Approval body for construction products and types of construction

Bautechnisches Prüfamt

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European Technical Assessment

ETA-18/0817 of 17 January 2019

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General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	KLIMAS screws
Product family to which the construction product belongs	Screws for use in timber constructions
Manufacturer	Klimas Sp. z o.o. Kuznica Kiedrzynska ul. Wincentego Witosa 135/137 42-233 MYKANÓW POLEN
Manufacturing plant	plant 1 plant 2
This European Technical Assessment contains	31 pages including 5 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	EAD 130118-00-0603

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Specific Part

1 Technical description of the product

WKCP, WKPP, WKCS, WKPS, WKLC, WKSS, WKFC and WKFS screws are self-tapping screws made from special carbon steel. The screws have an anti-friction coating. The outer thread diameter is not less than 5 mm and not greater than 10 mm. The overall length of the screw is ranging from 30 mm to 400 mm (nominal dimension). Further dimensions are shown in Annex 5.

2 Specification of the intended use in accordance with the applicable European Assessment Document

The performances given in Section 3 are only valid if the KLIMAS screws are used in compliance with the specifications and conditions given in Annex 1 and 2.

Durability is only ensured if the specifications of intended use according to Annex 1 and 2 are taken into account.

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the screws of at least 50 years. The indications given on the working life cannot be interpreted as a guarantee given by the producer, 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

3.1 Mechanical resistance and stability (BWR 1)

Essential characteristic	Performance
Dimensions	See Annex 5
Characteristic yield moment	See Annex 2
Bending angle	See Annex 2
Characteristic withdrawal parameter	See Annex 2
Characteristic head pull-through parameter	See Annex 2
Characteristic tensile strength	See Annex 2
Characteristic yield strength	See Annex 2
Characteristic torsional strength	See Annex 2
Insertion moment	See Annex 2
Spacing, end and edge distances of the screws and minimum thickness of the wood based material	See Annex 2
Slip modulus for mainly axially loaded screws	See Annex 2

3.2 Safety in case of fire (BWR 2)

Essential characteristic	Performance
Reaction to fire	Class A1

3.3 Safety and accessibility in use (BWR 4)

Same as BWR 1

4 Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base

In accordance with EAD No. 130118-00-0603, the applicable European legal act is: 97/176/EC.
The system to be applied is: 3

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

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

Issued in Berlin on 17 January 2019 by Deutsches Institut für Bautechnik

BD Dipl.-Ing. Andreas Kummerow
Head of Department

beglaubigt:
Dewitt

Annex 1 Specifications of intended use

A.1.1 Use of the KLIMAS screws only for:

- Static and quasi-static loads

A.1.2 Base materials

The screws are used for connections in load bearing timber structures between wood-based members or between those members and steel members:

- Solid timber (softwood) according to EN 14081-1[1],
- Glued laminated timber (softwood) according to EN 14080[2],
- Laminated veneer lumber LVL made of softwood according to EN 14374[3], arrangement of the screws only perpendicular to the plane of the veneers,
- Glued solid timber according to EN 14080 or national provisions that apply at the installation site,
- Cross-laminated timber made from softwood according to European Technical Assessments or national provisions that apply at the installation site.

The screws may be used for connecting the following wood-based panels to the timber members mentioned above:

- Plywood according to EN 636[4] and EN 13986[5],
- Oriented Strand Board, OSB according to EN 300[6] and EN 13986,
- Particleboard according to EN 312[7] and EN 13986,
- Fibreboards according to EN 622-2[8], EN 622-3[9] and EN 13986,
- Cement-bonded particle boards according to EN 634-2[10] and EN 13986,
- Solid-wood panels according to EN 13353[11] and EN 13986.

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

KLIMAS 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.

WKFC and WKFS screws may be used for reinforcing of timber structures perpendicular to the grain.

1	EN 14081-1:2005+A1:2011	Timber structures – Strength graded structural timber with rectangular cross section – Part 1: General requirements
2	EN 14080:2013	Timber structures - Glued laminated timber and glued solid timber - Requirements
3	EN 14374:2004	Timber structures - Structural laminated veneer lumber - Requirements
4	EN 636:2012+A1:2015	Plywood - Specifications
5	EN 13986:2004+A1:2015	Wood-based panels for use in construction - Characteristics, evaluation of conformity and marking
6	EN 300:2006	Oriented strand boards (OSB) – Definition, classification and specifications
7	EN 312:2010	Particleboards - Specifications
8	EN 622-2:2004	Fibreboards – Specifications – Part 2: Requirements for hardboards
9	EN 622-3:2004	Fibreboards - Specifications - Part 3: Requirements for medium boards
10	EN 634-2:2007	Cement-bonded particleboards – Specifications – Part 2: Requirements for OPC bonded particleboards for use in dry, humid and external conditions
11	EN 13353:2008+A1:2011	Solid wood panels (SWP) – Requirements

A.1.3 Use Conditions (environmental conditions)

The corrosion protection of the KLIMAS screws is specified in Annex A.2.6. With regard to the use and the environmental conditions the national provisions of the place of installation apply.

A.1.4 Installation provisions

EN 1995-1-1[12] in conjunction with the respective national annex applies for the installation.

The screws shall be driven into softwood without pre-drilling or after pre-drilling with a diameter not larger than the inner thread diameter for the length of the threaded part and with a maximum of the smooth shank diameter for the length of the smooth shank.

The screw holes in steel members shall be pre-drilled with an adequate diameter greater than the outer thread diameter.

A minimum of two screws shall be used for connections in load bearing timber structures. This does not apply for special situations specified in National Annexes to EN 1995-1-1.

If the 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.

By fastening screws in wood-based members the head of the screws shall be flush with the surface of the wood-based member. A deeper countersink is not allowed. For wafer head and WKLC head the head part remains unconsidered.

Screws may be used with appropriate washers according to Annex 5. After inserting the screw the washers shall touch the surface of the wood-based member completely.

[12] EN 1995-1-1:2004+A1:2008+A2:2014 Eurocode 5: Design of timber structures – Part 1-1: General - Common rules and rules for buildings

Annex 2 Characteristic load-bearing capacity values

Table A.2.1 Characteristic load-bearing capacities of KLIMAS screws

Outer thread diameter [mm]	**5.0**	**6.0**	**8.0**	**10.0**
Characteristic yield moment $M_{y,k}$ [Nm]	7	10	25	43
Characteristic tensile strength $f_{tens,k}$ [kN]	10	13	25	36
Characteristic torsional strength $f_{tor,k}$ [Nm]	7	10	27	45

A.2.1 General

All KLIMAS screws achieve a bending angle α of at least $45/d^{0.7} + 20$, where d is the outer thread diameter of the screws.

The minimum penetration length of the threaded part of the screw l_{ef} shall be

$$l_{ef} \geq \frac{4 \cdot d}{\sin \alpha} \tag{2.1}$$

where

α angle between screw axis and grain direction

d outer thread diameter of the screw.

The outer thread diameter of screws inserted in cross-laminated timber shall be at least 6 mm. The inner thread diameter d_1 of the screws shall be greater than the maximal width of the gaps in the layer of cross laminated timber.

A.2.2 Laterally loaded screws

A.2.2.1 General

The outer thread diameter d shall be used as effective diameter of the screw according to EN 1995-1-1.

The embedding strength for the screws in wood-based members or in wood-based panels shall be taken from EN 1995-1-1 or from national provisions that apply at the installation site.

A.2.2.2 Cross laminated timber

The embedding strength for screws arranged in the edge surfaces parallel to the plane of cross laminated timber may be assumed according to equation (2.2) independent of the angle between screw axis and grain direction, $15° \leq \alpha \leq 90°$:

$$f_{h,k} = 20 \cdot d^{-0.5} \text{ in N/mm}^2 \tag{2.2}$$

unless otherwise specified in the technical specification of the cross laminated timber.

Where d is the outer thread diameter of the screws in mm.

Equation (2.2) is only valid for softwood layers. The provisions in the European Technical Assessment or in national provisions of the cross laminated timber apply.

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 shall 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.

A.2.3 Axially loaded screws

A.2.3.1 Axial slip modulus

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

$K_{ser} = 25 \cdot l_{ef} \cdot d$ [N/mm] (2.3)

where

d outer thread diameter of the screw [mm]

l_{ef} penetration length of the threaded part of the screw in the wood-based member [mm].

