Deutsches Institut für Bautechnik
DIBt

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Approval body for construction products and types of construction

Bautechnisches Prüfamt

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European Technical Assessment

ETA-08/0184 of 5 February 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	BB joist hangers type 1, 2, 3 and 4
Product family to which the construction product belongs	Three-dimensional nailing plates (Joist hangers for wood to wood connections and wood to concrete or steel connections)
Manufacturer	BB Stanz- und Umformtechnik GmbH Nordhäuser Straße 42 06536 Berga DEUTSCHLAND
Manufacturing plant	BB Stanz- und Umformtechnik GmbH, 06536 Berga
This European Technical Assessment contains	46 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	ETAG 015, used as EAD according to Article 66 Paragraph 3 of Regulation (EU) No 305/2011.
This version replaces	ETA-08/0184 issued on 30 May 2013

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Specific part

1 Technical description of the product

BB joist hangers type 1, 2, 3 and 4 (1, 2-A, 3-A, type 4-A/B-2/2,5-S and type 4-A/B-2/2,5-L) are one-piece non-welded, face-fixed joist hangers to be used in timber to timber connections as well as in connections between a timber joist and a concrete structure or a steel member. They are installed as connections between wood based members according to Annex 2.

The joist hangers are made from pre-galvanized steel Grade S250GD+Z (min Z275) according to EN 10346[1]. Design, dimensions, hole positions and drawings of blank are shown in Annex 1 and 4.

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

The BB joist hangers type 1, 2, 3 and 4 are intended to be used in making joist-header-connections in load-bearing timber structures. They are also intended for use in making an end-grain connection between a timber joist and a concrete structure or a steel member.

The performances given in Section 3 are only valid if the BB joist hangers are used in compliance with the specifications and conditions given in Annex 1 to 5.

The verifications and assessment methods on which this European Technical Assessment is based lead to the assumption of a working life of the BB joist hangers 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
Load-carrying capacity	See Annex 3 and 5
Stiffness	No performance assessed
Ductility in cyclic testing	No performance assessed
Durability	See Annex 2

3.2 Safety in case of fire (BWR 2)

Essential characteristic	Performance
Reaction to fire	Class A1
Resistance to fire	No performance assessed

[1] EN 10346:2009 Continuously hot-dip coated steel flat products -Technical delivery conditions

3.3 Hygiene, health and the environment (BWR 3)

Essential characteristic	Performance
Release of dangerous substances	No performance assessed

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

In accordance with ETAG 015 the applicable European legal act is: [97/638/EC (EU)].

The system to be applied is: 2+

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 5 February 2019 by Deutsches Institut für Bautechnik

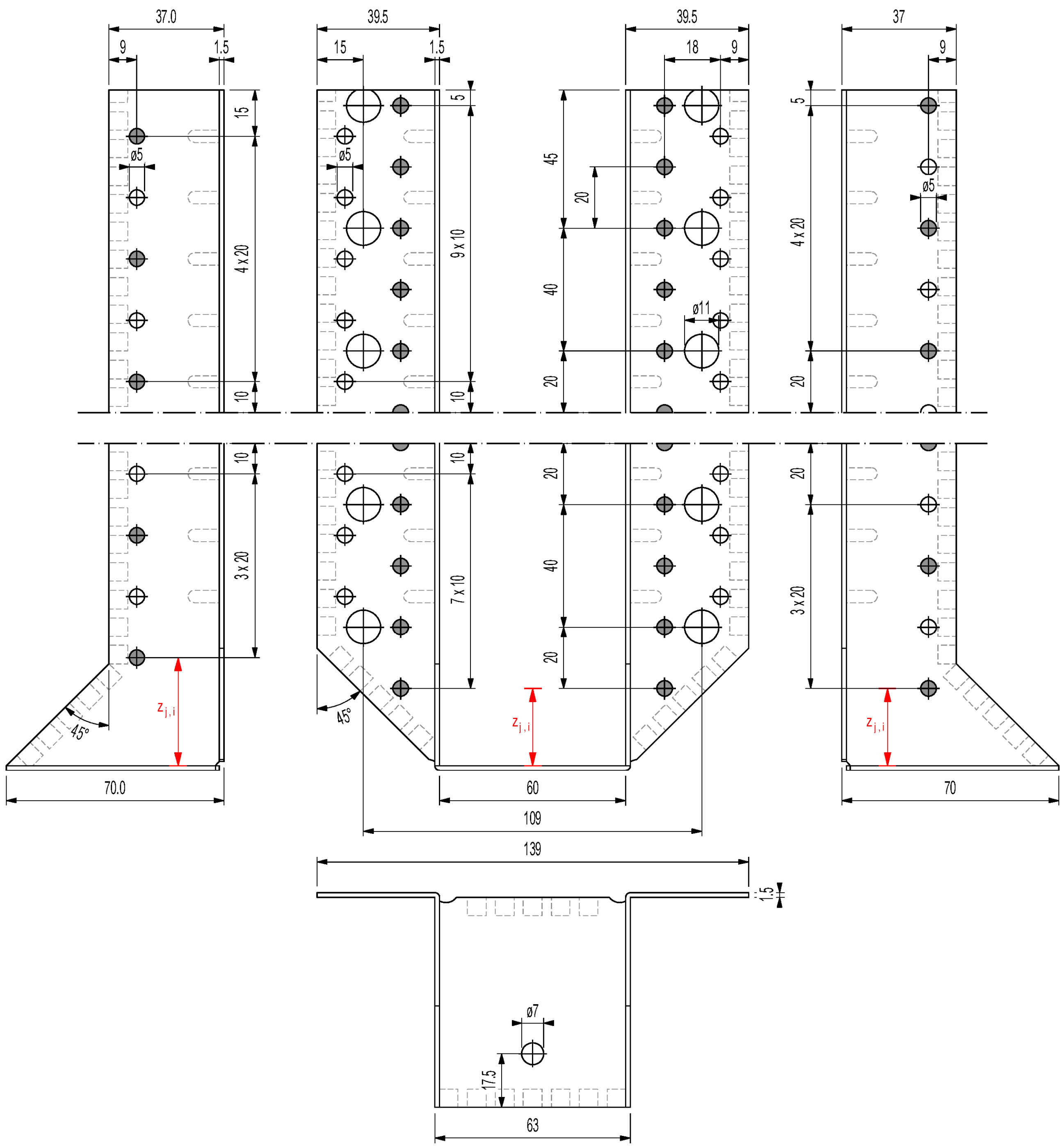
Dr.-Ing. Lars Eckfeldt
p. p. Head of Department

beglaubigt:
Baumann

Annex 1 Technical description of the product

BKA Typ 1: Example for partial nailing / screwing

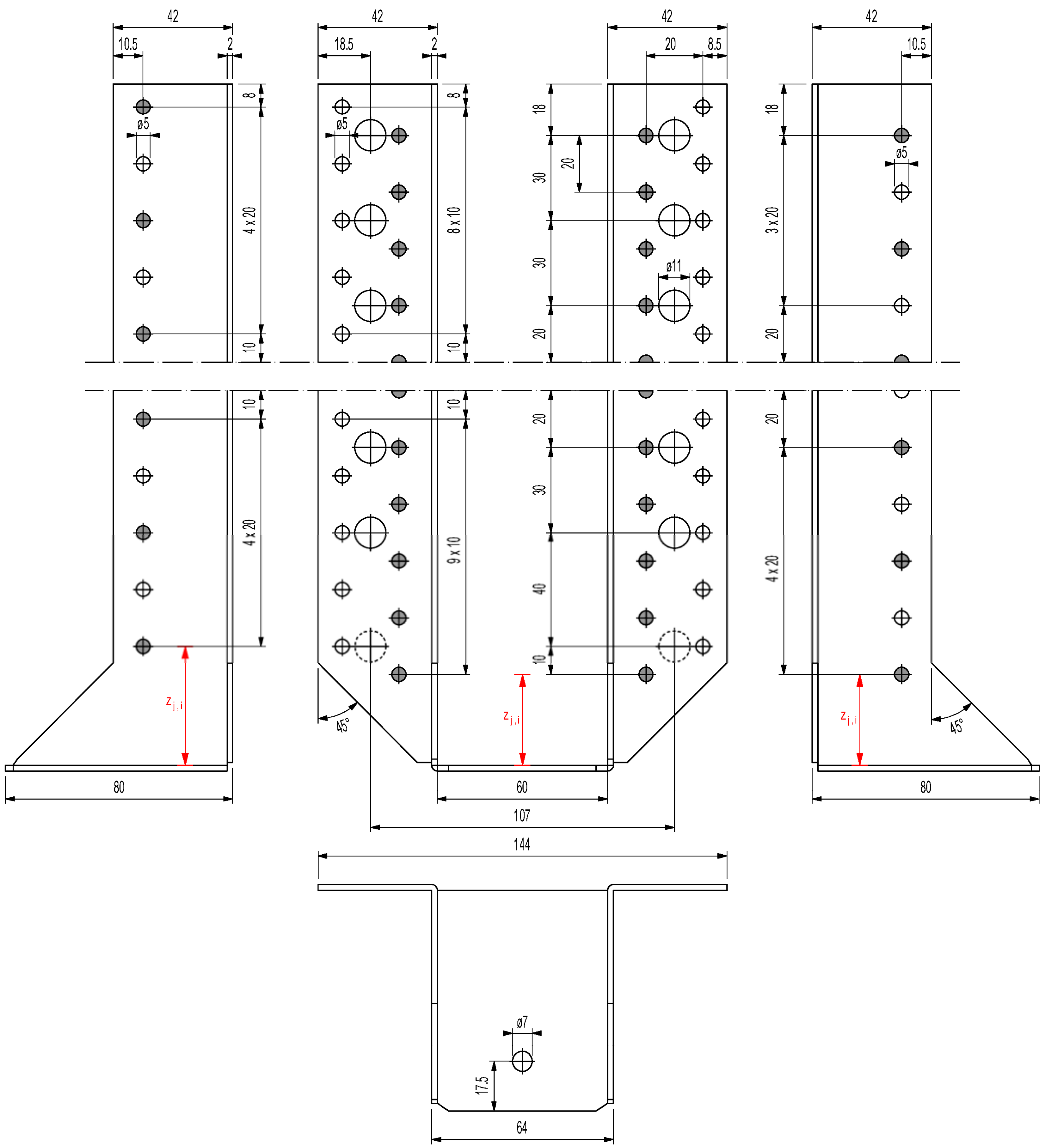
Allowed load directions: Fy and Fz



●	Partial nailing / screwing
Analog execution for partial nailing of joist hanger with interior flangs.	

BKA Typ 2-A: Example for partial nailing / screwing

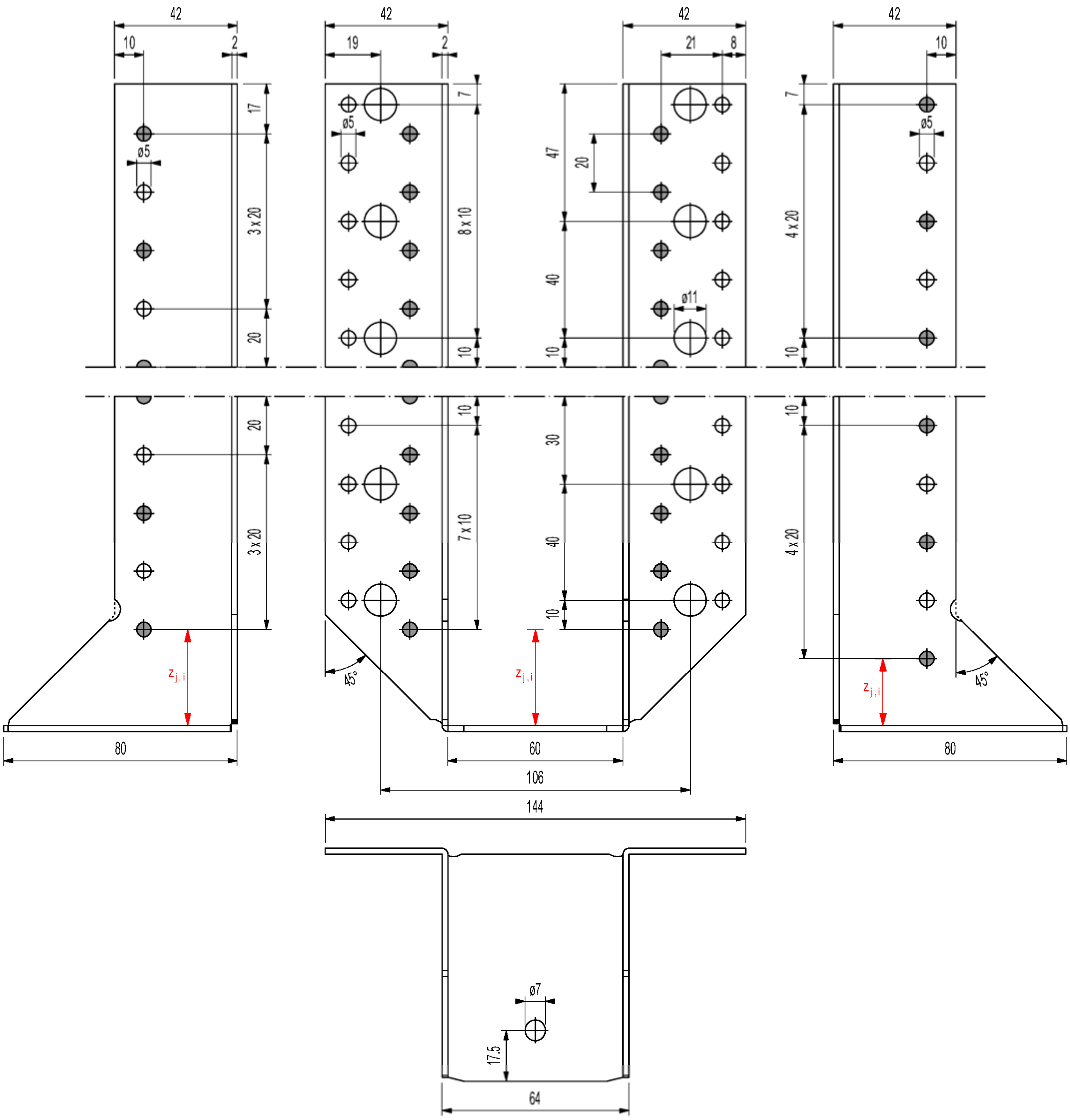
Allowed load directions: Fy and Fz



●	Partial nailing / screwing
Analog execution for partial nailing of joist hanger with interior flangs.	

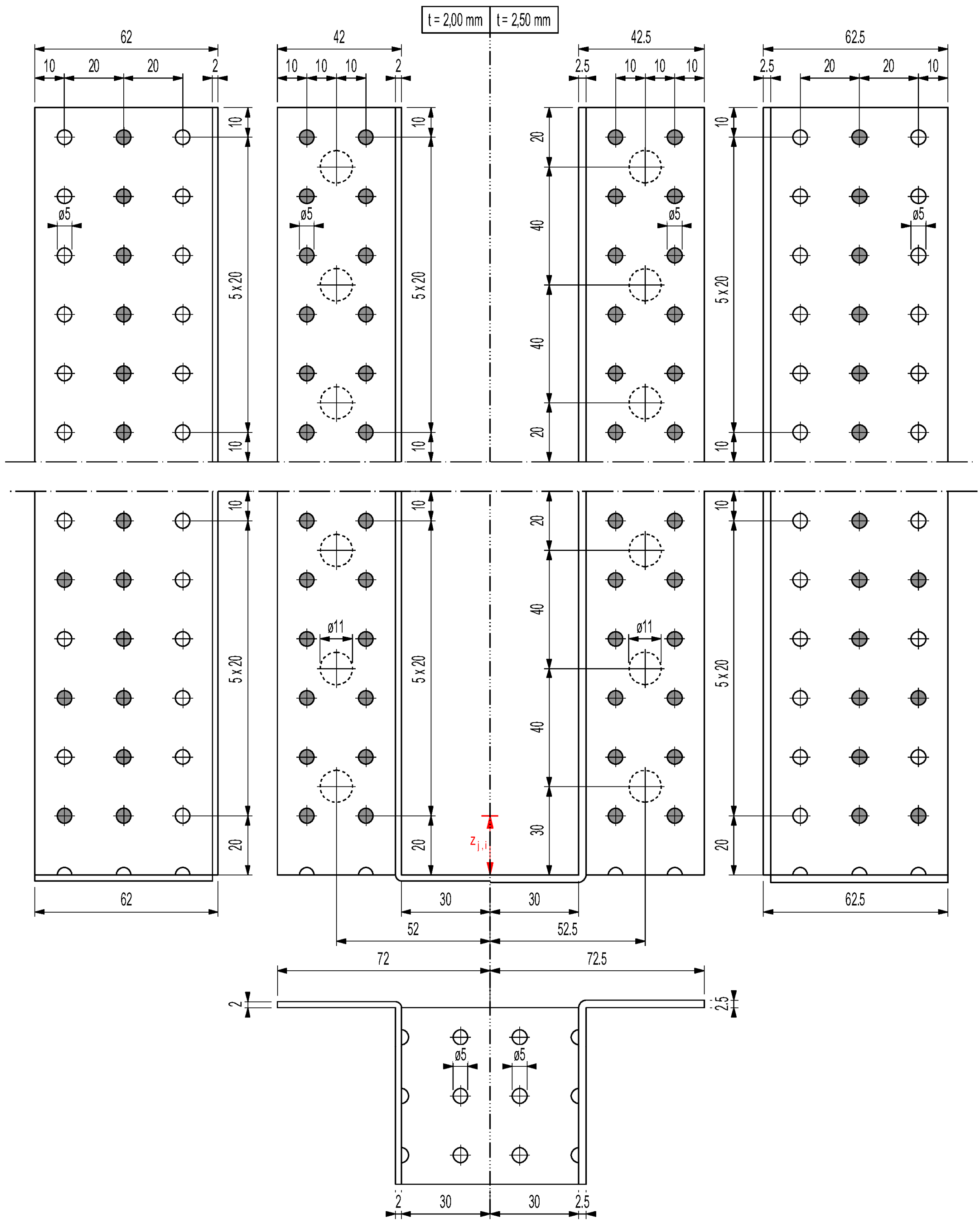
BKA Typ 3-A: Example for partial nailing / screwing

Allowed load directions: Fy and Fz



●	Partial nailing / screwing
Analog execution for partial nailing of joist hanger with interior flangs.	

