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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

European Technical Assessment ETA-09/0227 of 2017/12/04

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:	AV Joist Hangers type A, B and Split
Product family to which the above construction product belongs:	Three-dimensional nailing plate (Joist hanger for wood to wood connections and wood to concrete or steel connections)
Manufacturer:	August Vormann GmbH & Co. KG Postfach 1552 Heilenbecker Strasse 191 - 205 DE-58256 Ennepetal Tel. +49 02333 / 978 - 0 Fax +49 02333 / 978 - 241599 Internet www.vormann.com
Manufacturing plant:	August Vormann GmbH & Co. KG Berliner Strasse 50 DE-04910 Elsterwerda
This European Technical Assessment contains:	20 pages including 4 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:	Guideline for European Technical Approval (ETAG) No. 015 Three Dimensional Nailing Plates, April 2013, used as European Assessment Document (EAD).
This version replaces:	The ETA with the same number issued on 2014-09-16

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II SPECIFIC PART OF THE EUROPEAN TECHNICAL ASSESSMENT

1 Technical description of product and intended use

Technical description of the product
AV joist hangers type A and B are one-piece non-welded, face-fixed joist hangers to be used in timber to timber connections. AV joist hangers type A are also used for connections between a timber joist and a concrete structure or a steel member.

AV joist hangers type split are two-piece non-welded, face-fixed joist hangers to be used in timber to timber connections.

The joist hangers are made from pre-galvanized steel Grade S 250 GD + Z (min Z275) according to EN 10346:2009 or from stainless steel according to EN 10088-2:2014 with $R_{p0,2} \geq 240$ N/mm² and $R_m \geq 500$ N/mm². Dimensions, hole positions are described in annex A.

2 Specification of the intended use in accordance with the applicable EAD

The joist hangers are intended for use in making end-grain to side-grain connections in load bearing timber structures, as a connection between a wood based joist and a solid timber or wood based header, where requirements for mechanical resistance and stability and safety in use in the sense of the Basic Work Requirements 1 and 4 of the Regulation 305/2011 (EU) shall be fulfilled.

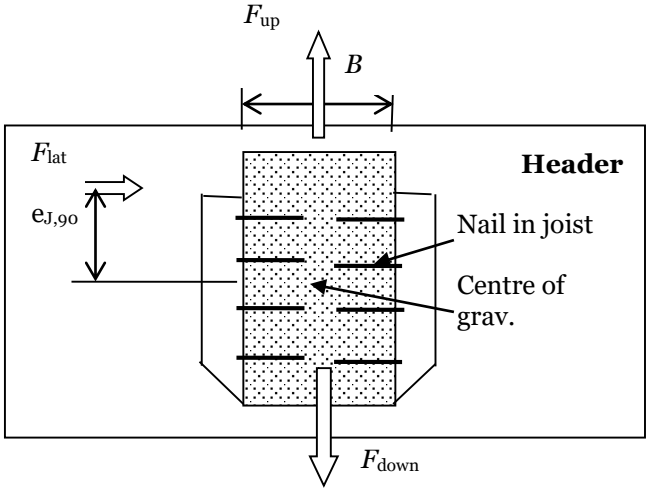
The joist hangers can be installed as connections between wood based members such as:

- Structural solid timber classified to C14-C40 according to EN 338 / EN 14081,
- Glulam classified to GL24-GL36 according to EN 1194 / EN 14080,
- LVL according to EN 14374,
- Parallam PSL,
- Intrallam LSL,
- Duo- and Triobalken,
- Layered wood plates,
- Kreuzbalken,
- I-beams with backer blocks on both sides of the web in the header and web stiffeners in the joist,
- Plywood according to EN 636.

However, the calculation methods are only allowed for a characteristic wood density of up to 460 kg/m³. Even though the wood based material may have a larger density, this must not be used in the formulas for the load-carrying capacities of the fasteners.

Annex B states the formulas for the characteristic load-carrying capacities of the connections with joist hangers type A and I and a table with characteristic load-carrying-capacities of connections with joist hangers type split. The design of the connections shall be in accordance with Eurocode 5 or a similar national Timber Code.

It is assumed that the forces acting on the joist hanger connection are the following F_{up}, F_{down} and F_{lat}, as shown in the figure below. The forces F_{up} and F_{down} shall act in the middle of the joist hanger. The force F_{lat} is assumed to act $e_{J,90}$ above the centre of gravity of the nails in the joist. It is assumed that the forces are acting right at the end of the joist.



It is assumed that the header beam is prevented from rotating. Similarly it is assumed that the concrete structure or the steel member to which the joist hanger is bolted does not rotate. If the header beam only has installed a joist hanger on one side the eccentricity moment $M_v = F_d \cdot (B_H / 2 + e_{J,0})$ shall be considered. The same applies when the header has joist hanger connections on both sides, but with vertical forces which differ more than 20%.

It is a condition for a force F_{lat} perpendicular to the vertical symmetry line that the joist hanger is connected to a wood-based header with nails in all holes (full nailing) or in all holes marked for partial nailing.

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

The zinc-coated hangers are for use in timber structures subject to the dry, internal conditions defined by the service classes 1 and 2 of EN 1995-1-1:2004, (Eurocode 5). The joist hangers made from stainless steel according to EN 10088-2:2014 with $R_{p0,2} \geq 240$ N/mm² and $R_m \geq 500$ N/mm² meet the requirements of Eurocode 5 (EN 1995-1-1: 2004), for use in structures subject to the wet conditions defined as service class 3.

The scope of the connectors regarding resistance to corrosion shall be defined according to national provisions that apply at the installation site considering environmental conditions and in conjunction with the

admissible service conditions according to EN 1995-1-1 and the admissible corrosivity category as described and defined in EN ISO 12944-2

Assumed working life

The assumed intended working life of the joist hangers for the intended use is 50 years, provided that they are subject to appropriate use and maintenance.

The information on the working life should not be regarded as a guarantee provided by the manufacturer or ETA Danmark. An "assumed intended working life" means that it is expected that, when this working life has elapsed, the real working life may be, in normal use conditions, considerably longer without major degradation affecting the essential requirements.

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

Characteristic	Assessment of characteristic
3.1 Mechanical resistance and stability (BWR 1)*)	
Characteristic load-carrying capacity	See Annex B
Stiffness	No performance determined
Ductility in cyclic testing	No performance determined
3.2 Safety in case of fire (BWR 2)	
Reaction to fire	The joist hangers are made from steel classified as **Euroclass A1** in accordance with EN 1350-1 and EC decision 96/603/EC, amended by EC Decision 2000/605/EC
3.3 Hygiene, health and the environment (BWR 3)	
Influence on air quality	The product does not contain/release dangerous substances specified in TR 034, dated March 2012
3.7 Sustainable use of natural resources (BWR 7)	No Performance Determined
3.8 General aspects related to the performance of the product	The joist hangers 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 class 1 and 2
Identification	See Annex A

*) See additional information in section 3.9 – 3.12.

In addition to the specific clauses relating to dangerous substances contained in this European technical Assessment, there may be other requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the Construction Products Regulation, these requirements need also to be complied with, when and where they apply.

