Deutsches Institut für Bautechnik DIBt

Approval body for construction products and types of construction

Bautechnisches Prüfamt

An institution established by the Federal and Laender Governments

European Technical Assessment

ETA-19/0594 of 2 December 2019

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	HASO-Screws
Product family to which the construction product belongs	Screws for use in timber contructions
Manufacturer	Josef Hansen GmbH & Co. KG Dellenfeld 4 42653 Solingen DEUTSCHLAND
Manufacturing plant	C1230, M1222, D1030, W1239, O1209, V1430, E1702, F1703, J0205, P1901, P1902, P1903, P1904
This European Technical Assessment contains	33 pages including 6 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 130118-01-0603

The European Technical Assessment is issued by the Technical Assessment Body in its official language. Translations of this European Technical Assessment in other languages shall fully correspond to the original issued document and shall be identified as such.

Communication of this European Technical Assessment, including transmission by electronic means, shall be in full. However, partial reproduction may only be made with the written consent of the issuing Technical Assessment Body. Any partial reproduction shall be identified as such.

This European Technical Assessment may be withdrawn by the issuing Technical Assessment Body, in particular pursuant to information by the Commission in accordance with Article 25(3) of Regulation (EU) No 305/2011.

Specific Part

1 Technical description of the product

HASO screws are screws made from special carbon. They are hardened. They have a corrosion protection according to Annex A.2.5. The outer thread diameter is not less than 3.0 mm and not greater than 12.0 mm. The overall length of the screws is ranging from 16 mm to 500 mm. Further dimensions are shown in Annex 3. The washers are made from carbon steel. The dimensions of the washers are given in Annex 3.

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 HASO screws are used in compliance with the specifications and conditions given in Annex 1.

Durability is only ensured if the specifications of intended use according to Annex 1 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 HASO 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 3
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
Durability against corrosion	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. 130118-01-0603, 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 2 December 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 HASO 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 of softwood according to EN 14374[3], arrangement of the screws only perpendicular to the plane of the veneers,
– Glued solid timber (softwood) according to EN 14080 or national provisions that apply at the installation site,
– Cross-laminated timber according to European Technical Assessments or national provisions that apply at the installation site.

Additionally the screws are used for connections in

– Oriented Strand Boards, OSB/3 or OSB/4 according to EN 300[4] and EN 13986[5] with a minimum thickness of 18 mm.

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

– Plywood according to EN 636[6] and EN 13986 with t_{min} = 6 mm,
– Oriented Strand Board, OSB according to EN 300[7] and EN 13986 with t_{min} = 8 mm,
– Particleboard according to EN 312[8] and EN 13986 with t_{min} = 8 mm,
– Fibreboards according to EN 622-2[9], EN 622-3[10] and EN 13986 with t_{min} = 6 mm,
– Cement-bonded particle boards according to EN 634-2[11] and EN 13986 with t_{min} = 8 mm,
– Solid-wood panels according to EN 13353[12] and EN 13986 with t_{min} = 12 mm.

Wood-based panels are only arranged on the side of the screw head, except OSB/3 and OSB/4 panels with a minimum thickness of 18 mm.

HASO screws with an outer thread diameter of at least 6 mm can be used for the fixing of thermal insulation material on top of rafters or on wood-based members in vertical façades.

HBS screws with d = 8 mm and a full thread can 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 300:2006 Oriented strand boards (OSB) – Definition, classification and specifications
[5] EN 13986:2004+A1:2015 Wood-based panels for use in construction - Characteristics, evaluation of conformity and marking
[6] EN 636:2012+A1:2015 Plywood - Specifications
[7] EN 300:2006 Oriented strand boards (OSB) – Definition, classification and specifications
[8] EN 312:2010 Particleboards - Specifications
[9] EN 622-2:2004 Fibreboards – Specifications – Part 2: Requirements for hardboards
[10] EN 622-3:2004 Fibreboards - Specifications - Part 3: Requirements for medium boards
[11] EN 634-2:2007 Cement-bonded particleboards – Specifications – Part 2: Requirements for OPC bonded particleboards for use in dry, humid and external conditions
[12] EN 13353:2011 Solid wood panels (SWP) – Requirements

A.1.3 Use Conditions (environmental conditions)

The corrosion protection of the HASO screws is specified in Annex A.2.5.

A.1.4 Installation provisions

EN 1995-1-1[13] in conjunction with the respective national annex applies for the installation.

The screws are either 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.

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

The minimum penetration length of the threaded part of the screw in the wood-based members l_{ef} shall be

$$l_{ef} \geq \frac{4 \cdot d}{\sin \alpha} \qquad \text{(A.1)}$$

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 is at least 6 mm. Only screws with an inner thread diameter d_1 that is greater than the maximal width of the gaps in the layer are screwed in cross laminated timber.

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

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

In the case of fastening battens on thermal insulation material on top of rafters the screws are 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 3. After inserting the screw the washers touch the surface of the wood-based member completely. Screws made from carbon steel are used with washers made from carbon steel and screws made from stainless steel shall be used with washers made from stainless steel.

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 covered by this ETA. For pan head, half-round head, head with washer face and hexagonal head the head part remains unconsidered.

[13] EN 1995-1-1: 2004+AC:2006+A1:2008+A2:2014 Eurocode 5: Design of timber structures – Part 1-1: General - Common rules and rules for buildings

ANNEX 2 - Characteristic values of the load-carrying capacities

Table A.2.1 Characteristic load-carrying capacities of HASO screws

Outer thread diameter [mm]			**3.0**	**3.5**	**4.0**	**4.5**	**5.0**	**5.5**	**6.0**	**7.0**	**8.0**	**10.0**	**12.0**
Characteristic yield moment $M_{y,k}$ [Nm]	Carbon steel		1.6	2.3	3.3	4.5	5.9	7.6	9.5	17.0	20.0	30.0	60.0
	Stainless steel		0.9	1.4	1.9	2.6	3.4	4.4	5.5	-	12.0	21.0	-
Characteristic tensile strength $f_{tens,k}$ [kN]	Carbon steel	Other screws	2.8	3.8	5.0	6.4	7.9	9.5	11.3	18.0	15.1	23.6	40.0
		HBS Full thread									20.1		
	Stainless steel		1.8	2.4	3.1	4.0	4.9	5.9	7.1	-	12.6	19.6	-
Characteristic torsional moment $f_{tor,k}$ [Nm]	Carbon steel	Other screws	1.6	2.0	3.5	5.0	6.0	9.0	12.0	18.0	22.0	36.0	68.0
		HBS Full thread									30.0		
	Stainless steel		1.0	1.4	2.2	3.0	4.0	6.0	8.0	-	18.0	34.0	-
Bending angle α			$\geq 45/d^{0.7} + 20$										
Ratio of characteristic torsional strength and mean insertion moment $f_{tor,k}/R_{tor,mean}$			≥ 1.5										
Characteristic value of the withdrawal parameter $f_{ax,90,k}$ [N/mm²] for													
Timber products according to clause A.1.2 with ρ_a = 350 kg/m³			12.5								11.0		
OSB/3 and OSB/4 plates with ρk = 600 kg/m³			-		10.0					-			
Characteristic value of the head pull-through parameter $f_{head,k}$ [N/mm²] for													
Timber products according to clause A.1.2 with ρ_a = 350 kg/m³			9.4										
Wood based panels according to clause A.1.2 with t > 20 mm and with ρ_a = 350 kg/m³			9.4										
Wood based panels according to clause A.1.2 with 12 mm ≤ t ≤ 20 mm and with ρ_a = 350 kg/m³			8.0										
Wood based panels according to clause A.1.2 with t_{min} ≤ t < 12 mm considering $t_{min} \geq 1.2 \cdot d$ and with ρ_a = 350 kg/m³			8.0[14]										

[14] Where the head pull-through capacity is limited to 400 N.

A.2.2 Slip modulus for mainly axially loaded screws

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

$$K_{ser} = 780 \cdot d^{0,2} \cdot l_{ef}^{0,4} \quad [N/mm] \qquad (A.2.1)$$

Where

d outer thread diameter of the screw [mm]

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

A.2.3 Characteristiv value of the yield stength

The characteristic yield strength is $f_{y,k}$ = 1000 N/mm² for fully threaded HASO screws with d = 8 mm.

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 HASO 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 members made from solid timber, glued laminated timber, glued solid timber, laminated veneer lumber and cross laminated timber is t = 30 mm for screws with d ≤ 8 mm, t = 40 mm for screws with d = 10 mm and t = 80 mm for screws with d = 12 mm.

Screws in non pre-drilled holes

For HASO screws minimum spacing and distances as well as the minimum member thickness are given in EN 1995-1-1, clause 8.3.1.2 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 are increased by 50%.

Minimum distances from loaded or unloaded ends are at least 15·d for screws with outer thread diameter d > 8 mm and timber thickness t < 5·d.

Minimum distances from the unloaded edge perpendicular to the grain can 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.

A.2.4.2 Only axially loaded screws

For HASO screws with d = 8 mm and a full thread loaded only axially, the minimum spacings, end and edge distances according to Table A.2.2 apply alternatively to paragraph A.2.4.1 for solid timber, glued laminated timber and similar glued products made from softwood.

Table A.2.2 Minimum Spacing, end and edge distances of the HASO screws and minimum thickness and width of the timber

Outer thread diameter d [mm]	**8**
Minimum spacing a_1 in a plane parallel to grain	5 d
Minimum spacing a_2 perpendicular to a plane parallel to grain	2.5 d
Minimum end distance of the centre of gravity of the threaded part in the timber member $a_{1,c}$	10 d
Minimum edge distance of the centre of gravity of the threaded part in the timber member $a_{2,c}$	4 d
Minimum product of spacing a_1 and a_2	$a_1 \cdot a_2 = 25\ d^2$
Crossed screw couples - Minimum spacing between the crossing screws[15]	$1.5 \cdot d$
Minimum timber thickness	10 d
Minimum timber width	$\max \begin{cases} 8 \cdot d \\ 60\ mm \end{cases}$

Are the spacing, end and edge distances less than the distances and thicknesses given in EN 1995-1-1 the verification of resistance according to EN 1995-1-1, clause 8.7.2 (1) the failure along the circumference of a group of screws has to be considered also for connections without steel plates.