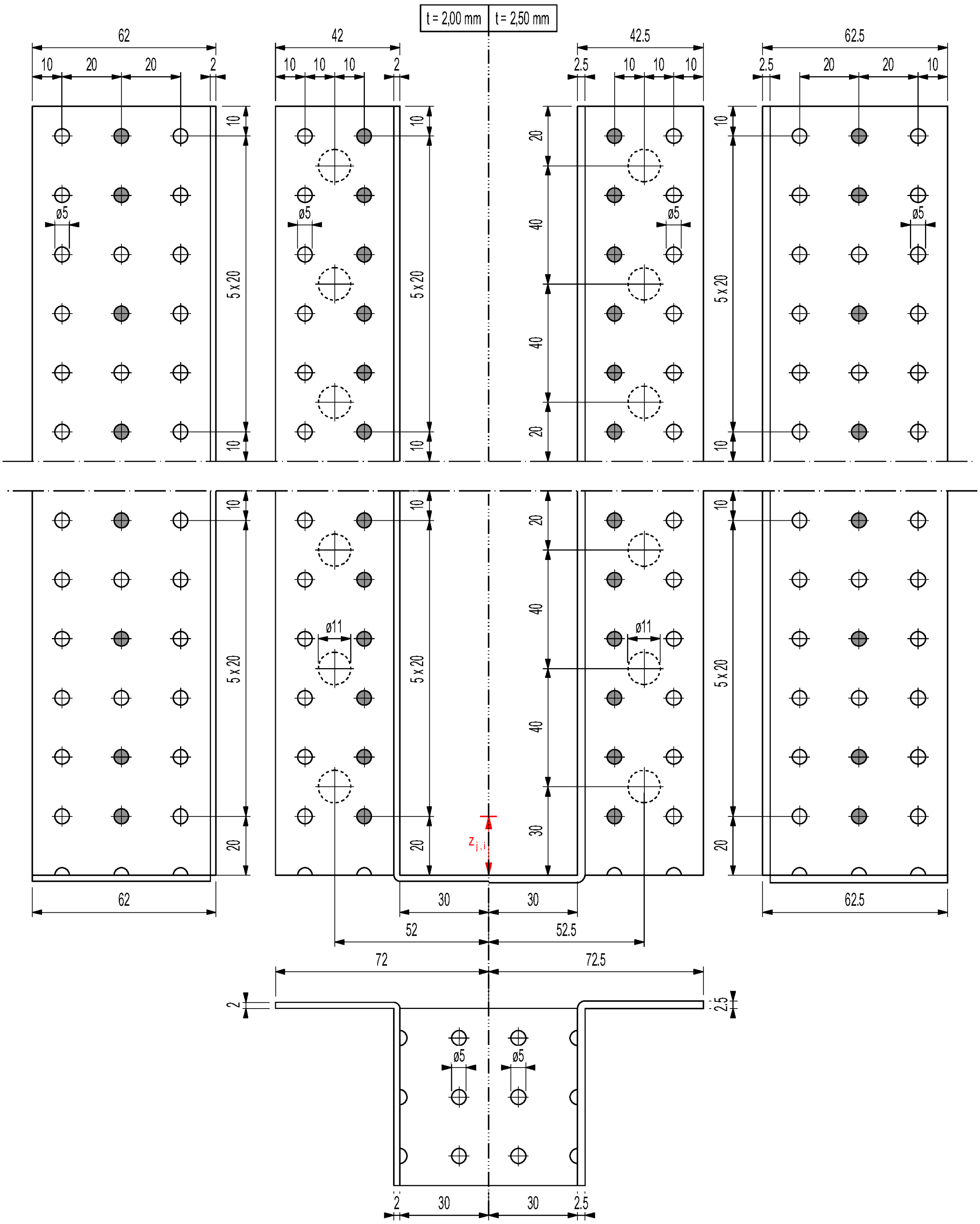
BKA Typ 4-A-2.0/2.5-S(-kombi): Full nailing / screwing   Allowed load directions: Fy and Fz



●	Full nailing / screwing
For the calculation of the load carrying capacity of the joist connection, the effecitve number of fasteners n_J can be assumed as the number of fasteners in the first row and maximum 15% of the possible number of fasteners in the second row.	
Analog execution for partial nailing of joist hanger with interior flangs.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

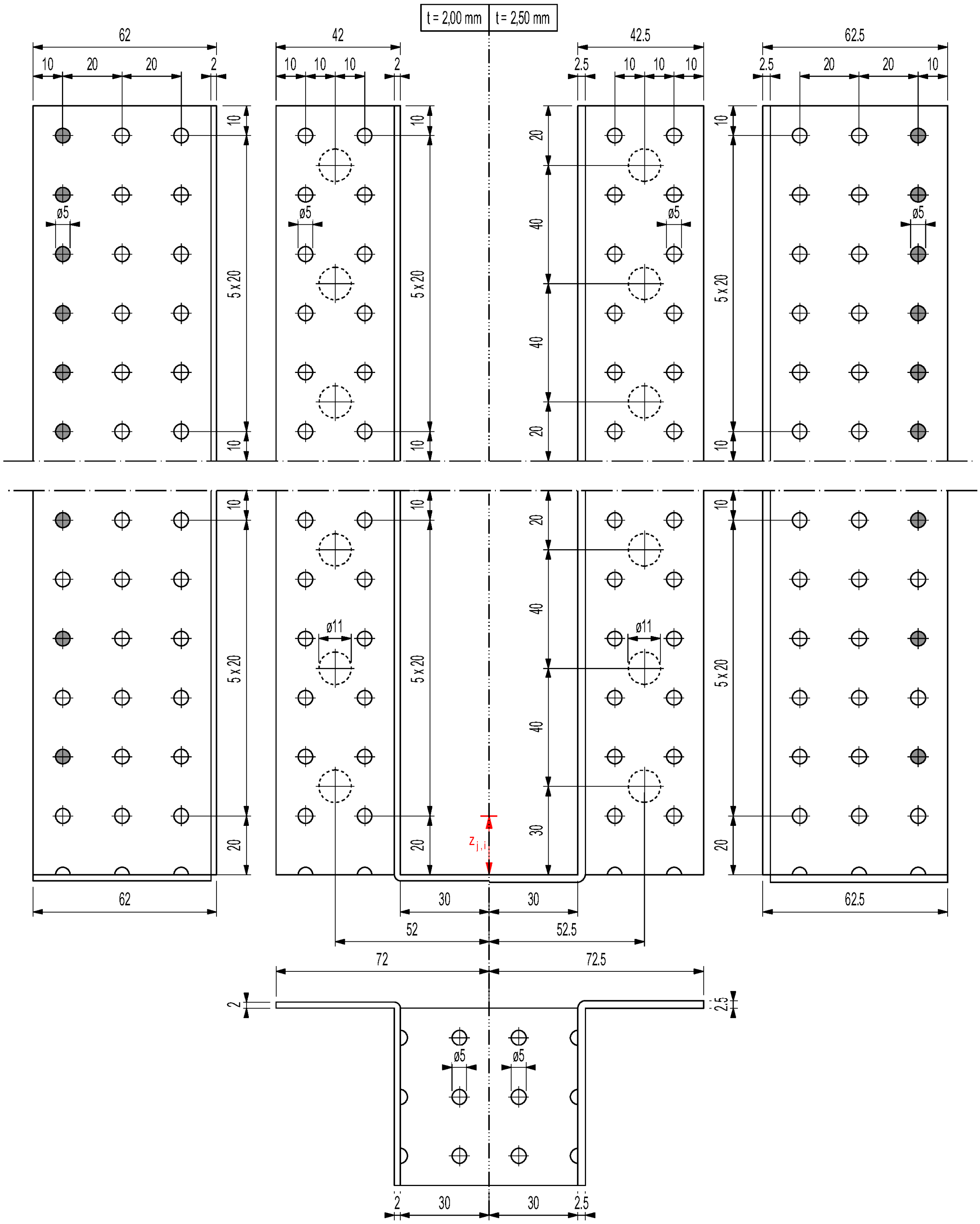
BKA Typ 4-A-2.0/2.5-S(-kombi): Example for partial nailing / screwing

Allowed load directions: Fy and Fz



● Partial nailing / screwing	
Analog execution for partial nailing of joist hanger with interior flangs.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

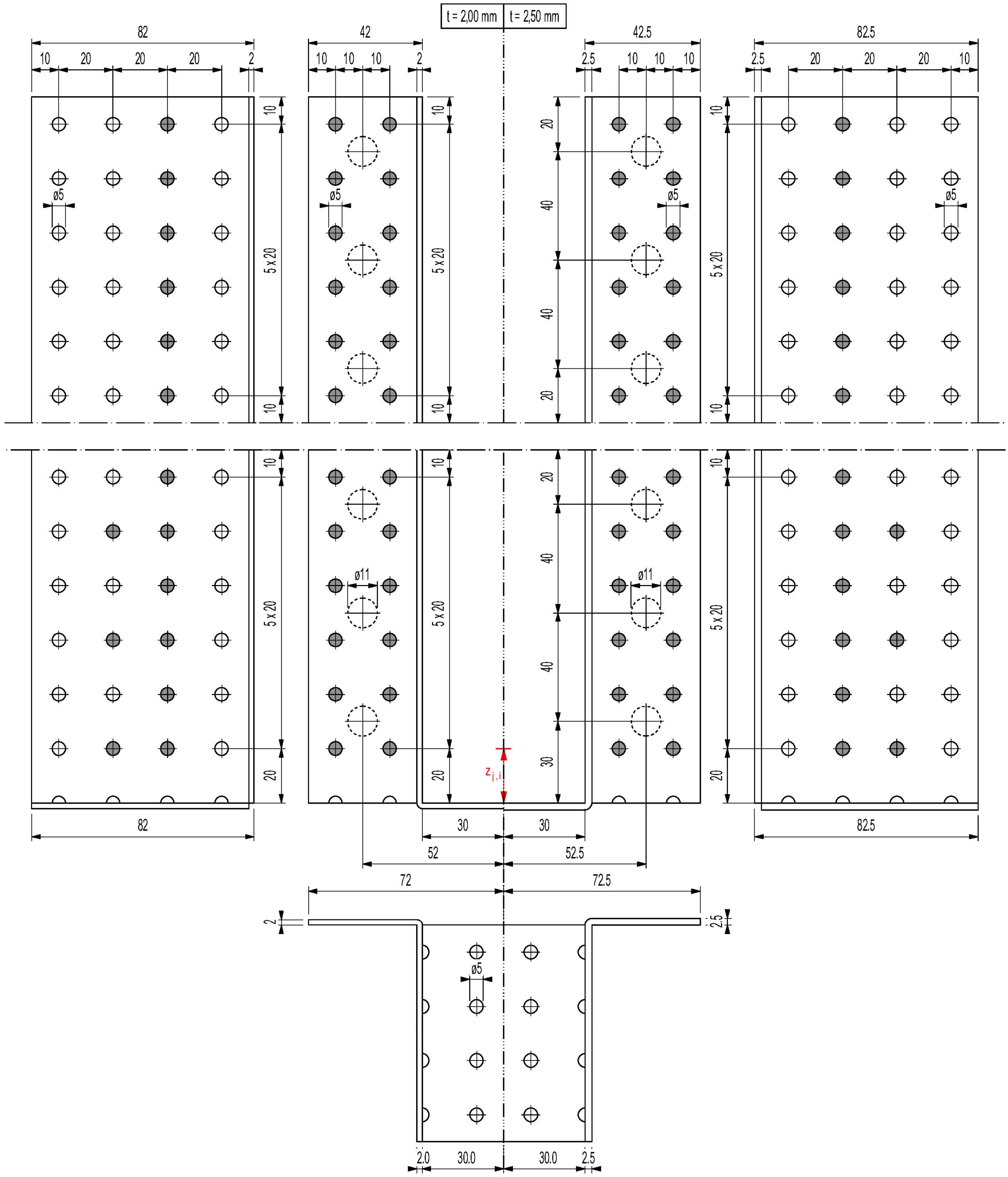
BKA Typ 4-A-2.0/2.5-S(-kombi): Example for additional nailing for Fx without inclined screw   Allowed load direction: Fx



●	Additional nailing for Fx without inclined screw.
The fasteners which are used for the loads Fz and / or Fy must not be used for the load Fx.	
Analog execution for partial nailing of joist hanger with interior flanges.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

BKA Typ 4-A-2.0/2.5-L(-kombi): Full nailing / screwing

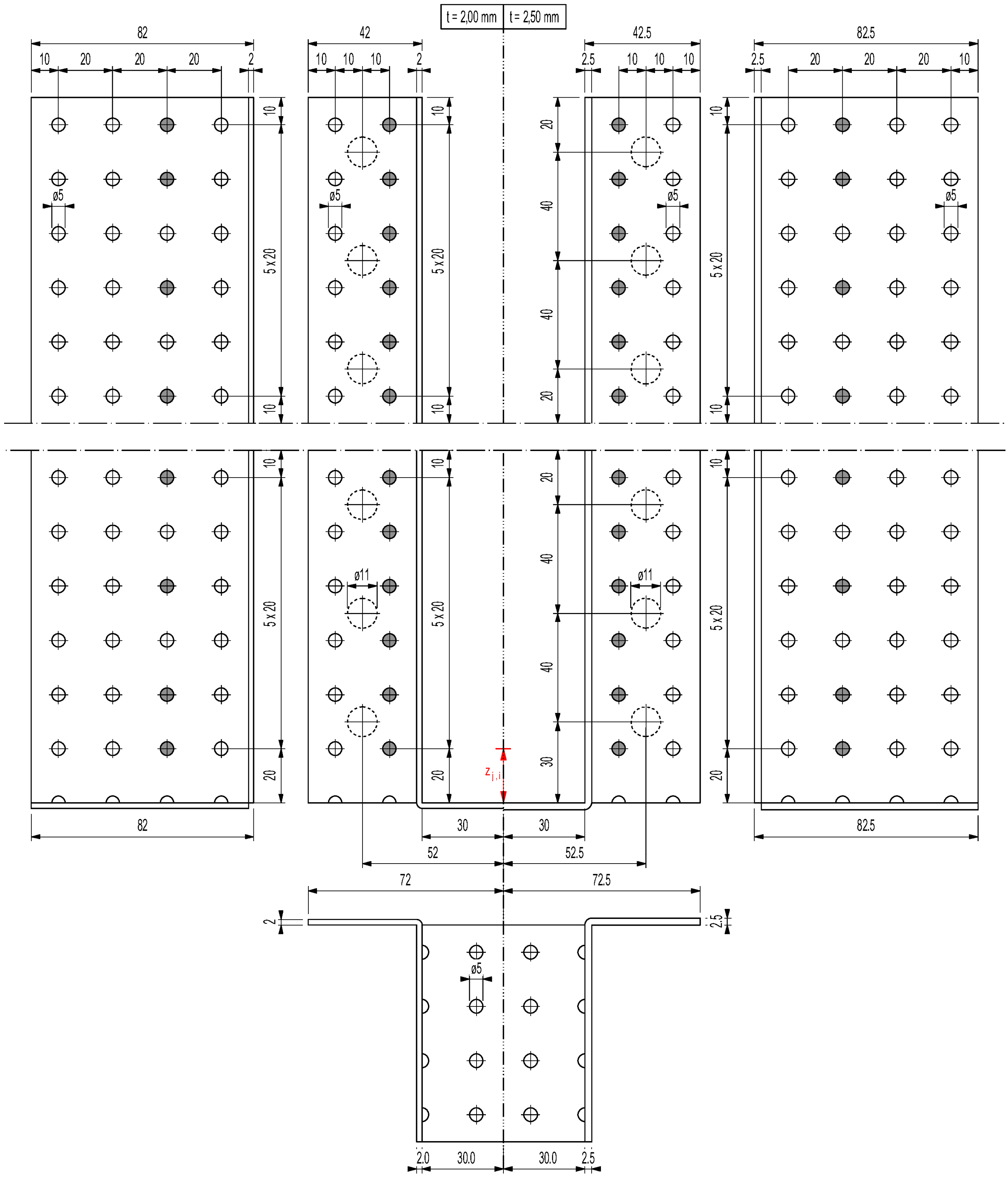
Allowed load directions: Fy and Fz



●	Full nailing / screwing
For the calculation of the load carrying capacity of the joist connection, the effecitve number of fasteners n_J can be assumed as the number of fasteners in the first row and maximum 15% of the possible number of fasteners in the second row.	
Analog execution for partial nailing of joist hanger with interior flangs.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