A.2.3.2 Axial withdrawal capacity

The characteristic withdrawal capacity in solid timber, glued laminated timber, cross laminated timber or laminated veneer lumber members (softwood) at an angle of 30° ≤ α ≤ 90° to the grain shall be calculated as:

$$F_{ax,\alpha,Rk} = n_{ef} \cdot k_{ax} \cdot f_{ax,k} \cdot d \cdot l_{ef} \cdot \left(\frac{\rho_k}{350}\right)^{0,8} \quad (2.4)$$

where

$F_{ax,\alpha,Rk}$ Characteristic withdrawal capacity of a screw group at an angle α to the grain [N]

n_{ef} Effective number of screws according to EN 1995-1-1, clause 8.7.2 (8)

k_{ax} Factor, taking into account the angle α between screw axis and grain direction

$k_{ax} = 1.0$ for 45° ≤ α ≤ 90°

$k_{ax} = 0.3 + \frac{0.7 \cdot \alpha}{45°}$ for 30° ≤ α < 45° (2.5)

$f_{ax,k}$ Characteristic withdrawal parameter at an angle α = 90° based on a characteristic density of the wood-based member ρ_a of 350 kg/m³

$f_{ax,k}$ = 13 N/mm² for d = 5 mm

$f_{ax,k}$ = 12 N/mm² for 6 mm ≤ d ≤ 8 mm

$f_{ax,k}$ = 11 N/mm² for d = 10 mm

The characteristic withdrawal parameter for LVL shall be assumed as given in the technical specification of the LVL at the installation site.

The characteristic withdrawal parameter is also valid for softwood layers of cross-laminated timber.

l_{ef} penetration length of the threaded part of the screw in the wood-based member [mm]

ρ_k Characteristic density of the wood-based member, for LVL ρ_k ≤ 500 kg/m³.

For screws penetrating more than one layer of cross laminated timber the different layers may be taken into account proportionally. In the lateral surfaces of the cross laminated timber the screws shall be fully inserted in one layer of cross-laminated timber.

A.2.3.3 Head pull-through capacity

The characteristic value of the head pull-through parameter for KLIMAS screws for a characteristic density of 350 kg/m³ of the softwood-based member and for wood-based panel like

- 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

with a thickness of more than 20 mm is

$f_{head,k}$ = 9.4 N/mm².

For wood-based panels a maximum characteristic density of 380 kg/m³ and for LVL a maximum characteristic density of 500 kg/m³ shall be used in equation (8.40b) of EN 1995-1-1.

The head diameter d_h shall be greater than $1{,}8 \cdot d_s$, where d_s is the smooth shank or the wire diameter. Otherwise is the characteristic value of the head pull-through parameter $f_{head,k} = 0$.

For wood based panels with a thickness 12 mm ≤ t ≤ 20 mm the characteristic value of the head pull-through parameter for KLIMAS screws is:

$f_{head,k}$ = 8 N/mm²

For wood based panels with a thickness of less than 12 mm the characteristic head pull-through capacity for KLIMAS screws shall be based on a characteristic value of the head pull-through parameter of 8 N/mm², and limited to 400 N complying with the minimum thickness of the wood based panels of $1.2 \cdot d$, with d as outer thread diameter and the values in Table A.2.2.

Table A.2.2 Minimum thickness of wood based panels

Wood based panel	Minimum thickness [mm]
Plywood	6
Fibreboards (hardboards and medium boards)	6
Oriented Strand Boards, OSB	8
Particleboards	8
Cement-bonded particle board	8
Solid wood Panels	12

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

A.2.3.4 Compressive capacity of KLIMAS screws

The design axial capacity $F_{ax,Rd}$ of WKFS and WKFC screws embedded in solid timber, glued solid timber or glued laminated timber made from softwood with an angle between screw axis and grain direction of 30° ≤ α ≤ 90° is the minimum of the axial resistance against pushing-in and the buckling resistance of the screw.

$$F_{ax,Rd} = \min\{k_{ax} \cdot f_{ax,d} \cdot d \cdot l_{ef}\ ;\ \kappa_c \cdot N_{pl,d}\} \qquad (2.6)$$

k_{ax}	Factor, taking into account the angle α between screw axis and grain direction according to clause A.2.3.2
$f_{ax,d}$	design value of the axial withdrawal capacity of the threaded part of the screw [N/mm²]
d	outer thread diameter of the screw [mm]
l_{ef}	penetration length of the threaded part of the screw in the timber member [mm]

$$\kappa_c = 1 \qquad \text{for } \bar{\lambda}_k \le 0{,}2 \qquad (2.7)$$

$$\kappa_c = \frac{1}{k + \sqrt{k^2 - \bar{\lambda}_k^2}} \qquad \text{for } \bar{\lambda}_k > 0{,}2 \qquad (2.8)$$

$$k = 0{,}5 \cdot \left[1 + 0{,}49 \cdot (\bar{\lambda}_k - 0{,}2) + \bar{\lambda}_k^2\right] \qquad (2.9)$$

and a relative slenderness ratio $\bar{\lambda}_k = \sqrt{\frac{N_{pl,k}}{N_{ki,k}}}$ (2.10)

where:

$N_{pl,k}$ characteristic plastic normal force related to the net cross-section of the inner thread diameter:

$$N_{pl,k} = \pi \cdot \frac{d_1^2}{4} \cdot f_{y,k} \qquad (2.11)$$

$f_{y,k}$ characteristic yield strength, $f_{y,k}$ = 1000 N/mm² for WKFS and WKFC screws

d_1 inner thread diameter of the screw [mm]

$$N_{pl,d} = \frac{N_{pl,k}}{\gamma_{M1}} \qquad (2.12)$$

γ_{M1} partial factor according to EN 1993-1-1 in conjunction with the particular national annex

characteristic ideal elastic buckling load:

$$N_{ki,k} = \sqrt{c_h \cdot E_S \cdot I_S} \quad [N] \qquad (2.13)$$

elastic foundation of the screw:

$$c_h = (0.19 + 0.012 \cdot d) \cdot \rho_k \cdot \left(\frac{90° + \alpha}{180°}\right) \quad [N/mm^2] \qquad (2.14)$$

ρ_k characteristic density of the wood-based member [kg/m³],

α angle between screw axis and grain direction, 30° ≤ α ≤ 90°

modulus of elasticity:

E_s = 210.000 N/mm²

second moment of area:

$$I_s \quad \frac{\pi \cdot d_1^4}{64} \quad [mm^4] \qquad (2.15)$$

A.2.4 Spacing, end and edge distances of the screws and minimum thickness of the wood based material

A.2.4.1 Laterally and/or axially loaded screws

Screws in pre-drilled holes

For KLIMAS screws in pre-drilled holes the minimum spacings, end and edge distances are given in EN 1995-1-1, clause 8.3.1.2 and Table 8.2 as for nails in pre-drilled holes. Here, the outer thread diameter d shall be considered.

Minimum thickness for structural wood-based members made from solid timber, glued laminated timber, glued solid timber, laminated veneer lumber and cross laminated timber 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 and t = 40 mm for screws with outer thread diameter d = 10 mm.

Screws in non pre-drilled holes

For KLIMAS screws minimum spacing and distances are given in EN 1995-1-1, clause 8.3.1.2 and Table 8.2 as for nails in non-predrilled holes. Here, the outer thread diameter d shall 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·d also for timber thickness t < 5·d, if the spacing parallel to the grain and the end distance is at least 25·d.

For KLIMAS screws in non-predrilled softwood members the minimum member thickness defined in EN 1995-1-1, clause 8.3.1.2 as for nails in non-predrilled holes is valid.

A.2.4.2 Only axially loaded screws

For KLIMAS screws the minimum spacings, end and edge distances are given in EN 1995-1-1, clause 8.3.1.2 and Table 8.2 as for nails in non-predrilled holes and clause 8.7.2, Table 8.6.

A.2.4.3 Cross laminated timber

The minimum requirements for spacing, end and edge distances of screws in the plane or edge surfaces of cross laminated timber are summarised in Table A.2.3. The definition of spacing, end and edge distance is shown in Figure A.2.1 and Figure A.2.2. The minimum spacing, end and edge distances in the edge surfaces are independent of the angle between screw axis and grain direction. They may be used based on the following conditions:

- Minimum thickness of cross laminated timber: 10 · d
- Minimum penetration depth in the edge surface: 10 · d

Unless a detailed verification is carried out the tensile stresses perpendicular to the grain shall be transferred by reinforcing screws for load components perpendicular to the plane surface.