15 Appropriate means have to ensure that the crossed screw threads do not touch each other when being inserted in the timber member.

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

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

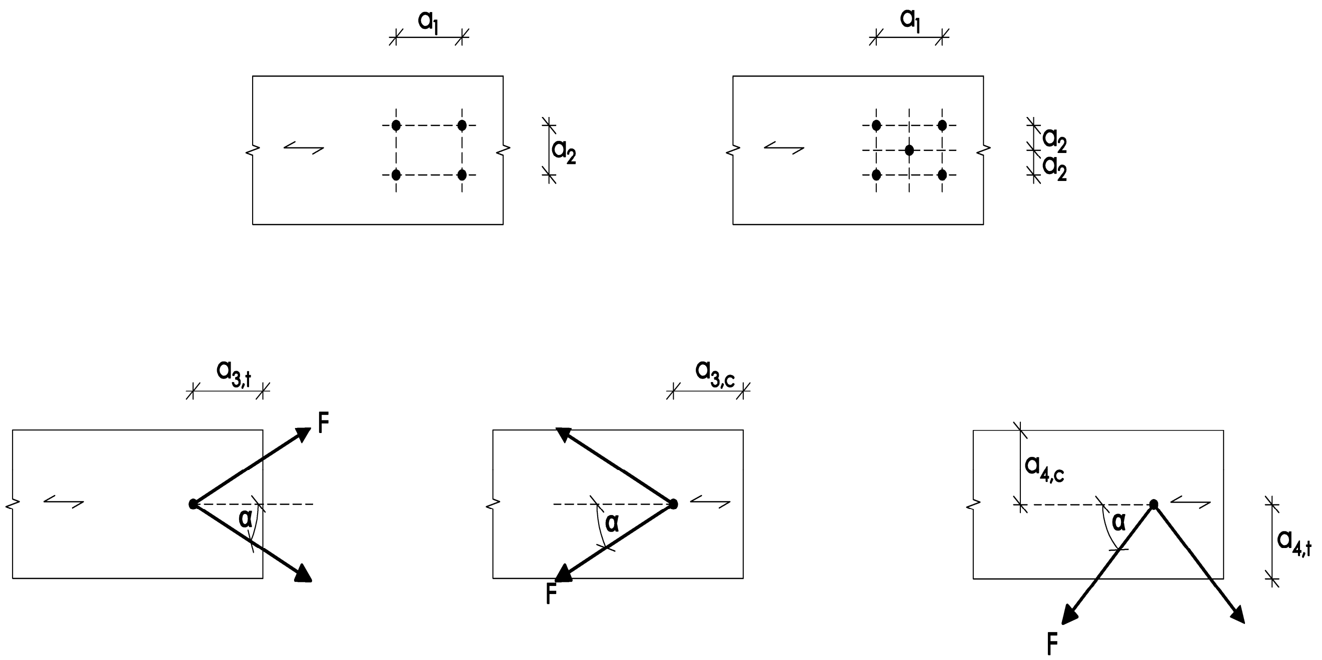


Figure A.2.1: Definition of spacing, end and edge distances in the plane surface

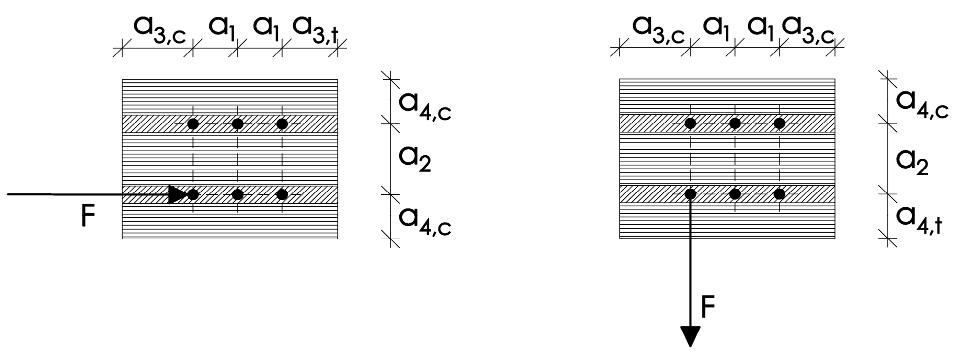
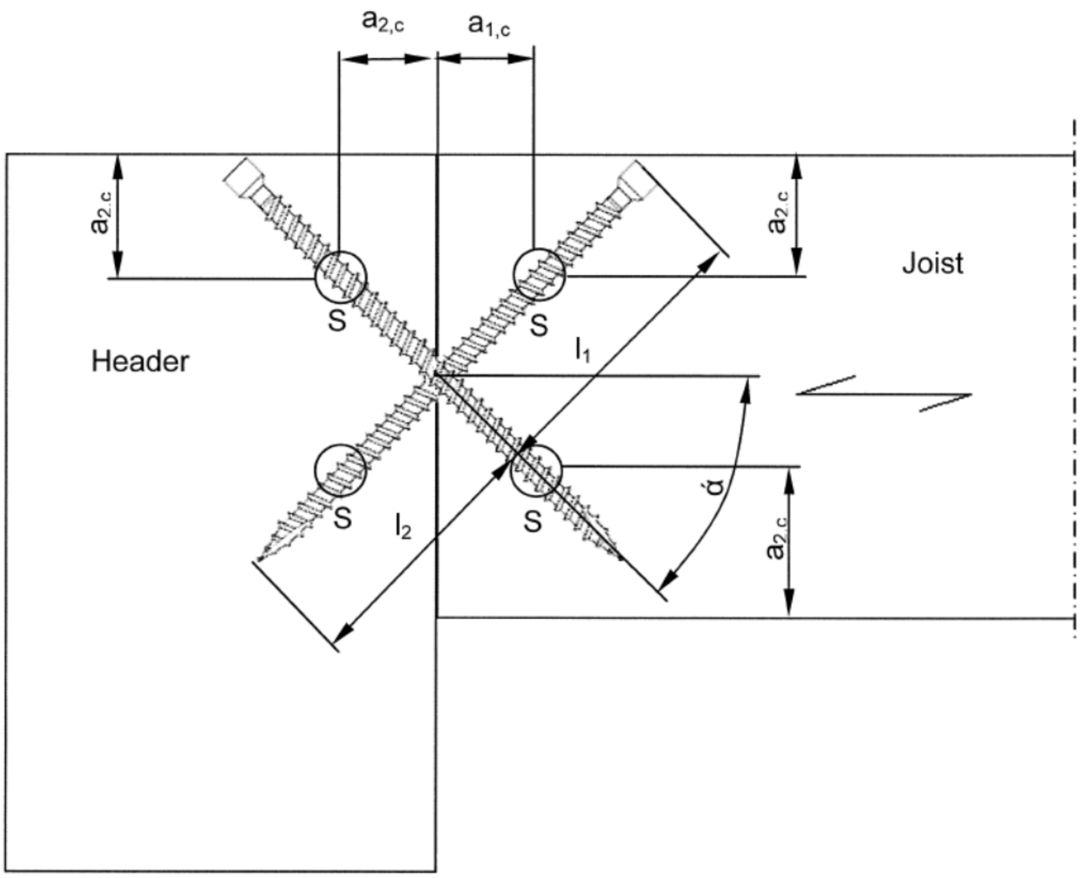


Figure A.2.2: Definition of spacing, end and edge distances in the edge surface

HASO screws	Annex 2.4
Spacing, end and edge distances	

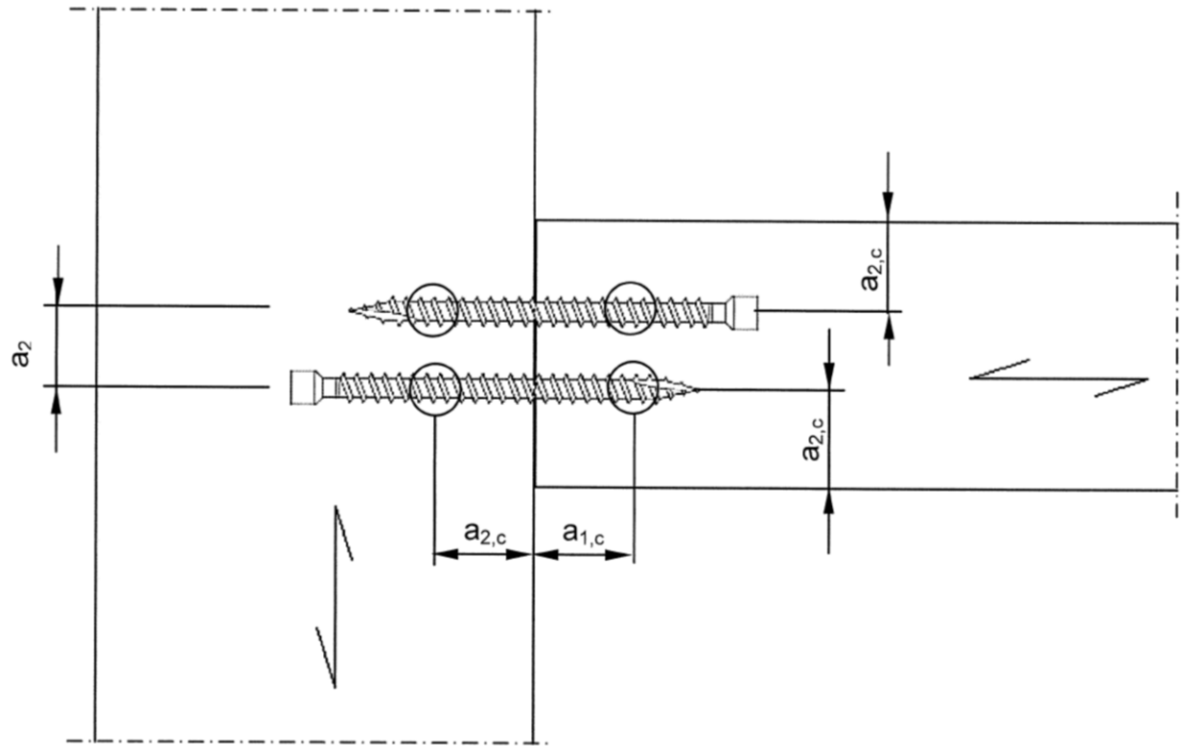
Examples of spacings and distances for HASO screws with d = 8 mm and a full thread