BKA Typ 4-A-2.0/2.5-L(-kombi): Example for partial nailing / screwing

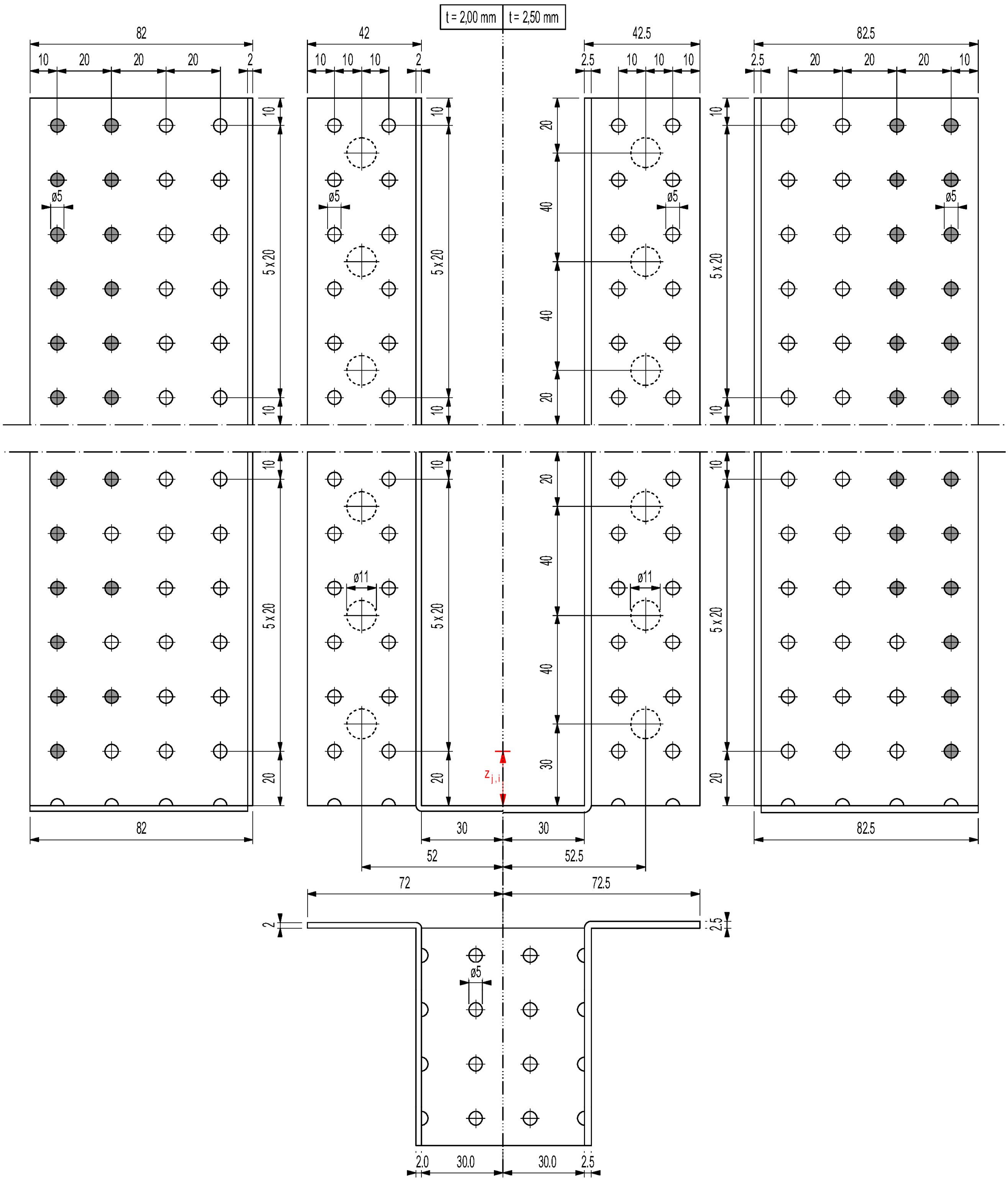
Allowed load directions: Fy and Fz



● Partial nailing / screwing	
Analog execution for partial nailing of joist hanger with interior flanges.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

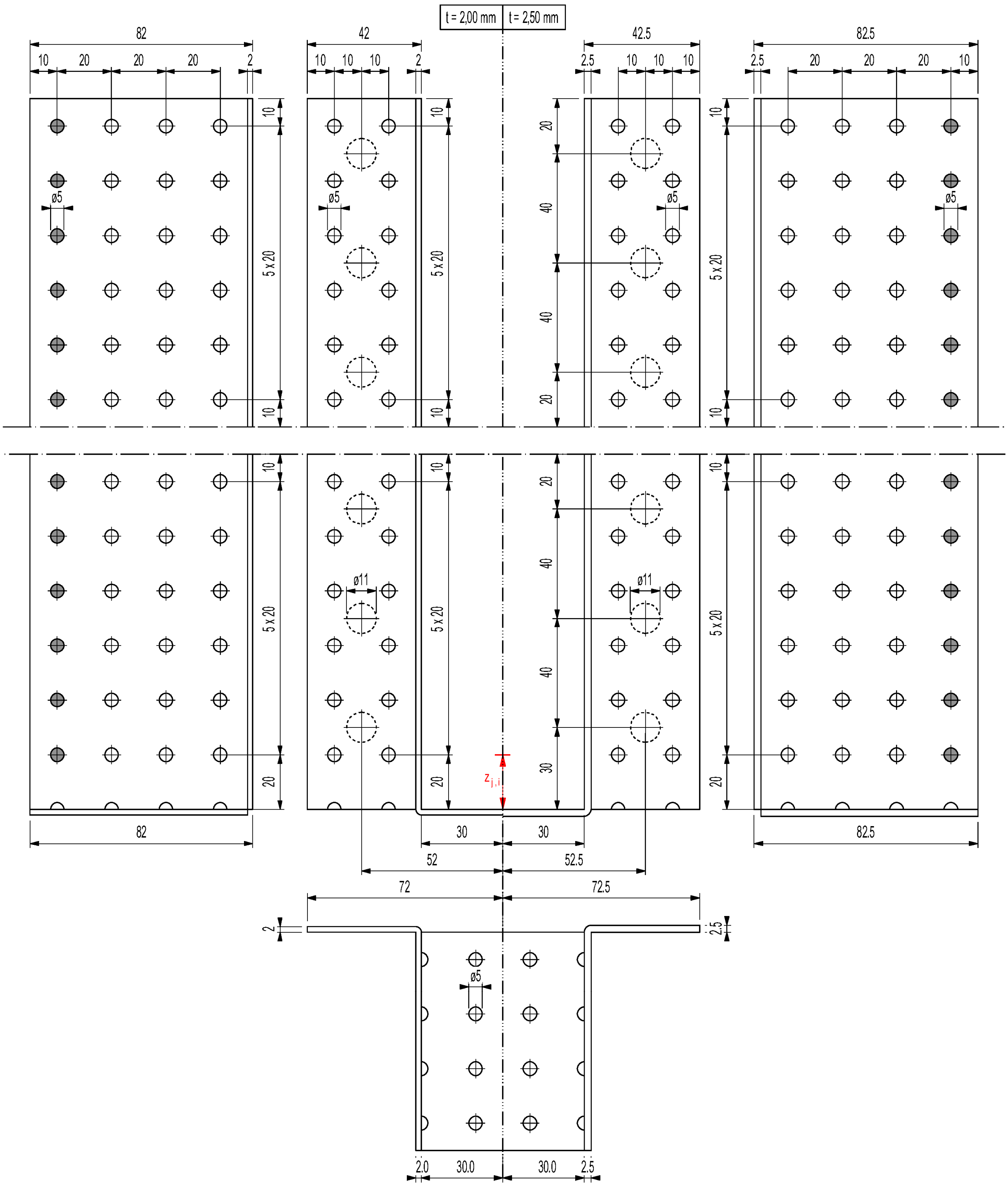
BKA Typ 4-A-2.0/2.5-L(-kombi): Example for additional nailing for Fx without inclined screw

Allowed load direction: Fx



●	Additional nailing for Fx without inclined screw.
The fasteners which are used for the loads Fz and / or Fy must not be used for the load Fx.	
Analog execution for partial nailing of joist hanger with interior flangs.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

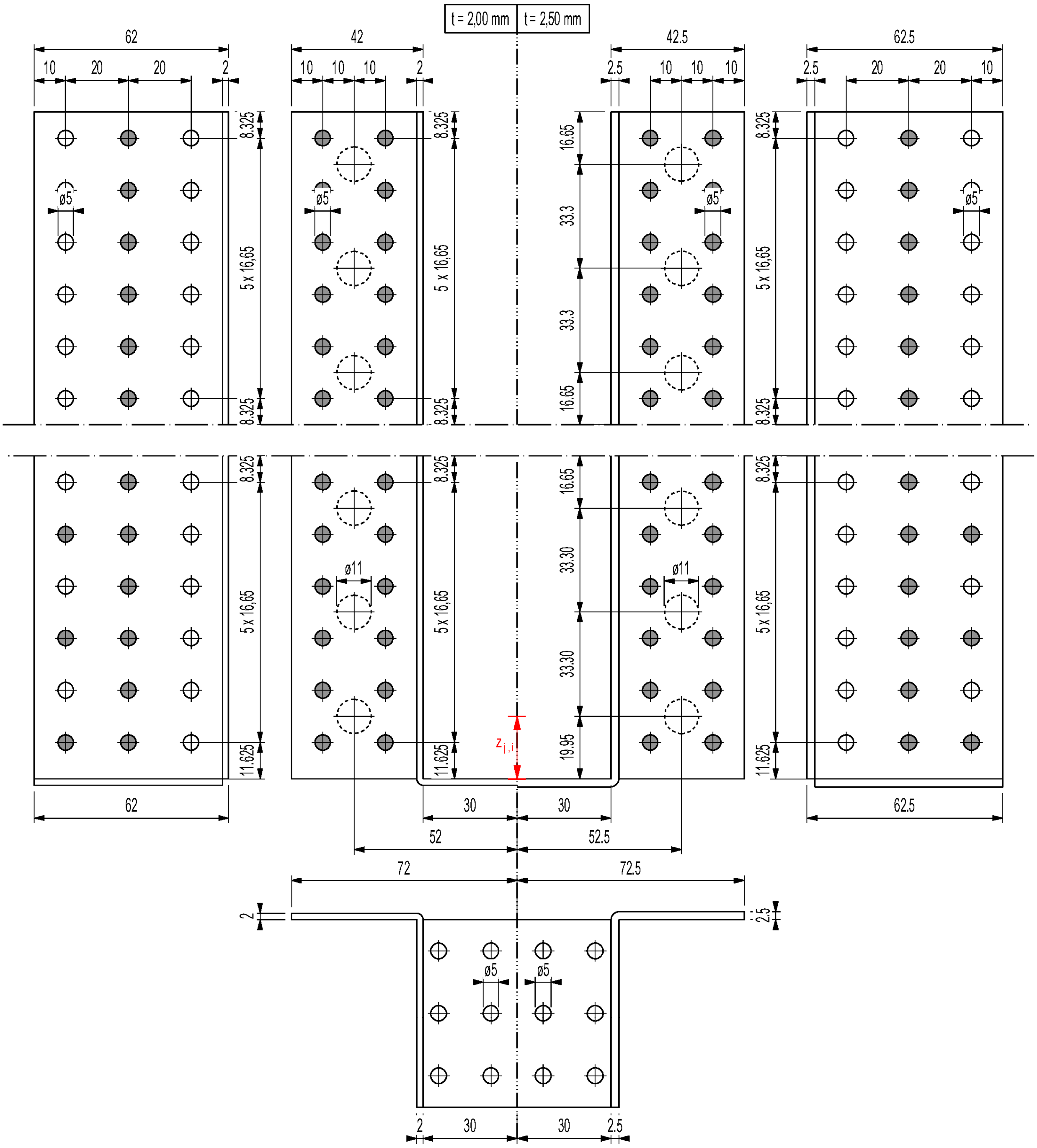
BKA Typ 4-A-2.0/2.5-L(-kombi): Example for additional screwing for Fx without inclined screw — Allowed load direction: Fx



●	Additional screwing for Fx without inclined screw.
The fasteners which are used for the loads Fz and / or Fy must not be used for the load Fx.	
Analog execution for partial nailing of joist hanger with interior flangs.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

BKA Typ 4-B-2.0/2.5-S(-kombi): Full nailing / screwing

Allowed load directions: Fy and Fz



●	Full nailing / screwing
For the calculation of the load carrying capacity of the joist connection, the effecitve number of fasteners n_J can be assumed as the number of fasteners in the first row and maximum 15% of the possible number of fasteners in the second row.	
For angles between grain and fastener axis $\alpha < 48^0$ only partial nailing is allowed.	
Analog execution for partial nailing of joist hanger with interior flangs.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

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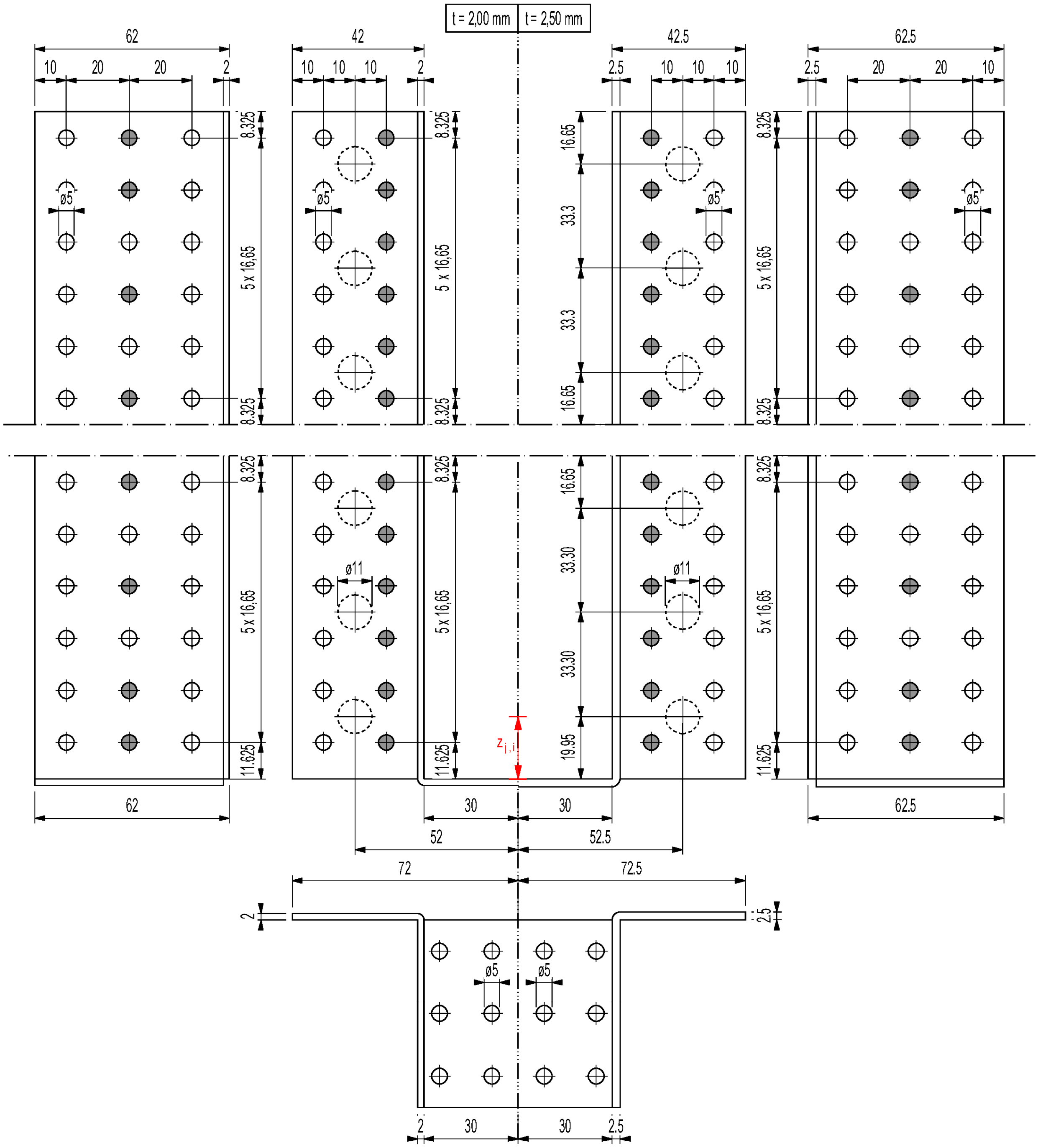
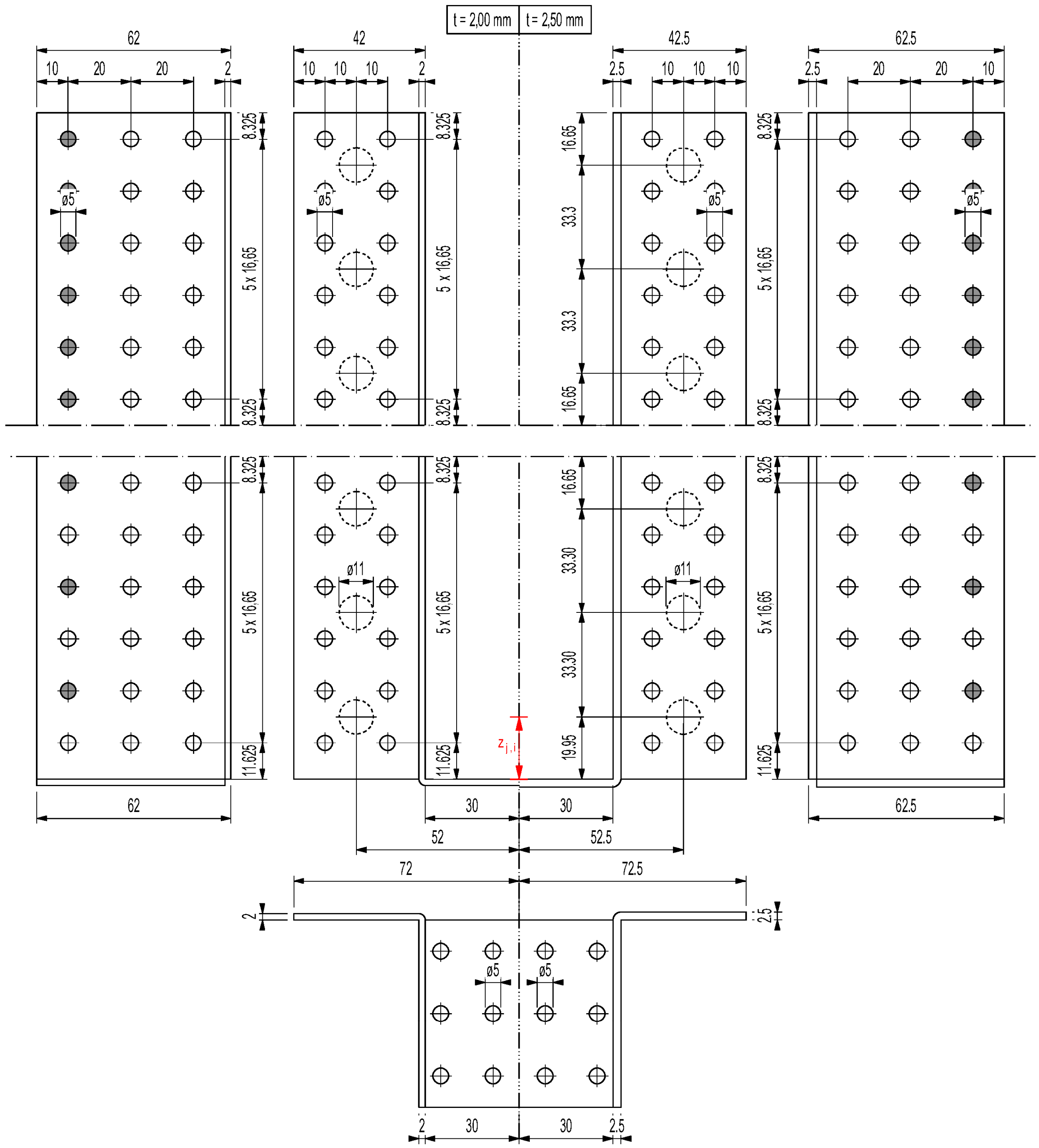
BKA Typ 4-B-2.0/2.5-S(-kombi): Example for partial nailing / screwing