Table A.2.3 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 A.2.1)	4 · d	6 · d	6 · d	2.5 · d	6 · d	2.5 · d
Edge surface (see Figure A.2.2)	10 · d	12 · d	7 · d	4 · d	6 · d	3 · d

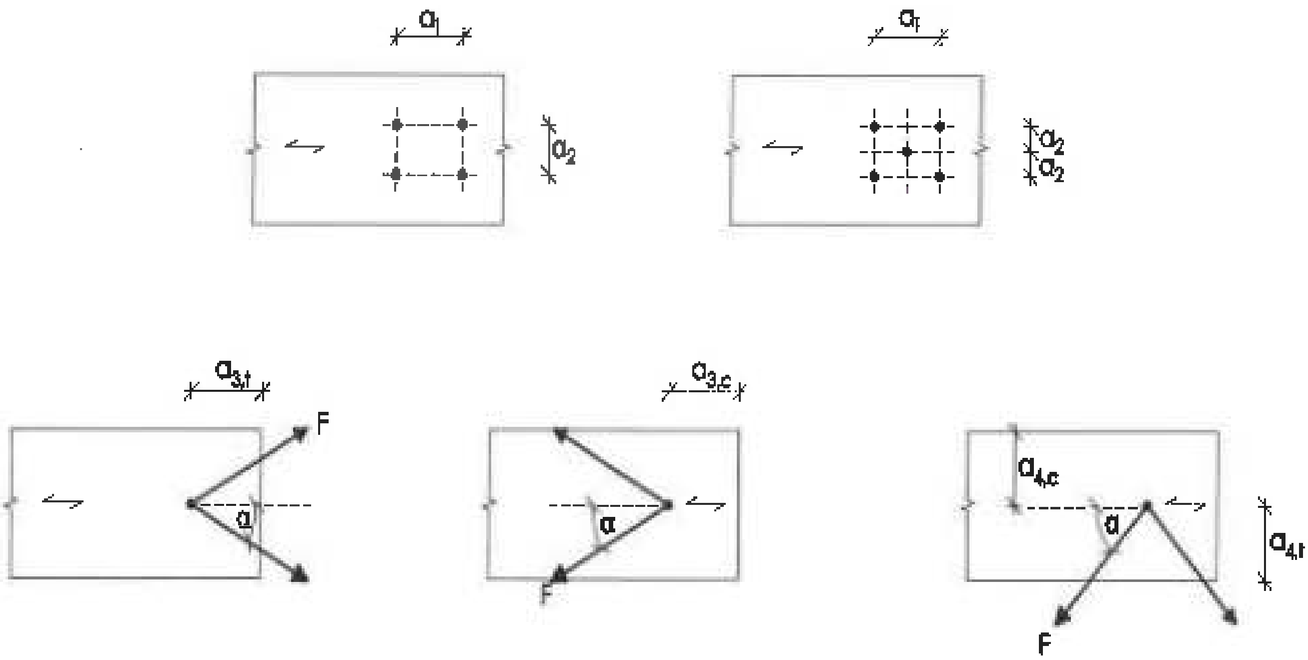

Figure A.2.1 Definition of spacing, end and edge distances in the plane surface of the cross laminated timber:

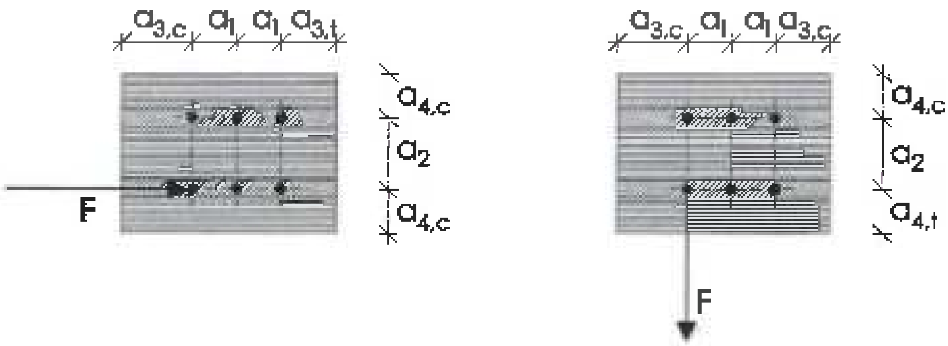

Figure A.2.2 Definition of spacing, end and edge distances in the edge surface of the cross laminated timber. For screws in the edge surface, a_1 and a_3 are parallel to the CLT plane face, a_2 and a_4 perpendicular to CLT plane face.

A.2.5 Insertion moment

The ratio between the characteristic torsional strength $f_{tor,k}$ and the mean value of insertion moment $R_{tor,mean}$ fulfills the requirement for all screws.

A.2.6 Durability against corrosion

The screws and washers may have the coatings according to Table A.2.4.

Table A.2.4 Coatings of the KLIMAS screws

Coating	Minimum thickness of the coating [µm]
Electrogalvanised	5
Non-electrolytically applied zinc flake coating	8

ANNEX 3 Compression reinforcement perpendicular to the grain

A.3.1 General

WKFS and WKFC screws may be used for compression reinforcement perpendicular to the grain. The provisions are valid for reinforcing timber members made from solid timber, glued solid timber or glued laminated timber made from softwood.

The compression force shall evenly be distributed to the screws used as compression reinforcement.

The screws are driven into the timber member perpendicular to the contact surface under an angle between the screw axis and the grain direction of 45° to 90°. The screw heads must be flush with the timber surface.

Compressive reinforcing screws for wood-based panels and timber members made of hardwood are not covered by this European Technical Assessment.

A.3.2 Design

For the design of reinforced contact areas the following conditions must be met independently of the angle between the screw axis and the grain direction.

The design resistance of a reinforced contact area is:

$$R_{90,d} = \min \begin{cases} k_{c,90} \cdot B \cdot l_{ef,1} \cdot f_{c,90,d} + n \cdot \min\{R_{ax,d}; \kappa_c \cdot N_{pl,d}\} \\ B \cdot l_{ef,2} \cdot f_{c,90,d} \end{cases} \quad (3.1)$$

where:

$k_{c,90}$ Parameter according to EN 1995-1-1, clause 6.1.5

B Bearing width [mm]

$l_{ef,1}$ Effective contact length according to EN 1995-1-1, clause 6.1.5 [mm]

$f_{c,90,d}$ Design compressive strength perpendicular to the grain [N/mm²]

n Number of reinforcing screws, $n = n_0 \cdot n_{90}$

n_0 Number of reinforcing screws arranged in a row parallel to the grain

n_{90} Number of reinforcing screws arranged in a row perpendicular to the grain

$R_{ax,d}$ $= f_{ax,d} \cdot d \cdot l_{ef}$ [N] (3.2)

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

d outer thread diameter of the screw [mm]

κ_c according to annex A.2.3.4,

$N_{pl,d}$ according to annex A.2.3.4 [N]

$l_{ef,2}$ Effective contact length in the plane of the screw tips (see Figure 3.1) [mm]

$l_{ef,2} = \{l_{ef} + (n_0 - 1) \cdot a_1 + \min(l_{ef} ; a_{1,c})\}$ for end supports (see Figure 3.1 left)

$l_{ef,2} = \{2 \cdot l_{ef} + (n_0 - 1) \cdot a_1\}$ for intermediate supports (see Figure 3.1 right)

l_{ef} Penetration length of the threaded part of the screw in the timber member [mm]

a_1 Spacing a_1 in a plane parallel to grain, see chapter A.2.4.2 [mm]

$a_{1,CG}$ End distance of the centre of gravity of the threaded part in the timber member, see chapter A.2.4.2 [mm]