Header-joist connection



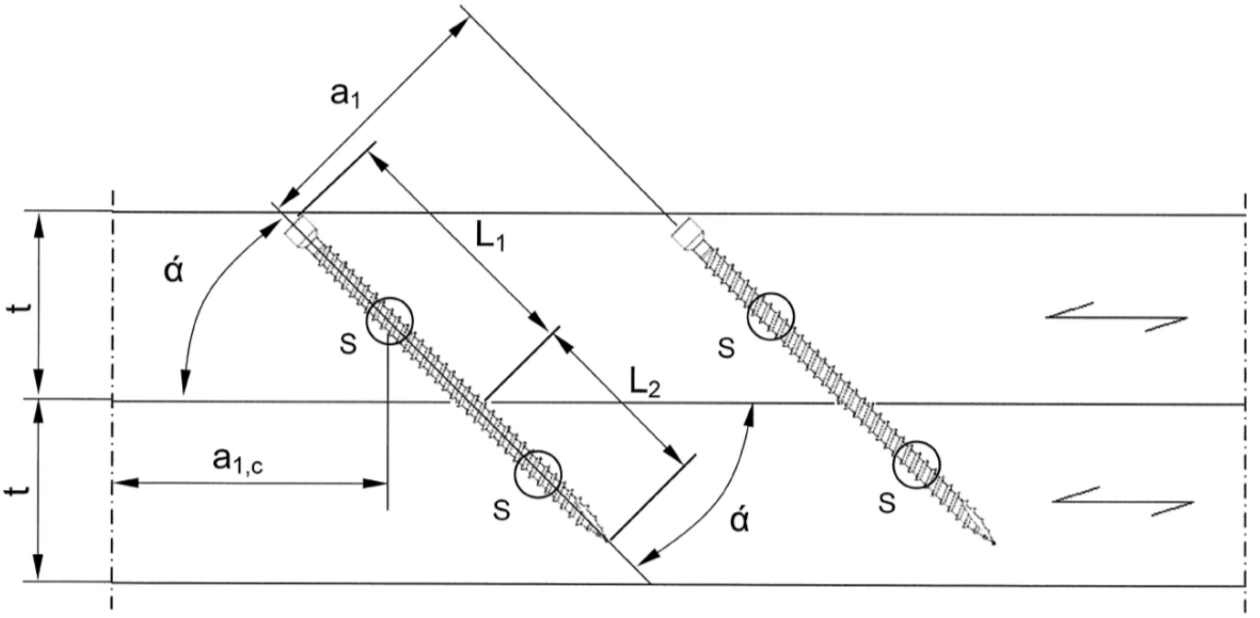
S Centroid of the part of the screw in the timber

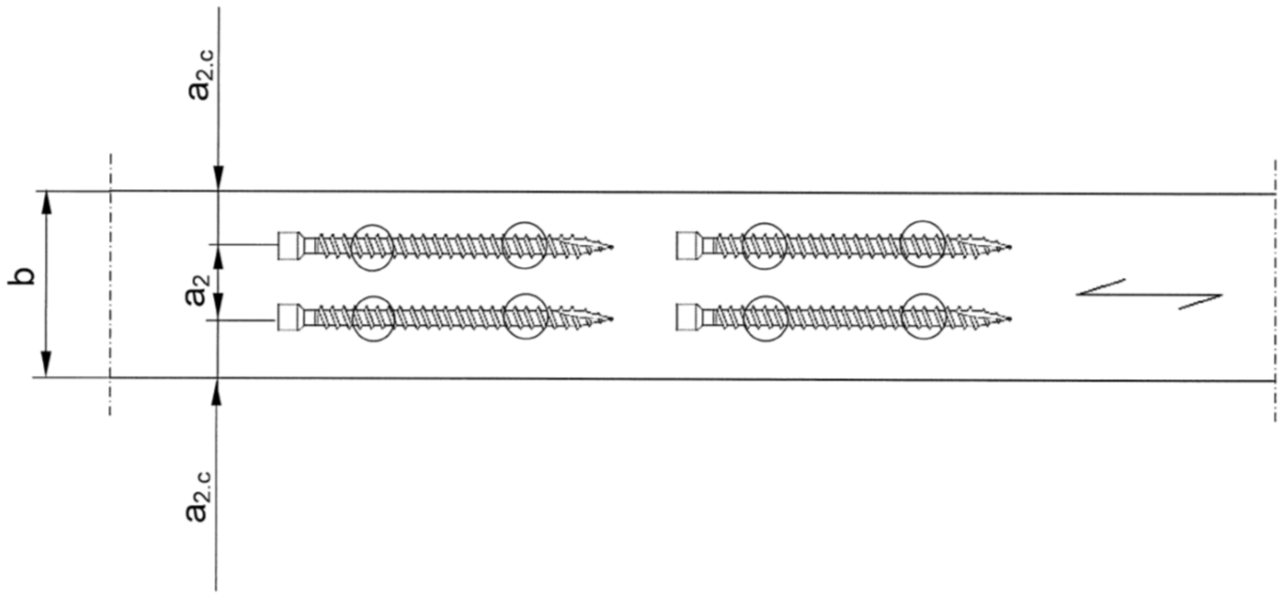
HASO-Screws	Annex 2.5
Examples of spacings and distances for HASO screws with d = 8 mm and a full thread	



HASO-Screws	Annex 2.6
Examples of spacings and distances for HASO screws with d = 8 mm and a full thread	

Parallel inclined screws to connect wood-based members



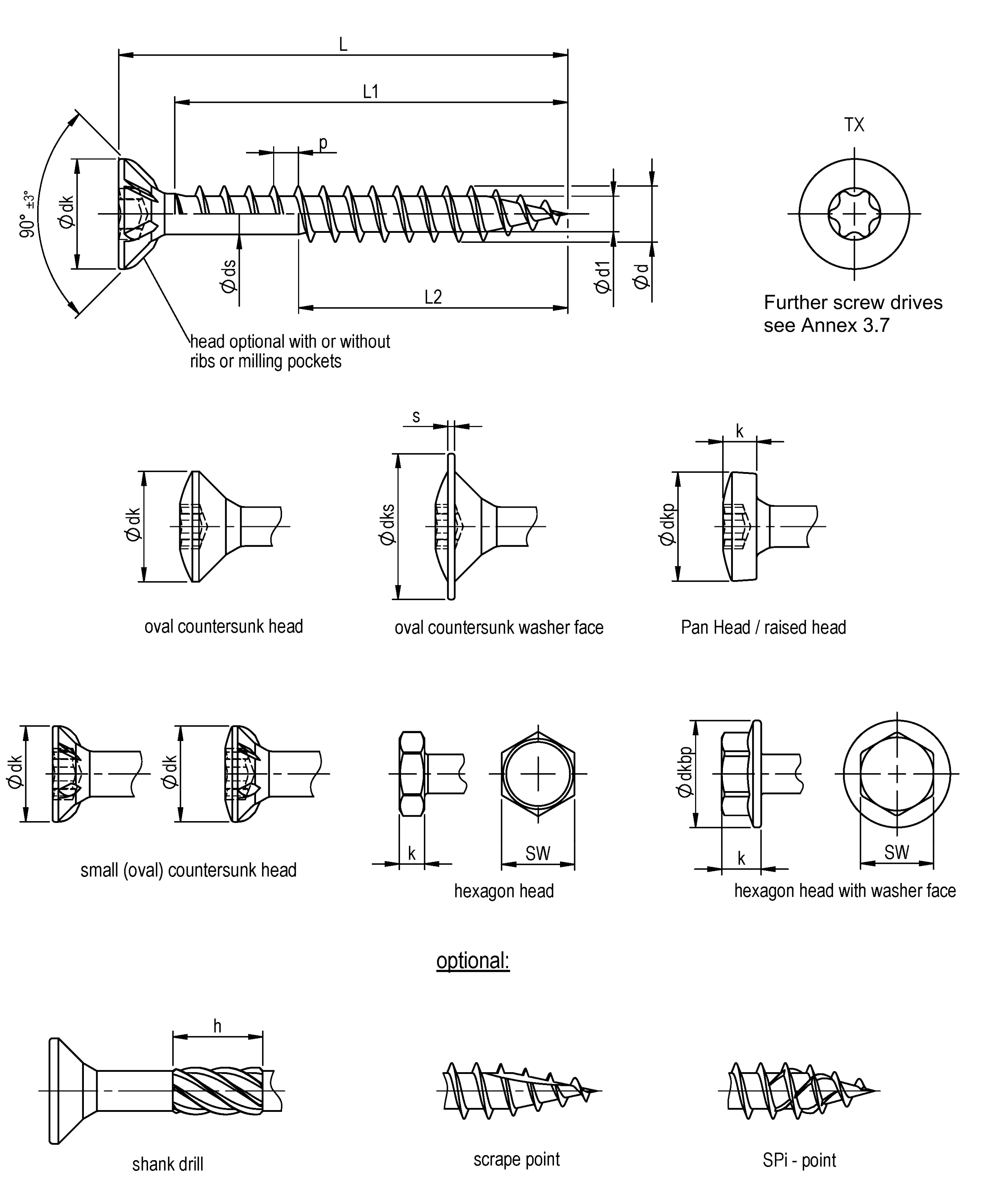


S Centroid of the part of the screw in the timber
t Thickness of the wood-based member
b Width of the wood-based member

A.2.5 Durability against corrosion

Screws made from carbon steel are electrogalvanised and yellow or blue chromated. The mean thickness of the zinc coating of the screws is 5 µm.