Allowed load directions: Fy and Fz



●	Partial nailing / screwing
For angles between grain and fastener axis $\alpha < 48^0$ only partial nailing is allowed.	
Analog execution for partial nailing of joist hanger with interior flangs.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

BKA Typ 4-B-2.0/2.5-S(-kombi): Example for additional nailing for Fx without inclined screw — Allowed load direction: Fx



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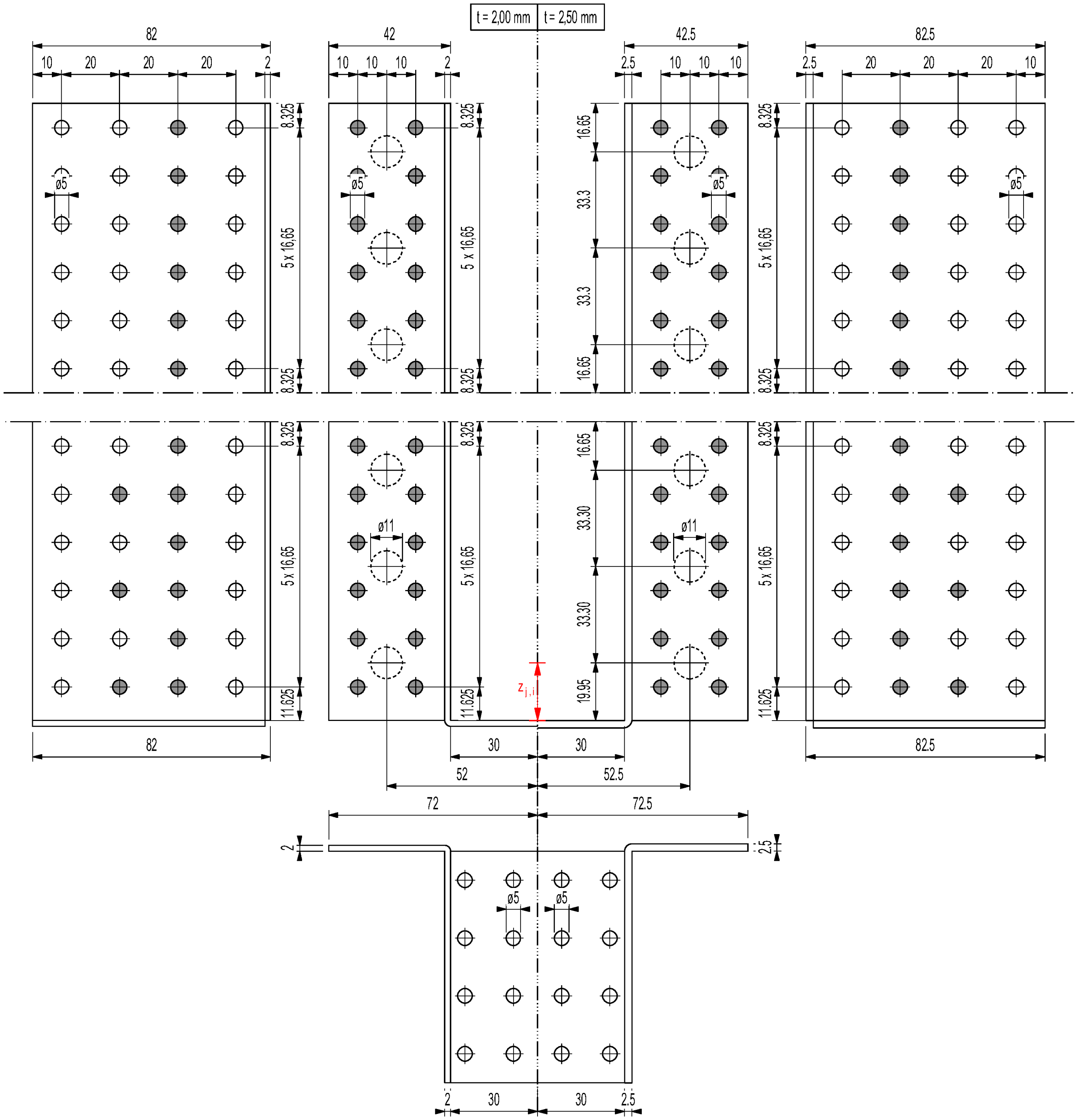
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

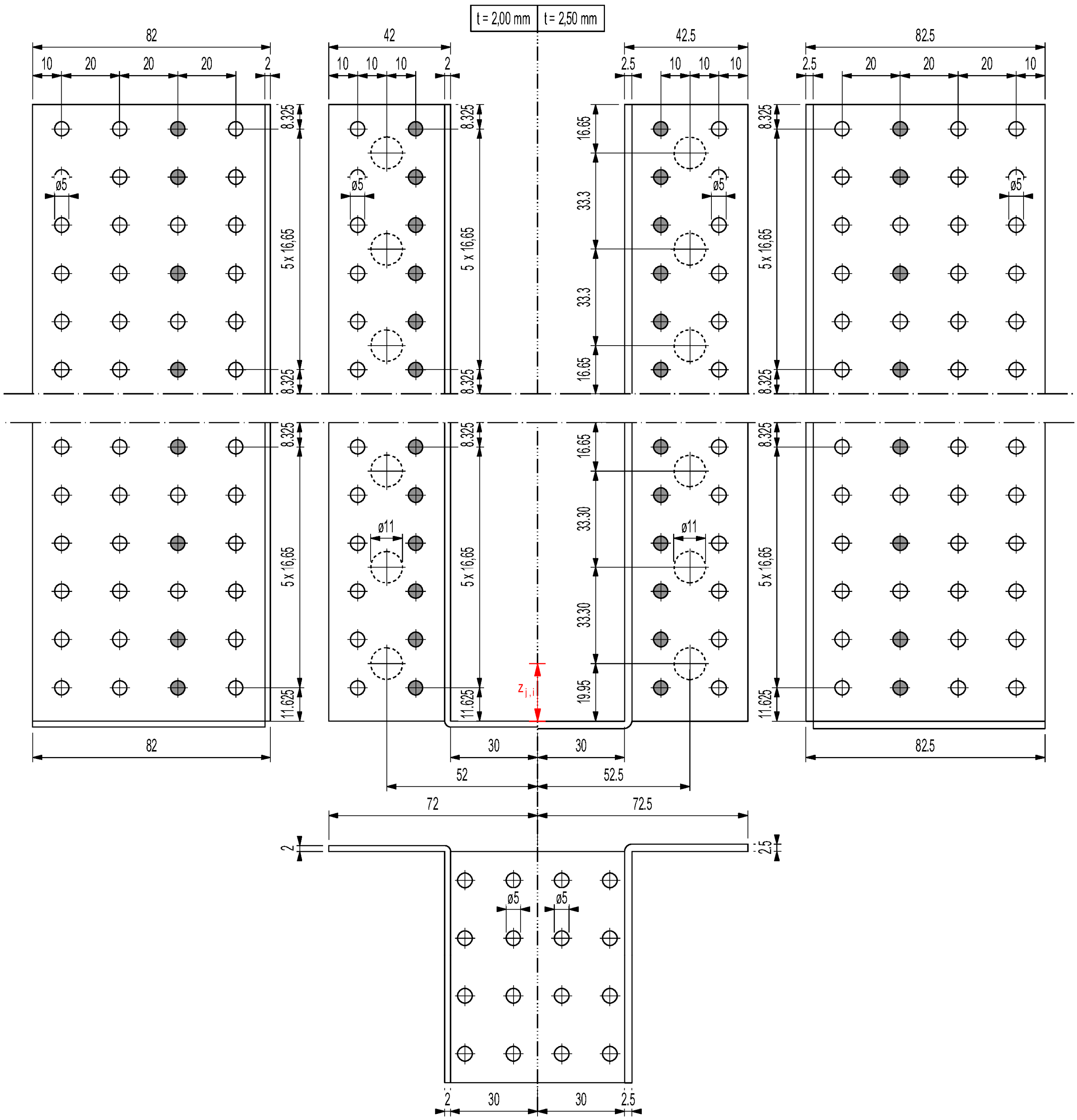
BKA Typ 4-B-2.0/2.5-L(-kombi): Full nailing / screwing   Allowed load directions: Fy and Fz



●	Full nailing / screwing
For the calculation of the load carrying capacity of the joist connection, the effecitve number of fasteners n_J can be assumed as the number of fasteners in the first row and maximum 15% of the possible number of fasteners in the second row.	
For angles between grain and fastener axis $\alpha < 48^0$ only partial nailing is allowed.	
Analog execution for partial nailing of joist hanger with interior flangs.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

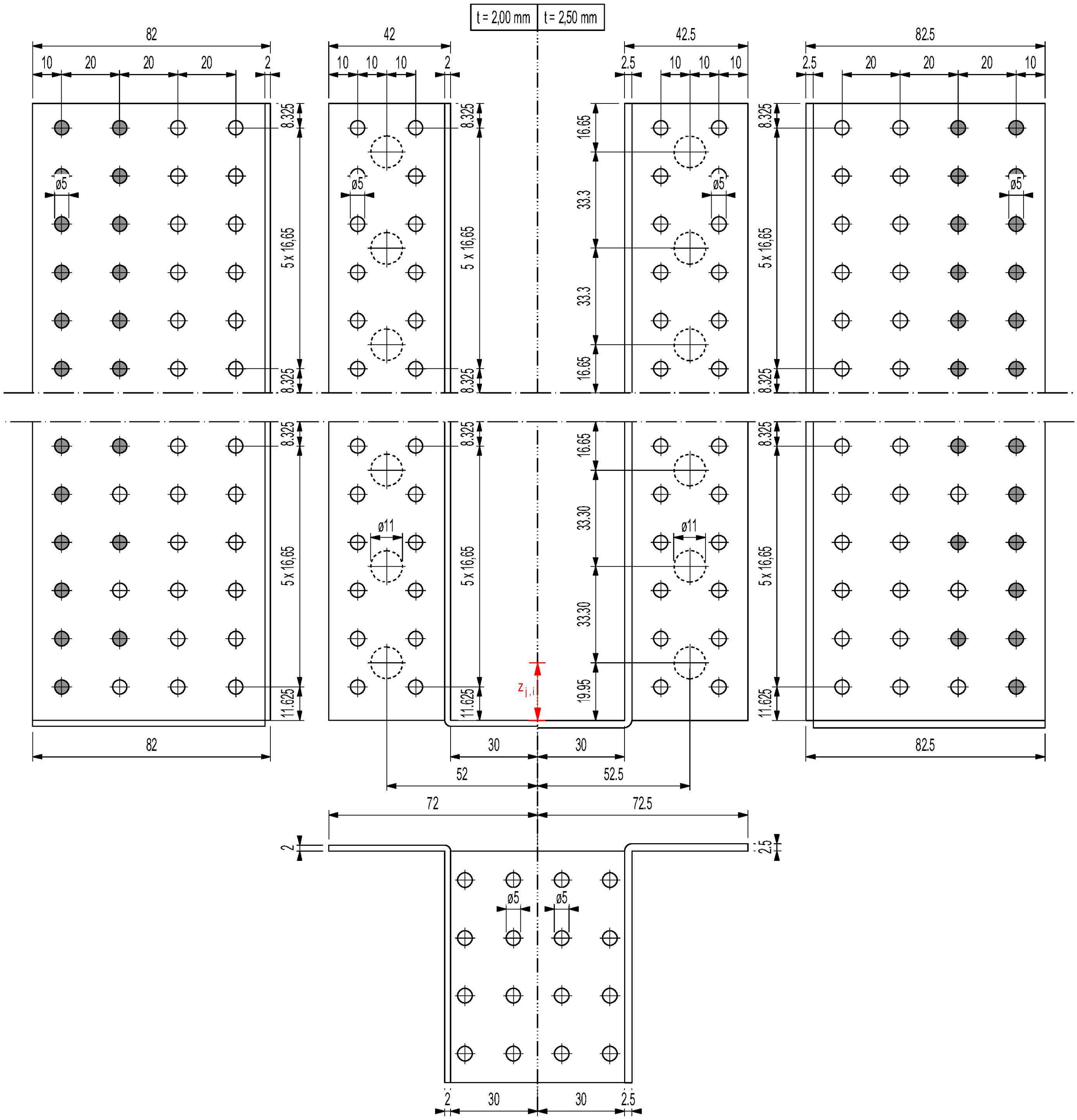
BKA Typ 4-B-2.0/2.5-L(-kombi): Example for partial nailing / screwing