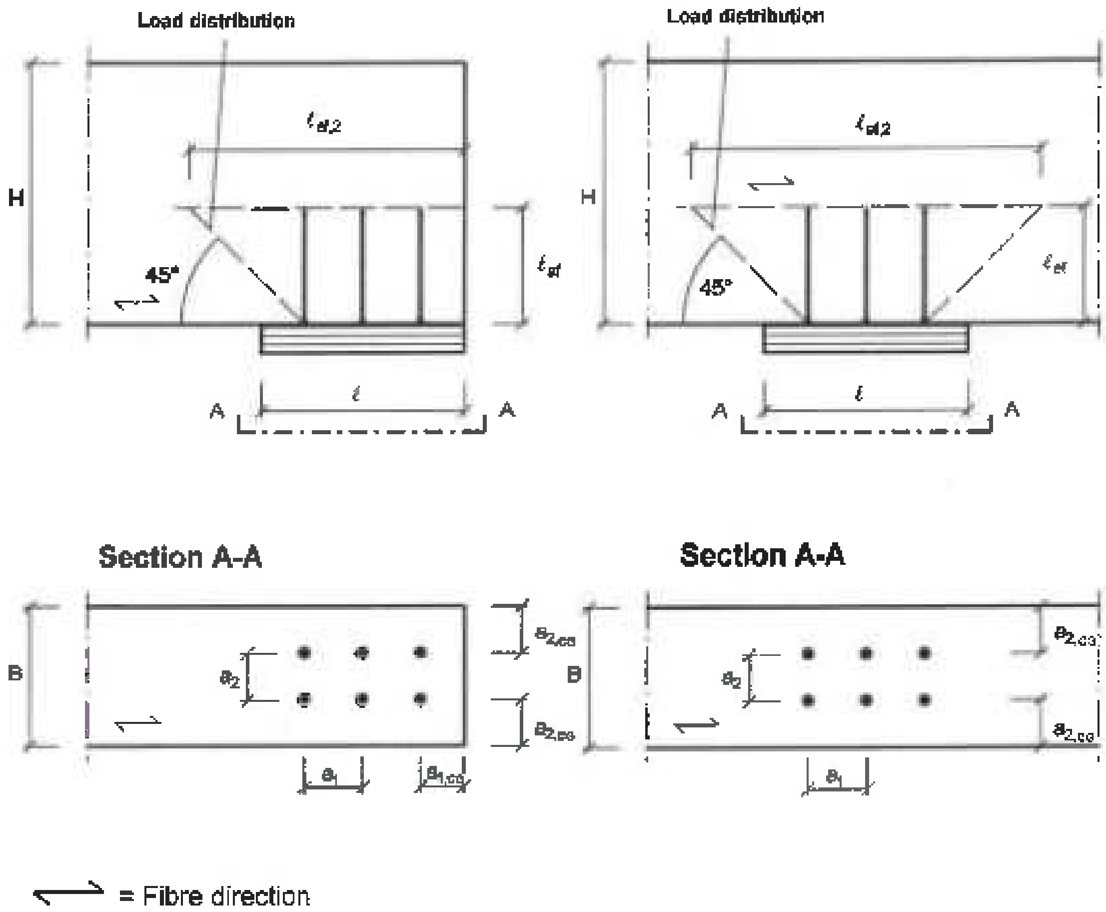

Figure A.3.1 Reinforced end support (left) and reinforced intermediate support (right)

KLIMAS screws	Annex 3
Compression reinforcement perpendicular to the grain	

ANNEX 4 Fastening of thermal insulation material on top of rafters

A.4.1 General

KLIMAS 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.

The thickness of the thermal insulation material may be up to 300 mm. The thermal insulation material shall be applicable as insulation on top of rafters according to national provisions that apply at the installation site.

The battens have to be from solid timber according to EN 338/ EN 14081-1. The minimum thickness t and the minimum width b of the battens are given in Table A.4.1:

Table A.4.1 Minimum thickness and minimum width of the battens

Outer thread diameter [mm]	Minimum thickness t [mm]	Minimum width b [mm]
6 and 8	30	50
10	40	60

The minimum width of the rafters is 60 mm.

The spacing between screws e_s shall be not more than 1.75 m.

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, respectively, shall be considered for design. Screws perpendicular to the grain of the rafter (angle $\alpha = 90$ °) may be arranged if necessary.

A.4.2 Parallel inclined screws and thermal insulation material in compression

A.4.2.1 Mechanical model

The system of rafter, thermal insulation material on top of rafter and counter battens parallel to the rafter may be considered as a beam on elastic foundation. The batten represents the beam, and the thermal insulation material on top of the rafter the elastic foundation. The minimum compression stress of the thermal insulation material at 10 % deformation, measured according to EN 826[13], shall be $\sigma_{(10\,\%)} = 0{,}05$ N/mm². The batten is loaded perpendicular to the axis by point loads F_b transferred by regularly spaced battens. Further point loads F_s are caused by the shear load of the roof due to dead and snow load, which are transferred from the screw heads into the counter battens.

[13] EN 826:2013 Thermal insulating products for building applications - Determination of compression behaviour

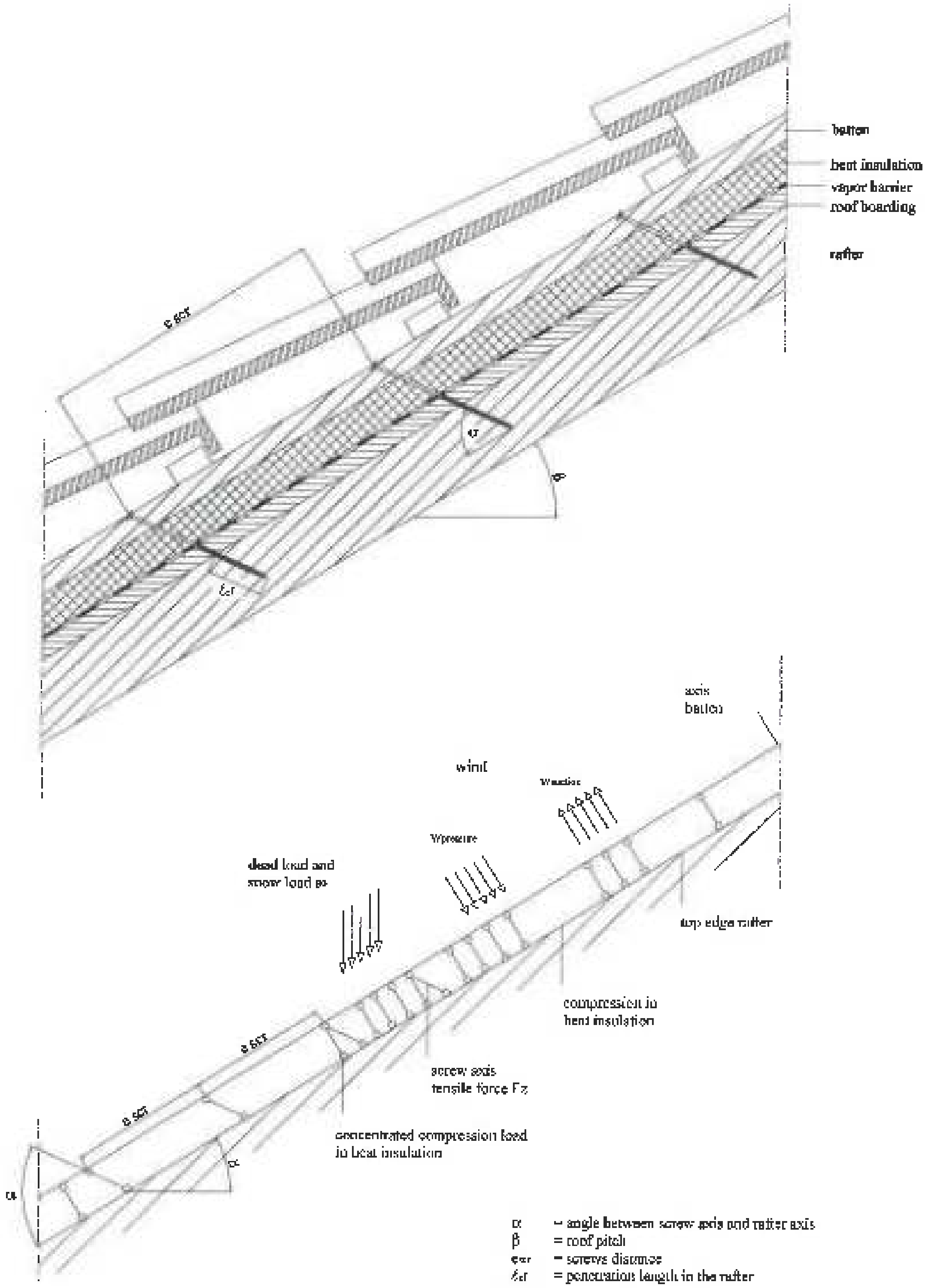

Figure A.4.1 Fastening of the thermal insulation material on top of rafters - structural system