HASO-Screws	Annex 2.7
Examples of spacings and distances for HASO screws with d = 8 mm and a full thread and durability against corrosion	



HASO-Screws	Annex 3.1
HASO screws with single thread made of carbon steel	

Deutsches Institut für Bautechnik DIBt

HASO screws with single thread				
thread dimensions				h
Ø d $_{-0,3}$	Ø d1 $^{+0,3}$	Ø ds ±0,2	p ±10%	
3,0 $^{+0,1}$	1,8	2,2	1,35	5,0
3,5 $^{+0,1}$	2,1	2,6	1,6	6,0
4,0 $^{+0,2}$	2,4	2,8	1,8	7,0
4,5 $^{+0,1}$	2,6	3,1	2,0	8,0
5,0 $^{+0,2}$	3,1	3,6	2,2	8,0
6,0 $^{+0,2}$	3,6	4,1	2,6	10,0

head shapes										
Ø d	(oval) countersunk head	small (oval) counterunk head	oval countersunk washer face		Panhead / raised head		hexagon head		hexagon head with washer face	
	dk ±0,5	dk ±0,3	dks ±0,3	s ±0,2	dkp $_{-0,5}$	k ±0,2	SW	k	dkbp max.	k
3,0	6,0		7,1	0,6	6,0	2,3				
3,5	7,0	5,0	8,1	0,6	7,0	2,6				
4,0	8,0	6,0	9,2	0,9	8,0	3,0				
4,5	9,0	7,0	10,3	0,9	9,0	3,2				
5,0	10,0	8,0	11,0	1,1	10,0	3,7	8	3,5	11,4	3,5
6,0	12,0	11,0	13,8	1,1	12,0	4,5	10	4,0		

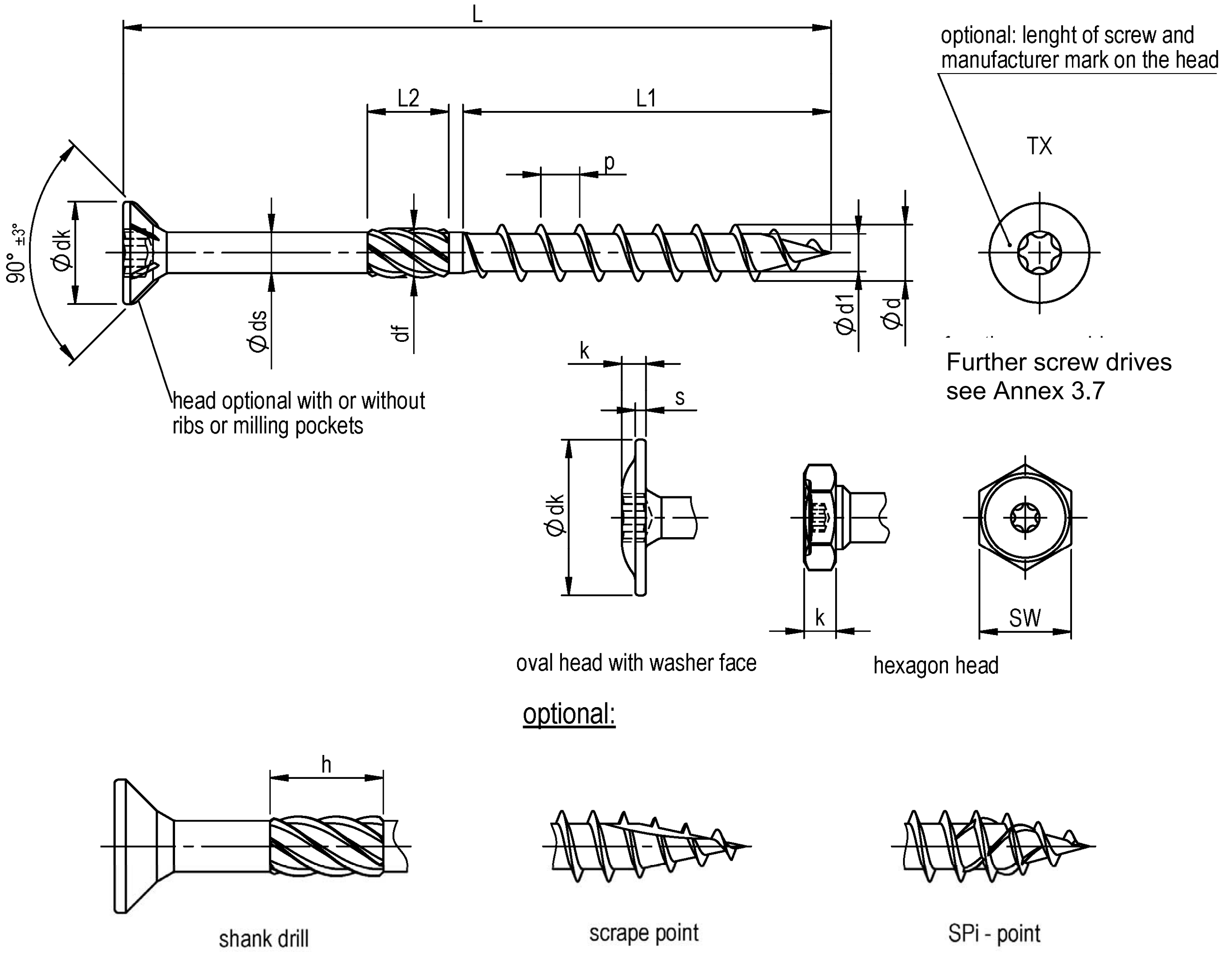
d	3,0		3,5		4,0		4,5		5,0		6,0	
L*	L1 ±2,0	L2 ±2,0	L1 ±2,0	L2 ±2,0	L1 ±2,0	L2 ±2,0	L1 ±2,0	L2 ±2,0	L1 ±2,0	L2 ±2,0	L1 ±2,0	L2 ±2,0
16 $^{-0,90}$	12											
20 $^{-1,05}$	16	min. 12 - max. 31	16	min. 14 - max. 31	16							
25 $^{-1,05}$	21		21		21	min. 16 - max. 50	21		21			
30 $^{-1,05}$	26		26		26		26	min. 18 - max. 50	26	min. 20 - max. 70	26	
35 $^{-1,25}$	31		31		31		31		31		31	min. 24 - max. 80
40 $^{-1,25}$	36		36		36		36		36		36	
45 $^{-1,25}$	41		41		41		41		41		41	
50 $^{-1,25}$			46		46		46		46		46	
55 $^{-1,50}$					51		51		51		51	
60 $^{-1,50}$					56		56		56		56	
70 $^{-1,50}$							66		66		66	
80 $^{-1,50}$									76		76	
90 $^{-1,50}$												
100 $^{-1,50}$												
110 $^{-1,75}$												
120-180 $^{-2,00}$												
200-300 $^{-3,00}$												

*deviant lengths between Lmin < L < Lmax possible

HASO-Screws	Annex 3.2
HASO screws with single thread made of carbon steel	

English translation prepared by DIBt

Deutsches Institut für Bautechnik DIBt



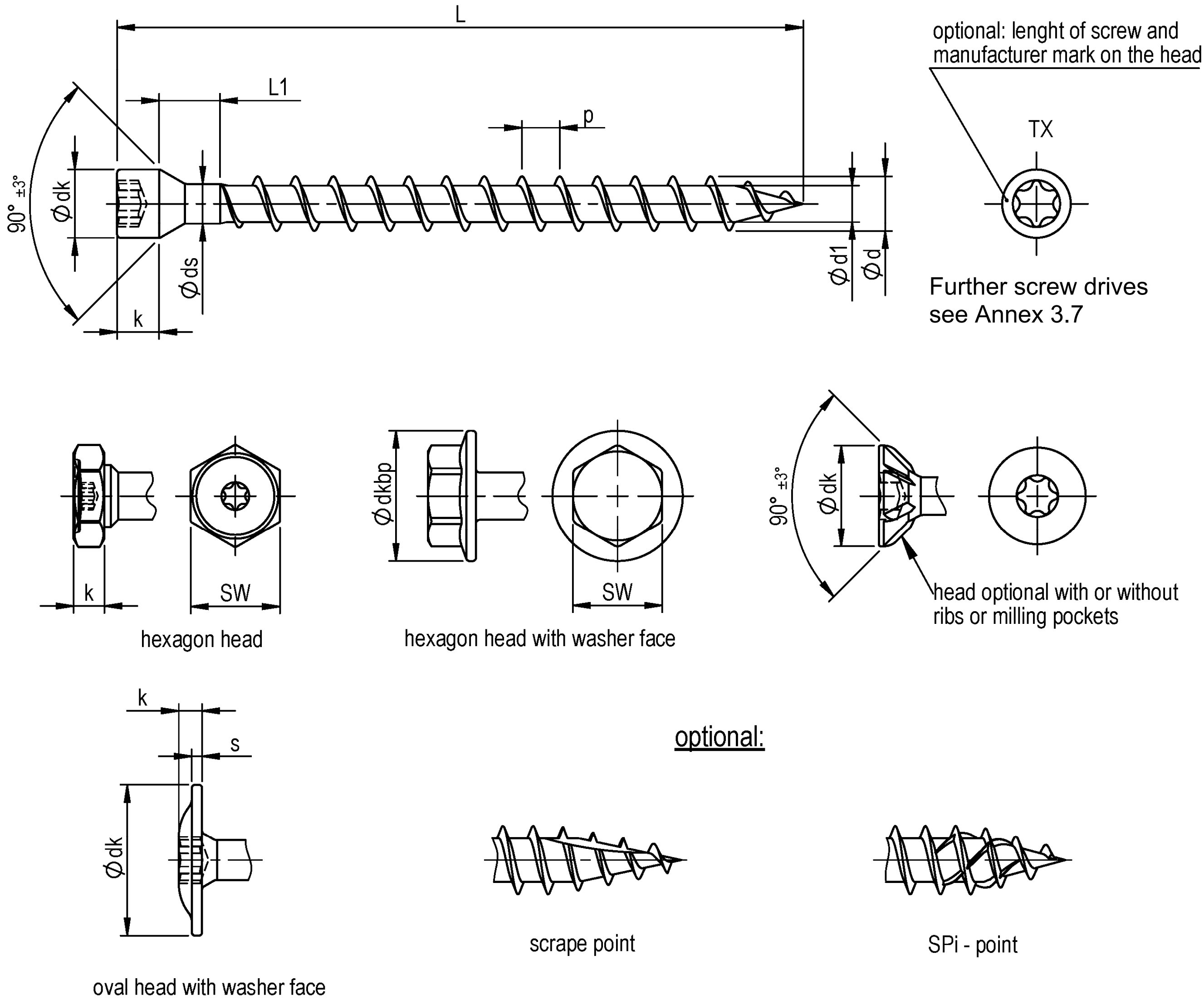
HASO screws with coarse thread						head shapes					
thread dimensions				shank drill		countersunk head	oval haed with washer face			hexagon head	
Ø d $_{-0,3}$	Ø d1 ±0,3	Ø ds ±0,2	p ±10%	Ø df ±0,3	L2 ± 2	Ø dk ± 0,6	Ø dk ± 1,0	k ±0,3	s ±0,3	SW	k ±1,0
8,0 $^{+0,2}$	5,2	5,8	5,5	7,0	12,0	14,5	20	4,0	1,6	12	4,5
10,0 $^{+0,2}$	6,25	7,0	6,6	8,25	12,0	17,8	24	4,8	2,0	15	5,5
12,0 $^{+0,2}$	7,12	8,2	6,8	9,5	12,0	20,0	30	5,5	2,4	17	6,5

nominal length L	Ø 8,0	Ø 10,0	Ø 12,0
	L1	L1	L1
70 - 120 $_{-1,75}$	60 ± 1,5		
121 - 500 $_{-2,5}$	80 ± 1,5		