3.9 Methods of verification

Safety principles and partial factors

The characteristic load-carrying capacities are based on the characteristic values of the nail connections and the joist hangers. To obtain design values the capacities have to be divided by different partial factors for the material properties, the nail connection in addition multiplied with the coefficient k_{mod}.

According to EN 1990 (Eurocode – Basis of design) paragraph 6.3.5 the design value of load-carrying capacity may be determined by reducing the characteristic values of the load-carrying capacity with different partial factors.

Thus, the characteristic values of the load–carrying capacity are determined also for timber failure $F_{Rk,H}$ (obtaining the embedment strength of nails subjected to shear or the withdrawal capacity of the most loaded nail, respectively) as well as for steel plate failure $F_{Rk,S}$. The design value of the load–carrying capacity is the smaller value of both load–carrying capacities.

$$F_{Rd} = \min\left\{\frac{k_{mod} \cdot F_{Rk,H}}{\gamma_{M,H}}; \frac{F_{Rk,S}}{\gamma_{M,S}}\right\}$$

Therefore, for timber failure the load duration class and the service class are included. The different partial factors γ_M for steel or timber, respectively, are also correctly taken into account.

3.10 Mechanical resistance and stability

See annex B for characteristic load-carrying capacities of the joist hangers.

The characteristic capacities of the joist hangers are determined by calculation assisted by testing as described in the EOTA Guideline 015 clause 5.1.2. They should be used for designs in accordance with Eurocode 5 or a similar national Timber Code.

The design models allow the use of fasteners described in the table on page 13 in Annex A:

Threaded nails (ringed shank nails) in accordance to EN 14592

In the formulas in Annex B the capacities for threaded nails calculated from the formulas of Eurocode 5 are used assuming a thick steel plate when calculating the lateral nail load-carrying-capacity.

Further, the joist hangers may be fastened to a concrete structure or steel member by bolts with a diameter of 10 mm in holes with a diameter up to 2 mm larger than the bolt.

The load bearing capacities of the brackets has been determined based on the use of connector nails 4,0 x L mm in accordance with the German national approval for the nails.

The characteristic withdrawal capacity of the nails has to be determined by calculation in accordance with EN 1995-1-1: 2004, paragraph 8.3.2 (head pull-through is not relevant):

$$F_{ax,Rk} = f_{ax,k} \times d \times t_{pen}$$

Where:

$f_{ax,k}$ Characteristic value of the withdrawal parameter in N/mm²
d Nail diameter in mm
t_{pen} Penetration depth of the profiles shank in mm

Based on tests by Versuchsanstalt für Stahl, Holz und Steine, University of Kalrsruhe, the characteristic value of the withdrawal resistance for the threaded nails used can be calculated as:

$$f_{ax,k} = 50 \times 10^{-6} \times \sigma_k^2$$

Where:

σ_k Characteristic density of the timber in kg/m³

The shape of the nail directly under the head shall be in the form of a truncated cone with a diameter under the nail head which exceeds the hole diameter.

4,0 mm threaded nails with a truncated cone below the head are used as fasteners, which are particularly suitable for nailed steel-to-timber connections. The specific shape below the head causes a clamping of nails in the steel plate.

No performance has been determined in relation to ductility of a joint under cyclic testing. The contribution to the performance of structures in seismic zones, therefore, has not been assessed.

No performance has been determined in relation to the joint's stiffness properties - to be used for the analysis of the serviceability limit state.

3.11 Aspects related to the performance of the product

Corrosion protection in service class 1 and 2.

In accordance with ETAG 015 the joist hanger have a zinc coating weight of min Z275. The steel employed is S250 GD with min Z275 according to EN 10346:2009.

The stainless steel joist hangers are made from stainless steel according to EN 10088-2:2014 with $R_{p0,2} \geq 240$ N/mm² and $R_m \geq 500$ N/mm².

3.12 General aspects related to the use of the product

AV joist hangers types A, B and split are manufactured in accordance with the provisions of this European Technical Approval using the manufacturing processes as identified in the inspection of the plant by the notified inspection body and laid down in the technical documentation.

AV Joist Hangers type A, B and Split

Joist hanger connections

A joist hanger connection is deemed fit for its intended use provided:

Header – support conditions

- The header beam shall be restrained against rotation and be free from wane under the joist hanger.

  If the header carries joists only on one side the eccentricity moment from the joists $M_{ec} = R_{joist}$ ($b_{header}/2+e_{J,0}$) shall be considered at the strength verification of the header.

R_{joist}	Reaction force from the joists
b_{header}	Width of header
$e_{J,0}$	Distance from the centroid of the nails in the joist to the surface of the header

- For a header with joists from both sides but with different reaction forces a similar consideration applies.

Wood to wood connections

- Joist hangers are fastened to wood-based members by nails.
- There shall be nails in all holes or a partial nailing pattern as prescribed in Annex A-D may be used.
- The characteristic capacity of the joist hanger connection is calculated according to the manufacturer's technical documentation, dated 2008-09-12.
- The joist hanger connection is designed in accordance with Eurocode 5 or an appropriate national code.
- The gap between the end of the joist and the surface, where contact stresses can occur during loading shall be limited. This means that for joist hangers with outward flaps the gap between the surface of the end of the joist and that of the header shall be maximum 3 mm.
  Joist hangers with inward flaps the gap between the surface of the nail heads in the inward flaps and the end of the joist shall be maximum 8 mm.
- For joist hangers A, B and split the width of the joist shall be at least l+4d, where l is the length of the fasteners and d is the fastener diameter in the joist, for full nailing and partial nailing without staggering the fasteners in the joist. For nailing with staggered fasteners in the joist the width shall be at least the penetration length of the fasteners.
- The cross section of the joist at the joist hanger connection shall have sharp edges at the lower side against the bottom plate, i.e. it shall be without wane.
- The cross section of the header shall have a plane surface against the whole joist hanger.
- The width B_J of the joist shall correspond to that of the joist hanger. B_J shall not be smaller than B-3 mm, where B is the inner width of the joist hanger.
- The depth of the joist shall be so large that the top of the joist is at least 20 mm above the upper fastener in the joist.
- Nails to be used shall have a diameter, which fits the holes of the joist hangers.

Wood to concrete or steel

The above mentioned rules for wood to wood connections are applicable also for the connection between the joist and the joist hanger.

- The joist hanger shall be in close contact with the concrete or steel over the whole face. There shall be no intermediate layers in between.
- The gap between the end of the joist and the surface, where contact stresses can occur during loading shall be limited. This means that the gap between the surface of the end of the joist and that of the concrete or steel shall be maximum 3 mm.
- The bolt shall have a diameter not less than the hole diameter minus 2 mm.
- The bolts shall be placed symmetrically about the vertical symmetry line. There shall always be bolts in the 2 upper holes.
- The upper bolts shall have washers according to EN ISO 7094.

4 Assessment and verification of constancy of performance (AVCP)

4.1 AVCP system

According to the decision 97/638/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 2+.

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.