KLIMAS screws	Annex 4
Fastening of thermal insulation material on top of rafters	

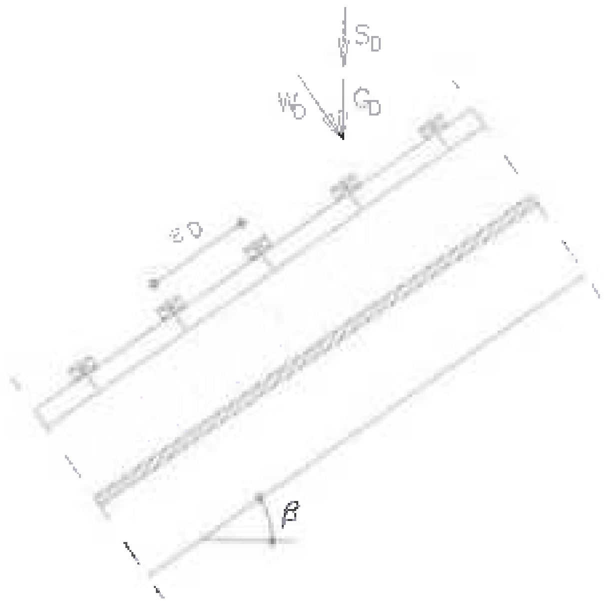

Figure A.4.2 Point loads F_b perpendicular to the battens

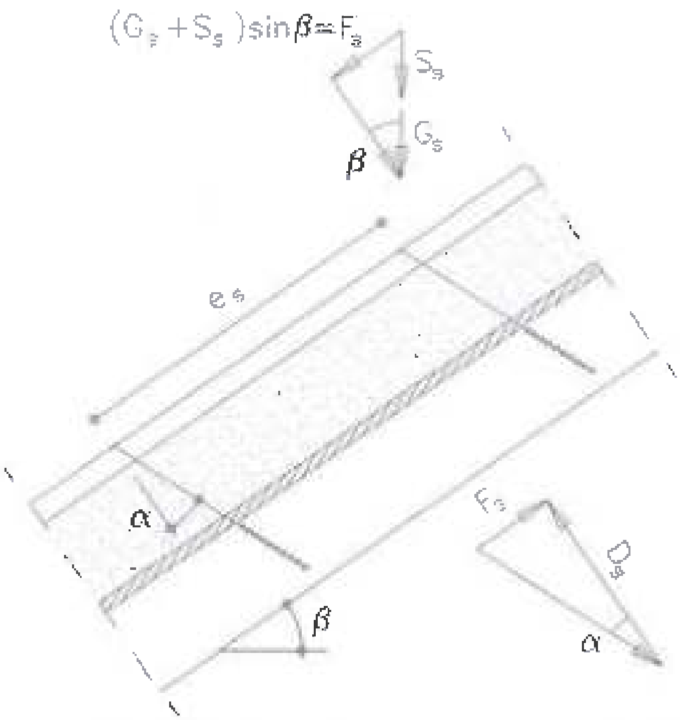

Figure A.4.3 Point loads F_s perpendicular to the battens, load application in the area of the screw heads

A.4.2.2 Design of the battens

It's assumed that the spacing between the counter battens exceeds the characteristic length l_{char}.

The characteristic values of the bending stresses are calculated as:

$$M_k = \frac{(F_b + F_s) \cdot l_{char}}{4} \quad (4.1)$$

where (4.2)

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

EI = bending stiffness of the batten

K = modulus of subgrade reaction

w_{ef} = effective width of the thermal insulation material

$F_{b,k}$ = point loads perpendicular to the battens

$F_{s,k}$ = point loads perpendicular to the battens, load application in the area of the screw heads

The modulus of subgrade reaction K may be calculated from the modulus of elasticity E_{HI} and the thickness t_{HI} of the thermal insulation material if the effective width w_{ef} of the thermal insulation material under compression is known. Due to the load extension in the thermal insulation material 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 material may be determined according to:

$$w_{ef} = w + t_{HI}/2 \quad (4.3)$$

where

w = minimum from width of the batten or rafter, respectively

t_{HI} = thickness of the thermal insulation material

$$K = \frac{E_{HI}}{t_{HI}} \quad (4.4)$$

The following condition shall be satisfied:

$$\frac{\sigma_{m,d}}{f_{m,d}} = \frac{M_d}{W \cdot f_{m,d}} \leq 1 \quad (4.5)$$

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

The characteristic values of the shear stresses shall be calculated according to:

$$V_k = \frac{(F_b + F_s)}{2} \quad (4.6)$$

The following condition need to be satisfied:

$$\frac{\tau_d}{f_{v,d}} = \frac{1.5 \cdot V_d}{A \cdot f_{v,d}} \leq 1 \quad (4.7)$$

For the calculation of the cross section area the net cross section shall be considered.

A.4.2.3 Design of the thermal insulation material

The characteristic value of the compressive stresses in the thermal insulation material shall be calculated according to:

$$\sigma_k = \frac{1.5 \cdot F_{b,k} + F_{S,k}}{2 \cdot l_{char} \cdot w} \tag{4.8}$$

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

A.4.2.4 Design of the screws

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

$$T_{S,k} = \frac{R_{S,k}}{\cos\alpha} \tag{4.9}$$

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 according to Annex 2.

In order to limit the deformation of the screw head for thermal insulation material with thickness over 220 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:

For screws with partial thread:

$$F_{ax,\alpha,Rd} = \min\left\{k_{ax} \cdot f_{ax,d} \cdot d \cdot l_{ef,r} \cdot k_1 \cdot k_2 \cdot \left(\frac{\rho_{r,k}}{350}\right)^{0.8}; f_{head,d} \cdot d_h^2 \cdot \left(\frac{\rho_{b,k}}{350}\right)^{0.8}; \frac{f_{tens,k}}{\gamma_{M2}}\right\} \tag{4.10}$$

For screws with full thread:

$$F_{ax,\alpha,Rd} = \min\left\{\begin{array}{l} k_{ax} \cdot f_{ax,d} \cdot d \cdot l_{ef,r} \cdot k_1 \cdot k_2 \cdot \left(\frac{\rho_{r,k}}{350}\right)^{0.8} \\ \max\left\{k_{ax} \cdot f_{ax,d} \cdot d \cdot l_{ef,b} \cdot k_1 \cdot k_2 \cdot \left(\frac{\rho_{b,k}}{350}\right)^{0.8}; f_{head,d} \cdot d_h^2 \cdot \left(\frac{\rho_{b,k}}{350}\right)^{0.8}\right\} \\ \frac{f_{tens,k}}{\gamma_{M2}} \end{array}\right\} \tag{4.11}$$

where:

k_{ax}	Factor, taking into account the angle α between screw axis and grain direction according to A.2.3.2
$f_{ax,d}$	design value of the axial withdrawal parameter of the threaded part of the screw [N/mm²]
d	outer thread diameter of the screw [mm]
$l_{ef,b}$	penetration length of the threaded part of the screw in the batten [mm]
$l_{ef,r}$	penetration length of the threaded part of the screw in the rafter [mm], $l_{ef} \geq 40$ mm
$\rho_{b,k}$	characteristic density of the batten [kg/m³], for LVL the assumed characteristic density shall not exceed 500 kg/m³

$\rho_{r,k}$	characteristic density of the rafter [kg/m³], for LVL the assumed characteristic density shall not exceed 500 kg/m³
α	angle α between screw axis and grain direction, $30° \leq \alpha \leq 90°$
$f_{head,d}$	design value of the head pull-through parameter of the screw [N/mm²]
d_h	head diameter [mm]
$f_{tens,k}$	characteristic tensile capacity of the screw according to Annex 2 [N]
γ_{M2}	partial factor according to EN 1993-1-1 in conjunction with the particular national annex
k_1	min {1; $220/t_{HI}$}
k_2	min {1; $\sigma_{10\%}/0.12$}
t_{HI}	thickness of the thermal insulation material [mm]
$\sigma_{10\%}$	compressive stress of the thermal insulation material under 10 % deformation [N/mm²]

If equation (4.10) or (4.11) is fulfilled, the deflection of the battens does not need to be considered when designing the load-carrying capacity of the screws.

A.4.3 Alternatively inclined screws and thermal insulation material non in compression

A.4.3.1 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_{II}.
- 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 ℓ = A + B. 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 characteristic values of the screw's normal forces are determined based on the loads parallel and perpendicular to the roof plane:

Compressive screw: $$N_{c,k} = (A+B) \cdot \left(-\frac{q_{II,k}}{\cos\alpha_1 + \sin\alpha_1 / \tan\alpha_2} - \frac{q_{\perp,k} \cdot \sin(90° - \alpha_2)}{\sin(\alpha_1 + \alpha_2)} \right) \quad (4.12)$$

Tensile screw: $$N_{t,k} = (A+B) \cdot \left(\frac{q_{II,k}}{\cos\alpha_2 + \sin\alpha_2 / \tan\alpha_1} - \frac{q_{\perp,k} \cdot \sin(90° - \alpha_1)}{\sin(\alpha_1 + \alpha_2)} \right) \quad (4.13)$$

A, B distances of the screws according to Figure A.4.5

$q_{II,k}$ characteristic value of the loads parallel to the roof plane

$q_{\perp,k}$ characteristic value of the loads perpendicular to the roof plane

α Angle a_1 and a_2 between screw axis and grain direction, $30° \le \alpha_1 \le 90°$, $30° \le \alpha_2 \le 90°$

Only screws with full thread shall be used.