Allowed load directions: Fy and Fz



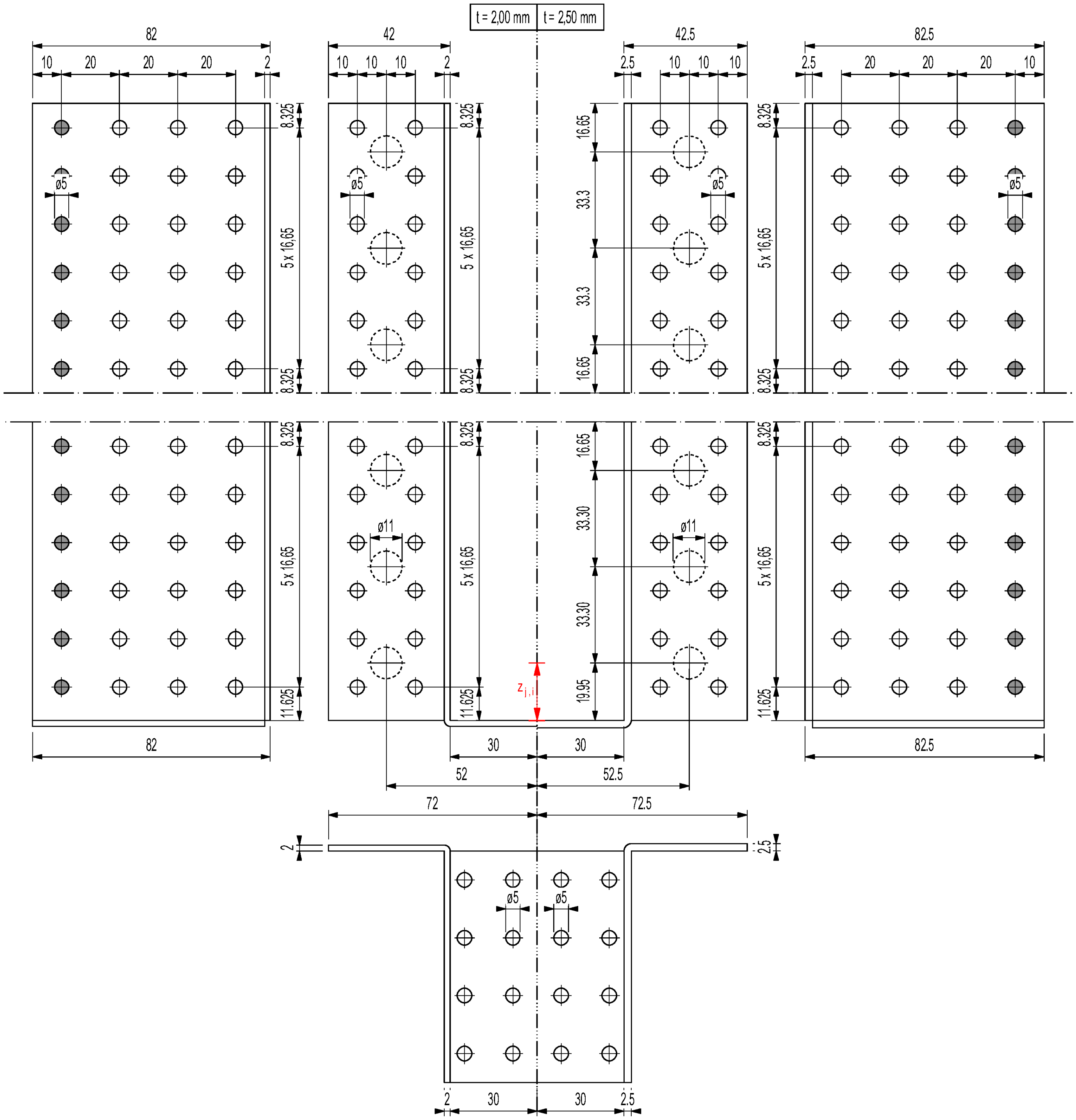
●	Partial nailing / screwing
For angles between grain and fastener axis $\alpha < 48^0$ only partial nailing is allowed.	
Analog execution for partial nailing of joist hanger with interior flangs.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

BKA Typ 4-B-2.0/2.5-L(-kombi): Example for additional nailing for Fx without inclined screw Allowed load direction: Fx



●	Additional nailing for Fx without inclined screw.
The fasteners which are used for the loads Fz and / or Fy must not be used for the load Fx.	
For angles between grain and fastener axis $\alpha < 48^0$ only partial nailing is allowed.	
Analog execution for partial nailing of joist hanger with interior flangs.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

BKA Typ 4-B-2.0/2.5-L(-kombi): Example for additional screwing for Fx without inclined screw — Allowed load direction: Fx



●	Additional screwing for Fx without inclined screw.
The fasteners which are used for the loads Fz and / or Fy must not be used for the load Fx.	
For angles between grain and fastener axis $\alpha < 48^0$ only partial nailing is allowed.	
Analog execution for partial nailing of joist hanger with interior flangs.	
Maximum number of fasteners at the header / joist connection: n_H = 62 / n_J = 38.	

Annex 2 Specifications of intended use

A.2.1 Loading

- Static and quasi-static loads (not relevant to fatigue)

A.2.2 Base material

BB joist hangers are installed as connections between wood based members such as:

- Solid timber (softwood) C14-C40 according to EN 338[1] / EN 14081-1[2],
- Glued laminated timber (softwood) according to EN 14080[3],
- Laminated veneer lumber LVL according to EN 14374[4] (connection only perpendicular to the plane of the veneer),
- Parallel strand lumber Parallam PSL (connection only perpendicular to the plane of the veneer),
- Laminated strand lumber Intrallam LSL (connection only perpendicular to the plane of the veneer),
- Glued solid timber according to 14080,
- Solid wood panels according to EN 13353[5] and EN 13986[6],
- Plywood according to EN 636[7] / EN 13986 (thickness t ≥ 25 mm).

The characteristic values (see Annex 3) only apply for a characteristic wood density of up to 460 kg/m³, even though the wood density is larger.

A.2.3 Use conditions (Environmental conditions)

A.2.3.1 Corrosion protection in service classes 1 and 2

BB joist hangers are made of pre-galvanized steel Grade S250GD+Z (min Z275) according to EN 10346[8].

The nails and screws used with the joist hangers are of uncoated steel for service class 1 and with corrosion protection Fe/Zn 12c or Z275 for service class 2 (in accordance with EN 1995-1-1:2010-12[9], Table 4.1).

A.2.3.2 Wood preservative

If preservative treatment of timber is used national regulations will apply.

A.2.3.3 Installation of BB joist hanger connections

BB joist hanger connections fulfil the following conditions:

Header - support conditions
The header is restrained against rotation and free from wane under the joist hanger.

If the header carries a joist only on one side, the eccentricity moment from the joist $M_v = F_d\ (B_H / 2 + 30\ mm)$ is considered at the strength verification of the header.

Where F_d Reaction force from the joists $F_{Z,Ed,up}$ or $F_{Z,Ed,down}$

B_H Width of the header

For a header with joists from both sides but with different reaction forces exceeding 20 % a similar consideration applies.

1	EN 338:2016	Timber structures - Strength classes
2	EN 14081-1:2016	Timber structures - Strength graded structural timber with rectangular cross section - Part 1: General requirements
3	EN 14080:2013	Timber structures - Glued laminated timber and glued solid timber - Requirements
4	EN 14374:2004	Timber structures - Structural laminated veneer lumber - Requirements
5	EN 13353:2008+A1:2011	Solid wood panels (SWP) – Requirements
6	EN 13986:2004+A1:2015	Wood-based panels for use in construction - Characteristics, evaluation of conformity and marking
7	EN 636:2012+A1:2015	Plywood - Specifications
8	EN 10346:2015-10	Continuously hot-dip coated steel flat products for cold forming – Technical delivery conditions
9	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

Wood to wood connections

BB joist hangers are fastened to wood or wood-based members by nails or screws.

There shall be nails or screws in all holes or a partial nailing pattern as prescribed in Annex 1 and 4 may be used (see drawings in Annex 1 and 4).

The design of the connections shall be carried out according to national provisions that apply at the installation site of the certified object in line with the partial safety factor format, e.g. in accordance with Eurocode 5.

The gap between the end of the joist and the surface of the header, where contact stresses can occur during loading shall not exceed 3 mm.

For BB joist hangers with overlapping nails or screws in the header (cf. Figure 8.5 in EN 1995-1-1:2010-12) its width shall be at least l+4d, where l is the length and d is the diameter of the nail or the screw in the header (see Figures A.2.1 to A.2.4). For joist hangers with staggered nails in the joist the width is at least the penetration length of the nails or screws.

The cross section of the joist at the joist hanger has sharp edges at the lower side against the bottom plate, i.e. it is without wane.

The header has a plane surface against the whole joist hanger.

The width b_J of the joist corresponds to that of the joist hanger. Therefore b_J is not smaller than b minus 3 mm, where b is the inner width of the joist hanger.

The height of the joist is so large that the top of the joist is at least 20 mm above the upper fastener in the joist.

Nails or screws have a diameter, which fits the holes of the joist hangers. Nails have a diameter which is not smaller than the diameter of the hole minus 1 mm.

To guarantee fitting accuracy of the nails at the joist hanger an appropriate nail is used (e.g. with a truncated cone directly under the head of the nail).

Wood to concrete or steel connections

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 is in close contact with the concrete or steel over the whole face. There are no intermediate layers in between.

The gap between the end of the joist and the surface, where contact stress can occur during loading does not exceed 3 mm.

The bolt has a diameter not less than the whole diameter minus 1 mm.

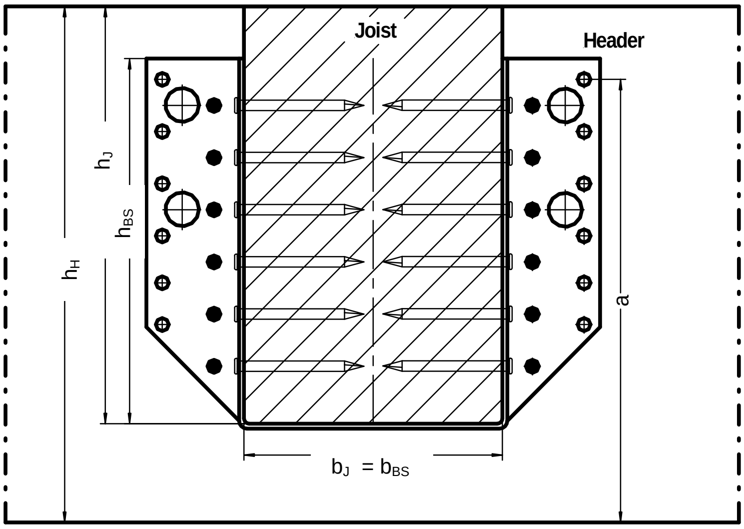
The bolts are placed symmetrically. There are always bolts in the 2 upper holes.

The upper bolts have washers according to EN ISO 7094[10].

[10] DIN EN ISO 7094:2000 Plain washers - Extra-large series, product grade C

BB joist hangers type 1, 2, 3 and 4	Annex 2.2
Specification of intended use Installation of BB joist hanger connections	

Figure A.2.1: BB joist hanger in wood/wood connection



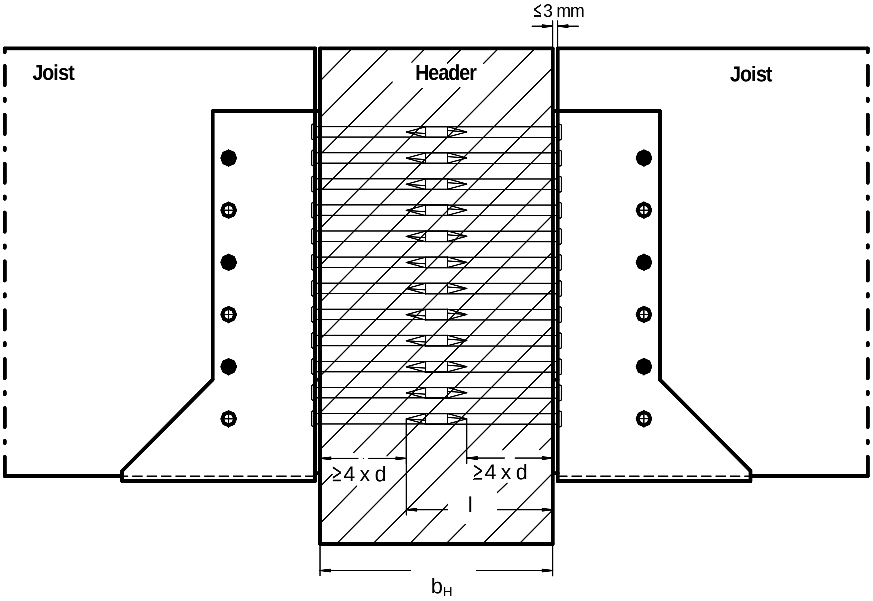
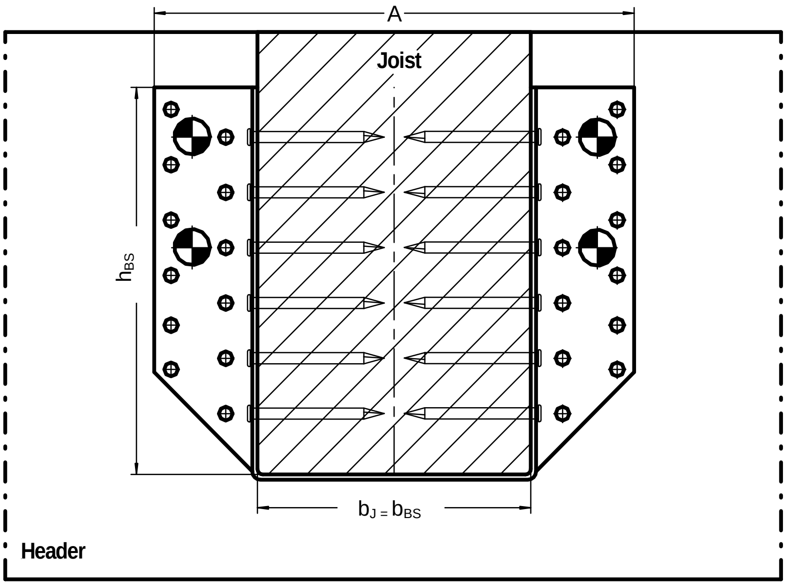


Figure A.2.2: BB joist hanger in wood/wood connection

BB joist hangers type 1, 2, 3 and 4	Annex 2.3
Specification of intended use Installation of BB joist hanger connections - BB joist hanger in wood/wood connection	

Figure A.2.3: BB joist hanger connected to concrete, lightweight concrete or steel members by bolts



Bolts M10
Washer according to EN ISO 7094

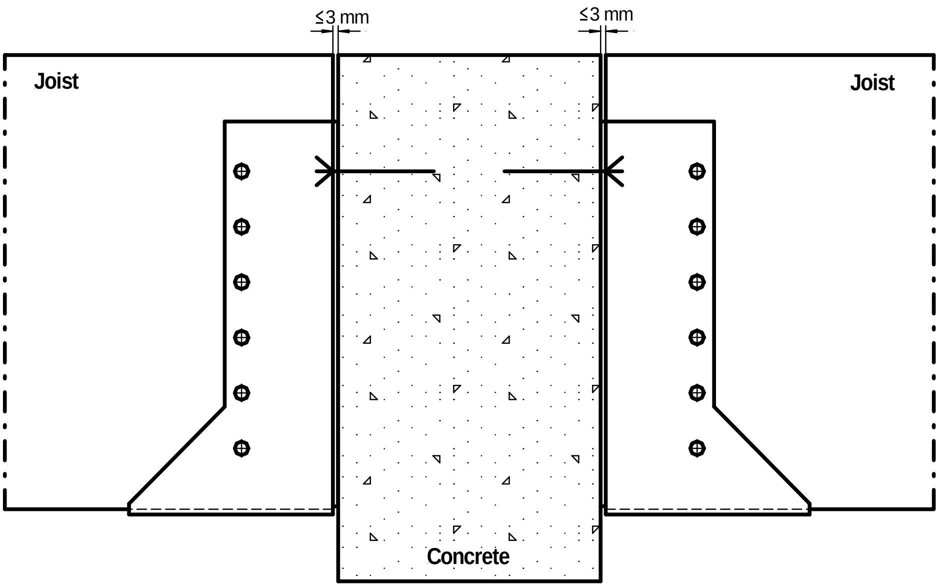


Figure A.2.4: BB joist hanger connected to concrete, lightweight concrete or steel members by bolts

BB joist hangers type 1, 2, 3 and 4	Annex 2.4
Specification of intended use BB joist hanger connected to concrete, lightweight concrete or steel members by bolts	

Annex 3 Specifications of essential characteristics

Characteristic load-carrying-capacities of BB joist hanger connections with nails or screws

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 $e_{z,J}$ or $e_{z,H}$ above the centre of gravity of the nails in the joist or header, respectively (see Figures A.3.1, A.3.2 and A.3.3).

Two nail/screw patterns are specified. A full pattern, where with the exception of joist hangers type 4 there are nails in all the holes, and a partial pattern, where the number of nails/screws in the joist and the header are at least half the numbers specified for full nailing/screwing. The nails/screws in the joist may be staggered and there shall always be a nail/screw in the upper and the lower holes. The other nails/screws are distributed evenly over the height. The nails/screws in the header shall be put in the holes closest to the bend line. The patterns for joist hanger types 1, 2, 3 and 4 are given in Annex 1.

The width of the joist hangers shall be at least the penetration length of the nails or screws.