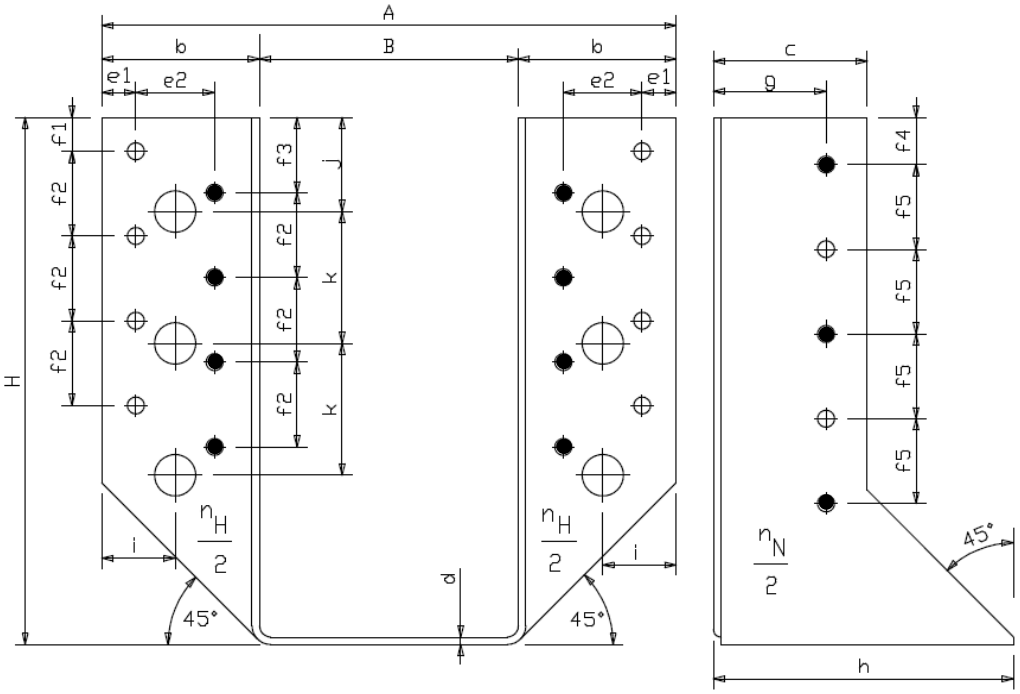
Issued in Copenhagen on 2017-12-04 by

Thomas Bruun
Managing Director, ETA-Danmark

Annex A
Product details and definitions

Joist hanger type A

Face mount hanger with external flanges. 2.0 mm thick pre-galvanized steel S250GD + Z (min Z275) according to EN 10326:2004 or from stainless steel according to EN 10088-2:2014 with $R_{p0,2} \geq 240$ N/mm² and $R_m \geq 500$ N/mm² with tolerances according to EN 10143:1993.



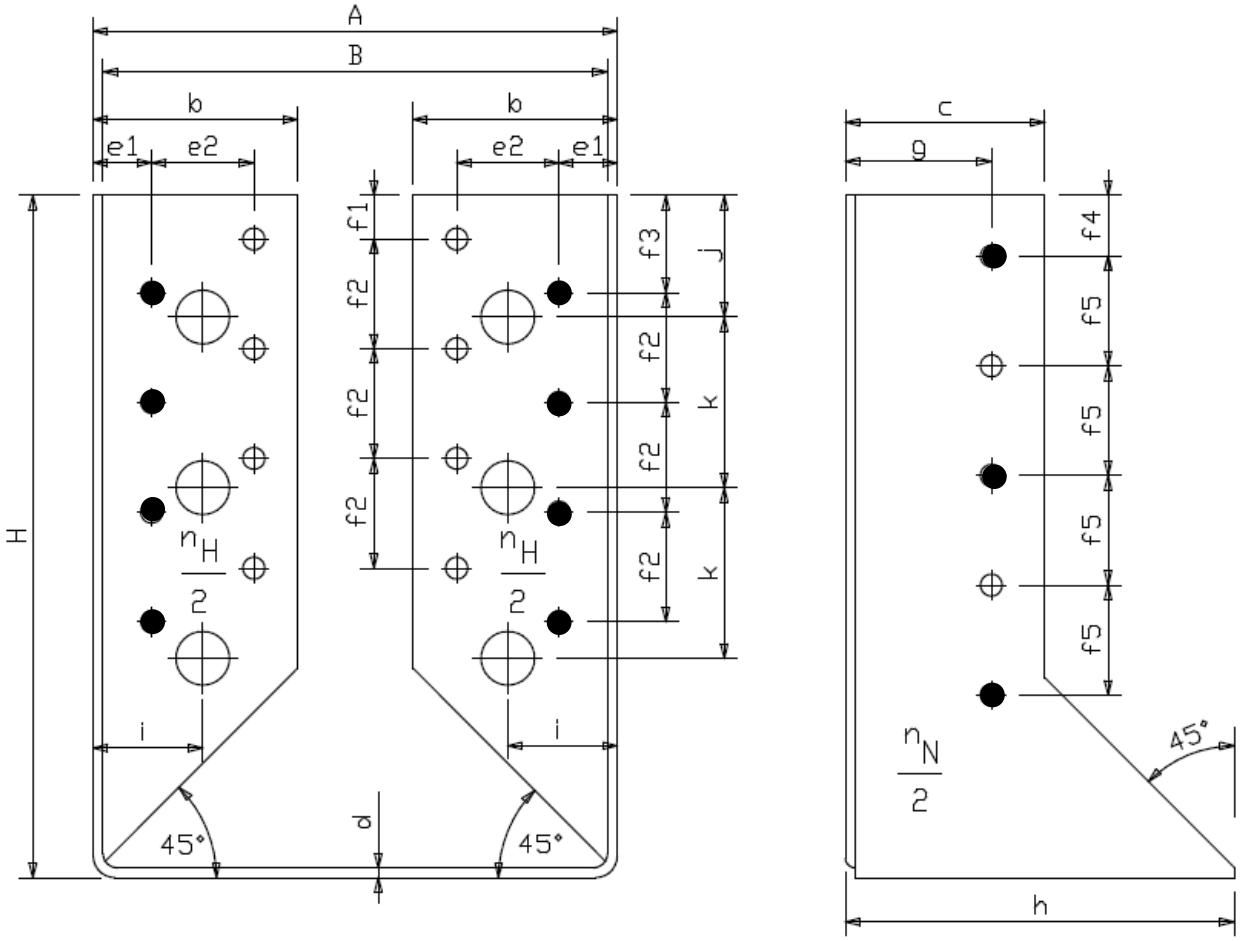
- Partial nailing; Drawing: Blank 380, 2,0 mm steel