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 characteristic value of the load component perpendicular to the batten from the tensile screw is:

$$F_{ZS,k} = (A+B) \cdot \left(\frac{q_{II,k}}{1/\tan\alpha_1 + 1/\tan\alpha_2} - \frac{q_{\perp,k} \cdot \sin(90° - \alpha_1) \cdot \sin\alpha_2}{\sin(\alpha_1 + \alpha_2)} \right) \quad (4.14)$$

A positive value for $F_{ZS,k}$ means a load towards the rafter, a negative value a load away from the rafter. The system of the continuous beam is shown in Figure A.4.5.

The battens fixed on the rafter shall be supported perpendicular to the load-bearing plane.

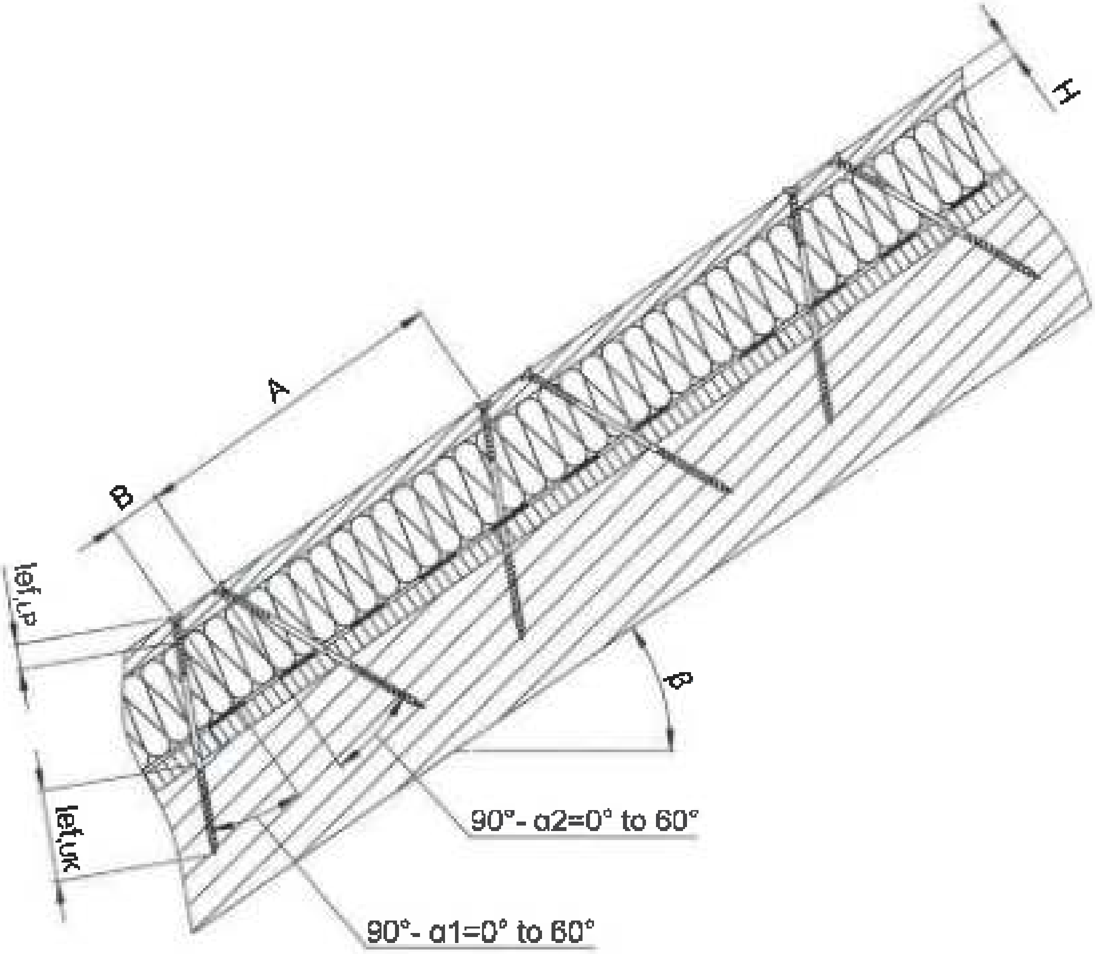

Figure A.4.4 Fastening of thermal insulation material on top of rafters - structural system for alternatively inclined screws

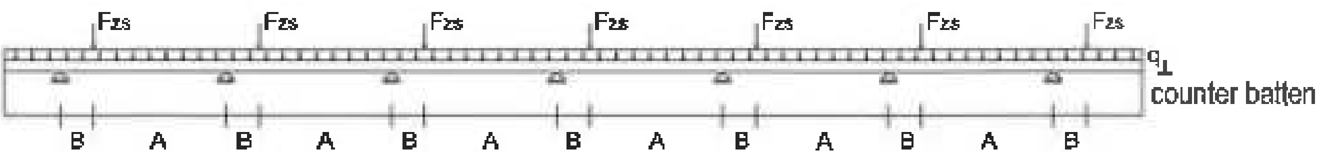

Figure A.4.5 Continuous batten under constant line loads from actions on the roof plane $q_{\perp}$ and concentrated loads from tensile screws F_{ZS}

A.4.3.2 Design of the screws

The design value of the load-carrying capacity of the screws shall be calculated according to equation (4.15) and (4.16).

Screws loaded in tension:

$$F_{ax,\alpha,Rd} = \min\left\{k_{ax} \cdot f_{ax,d} \cdot d \cdot l_{ef,b} \cdot \left(\frac{\rho_{b,k}}{350}\right)^{0.8}; k_{ax} \cdot f_{ax,d} \cdot d \cdot l_{ef,r} \cdot \left(\frac{\rho_{r,k}}{350}\right)^{0.8}; \frac{f_{tens,k}}{\gamma_{M2}}\right\} \tag{4.15}$$

Screws loaded in compression:

$$F_{ax,\alpha,Rd} = \min\left\{k_{ax} \cdot f_{ax,d} \cdot d \cdot l_{ef,b} \cdot \left(\frac{\rho_{b,k}}{350}\right)^{0.8}; k_{ax} \cdot f_{ax,d} \cdot d \cdot l_{ef,r} \cdot \left(\frac{\rho_{r,k}}{350}\right)^{0.8}; \frac{\kappa_c \cdot N_{pl,k}}{\gamma_{M1}}\right\} \tag{4.16}$$

where:

k_{ax}	Factor according to Annex A.2.3.2, taking into account the angle α between screw axis and grain direction
$f_{ax,d}$	design value of the axial withdrawal parameter of the threaded part of the screw [N/mm²]
d	outer thread diameter of the screw [mm]
$l_{ef,b}$	penetration length of the threaded part of the screw in the batten [mm]
$l_{ef,r}$	penetration length of the threaded part of the screw in the rafter, $l_{ef} \geq 40$ mm
$\rho_{b,k}$	characteristic density of the batten [kg/m³], for LVL the assumed characteristic density shall not exceed 500 kg/m³
$\rho_{r,k}$	characteristic density of the rafter [kg/m³], for LVL the assumed characteristic density shall not exceed 500 kg/m³
α	angle α_1 or α_2 between screw axis and grain direction, $30° \leq \alpha_1 \leq 90°$, $30° \leq \alpha_2 \leq 90°$
$f_{tens,k}$	characteristic tensile capacity of the screw according to Annex 2 [N]
γ_{M1}, γ_{M2}	partial factor according to EN 1993-1-1 in conjunction with the particular national Annex
$\kappa_c \cdot N_{pl,k}$	Buckling capacity of the screw according to table A.4.2 [N]

Table A.4.2 Characteristic buckling capacity of WKFS and WKFC screws $\kappa_c \cdot N_{pl,k}$ in N

Free screw length l between batten and rafter [mm]	Outer thread diameter d [mm]	
	8.0	10.0
	$\kappa_c \cdot N_{pl,k}$ [N]	
≤ 100	4680	8720
120	3580	6760
140	2820	5360
160	2280	4350
180	1880	3600
200	1570	3030
220	1330	-
240	1150	-
260	1000	-
280	870	-
300	770	-
320	690	-

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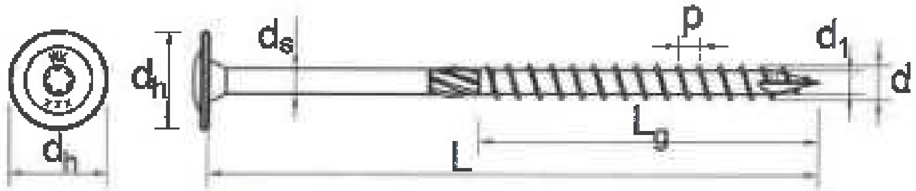
WKCP