A.3.1 Joist hangers fastened with threaded nails or screws

A.3.1.1 Threaded nails or screws

Force downward toward the bottom plate:

$$F_{Z,Rk} = \min \begin{cases} n_J \cdot F_{v,J,Rk} + 3,24 \cdot t \cdot \sqrt{\ell \cdot (\ell + 30) \cdot \rho_k} \\ \dfrac{1}{\sqrt{\left(\dfrac{1}{n_H \cdot F_{v,H,Rk}}\right)^2 + \left(\dfrac{1}{k_{H,1} \cdot F_{ax,H,Rk}}\right)^2}} \end{cases} \qquad \text{(A.3.1.1.1)}$$

Force upward away from the bottom plate:

$$F_{Z,Rk} = \min \begin{cases} n_J \cdot F_{v,J,Rk} \\ \dfrac{1}{\sqrt{\left(\dfrac{1}{n_H \cdot F_{v,H,Rk}}\right)^2 + \left(\dfrac{1}{k_{H,2} \cdot F_{ax,H,Rk}}\right)^2}} \end{cases} \qquad \text{(A.3.1.1.2)}$$

Lateral force:

$$F_{Y,Rk} = \min \begin{cases} \dfrac{n_J \cdot F_{v,J,Rk}}{\sqrt{\left(\dfrac{2 \cdot \sqrt{e_x^2 + e_{z,J}^2}}{b_J}\right)^2 + \left(\dfrac{F_{v,J,Rk}}{F_{ax,J,Rk}}\right)^2}} \\ \dfrac{F_{v,H,Rk}}{\sqrt{\left(\dfrac{1}{n_H} + \dfrac{e_{z,H} \cdot H^*}{2 \cdot I_{p,H,v}}\right)^2 + \left(\dfrac{e_{z,H} \cdot W}{2 \cdot I_{p,H,v}}\right)^2}} \end{cases} \qquad \text{(A.3.1.1.3)}$$

Load perpendicular to the header surface without inclined screw:

$$F_{X,Rk} = \min \begin{cases} n_{J,12d} \cdot F_{v,J,Rk} \\ 0,7 \cdot n_H^p \cdot F_{ax,H,Rk} \\ 0,05 \cdot f_{y,k} \cdot (a_1 - 5) \cdot (0,5 \cdot n_H^p - 1) \cdot t^2 \end{cases} \qquad \text{(A.3.1.1.4)}$$

Load perpendicular to the header surface with inclined screw:

$$F_{X,Rk} = \min\left\{F_{ax,Rk} \cdot \cos\delta; \left(F_{Z,Rk} - F_{Z,Ed}\right) / \tan\delta\right\} \quad \text{(A.3.1.1.5)}$$

Where:

n_J	total number of nails or screws in both sides of the joist
$n_{J,12d}$	number of nails or screws in both sides of the joist with an end distance of at least 12·d
n_H	total number of nails or screws in both header flaps
n_H^p	number of nails or screws for partial nailing pattern in both header flaps
t	steel plate thickness of joist hanger
ℓ	length of joist hanger's bottom plate parallel to joist axis
a_1	spacing of the header fasteners for partial fastener pattern
ρ_k	characteristic joist density ≤ 480 kg/m³
$f_{y,k}$	characteristic yield strength of joist hanger's steel plate
$F_{v,Rk}$	Characteristic lateral load-carrying capacity of the fasteners in the joist or in the header indicated by the indices J or H; a thick steel plate in single shear may be assumed.
$F_{ax,Rk}$	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 or nominal joist width, see figure A.3.2.
$e_{z,J}$	distance of the lateral force above the centre of gravity of the nails or screws in the joist, see figure A.3.1.
e_x	distance from the centre of gravity of the nails or screws in the joist to the surface of the header, see figure A.3.1.
$e_{z,H}$	distance of the lateral force above the centre of gravity of the nails or screws in the header.
$k_{H,1}$	form factor $k_{H,1} = \dfrac{I_{p,H,1,ax}}{e_x \cdot z_{H,max}}$
$z_{H,max}$	Distance from the centre of rotation of the joist end grain surface to the uppermost header nail or screw, see figure A.3.1 top
$I_{p,H,1,ax}$	polar moment of inertia of the header fastener group for axial fastener loading based on the centre of rotation of the joist end grain surface, see figure A.3.1 top
$k_{H,2}$	form factor $k_{H,2} = \dfrac{I_{p,H,2,ax}}{e_x \cdot z_{H,max}}$
$z_{H,max}$	Distance from the centre of rotation of the joist end grain surface to the uppermost header nail or screw, see figure A.3.1 bottom
$I_{p,H,2,ax}$	polar moment of inertia of the header fastener group for axial fastener loading based on the centre of rotation of the joist end grain surface, see figure A.3.1 bottom
$I_{p,H,v}$	polar moment of inertia of the header fastener group for lateral fastener loading
H*	distance parallel to the symmetry plane between the two outermost nails or screws of the header connection, see figure A.3.2;
W	distance perpendicular to the symmetry plane between the two outermost nails or screws of the header connection see figure A.3.2;

For an example of calculation, see Annex 5

BB joist hangers type 1, 2, 3 and 4	Annex 3.2
Characteristic load-carrying-capacities of BB joist hanger connections with nails or screws	

The forces acting on the joist hanger connection are $F_{Z,up,Ed}$, $F_{Z,down,Ed}$ and $F_{Y,Ed}$ as shown in figures A.3.1, A.3.2 and A.3.3 below. The forces $F_{Z,up,Ed}$ and $F_{Z,down,Ed}$ act in the plane of symmetry of the joist hanger. The force $F_{Y,Ed}$ acts with the distance $e_{z,J}$ above the centre of gravity of the nail connection. It is assumed that the forces act right at the end of the joist.

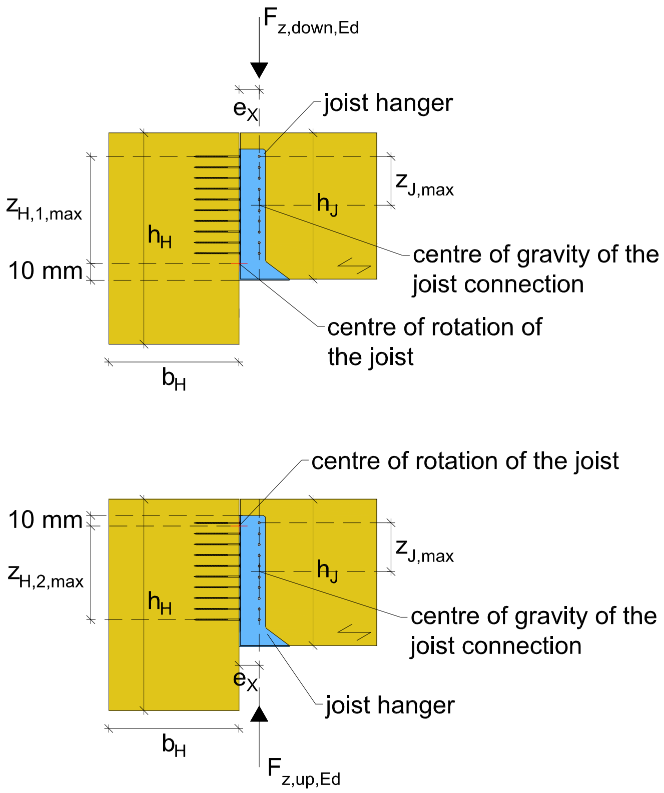


Figure A.3.1: Load direction Z: notation and joist hanger dimensions

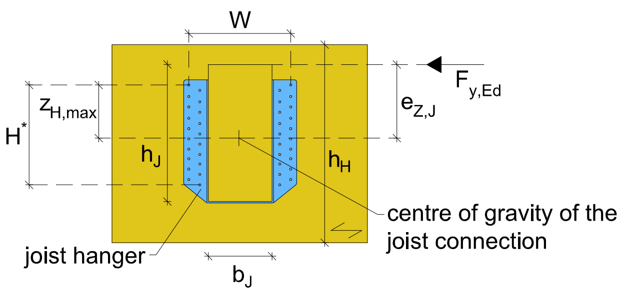


Figure A.3.2: Load direction Y: notation and joist hanger dimensions

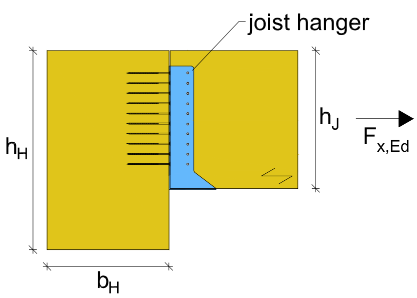


Figure A.3.3: Load direction X: notation and joist hanger dimensions

BB joist hangers type 1, 2, 3 and 4	Annex 3.3
Characteristic load-carrying-capacities of BB joist hanger connections with nails or screws	

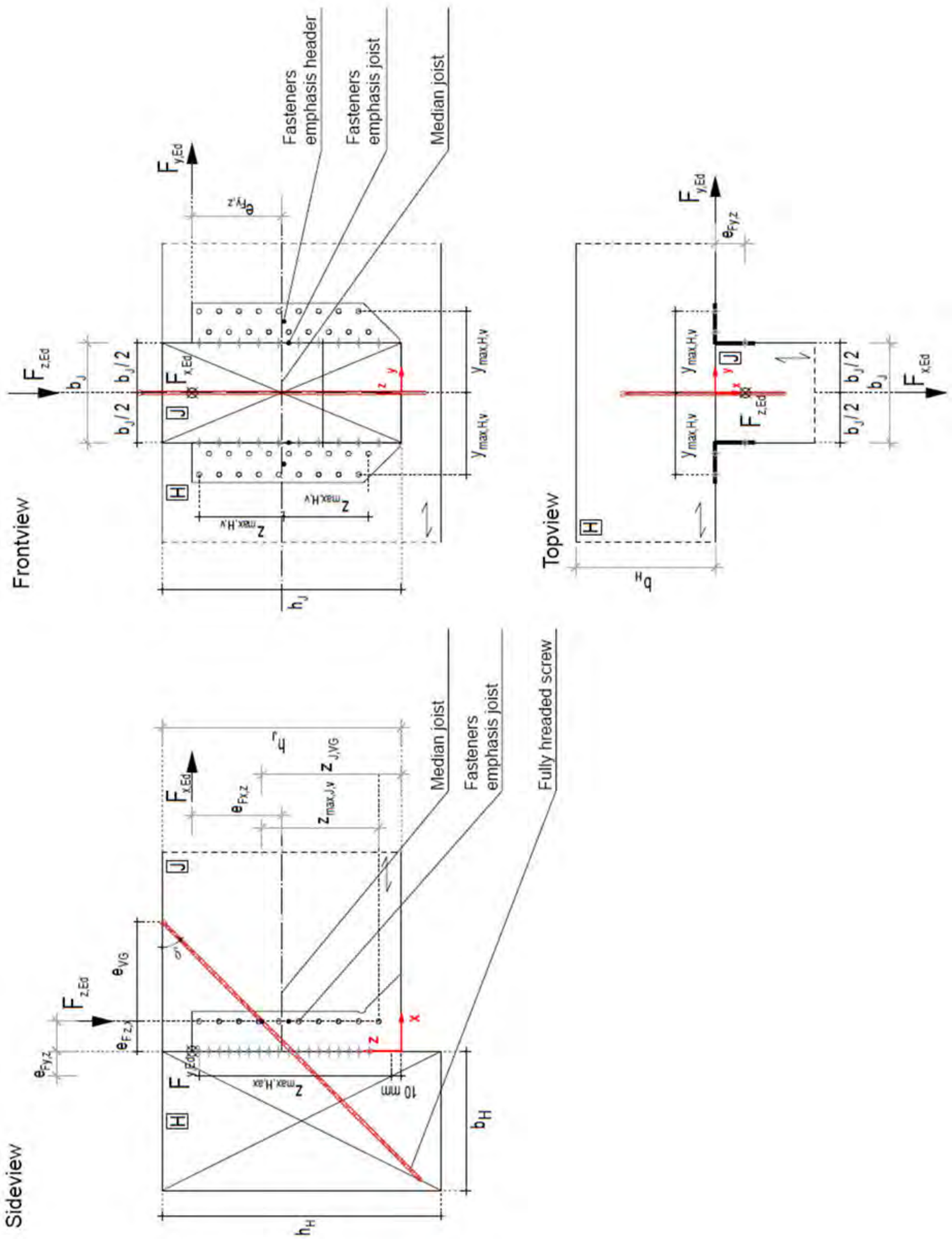


Figure A.3.4: Inclined screw for force $F_{x,Ed}$

BB joist hangers type 1, 2, 3 and 4 Characteristic load-carrying-capacities of BB joist hanger connections with nails or screws	Annex 3.4

A.3.1.2 Combined forces

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

$$\left(\frac{F_{X,Ed}}{F_{X,Rd}}\right)^2 + \left(\frac{F_{Y,Ed}}{F_{Y,Rd}}\right)^2 + \left(\frac{F_{Z,Ed}}{F_{Z,Rd}}\right)^2 \leq 1 \qquad \text{(A.3.1.2.1)}$$

A.3.2 Characteristic load-carrying-capacities of the joist hanger connections with bolts

For joist hangers 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 force transfer from the joist to the joist hanger is as for a wood-wood connection, see clause A.3.1.

The bolts shall always be positioned symmetrically about the vertical axis of the joist hanger.

Washers according to EN ISO 7094 shall be installed under the upper 2 bolt heads or nuts.

Description of the static model

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

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

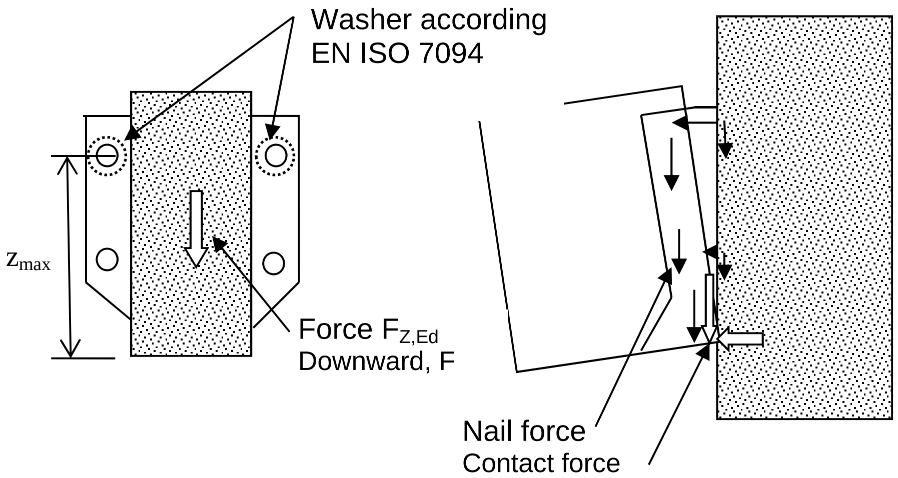


Figure A.3.5 Left: Cross section in joist. Right: The joist will deflect and rotate, at the bottom a contact force will occur at the bottom plate, and the withdrawal forces in the bolts in the wall will vary linearly as assumed for nailed connections in the header.

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 an upper bolt can be calculated from

$$F_{ax,bolt} = \frac{F_{Z,Ed} \cdot e_x}{2 \cdot z_{H,max}} \qquad \text{(A.3.2.1)}$$

BB joist hangers type 1, 2, 3 and 4	Annex 3.5
Characteristic load-carrying-capacities of BB joist hanger connections with nails or screws	

Where

$F_{Z,Ed}$ downward directed force toward the bottom plate
e_x distance from the centre of gravity of the nails in the joist to the surface of the header
$z_{H,max}$ max distance from upper bolt to the bottom plate (rotation point), see figure B4

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 $F_{Z,Ed}$.

$$F_{lat,bolt} = F_{Z,Ed} / n_{bolt} \qquad \text{(A.3.2.2)}$$

Characteristic capacities of a bolted joist hanger connection

The characteristic capacity of the connection between the joist and the joist hanger can be calculated from the same assumptions and formulas as for joist hangers nailed or screwed to a wooden header.

$$F_{Z,Rk} = n_J \cdot F_{v,J,Rk} + 3{,}24 \cdot t \cdot \sqrt{\ell \cdot (\ell + 30) \cdot \rho_k} \qquad \text{(A.3.2.3)}$$

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

From the characteristic 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.

$$F_{bear,Rk} = n_{bolt} \cdot f_{u,k} \cdot d \cdot t \qquad \text{(A.3.2.4)}$$

Where

n_{bolt} total number of bolts in the 2 flaps
$f_{u,k}$ characteristic ultimate tensile strength of the steel, 330 MPa
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 (A.3.2.3) from the nails or screws in the joist
- The capacity determined from (A.3.2.4) from the embedding strength of the steel plate against the bolt
- The capacity controlled by the bolt forces given by (A.3.2.1) and (A.3.2.2).