Blank	Total n° of nail holes		Width interval		Height interval		Bolt holes		Joist hanger dimension					
	n_H	n_J	min	max	min	max	n°	d	A	e1	e2	f1	f3	f4
240	14	8	40	40	100	100	4	11	= B + 84	9	22	18	8	12
245	14	8	45	45	100	100	4	11	= B + 84	9	22	18	8	12
250	14	8	32	50	100	109	4	11	= B + 84	9	22	18	8	12
255	14	8	64	64	95	95	6	11	= B + 84	9	22	18	8	13
260	14	8	60	60	100	100	4	11	= B + 84	9	22	18	8	13
265	8	6	90	90	88	88	2	11	= B + 84	10	15	17	33	20
310	16	10	38	70	120	136	4	11	= B + 84	9	20	9	19	13
320	16	10	60	80	120	130	6	11	= B + 84	9	20	9	19	13
325	16	10	45	45	140	140	6	11	= B + 84	9	20	9	19	13
340	16	10	38	76	132	151	4	11	= B + 84	9	20	9	19	13
380	16	10	60	100	140	160	6	11	= B + 84	9	21	9	20	12,5
440	24	12	60	120	160	190	6	11	= B + 84	9	21	9	19	19
500	26	14	60	140	180	220	6	11	= B + 84	8	22	25	15	15
560	30	16	120	160	200	220	6	11	= B + 84	9	22	25	15	15
620	34	18	120	180	220	250	6	11	= B + 84	9	22	25	15	15

Joist hanger's height = (blank – width)/2

Joist hanger type B

Face mount hanger with interior flanges. 2.0 mm thick pre-galvanized steel S250GD + Z (min Z275) according to EN 10326:2004 or from stainless steel according to EN 10088-2:2014 with $R_{p0,2} \geq 240$ N/mm² and $R_m \geq 500$ N/mm² with tolerances according to EN 10143:1993.



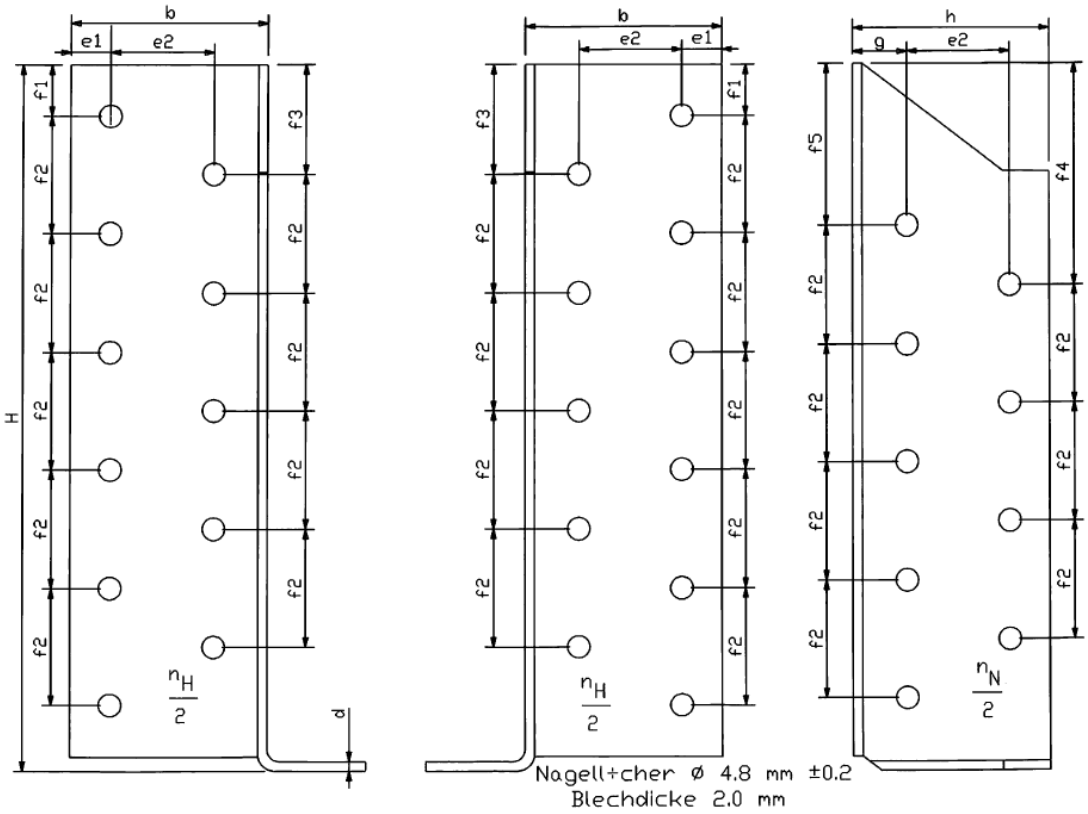
- Partial nailing; Drawing: Blank 380, 2,0 mm steel

Blank	Total n° of nail holes		Width interval		Height interval		Joist hanger dimension				
	n_H	n_J	min	max	min	max	e1	e2	f1	f3	f4
240	8	8	51	51	94	94	11	-	-	8	12
245	8	8	45	45	100	100	11	-	-	8	12
250	8	8	38	38	106	106	11	-	-	8	12
255	8	8	64	64	95	95	11	-	-	8	13
260	8	8	60	60	100	100	11	-	-	8	13
265	8	6	90	90	88	88	17	20	17	33	20
310	8	10	64	70	120	123	13	-	-	19	13
320	16	10	80	80	120	120	13	20	9	19	13
340	8/16	10	64	76	132	138	13	-/20	-/9	19	13
380	8/16	10	64	100	140	158	12	-/21	-/9	20	12,5
440	24	12	76	120	160	182	12	21	9	20	19
500	26	14	80	140	180	210	12	20	25	15	15

Joist hanger's height = (blank – width)/2

Joist hanger type split

Face mount hanger with external flanges. 2.0 mm thick pre-galvanized steel S250GD + Z (min Z275) according to EN 10326:2004 from stainless steel according to EN 10088-2:2014 with $R_{p0,2} \geq 240$ N/mm² and $R_m \geq 500$ N/mm² with tolerances according to EN 10143:1993.



- Drawing: Size 24 x 148, 2,0 mm steel

Size	Total n° of nail holes	
	n_H	n_J
24 x 148	22	18

Fastener types and sizes

NAIL diameter	Length Min – max	Nail type
4.0	40 - 100	Ringed shank nails according to prEN 14592

In the formulas in Annex B the capacities for threaded nails calculated from the formulas of Eurocode 5 are used assuming a thick steel plate when calculating the lateral nail load-carrying-capacity. The load bearing capacities of the joist hangers has been determined based on the use of connector nails 4,0 x L mm in accordance with the German national approval for the nails. The characteristic withdrawal capacity of the nails has to be determined by calculation in accordance with EN 1995-1-1: 2004, paragraph 8.3.2 (head pull-through is not relevant):

$F_{ax,Rk} = f_{1,k} \times d \times t_{pen}$

Where:

$f_{1,k}$ Characteristic value of the withdrawal parameter in N/mm^2
d Nail diameter in mm
t_{pen} Penetration depth of the profiled shank in mm

Based on tests by Versuchsanstalt für Stahl, Holz und Steine, University of Karlsruhe, the characteristic value of the withdrawal resistance for the threaded nails used can be calculated as:

$f_{1,k} = 50 \times 10^{-6} \times \rho_k^2$

Where:

ρ_k Characteristic density of the timber in kg/m^3

The shape of the nail directly under the head shall be in the form of a truncated cone with a diameter under the nail head which exceeds the hole diameter.