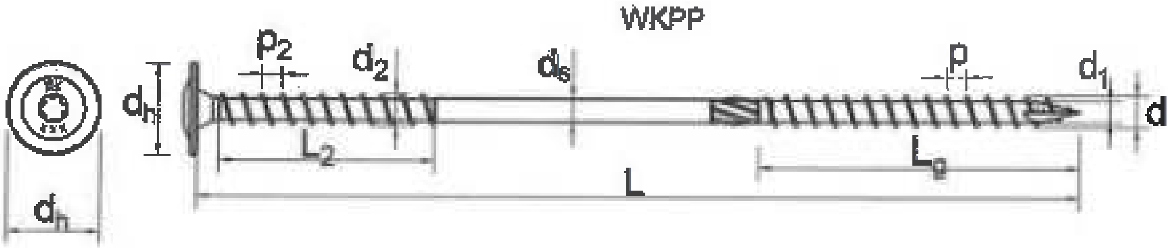


d [mm]	$6,0^{\pm 0,3}$	$6,0^{\pm 0,3}$	$8,0^{\pm 0,4}$	$10,0^{\pm 0,5}$
d_h [mm]	$14,00^{\pm 0,7}$	$14,00^{\pm 0,7}$	$20,00^{\pm 1,0}$	$25,00^{\pm 1,25}$
d_s [mm]	$4,30^{\pm 0,3}$	$4,30^{\pm 0,3}$	$5,80^{\pm 0,3}$	$7,00^{\pm 0,35}$
d_1 [mm]	$3,90^{\pm 0,3}$	$3,90^{\pm 0,3}$	$5,40^{\pm 0,3}$	$6,40^{\pm 0,32}$
p [mm]	$3,1^{\pm 0,31}$	$4,50^{\pm 0,45}$	$5,20^{\pm 0,52}$	$6,00^{\pm 0,60}$

d=6,0		d=8,0		d=10,0	
L [mm]	L_g [mm]	L [mm]	L_g [mm]	L [mm]	L_g [mm]
50	30	80	50	100	50
60	35	90	50	120	60/80
70	40	100	50	140	60/80
80	50	120	60/80	160	80
90	50	140	60/80	180	80
100	50/60	160	80	200	80
110	60/70	180	80	220	80
120	60/70	200	80	240	80
130	60/70	220	80	260	80
140	70/75	240	80	280	80
160	70/75	260	80	300	80
180	70/75	280	80	320	80
200	70/75	300	80	340	80
220	70/75	320	80	360	80
240	70/75	340	80	380	80
260	70/75	360	80	400	80
280	70/75	380	80		
300	70/75	400	80		

KLIMAS screws	Annex 5.1
WKCP screws d = 6 mm with p = 3.1 mm, d = 6 mm with p = 4.5 mm, d = 8 mm and d = 10 mm	

WKPP



d [mm]	$6,0^{\pm0,3}$	$6,0^{\pm0,3}$	$8,0^{\pm0,4}$	$10,0^{\pm0,5}$
d_h [mm]	$14,00^{\pm0,7}$	$14,00^{\pm0,7}$	$20,00^{\pm1,0}$	$25,00^{\pm1,25}$
d_s [mm]	$4,30^{\pm0,3}$	$4,30^{\pm0,3}$	$5,80^{\pm0,3}$	$7,00^{\pm0,35}$
d_1 [mm]	$3,90^{\pm0,3}$	$3,90^{\pm0,3}$	$5,40^{\pm0,3}$	$6,40^{\pm0,32}$
d_2 [mm]	$6,0^{\pm0,3}$	$6,0^{\pm0,3}$	$8,0^{\pm0,4}$	$10,0^{\pm0,5}$
p [mm]	$3,1^{\pm0,31}$	$4,50^{\pm0,45}$	$5,20^{\pm0,52}$	$6,00^{\pm0,60}$
p_2 [mm]	$3,1^{\pm0,31}$	$4,50^{\pm0,45}$	$5,20^{\pm0,52}$	$6,00^{\pm0,60}$
L_2 [mm]	$40^{\pm2,0}$	$40^{\pm2,0}$	$60^{\pm2,3}$	$60^{\pm2,3}$

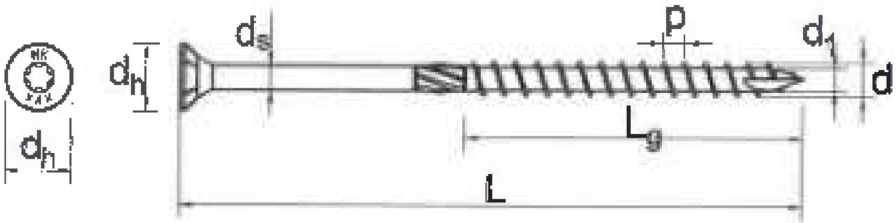
d=6,0		d=8,0		d=10,0	
L [mm]	L_g [mm]	L [mm]	L_g [mm]	L [mm]	L_g [mm]
130	60	140	60/80	140	60/80
140	70/75	160	80	160	80
160	70/75	180	80	180	80
180	70/75	200	80	200	80
200	70/75	220	80	220	80
220	70/75	240	80	240	80
240	70/75	260	80	260	80
260	70/75	280	80	280	80
280	70/75	300	80	300	80
300	70/75	320	80	320	80
		340	80	340	80
		360	80	360	80
		380	80	380	80
		400	80	400	80

KLIMAS screws

WKPP screws
d = 6 mm with p = 3.1 mm, d = 6 mm with p = 4.5 mm, d = 8 mm and d = 10 mm

Annex 5.2

WKCS



d [mm]	$6,0^{\pm 0,3}$	$6,0^{\pm 0,3}$	$8,0^{\pm 0,4}$	$10,0^{\pm 0,5}$
d_h [mm]	$12,0^{\pm 0,6}$	$12,0^{\pm 0,6}$	$14,50^{\pm 0,725}$	$18,00^{\pm 0,9}$
d_s [mm]	$4,30^{\pm 0,3}$	$4,30^{\pm 0,3}$	$5,80^{\pm 0,3}$	$7,00^{\pm 0,35}$
d_1 [mm]	$3,90^{\pm 0,3}$	$3,90^{\pm 0,3}$	$5,40^{\pm 0,3}$	$6,40^{\pm 0,32}$
p [mm]	$3,1^{\pm 0,31}$	$4,50^{\pm 0,45}$	$5,20^{\pm 0,62}$	$6,00^{\pm 0,60}$

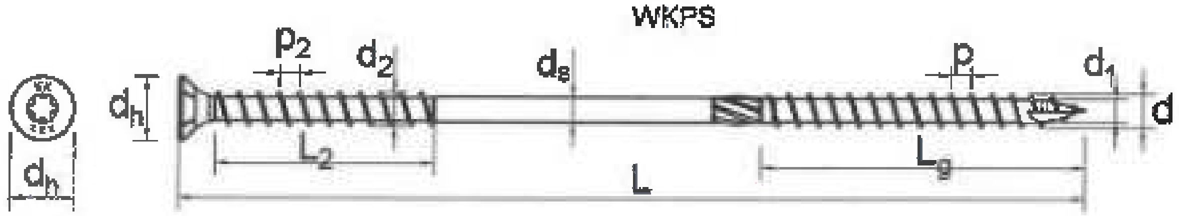
d=6,0		d=8,0		d=10,0	
L [mm]	L_g [mm]	L [mm]	L_g [mm]	L [mm]	L_g [mm]
50	30	80	50	100	50
60	35	90	50	120	60/80
70	40	100	50	140	60/80
80	50	120	60/80	160	80
90	50	140	60/80	180	80
100	50/60	160	80	200	80
110	60/70	180	80	220	80
120	60/70	200	80	240	80
130	60/70	220	80	260	80
140	70/75	240	80	280	80
160	70/75	260	80	300	80
180	70/75	280	80	320	80
200	70/75	300	80	340	80
220	70/75	320	80	360	80
240	70/75	340	80	380	80
260	70/75	360	80	400	80
280	70/75	380	80		
300	70/75	400	80		

KLIMAS screws

WKCS screws
d = 6 mm with p = 3.1 mm, d = 6 mm with p = 4.5 mm, d = 8 mm and d = 10 mm

