendicular to the grain

Unless specified otherwise in national provisions that apply at the installation site, the axial capacity of a reinforcement of a timber member loaded by a connection force perpendicular to the grain shall fulfil the following condition:

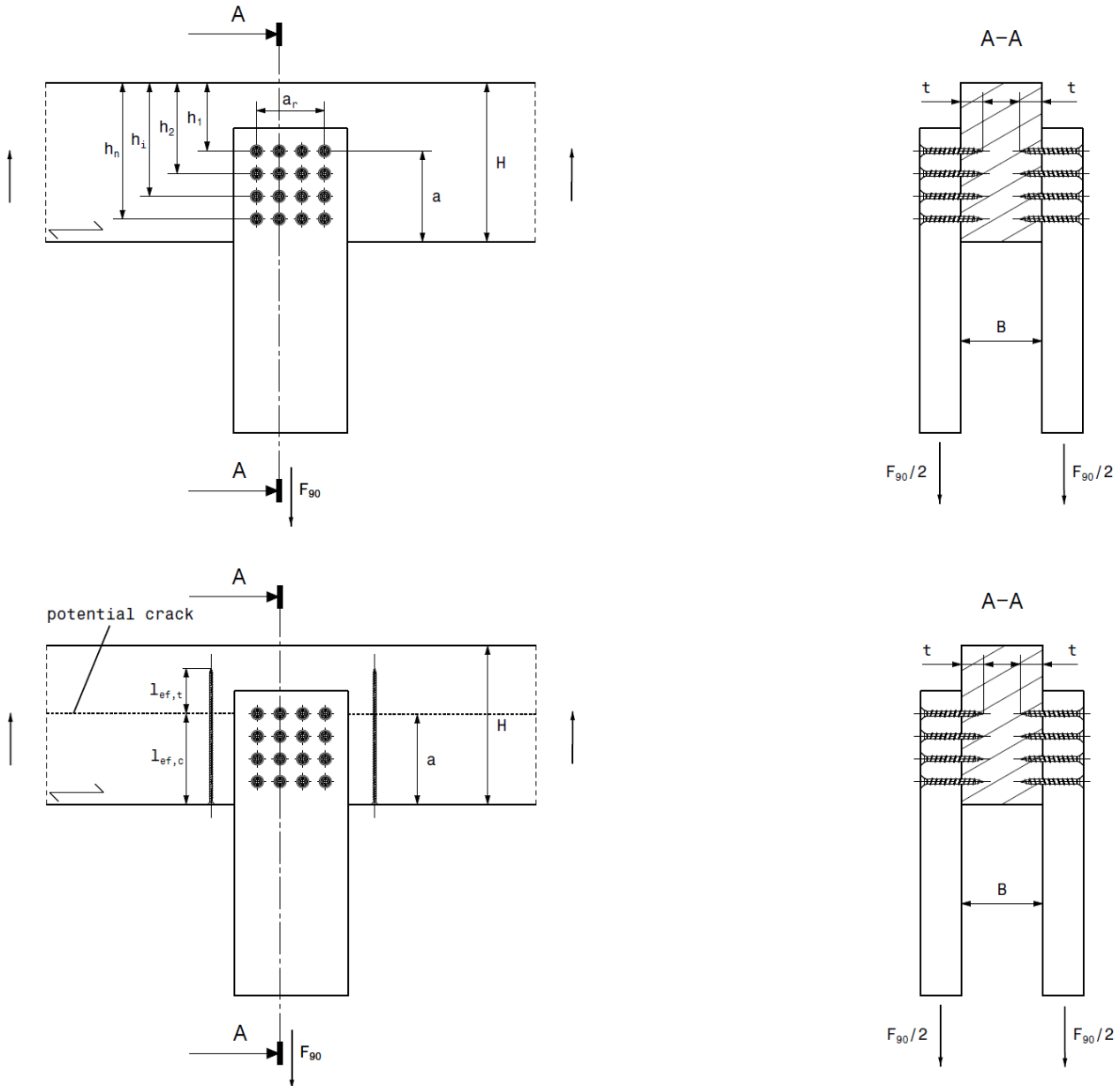$$\frac{\left[1 - 3 \cdot \alpha^2 + 2 \cdot \alpha^3\right] \cdot F_{90,d}}{F_{ax,Rd}} \leq 1$$

Where

$F_{90,d}$ Design value of the force component perpendicular to the grain in N,

α $= a/H$

H $=$ member depth in mm

$F_{ax,Rd}$ Minimum of the design values of the withdrawal capacity and the tensile capacity of the reinforcing screws where ℓ_{ef} is the smaller value of the penetration depth below or above the potential crack in N