BOLTS diameter	Correspondence Hole diameter	Bolts type
10.0	Max. 2 mm. larger than the bolt diameter	See specification of the manufacturer

Annex B
Characteristic values of load-carrying-capacities

Characteristic capacities of the joist hanger connections with nails only

The downward and the upward directed forces are assumed to act in the middle of the joist. The lateral force is assumed to act at an distance $e_{J,90}$ above the centre of gravity of the nails in the joist.

Two nails patterns are specified. A full nailing pattern, where there are nails in all the holes and a partial nailing pattern, where the number of nails in the joist and the header are at least half the numbers specified for full nailing. The nails in the joist may be staggered. The nails in the header shall be put in the holes closest to the bend line.

For AV joist hangers the width of the joist shall be at least l+4d, where l is the length of the nails and d is the diameter of the nails in the joist, for full nailing and partial nailing without staggering the nails in the joist. For partial nailing with staggered nails in the joist the width shall be at least the penetration length of the nails.

B.1 Joist hangers types A and B fastened with nails

Force downward toward the bottom plate:

$$F_{Z,Rd} = \min \begin{cases} (n_J + 2) \cdot F_{v,J,Rd} \\ \dfrac{1}{\sqrt{\left(\dfrac{1}{n_H \cdot F_{v,H,Rd}}\right)^2 + \left(\dfrac{1}{k_{H,1} \cdot F_{ax,H,Rd}}\right)^2}} \end{cases} \qquad \text{(B.1.1.1)}$$

Force upward away from the bottom plate:

$$F_{Z,Rd} = \min \begin{cases} n_J \cdot F_{v,J,Rd} \\ \dfrac{1}{\sqrt{\left(\dfrac{1}{n_H \cdot F_{v,H,Rd}}\right)^2 + \left(\dfrac{1}{k_{H,2} \cdot F_{ax,H,Rd}}\right)^2}} \end{cases} \qquad \text{(B.1.1.2)}$$

Lateral force:

$$F_{Y,Rd} = \min \begin{cases} \dfrac{n_J \cdot F_{v,J,Rd}}{\sqrt{\left(\dfrac{2 \cdot \sqrt{e_{J,0}^2 + e_{J,90}^2}}{b_J}\right)^2 + \left(\dfrac{F_{v,J,Rd}}{F_{ax,J,Rd}}\right)^2}} \\ \dfrac{F_{v,H,Rd}}{\sqrt{\left(\dfrac{1}{n_H} + \dfrac{e_H}{e_1}\right)^2 + \left(\dfrac{e_H}{e_2}\right)^2}} \end{cases} \qquad \text{(B.1.1.3)}$$

n_J total number of nails in both sides of the joist

n_H total number of nails in the side of the header

$F_{v,Rd}$ Characteristic lateral load-carrying capacity of the fasteners in the joist or in the header indicated by the indices J or H

$F_{ax,Rd}$ Characteristic axial load-carrying capacity of the fasteners in the joist or in the header indicated by the indices J or H

b_J width of the joist hanger, see figure B1.

$e_{J,90}$ distance of the lateral force above the centre of gravity of the nails in the joist, see figure B1.

$e_{J,0}$ distance from the nails in the joist to the surface of the header, see figure B1.

e_H distance of the lateral force above the centre of gravity of the nails in the header.

e_1 joist hanger dimension, see Annex C

e_2 joist hanger dimension, see Annex C

$k_{H,1}$ form factor, see Annex C

$k_{H,2}$ form factor, see Annex C

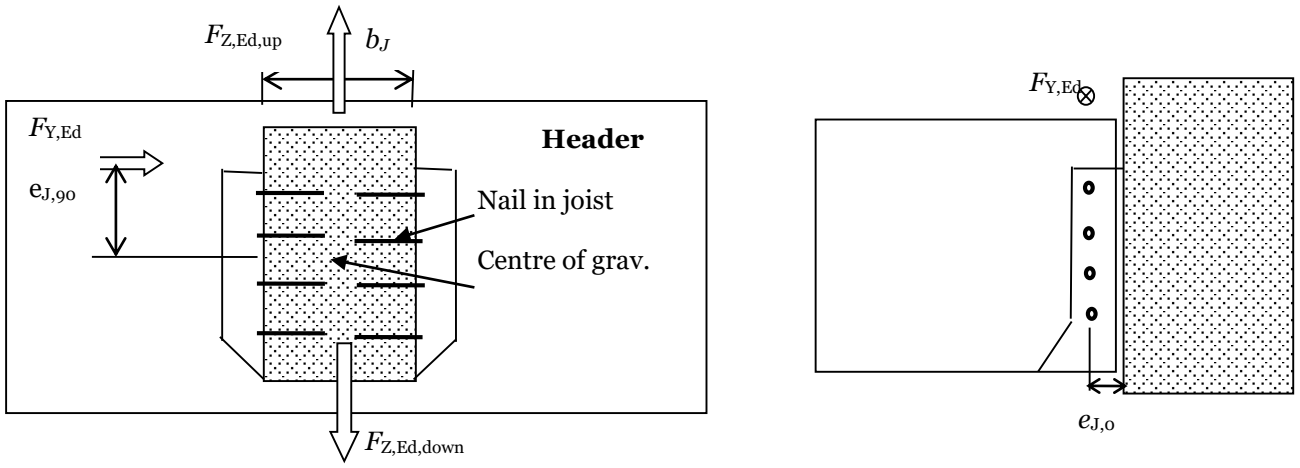


Figure B1: Definition of $e_{J,90}$ and $e_{J,0}$

B.1.2 Combined forces

In case of combined forces shall the following inequality be fulfilled:

$$\left(\frac{F_{Y,Ed}}{F_{Y,Rd}}\right)^2 + \left(\frac{F_{Z,Ed}}{F_{Z,Rd}}\right)^2 \leq 1 \qquad \text{(B.1.2.1)}$$

B.2 One pair of joist hangers type split fastened with nails

Type	Force downward towards to or upward away from the bottom plate $F_{Z,Rk}$ [kN]	Lateral Force $F_{Y,Rk}$ [kN]	
	Timber	Timber	Steel
24 x 148	24,1	9,70	8,53
For timber or wood based material with a lower characteristic density than 350 kg/m^3 the load-carrying capacities shall be reduced by the k_{dens} factor: $k_{dens} = \left(\frac{\rho_k}{350}\right)^2$ where ρ_k is the characteristic density of the timber in kg/m^3.			

B.2.2 Combined forces

If the forces $F_{Y,Ed}$ and $F_{Z,Ed}$ act at the same time or if $e_H \neq 0$, the following inequality shall be fulfilled:

$$\left(\frac{F_{Y,Ed}}{F_{Y,Rd}}\right)^2 + \left(\frac{F_{Z,Ed} + 2 \cdot \Delta F_{Z,Ed}}{F_{Z,Rd}}\right)^2 \leq 1 \qquad \text{(B.2.1)}$$

Where:

$$\Delta F_{Z,Ed} = F_{Y,Ed} \cdot \frac{e_H}{B} \qquad \text{(B.2.2)}$$

B.3 Characteristic capacities of the joist hanger type A connections with bolts

For joist hangers type A connected to a wall of concrete, lightweight concrete or to a steel member the assumptions for the calculation of the load-carrying capacity of the connection are:

- The transfer of force from the joist to the joist hanger is as for a wood-wood connection, see clause B.1;
- The bolts shall always be positioned symmetrically about the vertical axis of the joist hanger;
- Washers according to EN ISO 7094 shall be installed at least under the upper 2 bolt heads or nuts.