Annex 5.3

WKPS



d [mm]	$6,0^{\pm0,3}$	$6,0^{\pm0,3}$	$8,0^{\pm0,4}$	$10,0^{\pm0,5}$
d_h [mm]	$12,0^{\pm0,6}$	$12,0^{\pm0,6}$	$14,50^{\pm0,725}$	$18,00^{\pm0,9}$
d_s [mm]	$4,30^{\pm0,3}$	$4,30^{\pm0,3}$	$5,80^{\pm0,3}$	$7,00^{\pm0,35}$
d_1 [mm]	$3,90^{\pm0,3}$	$3,90^{\pm0,3}$	$5,40^{\pm0,3}$	$6,40^{\pm0,32}$
d_2 [mm]	$6,0^{\pm0,3}$	$6,0^{\pm0,3}$	$8,0^{\pm0,4}$	$10,0^{\pm0,5}$
p [mm]	$3,1^{\pm0,31}$	$4,50^{\pm0,45}$	$5,20^{\pm0,52}$	$6,00^{\pm0,60}$
p_2 [mm]	$3,1^{\pm0,31}$	$4,50^{\pm0,45}$	$5,20^{\pm0,52}$	$6,00^{\pm0,60}$
L_2 [mm]	$40^{\pm2,0}$	$40^{\pm2,0}$	$60^{\pm2,3}$	$60^{\pm2,3}$

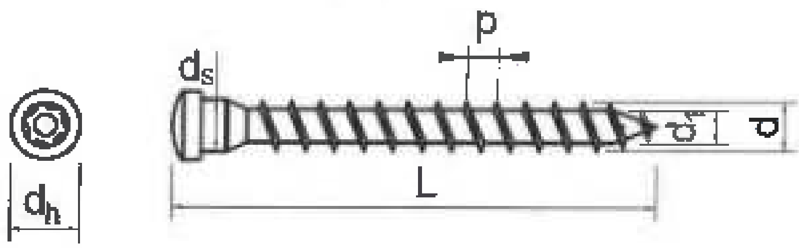
d=6,0		d=8,0		d=10,0	
L [mm]	L_g [mm]	L [mm]	L_g [mm]	L [mm]	L_g [mm]
130	60	140	60/80	140	60/80
140	70/75	160	80	160	80
160	70/75	180	80	180	80
180	70/75	200	80	200	80
200	70/75	220	80	220	80
220	70/75	240	80	240	80
240	70/75	260	80	260	80
260	70/75	280	80	280	80
280	70/75	300	80	300	80
300	70/75	320	80	320	80
		340	80	340	80
		360	80	360	80
		380	80	380	80
		400	80	400	80

KLIMAS screws

WKPS screws
d = 6 mm with p = 3.1 mm, d = 6 mm with p = 4.5 mm, d = 8 mm and d = 10 mm

Annex 5.4

WKLC



d [mm]	**$5,0^{\pm 0,3}$**
d_h [mm]	**$7,40^{\pm 0,5}$**
d_s [mm]	**$4,80^{\pm 0,3}$**
d_1 [mm]	**$3,30^{\pm 0,3}$**
p [mm]	**$2,20^{\pm 0,22}$**

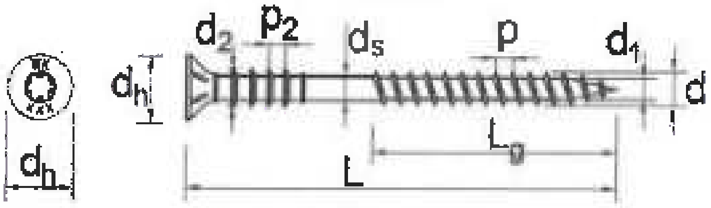
d=5,0	
L [mm]	**L_g [mm]**
30	20
35	25
40	30
50	40
60	40

KLIMAS screws

WKLC screws

Annex 5.5

WKSS

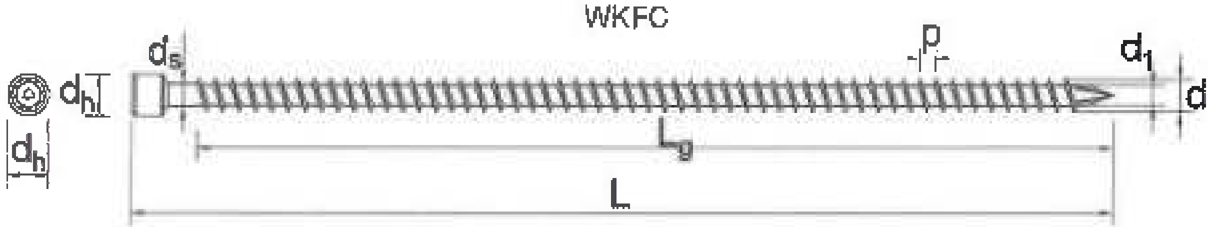


d [mm]	$6{,}0^{\pm 0{,}3}$
d_h [mm]	$10{,}00^{\pm 0{,}8}$
d_s [mm]	$4{,}30^{\pm 0{,}3}$
d_1 [mm]	$3{,}90^{\pm 0{,}3}$
p [mm]	$3{,}1^{\pm 0{,}31}$
d_2 [mm]	$6{,}70^{\pm 0{,}335}$
p_2 [mm]	$4{,}00^{\pm 0{,}4}$

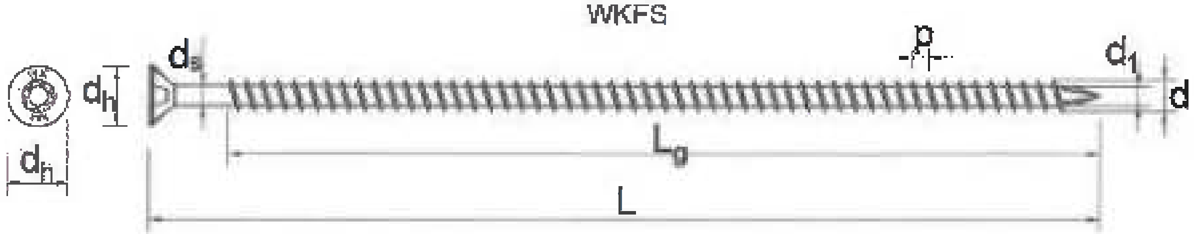
d=6,0	
L [mm]	L_g [mm]
50	30
60	35
70	40
80	50
90	50
100	50/60
110	60/70
120	60/70
130	60/70
140	70/75
160	70/75
180	70/75
200	70/75
220	70/75
240	70/75
260	70/75
280	70/75
300	70/75

KLIMAS screws	Annex 5.6
WKSS screws	

WKFC



WKFS

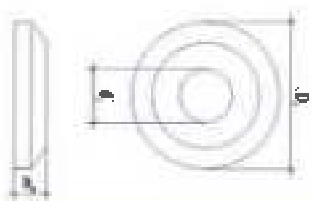


d [mm]	$8{,}0^{\pm 0{,}4}$	$10{,}0^{\pm 0{,}4}$
d_h [mm] WKFC	$10{,}00^{\pm 0{,}6}$	$13{,}00^{\pm 0{,}65}$
d_h [mm] WKFS	$14{,}00^{\pm 0{,}7}$	$18{,}00^{\pm 0{,}9}$
d_s [mm]	$5{,}80^{\pm 0{,}3}$	$7{,}00^{\pm 0{,}35}$
d_1 [mm]	$5{,}0^{\pm 0{,}3}$	$6{,}2^{\pm 0{,}31}$
p [mm]	$4{,}0^{\pm 0{,}4}$	$4{,}60^{\pm 0{,}46}$

d=8,0		d=10,0	
L [mm]	L_g [mm]	L [mm]	L_g [mm]
80-400	l-15	100-300	l-15

Tolerances of dimesion L, L_g [mm]									
Above	10	18	30	50	80	120	180	250	315
Up to end including	18	30	50	80	120	180	250	315	400
Tolerances	±1,5	±1,7	±2,0	±2,3	±2,7	±3,2	±3,6	±4,1	±4,5

PWKCS 6/8/10



Nom.	Ø6,0	Ø8,0	Ø10,0
d_p [mm]	$7{,}5^{\pm 0{,}6}$	$8{,}5^{\pm 0{,}8}$	$11{,}0^{\pm 0{,}6}$
D_p [mm]	$20{,}0^{\pm 1{,}0}$	$25{,}0^{\pm 1{,}26}$	$32{,}0^{\pm 1{,}6}$
h_p [mm]	$4{,}0^{\pm 0{,}3}$	$5{,}0^{\pm 0{,}3}$	$6{,}0^{\pm 0{,}3}$

KLIMAS screws

WKFC screws, WKFS screws and PWKCS washers

Annex 5.7