Notched beam supports

Unless specified otherwise in national provisions that apply at the installation site, the axial capacity of a reinforcement of a notched beam support shall fulfil the following condition:

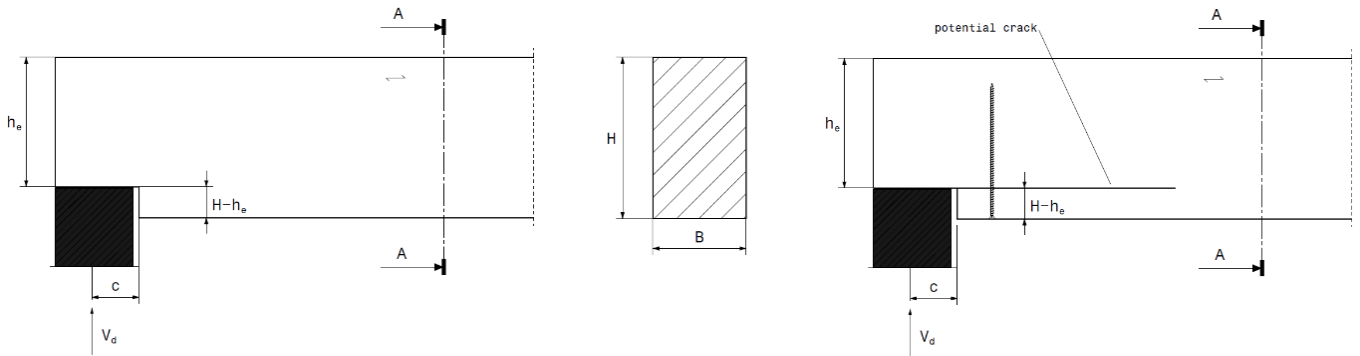$$\frac{1,3\cdot V_d \cdot \left[3\cdot(1-\alpha)^2 - 2\cdot(1-\alpha)^3 \right]}{F_{ax,Rd}} \leq 1$$

Where

V_d Design value of the shear force in N,

α $= H/h_e$

H   = member depth in mm

$F_{ax,Rd}$ Minimum of the design values of the withdrawal capacity and the tensile capacity of the reinforcing screws where ℓ_{ef} is the smaller value of the penetration depth below or above the potential crack in N

Beams with holes

Unless specified otherwise in national provisions that apply at the installation site, the axial capacity of a reinforcement of a hole in a beam shall fulfil the following condition:

$$\frac{F_{t,V,d} + F_{t,M,d}}{F_{ax,Rd}} \leq 1$$

Where

$F_{t,V,d}$ Design value of the force perpendicular to the grain due to shear force in N:

$$F_{t,V,d} = \frac{V_d \cdot h_d}{4 \cdot H} \cdot \left[3 - \frac{h_d^2}{H^2} \right]$$

V_d Design value of the member shear force at the hole end in N,
H = member depth in mm
h_d = hole depth for rectangular holes in mm
h_d = 70 % of hole diameter for circular holes in mm
$F_{t,M,d}$ Design value of the force perpendicular to the grain due to bending moment in N:

$$F_{t,M,d} = 0,008 \cdot \frac{M_d}{h_r}$$

M_d Design value of the member bending moment at the hole end in Nm,
h_r = min $(h_{ro} ; h_{ru})$ for rectangular holes in mm
h_r = min $(h_{ro} ; h_{ru}) + 0,15 \cdot h_d$ for circular holes in mm
$F_{ax,Rd}$ Minimum of the design values of the withdrawal capacity and the tensile capacity of the reinforcing screws where ℓ_{ef} is the smaller value of the penetration depth below or above the potential crack in N.
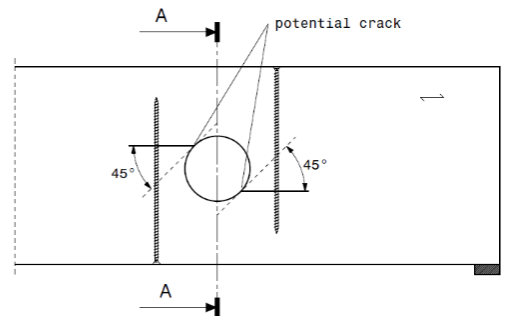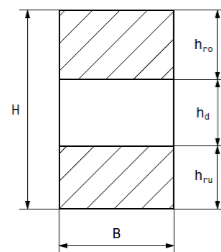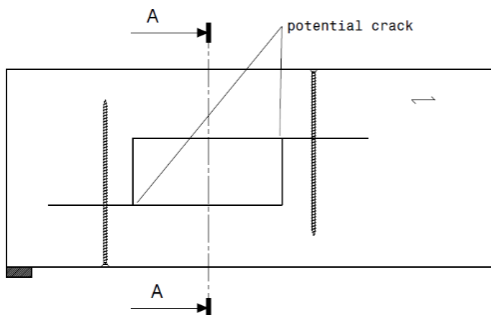
Annex F
Shear reinforcement