Description of the static model

For a downward directed force toward the bottom plate the static behavior is basically the same as for a wood-wood connection with nails.

The nails in the joist are subjected to a lateral force, which is equally distributed over all nails in the joist.

Since the concrete and steel have a larger compressive strength than timber subjected perpendicular to the grain the rotation point may be assumed positioned at the top of the bottom plate.

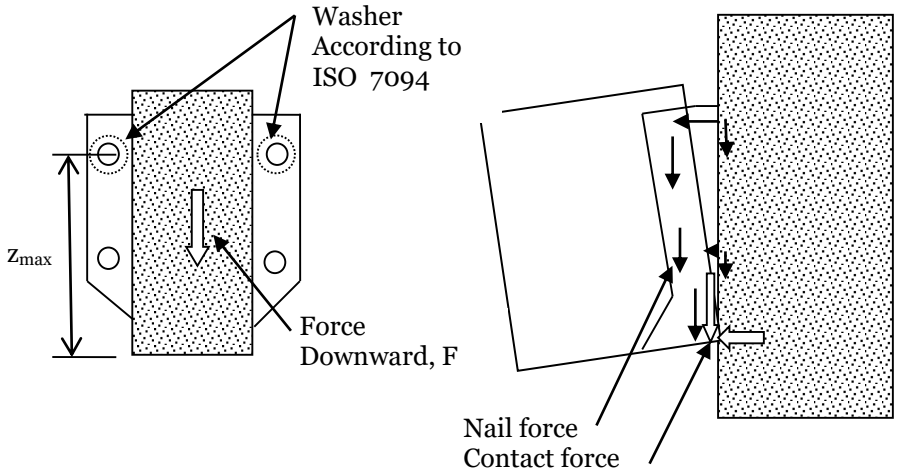


Figure B2 Left: Cross section in joist. Right: The joist will deflect and rotate, at the bottom a contact force will occur at the bottom plate, and the withdrawal forces in the bolts in the wall will vary linearly as assumed for nailed connections in the header.

The forces in the bolts will be partly lateral forces, partly withdrawal forces. The lateral forces are distributed evenly over all bolts. The withdrawal forces are on the safe side assumed to be taken by the 2 upper bolts with washers. The maximum withdrawal force in a upper bolt can be calculated from

$$F_{ax,bolt} = \frac{F \cdot e_{J,0}}{2 \cdot z_{max}} \qquad (B.3.1)$$

Where

F downward directed force toward the bottom plate;

$e_{J,0}$ eccentricity = distance from the nail column in the joist to the surface of the header;

z_{max} max distance from upper bolt to the bottom plate (rotation point).

The upper 2 bolts are critical. They are subjected to a lateral force and a withdrawal force. The lateral force is determined assuming an even distribution of the downward force F.

$$F_{lat,bolt} = F / n_{bolt} \qquad (B.3.2)$$

Characteristic capacities of a bolted joist hanger connection

The Characteristic capacity of the connection between the joist and the joist hanger may be calculated from the same assumptions and formulas as for joist hangers nailed to a wooden header beam.

$$F_{Z,Rk} = (n_J + 2) \cdot F_{v,J,Rk} \quad \text{for threaded nails} \quad \text{(B.3.3)}$$

The upper 2 bolts are critical. They are subjected to a lateral force calculated from formula (B.3.2).

The withdrawal force in an upper bolt is calculated from (B.3.1).

Where

F downward directed force toward the bottom plate

n_{bolt} total number of bolts in the joist hanger

$e_{J,0}$ eccentricity = distance from the nail column in the joist to the surface of the header

z_{max} max distance from the upper bolt to the bottom plate (rotation point)

It shall be verified by the design of the bolted connection that the upper bolts have sufficient load-carrying capacity to carry the combined lateral and axial forces.

From the Characteristic load-carrying-capacity of the bearing resistance between the bolt and the plate of the joist hanger the following maximum characteristic capacity of the joist hanger connection can be determined.

$$F_{bear,Rk} = n_{bolt} \cdot f_{u,k} \cdot d \cdot t \quad \text{(B.3.4)}$$

where

n_{bolt} total number of bolts in the 2 flaps

$f_{u,k}$ characteristic ultimate tensile strength of the steel

d diameter of the bolt

t thickness of the steel plate of the joist hanger

The characteristic load-carrying capacity of the joist hanger connections is the minimum of:

- The capacity determined from (B.3.3) from the fasteners in the joist;
- The capacity determined from (B.3.4) from the embedding strength of the steel plate against the bolt;
- The capacity controlled by the bolt forces given by (B.3.1) and (B.3.2).

Annex C
Form factors $k_{H,1}$ and $k_{H,2}$ and dimensions e_1, e_2 and $e_{J,0}$

Table C1: AV Joist hanger type A with external flanges:
Form factors $k_{H,1}$ and $k_{H,2}$ and dimensions e_1, e_2 and $e_{J,0}$