HASO-Screws

HASO screws coarse thread made of carbon steel

Annex 3.3



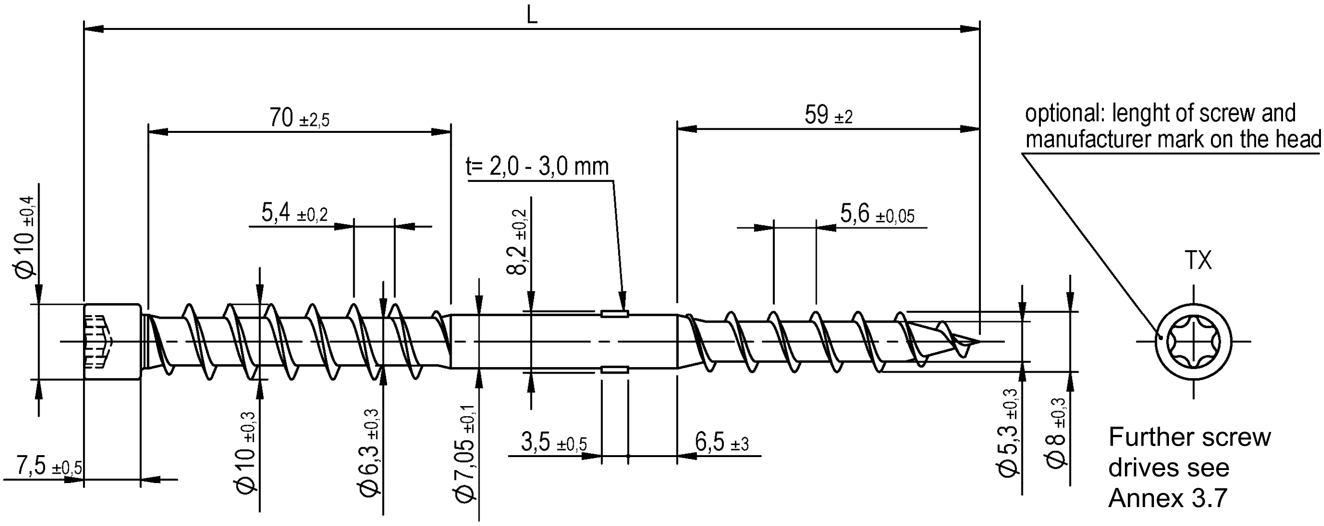
nominal length L max.	L1 ±2,0
500	12

fully threaded HASO screws				head shapes								
thread dimensions				cylindrical head		countersunk head	oval head with washer face			hexagon head (with washer face)		
Ø d $_{-0,3}$	Ø d1 ±0,3	Ø ds ±0,2	p ±10%	Ø dk -0,5	k ±0,3	Ø dk ± 0,6	Ø dk ± 1,0	k ±0,3	s ±0,3	SW	k ±1,0	dkbp
8,0 $^{+0,2}$	5,2	5,8	5,5	10,0	7,0	14,5	20	4,0	1,6	12	4,5	13,6

HASO-Screws

Fully threaded HASO screws made of carbon steel

Annex 3.4

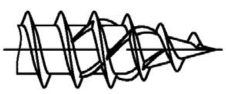


Further screw drives see Annex 3.7

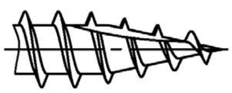
nominal diameter 8,0 mm

L	L min
160	158
180	178
200	197
220	217
230	227
240	237
250	247
260	257
270	267
280	277
300	297
320	317
330	327
340	337
350	347
360	357
380	377
400	397
420	417
440	437
460	457
480	477
500	497

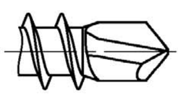
optional:



SPi - point



scrape point

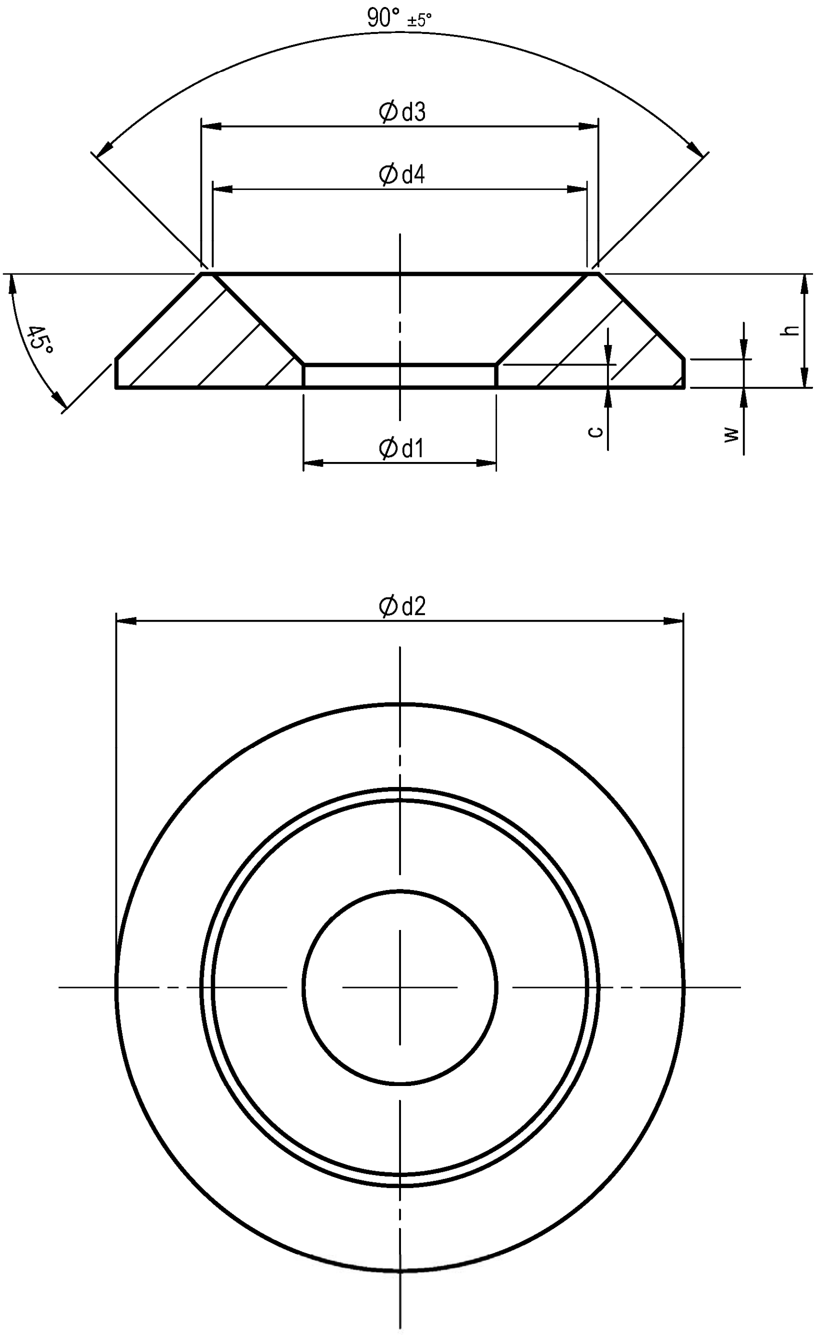


tapping point

HASO-Screws

HASO screws with thread under head with d = 8 mm made of carbon steel

Annex 3.5



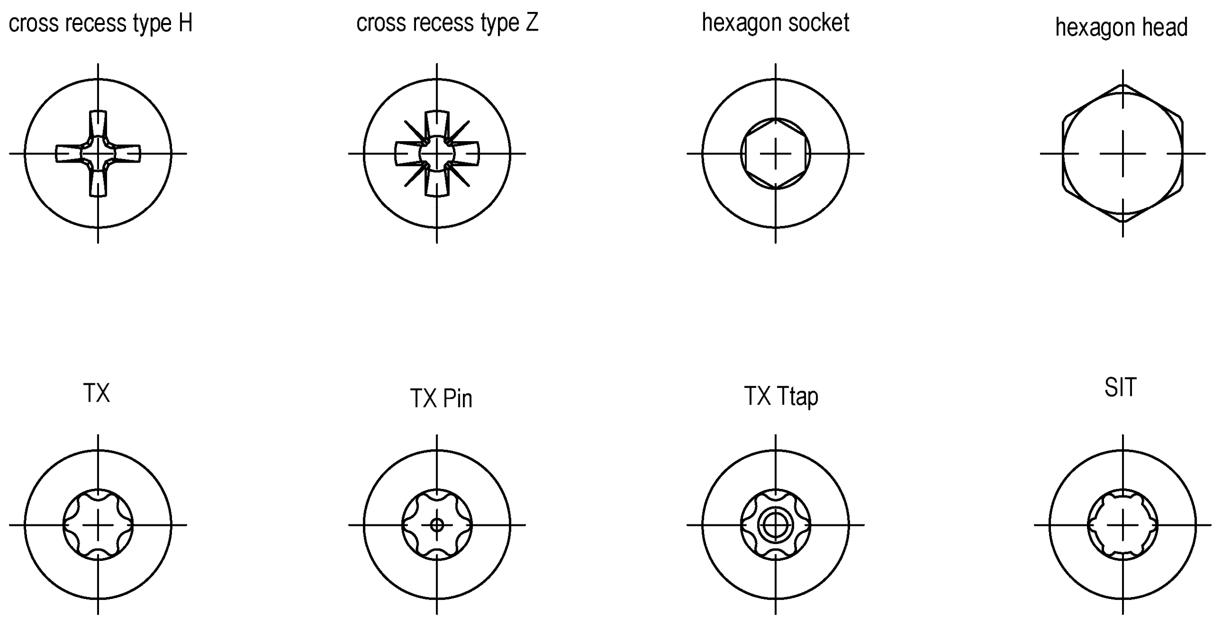
	d1 ±0,3	d2 ±0,3	d3 ±0,3	d4 ±0,3	h ±0,3	w	c
Ø 8,0	8,5	25,0	17,5	16,5	5,0	~ 1,25	~ 1,0
Ø 10,0	11,0	32,0	22,5	21,5	6,0	~ 1,4	~ 0,75

Washers made of carbon steel shall be only used with screws made of carbon steel.