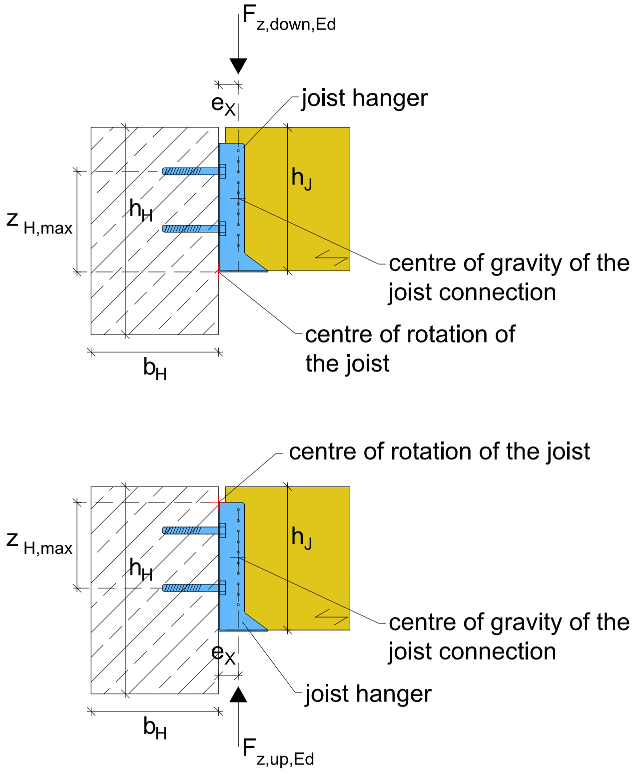


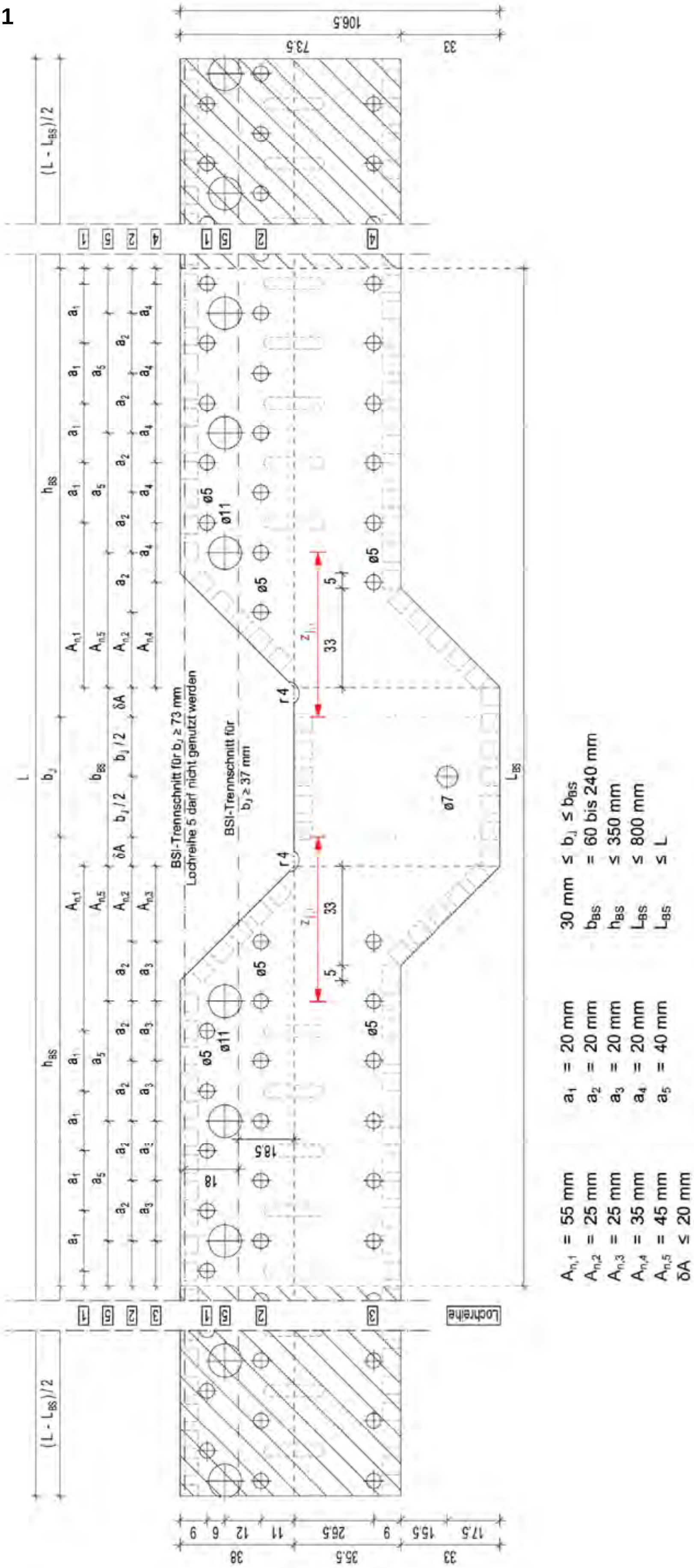
Figure A.3.5: Load direction Z: notation and joist hanger dimensions

BB joist hangers type 1, 2, 3 and 4	Annex 3.7
Characteristic load-carrying-capacities of BB joist hanger connections with nails or screws	

BB joist hanger type 1

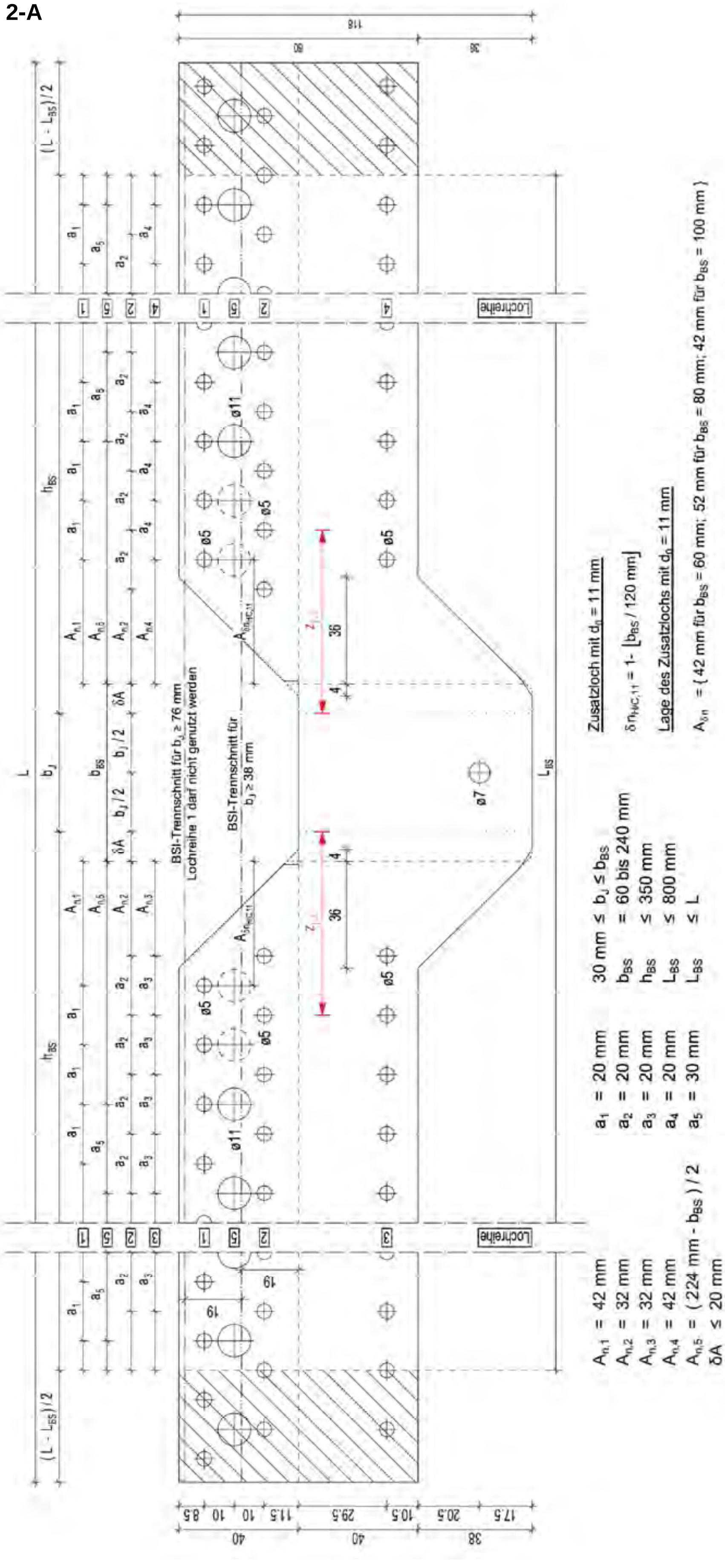
Drawing of blank

Annex 4



BB joist hanger type 2-A

Drawing of blank



BB joist hanger type 3-A

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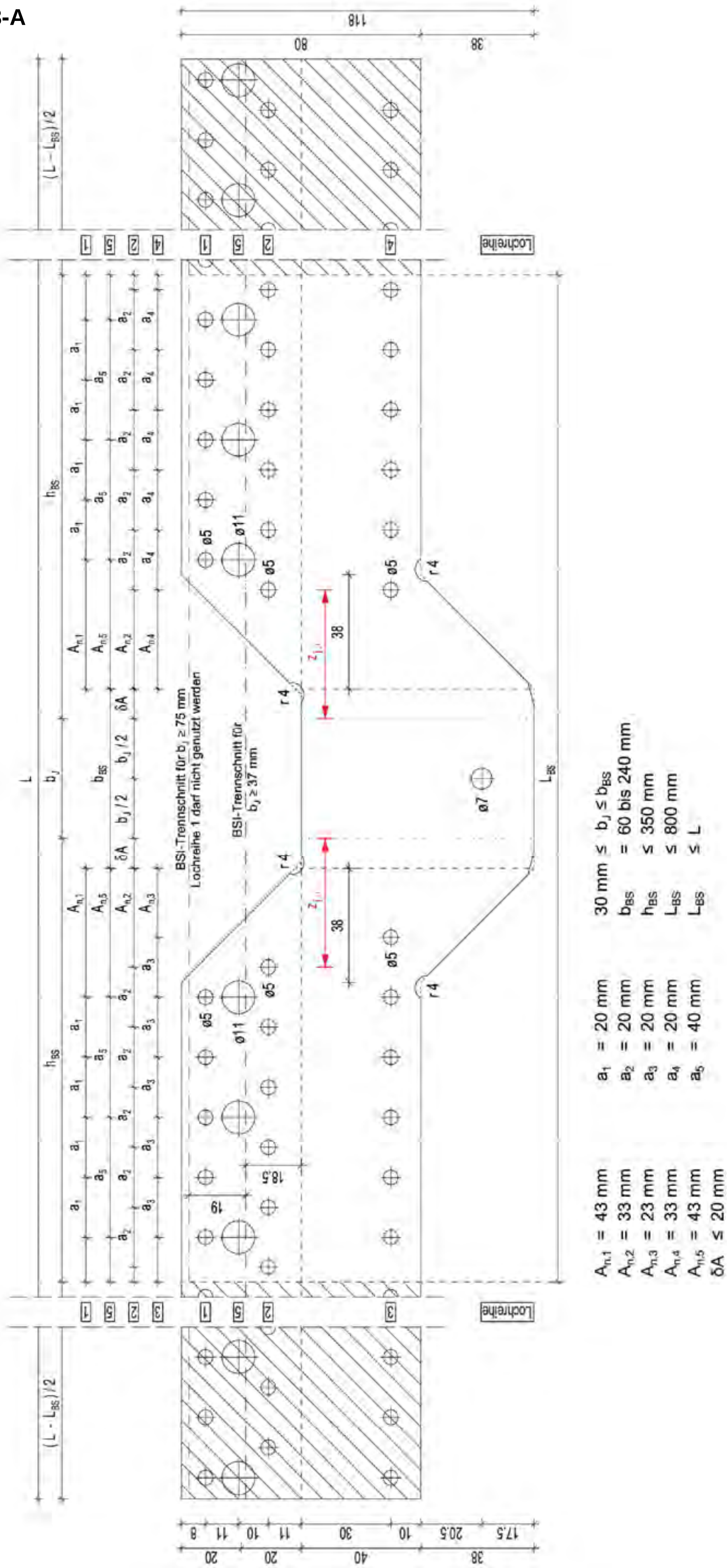

BB joist hanger type 4-A/B-2/2,5-S

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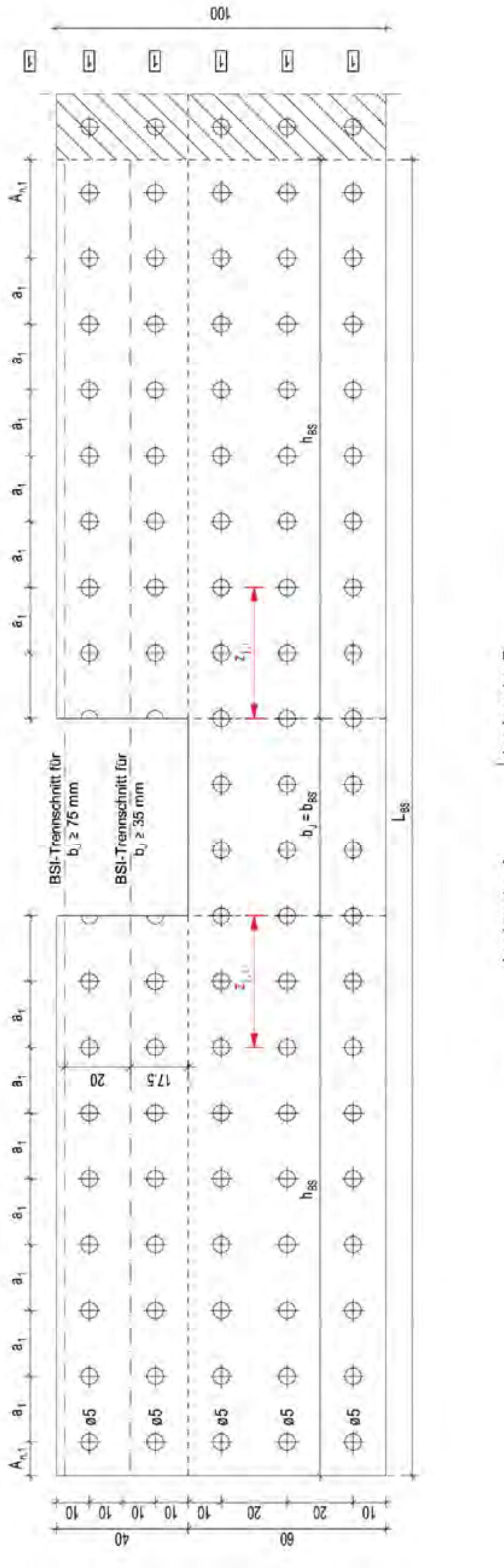

		Lochraster A	Lochraster B
$A_{n,1}$	=	10 mm	8.325 mm
$A_{n,2}$	=	20 mm	16.65 mm
a_1	=	20 mm	16.65 mm
a_2	=	40 mm	33.30 mm
b_J	=	$b_{BS} \leq 260$ mm	
L_{BS}	=	ohne 11 mm Loch:	$n \cdot (2 \cdot a_1)$
		mit 11 mm Loch (kombi):	$n \cdot (4 \cdot a_1)$

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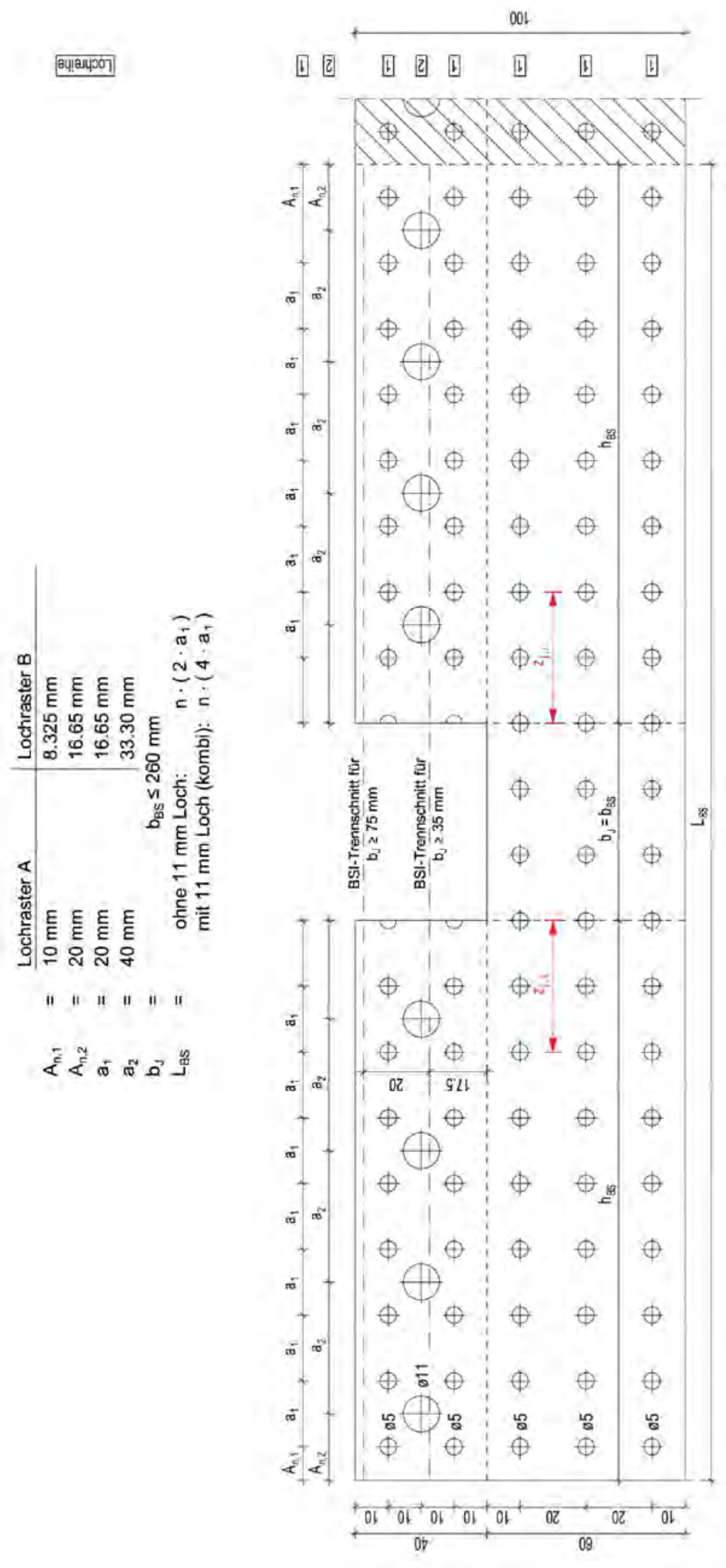
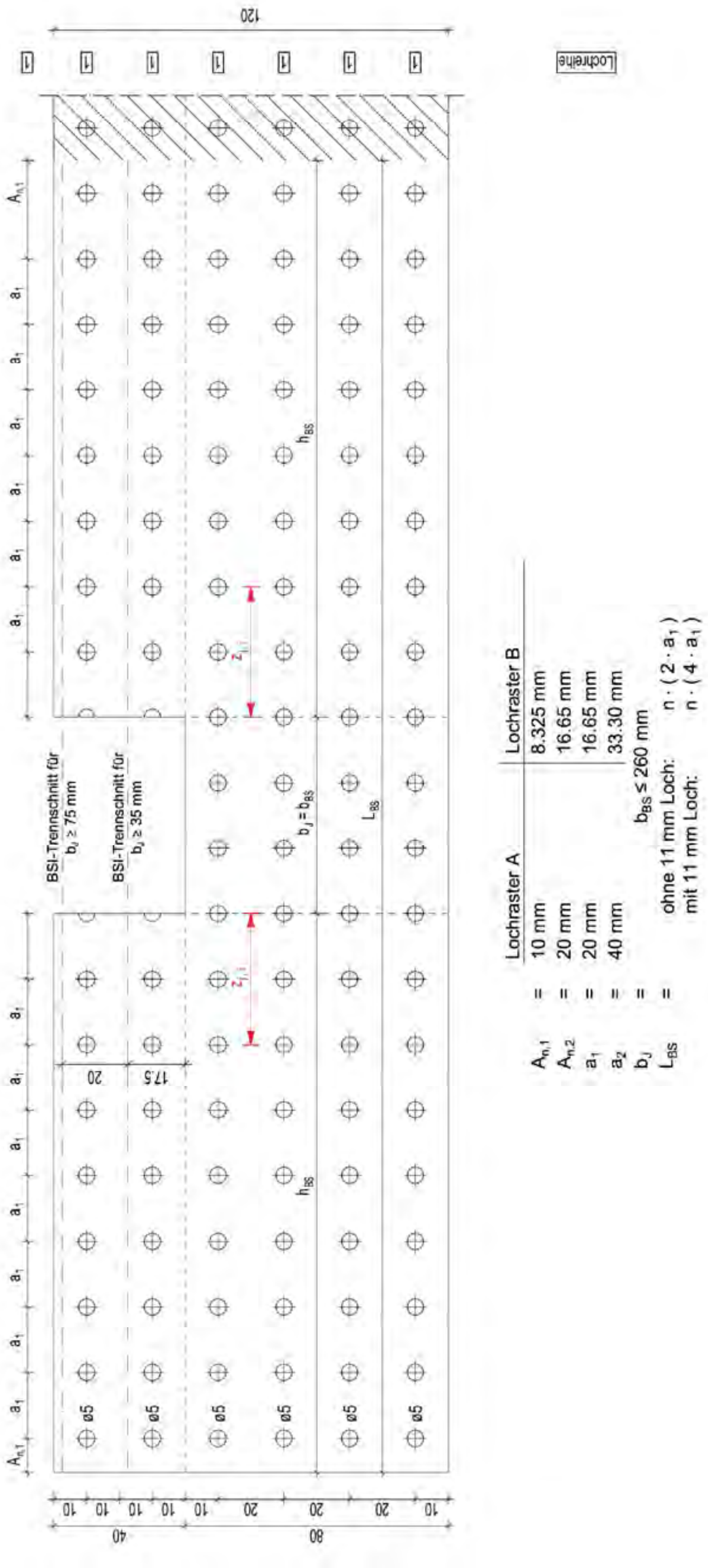
BB joist hanger type 4-A/B-2/2,5-S kombi