B [mm]	H [mm]	n_H	n_J	$k_{H,1}$	$k_{H,2}$	e_1 [mm]	e_2 [mm]	$e_{J,0}$ [mm]	n_H	n_J	$k_{H,1}$	$k_{H,2}$	e_1 [mm]	e_2 [mm]	$e_{J,0}$ [mm]
		Full nailing							Partial nailing						
40	100	14	8	17,1	7,16	1005	569	31	8	4	10,1	4,41	390	377	31
45	100	14	8	17,1	7,16	1102	596	31	8	4	10,1	4,41	433	387	31
32	109	14	8	20,5	6,45	861	527	31	8	4	12,0	3,97	328	364	31
38	106	14	8	19,3	6,67	967	558	31	8	4	11,3	4,11	373	373	31
50	100	14	8	17,1	7,16	1205	623	31	8	4	10,1	4,41	479	399	31
60	100	14	8	17,7	7,40	1429	680	30	8	4	10,4	4,55	582	426	30
64	95	14	8	15,8	7,88	1525	704	30	8	4	9,38	4,85	626	437	30
38	136	16	10	32,0	7,72	1092	735	31	8	6	17,8	3,09	348	381	31
50	130	16	10	29,3	8,14	1339	808	31	8	6	16,4	3,25	444	409	31
70	120	16	10	24,9	8,94	1824	939	31	8	6	14,2	3,58	641	467	31
45	140	16	10	33,8	7,46	1232	777	31	8	6	18,7	2,99	402	397	31
60	130	16	10	29,3	8,14	1570	872	31	8	6	16,4	3,25	537	437	31
80	120	16	10	24,9	8,94	2100	1007	31	8	6	14,2	3,58	756	499	31
38	151	16	10	38,8	6,84	1092	735	31	8	6	21,3	2,74	348	381	31
60	140	16	10	33,8	7,46	1570	872	31	8	6	18,7	2,99	537	437	31
64	138	16	10	32,9	7,59	1669	898	31	8	6	18,3	3,04	577	449	31
70	135	16	10	31,5	7,79	1824	939	31	8	6	17,6	3,11	641	467	31
76	132	16	10	30,2	7,99	1987	979	31	8	6	16,9	3,20	709	486	31
60	160	16	10	41,6	8,38	1435	897	30	8	6	23,0	3,35	487	457	30
64	158	16	10	40,6	8,50	1522	922	30	8	6	22,5	3,40	522	467	30
70	155	16	10	39,2	8,69	1658	960	30	8	6	21,7	3,47	577	484	30
76	152	16	10	37,8	8,88	1802	999	30	8	6	21,0	3,55	637	501	30
80	150	16	10	36,9	9,02	1902	1026	30	8	6	20,5	3,61	678	513	30
90	145	16	10	34,6	9,38	2166	1094	30	8	6	19,4	3,75	789	545	30
100	140	16	10	32,3	9,76	2451	1163	30	8	6	18,2	3,90	910	578	30
60	190	24	12	64,2	18,5	1771	1546	32	12	6	34,7	8,04	639	837	32
70	185	24	12	61,1	19,1	2011	1626	32	12	6	33,0	8,28	737	862	32
76	182	24	12	59,2	19,4	2165	1677	32	12	6	32,1	8,44	778	874	32
80	180	24	12	57,9	19,6	2273	1712	32	12	6	31,4	8,54	845	893	32
100	170	24	12	51,7	20,9	2862	1896	32	12	6	28,2	9,11	1093	970	32
116	162	24	12	46,9	22,1	3396	2052	32	12	6	25,7	9,62	1324	1040	32
120	160	24	12	45,7	22,4	3538	2092	32	12	6	25,1	9,75	1386	1058	32
60	220	26	14	81,8	20,8	1837	1723	32	14	8	44,5	11,7	785	1121	32
76	212	26	14	76,2	21,7	2227	1856	32	14	8	41,5	12,2	957	1148	32
80	210	26	14	74,8	22,0	2333	1891	32	14	8	40,7	12,3	1004	1159	32
100	200	26	14	67,9	23,2	2915	2082	32	14	8	37,1	13,0	1270	1229	32
120	190	26	14	61,2	24,6	3583	2287	32	14	8	33,5	13,8	1583	1319	32
140	180	26	14	54,6	26,2	4339	2503	32	14	8	30,0	14,7	1942	1421	32
120	220	30	16	86,8	33,6	3682	2771	31	16	8	46,9	18,5	1632	1609	31
140	210	30	16	78,9	35,4	4421	3005	31	16	8	42,8	19,5	1980	1711	31
160	200	30	16	71,3	37,4	5247	3250	31	16	8	38,7	20,6	2373	1825	31
120	250	34	18	118	44,3	3884	3341	30	18	10	63,2	24,2	1734	1954	30
140	240	34	18	109	46,4	4618	3587	30	18	10	58,3	25,3	2076	2051	30

Table C1 (contd.): AV Joist hanger type A with external flanges:
Form factors $k_{H,1}$ and $k_{H,2}$ and dimensions e_1, e_2 and $e_{J,0}$

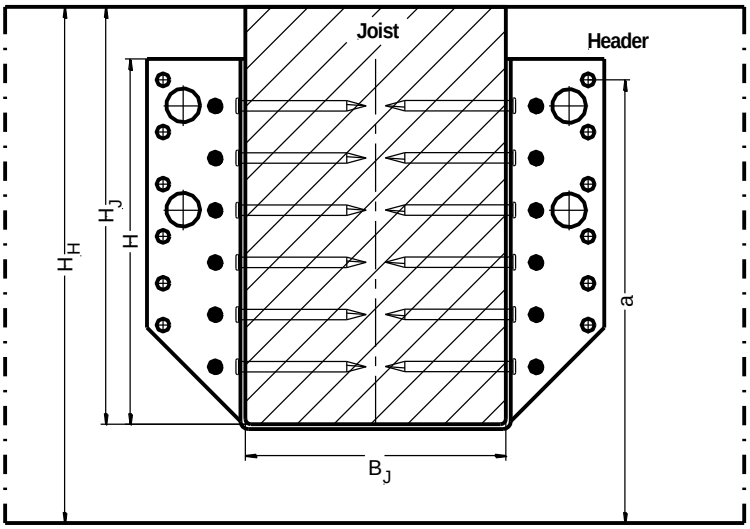
B [mm]	**H [mm]**	$\mathbf{n_H}$	$\mathbf{n_J}$	$\mathbf{k_{H,1}}$	$\mathbf{k_{H,2}}$	$\mathbf{e_1}$ **[mm]**	$\mathbf{e_2}$ **[mm]**	$\mathbf{e_{J,0}}$ **[mm]**	$\mathbf{n_H}$	$\mathbf{n_J}$	$\mathbf{k_{H,1}}$	$\mathbf{k_{H,2}}$	$\mathbf{e_1}$ **[mm]**	$\mathbf{e_2}$ **[mm]**	$\mathbf{e_{J,0}}$ **[mm]**
		Full nailing							Partial nailing						
160	230	34	18	99,7	48,7	5437	3849	30	18	10	53,5	26,5	2463	2165	30
180	220	34	18	90,8	51,1	6341	4124	30	18	10	48,9	27,9	2895	2293	30
90	88	8	6	9,57	0,86	3311	516	34	4	4	5,54	0,25	1303	252	34

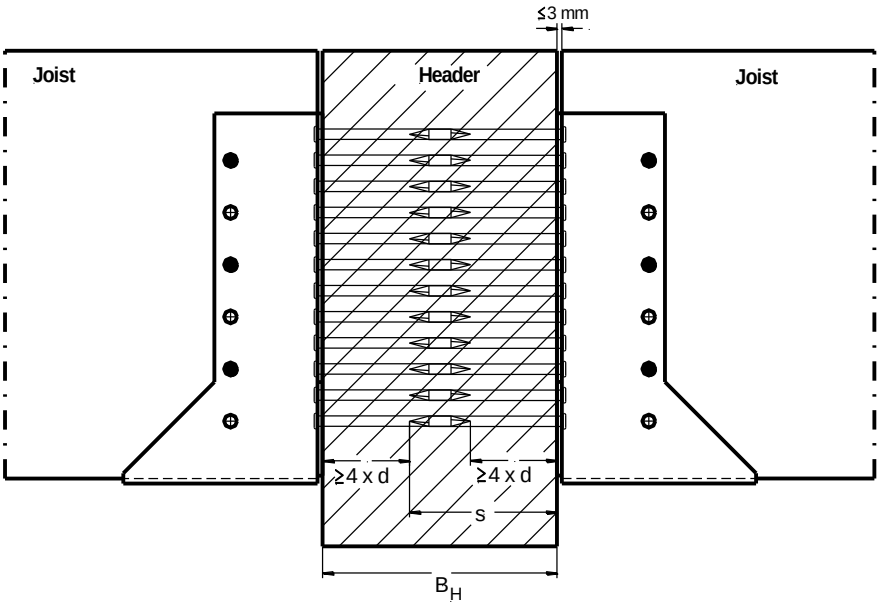
Table C2: Joist hanger type B with interior flanges:
Form factors $k_{H,1}$ and $k_{H,2}$ and dimensions e_1, e_2 and $e_{J,0}$