Unless specified otherwise in national provisions that apply at the installation site, the shear stress in reinforced areas of timber members with a stress component parallel to the grain shall fulfil the following condition:

$$\tau_d \le \frac{f_{v,d} \cdot k_\tau}{\eta_H}$$

Where: τ_d is the design shear stress disregarding the reinforcement [N/mm²];

$f_{v,d}$ is the design shear strength [N/mm²];

$k_\tau = 1 - 0,46 \cdot \sigma_{90,d} - 0,052 \cdot \sigma_{90,d}^2$

$\sigma_{90,d}$ is the design stress perpendicular to the grain (negative value for compression) [N/mm²];

$$\sigma_{90,d} = \frac{F_{ax,d}}{\sqrt{2} \cdot b \cdot a_1}$$

$$F_{ax,d} = \frac{\sqrt{2} \cdot (1 - \eta_H) \cdot V_d \cdot a_1}{H}$$

$$\eta_H = \frac{G \cdot b}{G \cdot b + \dfrac{1}{2 \cdot \sqrt{2}\left(\dfrac{6}{\pi \cdot d \cdot H \cdot k_{ax}} + \dfrac{a_1}{EA_S}\right)}}$$

V_d is the design shear force [N];

G is the shear modulus of the timber member, $G = 650$ N/mm²,

b is the width of the timber member in mm,

d is the outer thread diameter in mm,

H is the depth of the timber member in mm,

k_{ax} is the connection stiffness between screw d and timber member in N/mm³,
$k_{ax} = 12,5$ N/mm³ for WBS VG screws $d = 8,0$ mm,

a_1 is the spacing parallel to the grain of the screws arranged in one row in mm,

EA_S is the axial stiffness of one screw [N],

$$EA_S = \frac{E \cdot \pi \cdot d_1^2}{4} = 165.000 \, d_1^2$$

d_1 is the inner thread diameter of the screw in mm,
5,28 mm for screw WBS VG 8,0 mm.

The axial capacity of a threaded screw shall fulfil the following condition:

$$\frac{F_{ax,d}}{F_{ax,Rd} * n_r} \le 1$$

Where:

$F_{ax,Rd}$ Minimum of the design values of the withdrawal capacity and the tensile capacity of the reinforcing screws [N]. The effective penetration length is 50 % of the threaded length.

n_r Number of screw rows. Multiple screw rows should be arranged evenly and symmetrically over the width of the timber.

A minimum of four screws in a row are required in each reinforced area. Outside reinforced areas (shaded area in Figure F.1) the shear design shall fulfil the conditions for unreinforced members.
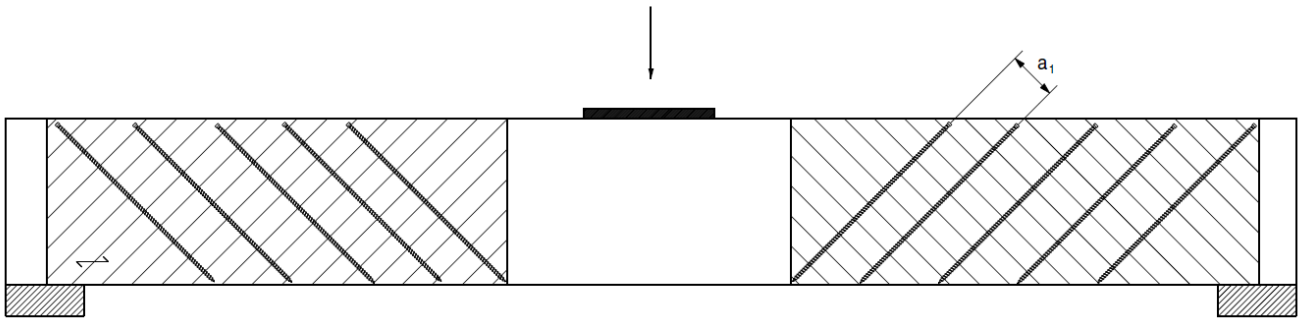
Figure F.1: Timber member with shear reinforcement; shaded areas: reinforced areas with screws arranged under 45°