HASO-Screws

Countersunk washers made of carbon steel

Annex 3.6



sizes of screw drives

screw drive	Ø 3,0	Ø 3,5	Ø 4,0	Ø 4,5	Ø 5,0	Ø 5,5	Ø 6,0	Ø 7,0	Ø 8,0	Ø 10	Ø 12
cross recess type H / cross recess type Z	1	1 / 2	2	2	2	2 / 3	3	3			
TX / TX Pin / TX Ttap / SIT	10	10 / 15 / 20	15 / 20	20	20 / 25	20 / 25	25 / 30	30	30 / 40	40 / 50	40 / 50
heaxagon head					SW8		SW10		SW12	SW15	SW17
hexagon socket					SW 4		SW 5		SW 6		

HASO-Screws	Annex 3.7
Screw drives	

ANNEX 4 - Additional provisions (informative)

A.4.1 Laterally loaded screws

A.4.1.1 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 timber members or in wood-based panels shall be taken from EN 1995-1-1 or from national provisions that apply at the installation site unless otherwise specified in the following.

A.4.1.2 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 (A.4.1) independent of the angle between screw axis and grain direction, $0° \leq \alpha \leq 90°$:

$$f_{h,k} = 20 \cdot d^{-0,5} \text{ in N/mm}^2 \qquad \text{(A.4.1)}$$

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 (A.4.1) 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. Where applicable, 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.4.2 Axially loaded screws

A.4.2.1 General

For LVL a maximum characteristic density of 500 kg/m³ shall be used in equations (8.40a) and (8.40b) of EN 1995-1-1.

Outer diameter of washer d_k > 32 mm shall not be considered.

A.4.2.2 Cross lamianted timber

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. The axial withdrawal capacity for screws arranged parallel to the plane of cross laminated timber, independent of the angle between screw axis and grain direction, $30° \leq a \leq 90°$, may be calculated from:

$$F_{ax,Rk} = 20 \cdot d^{0,8} \cdot l_{ef}^{0,9} \quad \text{in N/mm}^2 \qquad \text{(A.4.2)}$$

Where

d outer thread diameter of the screw [mm]

l_{ef} penetration length of the screw in the cross laminated timber [mm].

A.4.2.3 Compressive capacity of fully threaded HASO screws with d = 8 mm

The design axial capacity $F_{ax,Rd}$ of HBS screws with d = 8 mm and a full thread 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.

$$F_{ax,Rd} = \min\left\{f_{ax,d} \cdot d \cdot \ell_{ef};\ \kappa_c \cdot N_{pl,d}\right\} \qquad (A.4.3)$$

$f_{ax,d}$	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]

$$\kappa_c = 1 \qquad \text{für } \bar{\lambda}_k \le 0{,}2 \qquad (A.4.4)$$

$$\kappa_c = \frac{1}{k + \sqrt{k^2 - \bar{\lambda}_k^2}} \qquad \text{für } \bar{\lambda}_k > 0{,}2 \qquad (A.4.5)$$

$$k = 0{,}5 \cdot \left[1 + 0{,}49 \cdot \left(\bar{\lambda}_k - 0{,}2\right) + \bar{\lambda}_k^2\right] \qquad (A.4.6)$$

and a relative slenderness ratio $\bar{\lambda}_k = \sqrt{\frac{N_{pl,k}}{N_{ki,k}}}$ (A.4.7)

where:

$N_{pl,k}$ characteristic plastic normal force related to the net cross-section of the inner thread diameter: $N_{pl,k} = \pi \cdot \frac{d_1^2}{4} \cdot f_{y,k}$ (A.4.8)

$f_{y,k}$ characteristic yield strength, $f_{y,k}$ = 1000 N/mm² for fully threaded HBS screws with d = 8 mm

d_1 inner thread diameter of the screw [mm]

$$N_{pl,d} = \frac{N_{pl,k}}{\gamma_{M1}} \qquad (A.4.9)$$

γ_{M1} partial factor according to EN 1993-1-1 in conjunction with the particular national annex characteristic ideal elastic buckling load:

$$N_{ki,k} = \sqrt{c_h \cdot E_S \cdot I_S} \quad [N] \qquad (A.4.10)$$

elastic foundation of the screw:

$$c_h = \left(0{,}19 + 0{,}012 \cdot d\right) \cdot \rho_k \cdot \left(\frac{90° + \alpha}{180°}\right) \quad [N/mm^2] \qquad (A.4.11)$$

ρ_k characteristic density of the timber member [kg/m³],

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

modulus of elasticity:

E_s = 210000 N/mm²

second moment of area:

$$I_s = \frac{\pi \cdot d_1^4}{64} \quad [mm^4] \qquad (A.4.12)$$

ANNEX 5 - Compression reinforcement perpendicular to the grain (informative)

A.5.1 General

Only HASO screws with d = 8 mm and a full thread shall 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 shall be flush with the timber surface.

A.5.2 Design

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

The design resistance of a reinforced contact area is:

$$R_{90,d} = \min \begin{Bmatrix} k_{c,90} \cdot B \cdot \ell_{ef,1} \cdot f_{c,90,d} + n \cdot \min\{R_{ax,d}; \kappa_c \cdot N_{pl,d}\} \\ B \cdot \ell_{ef,2} \cdot f_{c,90,d} \end{Bmatrix} \qquad \text{(A.5.1)}$$

where:

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

B bearing width [mm]

$\ell_{ef,1}$ 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

$$R_{ax,d} = f_{ax,d} \cdot d \cdot \ell_{ef} \ \text{[N]} \qquad \text{(A.5.2)}$$

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

d outer thread diameter of the screw [mm]

$$\kappa_c \cdot N_{pl,d} = \frac{\kappa_c \cdot N_{pl,k}}{\gamma_{M1}} \quad \text{with } \kappa_c \cdot N_{pl,k} \text{ according to Table A.5.1} \quad \text{[N]} \qquad \text{(A.5.3)}$$

$\ell_{ef,2}$ effective contact length in the plane of the screw tips (see Figure A.5.1) [mm]

$\ell_{ef,2} = \{\ell_{ef} + (n_0 - 1) \cdot a_1 + \min(\ell_{ef} ; a_{1,c})\}$ for end supports (see Figure A.5.1 left)

$\ell_{ef,2} = \{2 \cdot \ell_{ef} + (n_0 - 1) \cdot a_1\}$ for intermediate supports (see Figure A.5.1 right)

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

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

[1] EN 1993-1-1:2005 Eurocode 3: Design of steel structures. Part 1-1: General rules and rules for buildings

Table A.5.1: Characteristic load-carrying capacity $\kappa_c \cdot N_{pl,k}$ for fully threaded HASO screws in N

ρ_k [kg/m³]	d [mm]
	8.0
310	11800
350	12200
380	12500
410	12700
450	13000

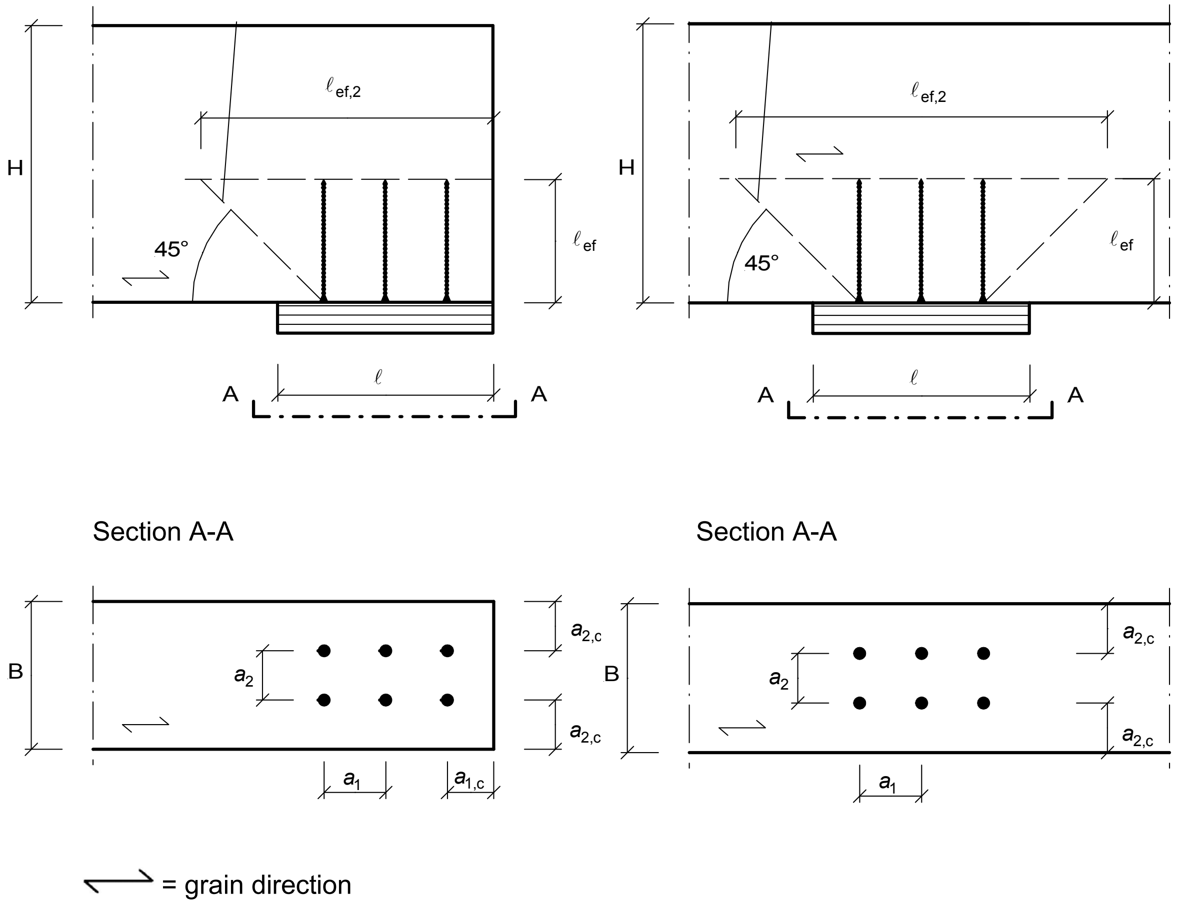


Figure A.5.1: Reinforced end support (left) and reinforced intermediate support (right)

HASO-Screws	Annex 5.2
Compression reinforcement perpendicular to the grain	

ANNEX 6 - Fastening of thermal insulation material on top of rafters (informative)

A.6.1 General

HASO 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 400 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.6.1:

Table A.6.1 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
12	80	100

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.6.2 Parallel inclined screws and thermal insulation material in compression

A.6.2.1 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 compressive stress of the thermal insulation material at 10 % deformation, measured according to EN 826[2], 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.