B [mm]	**H [mm]**	$\mathbf{n_H}$	$\mathbf{n_J}$	$\mathbf{k_{H,1}}$	$\mathbf{k_{H,2}}$	$\mathbf{e_1}$ **[mm]**	$\mathbf{e_2}$ **[mm]**	$\mathbf{e_{J,0}}$ **[mm]**	$\mathbf{n_H}$	$\mathbf{n_J}$	$\mathbf{k_{H,1}}$	$\mathbf{k_{H,2}}$	$\mathbf{e_1}$ **[mm]**	$\mathbf{e_2}$ **[mm]**	$\mathbf{e_{J,0}}$ **[mm]**
		Full nailing							Partial nailing						
45	100	8	8	10,1	4,41	156	404	31	8	4	10,1	4,41	156	404	31
38	106	8	8	11,3	4,11	137	480	31	8	4	11,3	4,11	137	480	31
51	94	8	8	8,88	4,75	177	374	31	8	4	8,88	4,75	177	374	31
60	100	8	8	10,4	4,55	215	358	30	8	4	10,4	4,55	215	358	30
64	95	8	8	9,38	4,85	235	358	30	8	4	9,38	4,85	235	358	30
64	123	8	10	12,6	3,84	215	358	31	8	6	12,6	3,84	215	358	31
70	120	8	10	12,0	3,97	246	359	31	8	6	12,0	3,97	246	359	31
80	120	16	10	24,9	8,94	451	544	31	8	6	14,2	3,58	307	370	31
64	138	8	10	16,0	3,31	215	358	31	8	6	16,0	3,31	215	358	31
70	135	8	10	15,3	3,41	246	359	31	8	6	15,3	3,41	246	359	31
76	132	16	10	30,2	7,99	418	542	31	8	6	16,9	3,20	281	364	31
64	158	8	10	20,1	3,66	218	409	30	8	6	20,1	3,66	218	409	30
70	155	8	10	19,1	3,78	256	403	30	8	6	19,1	3,78	256	403	30
76	152	16	10	38,3	8,66	437	614	30	8	6	21,0	3,55	288	405	30
100	140	16	10	32,7	9,52	666	655	30	8	6	18,2	3,90	454	447	30
76	182	24	12	59,2	19,4	702	1378	32	12	6	32,1	8,44	426	836	32
80	180	24	12	57,9	19,6	734	1346	32	12	6	31,4	8,54	451	827	32
100	170	24	12	51,7	20,9	948	1303	32	12	6	28,2	9,11	604	830	32
120	160	24	12	45,7	22,4	1249	1374	32	12	6	25,1	9,75	800	880	32
80	210	26	14	72,0	22,4	833	1666	32	14	8	39,3	12,6	583	1167	32
100	200	26	14	67,9	23,2	1060	1590	32	14	8	37,1	13,0	747	1120	32
120	190	26	14	61,2	24,6	1370	1644	32	14	8	33,5	13,8	957	1148	32
140	180	26	14	54,6	26,2	1767	1767	32	14	8	30,0	14,7	1213	1213	32
90	88	8	6	7,26	2,78	260	208	34	4	4	4,40	0,99	193	154	34

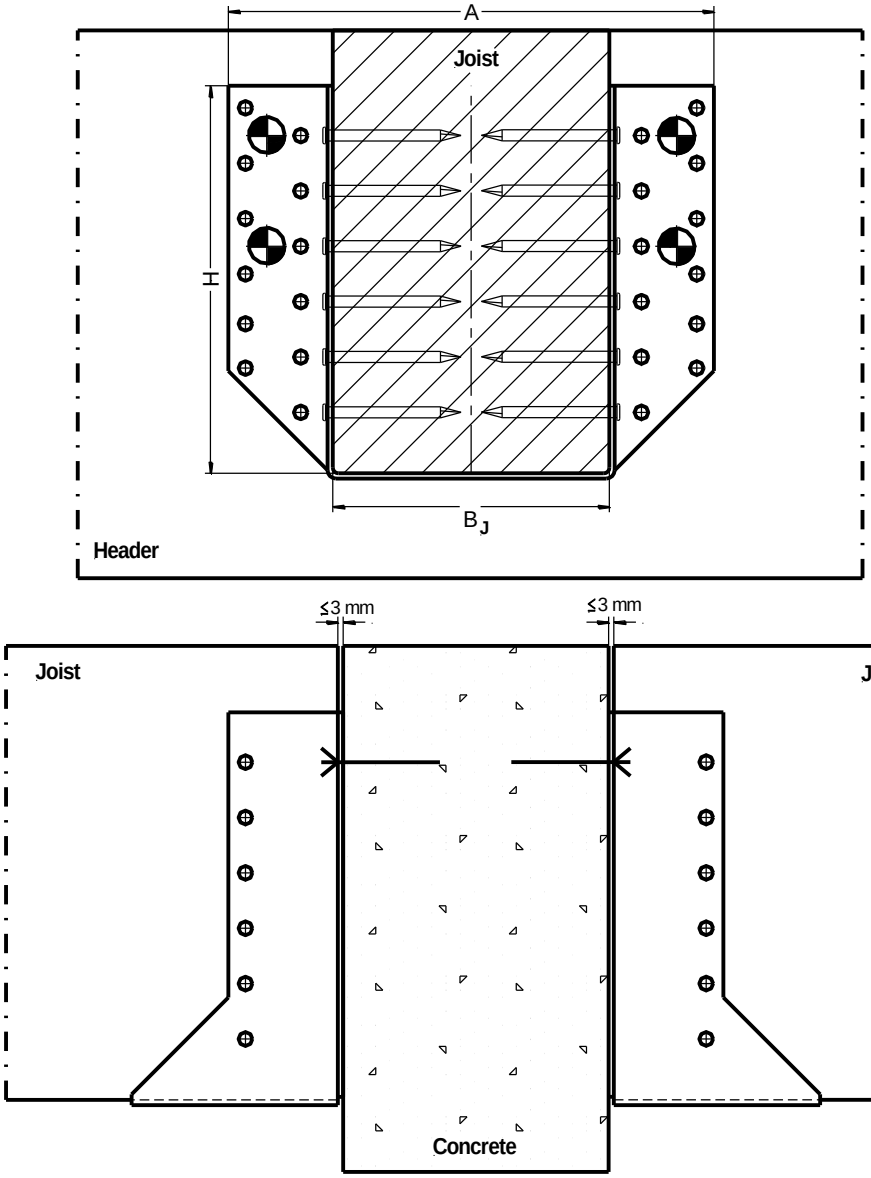
Annex D
Installation of joist hangers

Joist hanger in wood/wood connection





Joist hanger connected to concrete, lightweight concrete or a steel member by bolts



Bolts M10
Washer according to EN ISO 7094