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

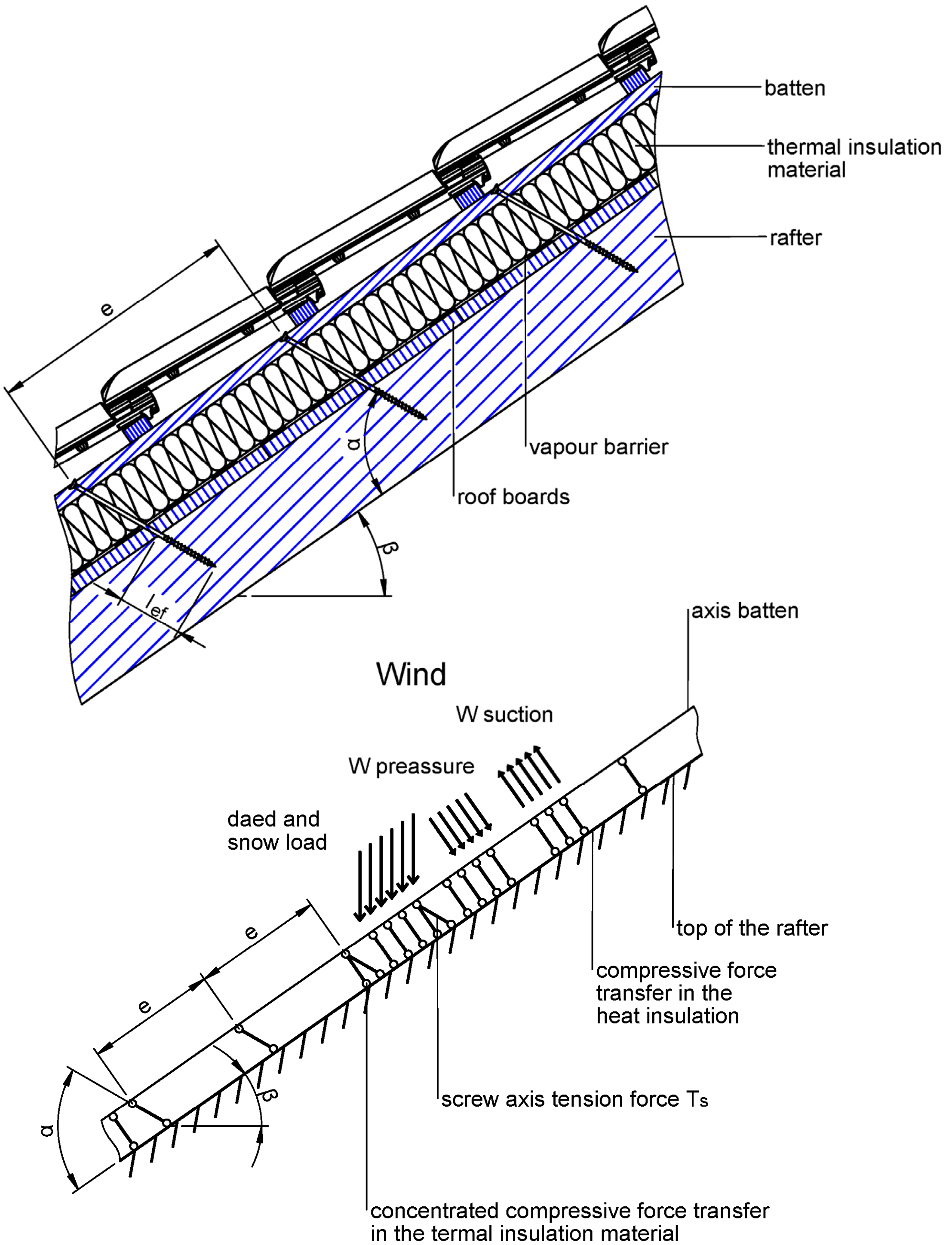


Figure A.6.1 Fastening of the thermal insulation material on top of rafters - structural system

HASO-Screws	Annex 6.2
Fastening of thermal insulation material on top of rafters	

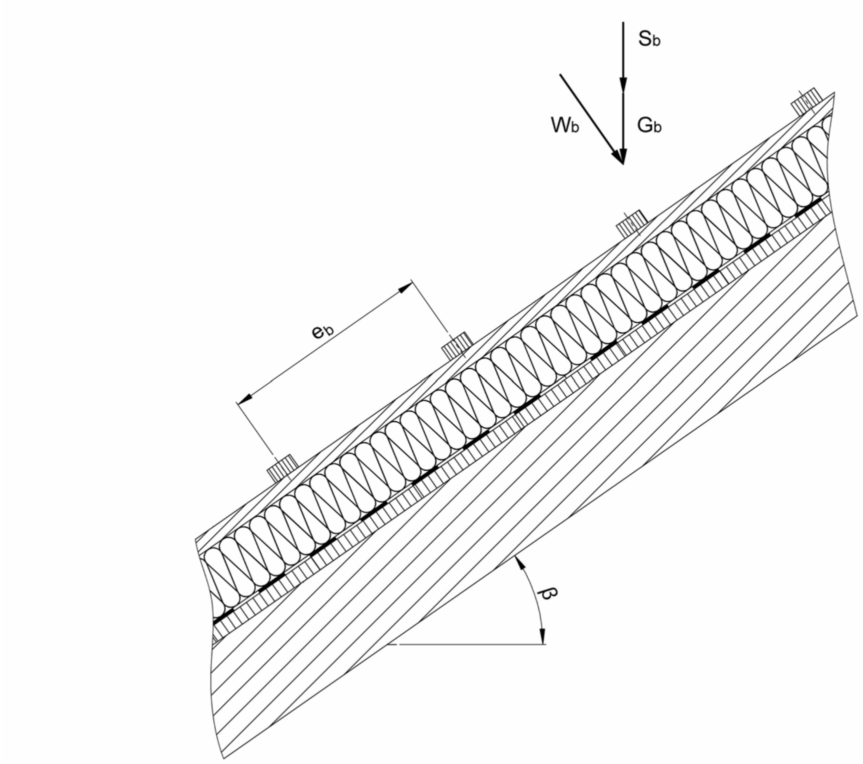


Figure A.6.2 Point loads F_b perpendicular to the battens

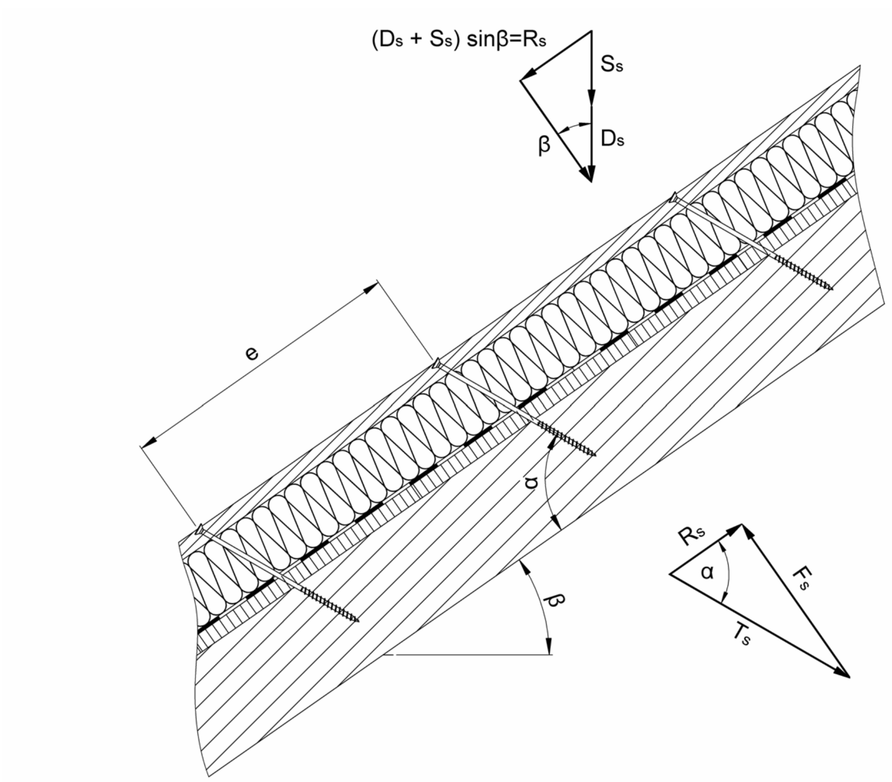


Figure A.6.3 Point loads F_s perpendicular to the battens, load application in the area of the screw heads

HASO-Screws	Annex 6.3
Fastening of thermal insulation material on top of rafters	

A.6.2.2 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:

$$M_k = \frac{(F_{b,k} + F_{s,k}) \cdot l_{char}}{4} \qquad \text{(A.6.1)}$$

where

$$l_{char} = \text{characteristic length } l_{char} = \sqrt[4]{\frac{4 \cdot EI}{w_{ef} \cdot K}} \qquad \text{(A.6.2)}$$

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:

$$w_{ef} = w + t_{HI} / 2 \qquad \text{(A.6.3)}$$

where
w = minimum from width of the batten or rafter, respectively
t_{HI} = thickness of the thermal insulation material

$$K = \frac{E_{HI}}{t_{HI}} \qquad \text{(A.6.4)}$$

The following condition shall be satisfied:

$$\frac{\sigma_{m,d}}{f_{m,d}} = \frac{M_d}{W \cdot f_{m,d}} \leq 1 \qquad \text{(A.6.5)}$$

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:

$$V_k = \frac{(F_{b,k} + F_{s,k}}{2} \qquad \text{(A.6.6)}$$

The following condition need to be satisfied:

$$\frac{\tau_d}{f_{v,d}} = \frac{1.5 \cdot V_d}{A \cdot f_{v,d}} \leq 1 \qquad \text{(A.6.7)}$$

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

A.6.2.3 Design of the thermal insulation material

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

$$\sigma_k = \frac{1.5 \cdot F_{b,k} + F_{s,k}}{2 \cdot l_{char} \cdot w} \tag{A.6.8}$$

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.6.2.4 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:

$$T_{S,k} = \frac{R_{S,k}}{\cos\alpha} \tag{A.6.9}$$

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:

$$F_{ax,\alpha,Rd} = \min\left\{\frac{f_{ax,d} \cdot d \cdot l_{ef} \cdot k_1 \cdot k_2}{1.2 \cdot \cos^2\alpha + \sin^2\alpha} \cdot \left(\frac{\rho_k}{350}\right)^{0.8}; f_{head,d} \cdot d_h^2 \cdot \left(\frac{\rho_k}{350}\right)^{0.8}; \frac{f_{tens,k}}{\gamma_{M2}}\right\} \tag{A.6.10}$$

where:

$f_{ax,d}$	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}	penetration length of the threaded part of the screw in the rafter [mm], $l_{ef} \geq 40$ mm
ρ_k	characteristic density of the timber member [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 (A.6.10) is fulfilled, the deflection of the battens does not need to be considered when designing the load-carrying capacity of the screws.

HASO-Screws	Annex 6.5
Fastening of the thermal insulation material on top of rafters	

A.6.3 Alternatively inclined screws and thermal insulation material non in compression

A.6.3.1 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 $q_{||}$.
- 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: $$N_{c,k} = (A + B) \cdot \left(-\frac{q_{II,k}}{\cos\alpha_1 + \sin\alpha_1 / \tan\alpha_2} - \frac{q_{\perp,k} \cdot \sin(90° - \alpha_2)}{\sin(\alpha_1 + \alpha_2)} \right) \quad (A.6.11)$$

Tensile screw: $$N_{t,k} = (A + B) \cdot \left(\frac{q_{II,k}}{\cos\alpha_2 + \sin\alpha_2 / \tan\alpha_1} - \frac{q_{\perp,k} \cdot \sin(90° - \alpha_1)}{\sin(\alpha_1 + \alpha_2)} \right) \quad (A.6.12)$$

A, B distances of the screws according to Figure A.6.5
$q_{II,k}$ 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:

$$F_{ZS,k} = (A + B) \cdot \left(\frac{q_{II,k}}{1/\tan\alpha_1 + 1/\tan\alpha_2} - \frac{q_{\perp,k} \cdot \sin(90° - \alpha_1) \cdot \sin\alpha_2}{\sin(\alpha_1 + \alpha_2)} \right) \quad (A.6.13)$$

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.6.5.

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

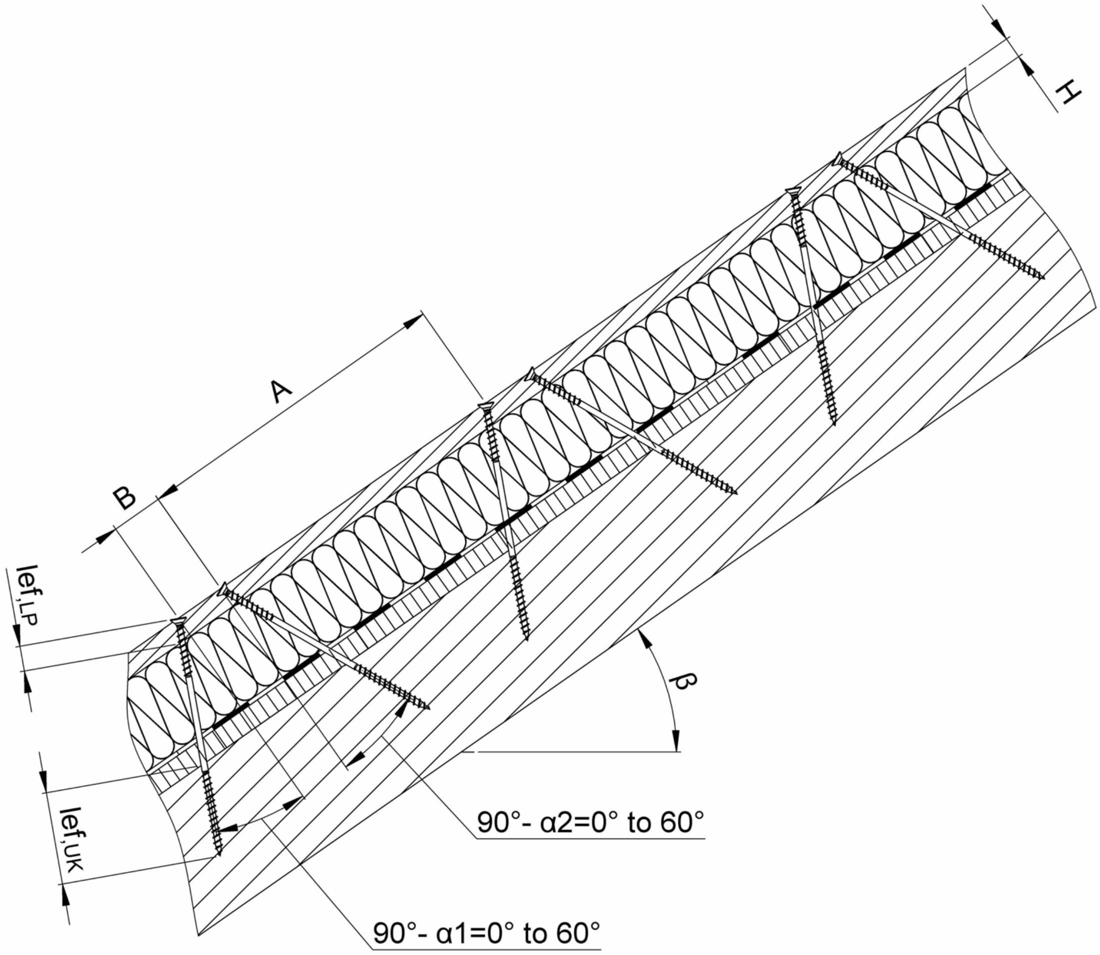


Figure A.6.4 Fastening of thermal insulation material on top of rafters - structural system for alternatively inclined screws

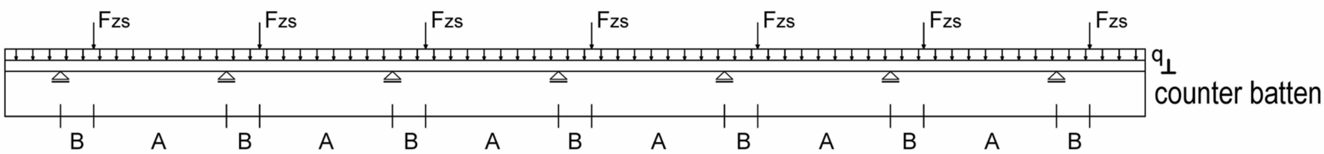


Figure A.6.5 Continuous batten under constant line loads from actions on the roof plane $q_{\perp}$ and concentrated loads from tensile screws F_{ZS}

HASO-Screws	Annex 6.7
Fastening of thermal insulation material on top of rafters	

A.6.3.2 Design of the screws

The design value of the load-carrying capacity of the screws shall be calculated according to equation (A.6.14) and (A.6.15).

Screws loaded in tension:

$$F_{ax,\alpha,Rd} = \min\left\{\frac{f_{ax,d} \cdot d \cdot l_{ef,b}}{1.2 \cdot \cos^2\alpha_2 + \sin^2\alpha_2} \cdot \left(\frac{\rho_{b,k}}{350}\right)^{0.8}; \frac{f_{ax,d} \cdot d \cdot l_{ef,r}}{1.2 \cdot \cos^2\alpha_2 + \sin^2\alpha} \cdot \left(\frac{\rho_{r,k}}{350}\right)^{0.8}; \frac{f_{tens,k}}{\gamma_{M2}}\right\} \qquad (A.6.14)$$

Screws loaded in compression:

$$F_{ax,\alpha,Rd} = \min\left\{\frac{f_{ax,d} \cdot d \cdot l_{ef,b}}{1.2 \cdot \cos^2\alpha_1 + \sin^2\alpha_1} \cdot \left(\frac{\rho_{b,k}}{350}\right)^{0.8}; \frac{f_{ax,d} \cdot d \cdot l_{ef,r}}{1.2 \cdot \cos^2\alpha_1 + \sin^2\alpha_1} \cdot \left(\frac{\rho_{r,k}}{350}\right)^{0.8}; \frac{\kappa_c \cdot N_{pl,k}}{\gamma_{M1}}\right\} \qquad (A.6.15)$$

where:

$f_{ax,d}$	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.6.2 [N]

Table A.6.2 Characteristic buckling capacity of the screws $\kappa_c \cdot N_{pl,k}$ in N

Free screw length l between batten and rafter [mm]	HASO screws with thread under head
	Outer thread diameter d [mm]
	8.0/ 10.0
	$\kappa_c \cdot N_{pl,k}$ [N]
≤ 100	13300
120	10400
140	8300
160	6800
180	5600
200	4700
220	4000
240	3500
260	3000
280	2700
300	2300
320	2100
340	1900
360	1700
380	1500
400	1400