Drawing of blank



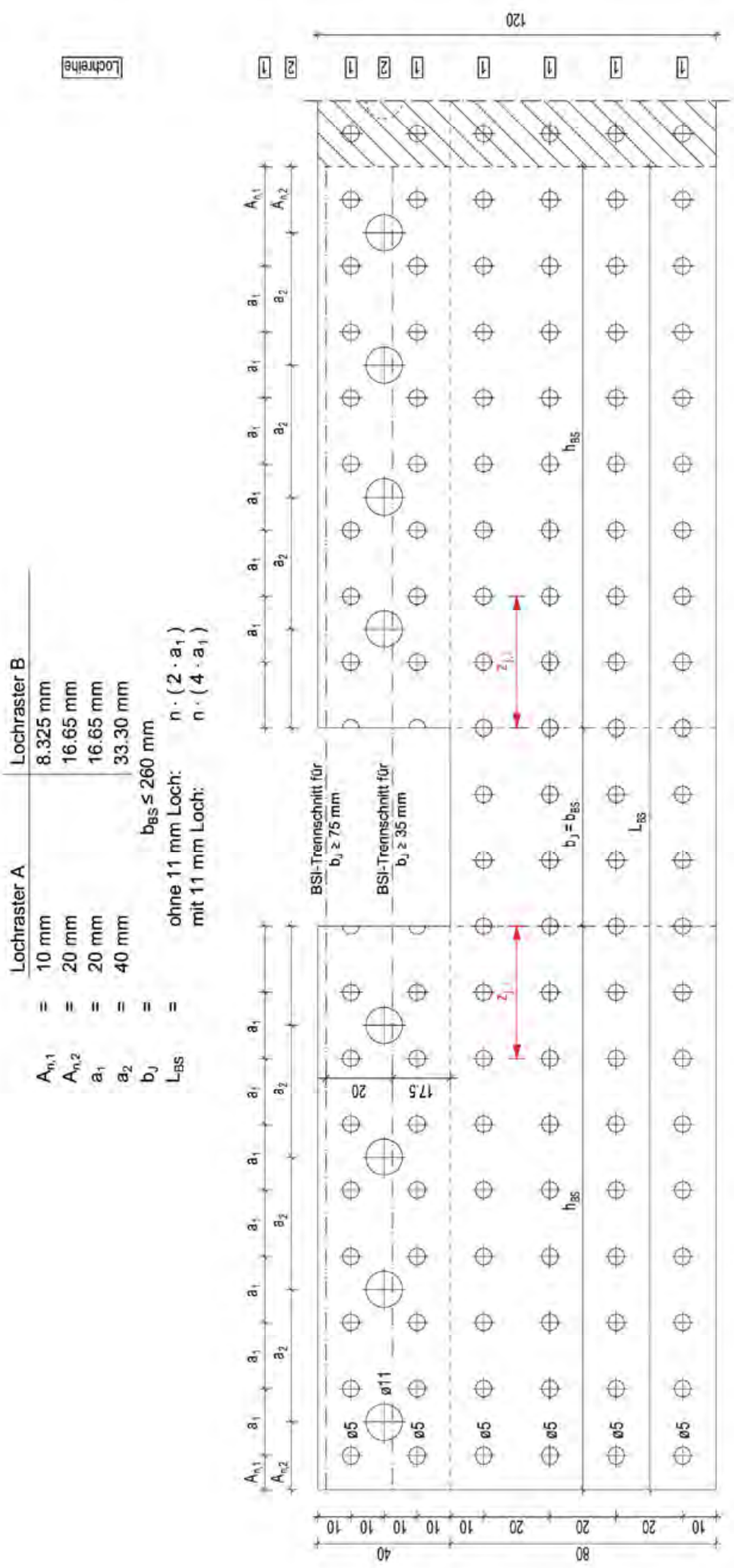
BB joist hanger type 4-A/B-2/2,5-L

Drawing of blank

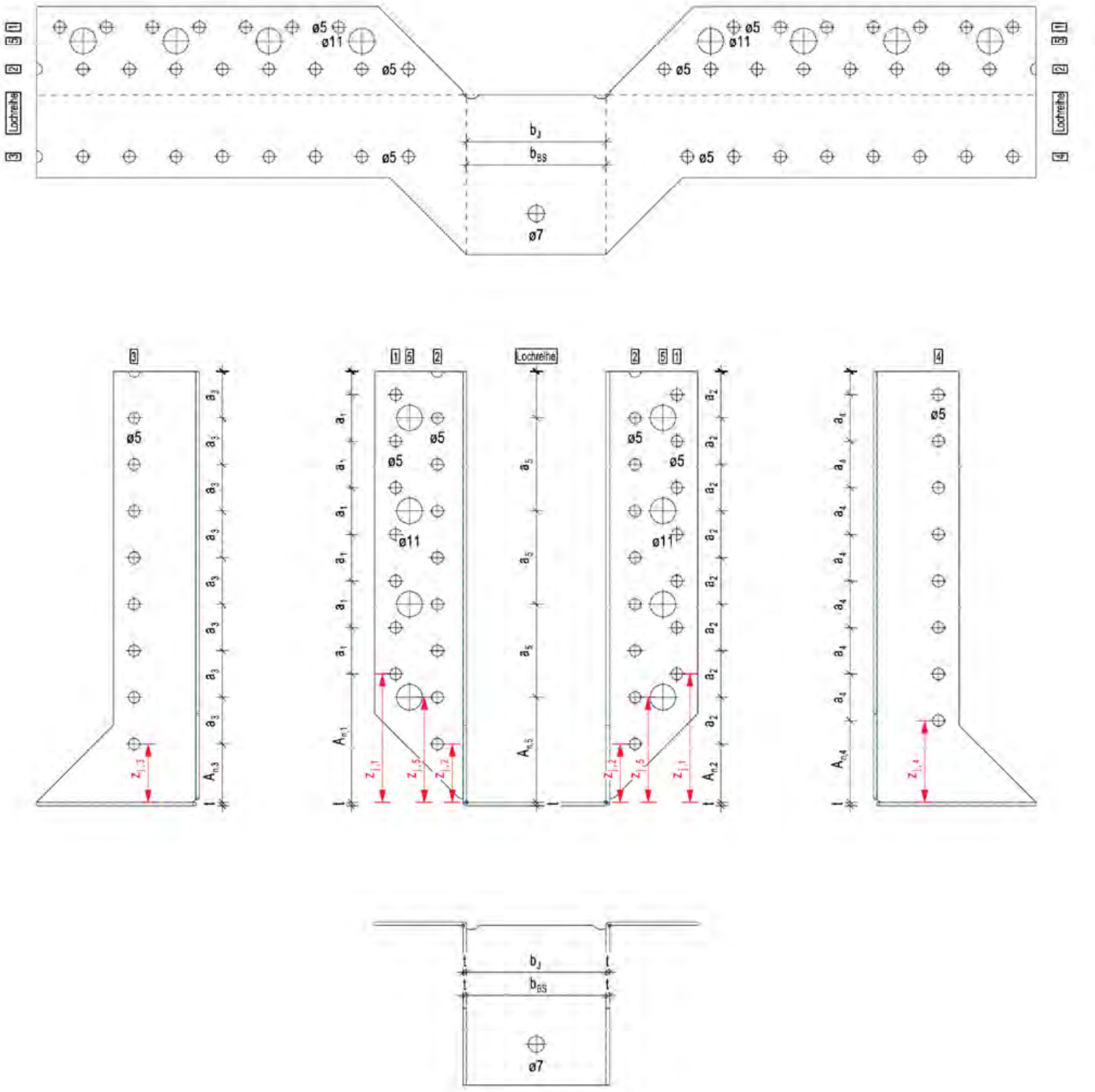


BB joist hanger type 4-A/B-2/2,5-I kombi

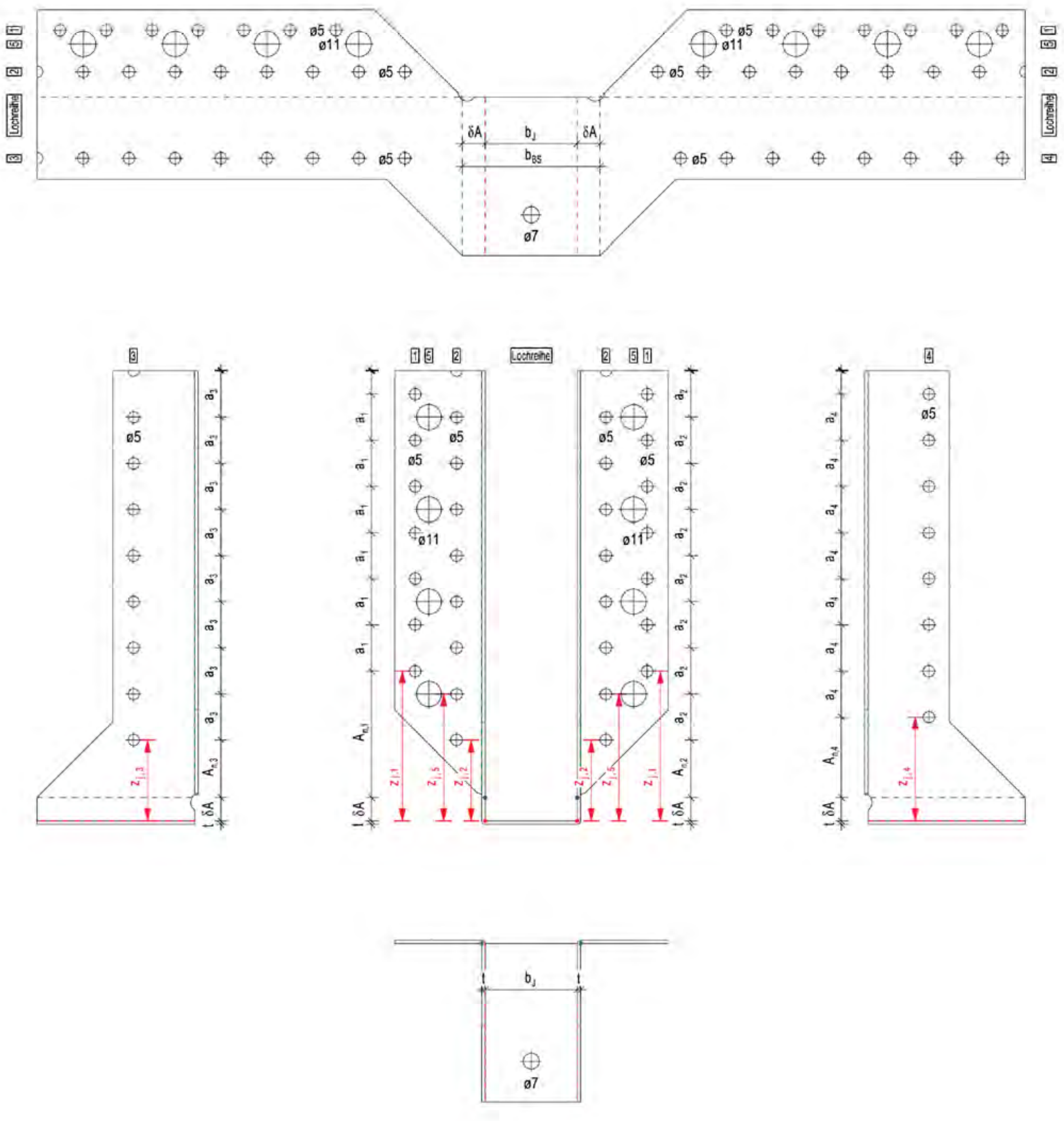
Drawing of blank



Explanation 1 (δA = 0)



Explanation 2 (0 < δA ≤ 20 mm)



Explanation of terms

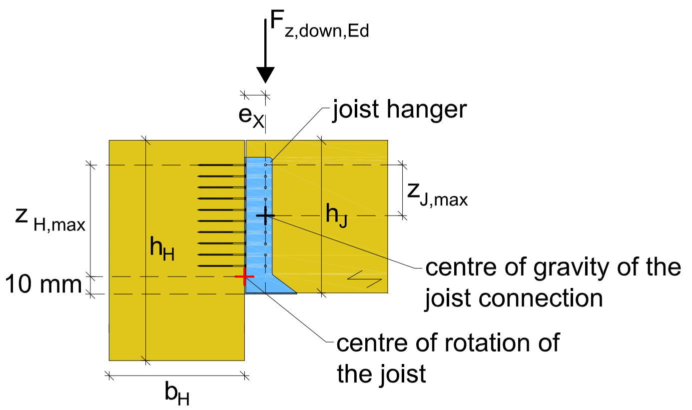
t	steel plate thickness of joist hanger
b_{BS}	width of joist hanger's bottom plate
h_{BS}	height of joist hanger
L_{BS}	length of joist hanger's punch-platine
i	index of the hole lines $1 \leq i \leq 5$
d	diameter of fasteners
$d_{0,I}$	diameter of punched hole of hole row i
δA	difference between the width of joist hanger's bottom plate and the width of the joist beam
$A_{0,I}$	distance to the first hole in in hole row i
$A_{1,I}$	distance to the first countable hole of hole row i taking into account the required edge distances of the plate
$A_{n,I}$	defined distance between the last hole in hole row i and the recessed corner on the beam shoe bottom plate.
a_i	axial distance of the holes of hole row i in the direction of the z-axis
j	index of the hole $1 \leq j \leq n_i$
$z_{j,I}$	z-coordinate of hole j in hole row i starting at the upper edge of the joist hanger's bottom plate
n_i	number of holes in hole row i, per joist hanger's leg
$n_{H/c,5}$	total number of existing holes with d_0 = 5 mm on header / column
$n_{H/c,11}$	total number of existing holes with d_0 = 11 mm on header / column
$n_{j,5}$	total number of existing holes with d_0 = 5 mm on joist beam
$\delta n_{H/C,11}$	Type 2: additional hole with d_0 = 11 mm on header / column
$A_{\delta nH/C,11}$	Type 2: position of the additional hole with d_0 = 11 mm on header / column

Annex 5 Example of calculation

Material Properties:

Header	b_H/h_H = 180/400; Glued Laminated Timber GL24h
Joist	b_J/h_J = 100/160; Glued Laminated Timber GL24h
Joist Hanger	b_{BS}/h_{BS} = 100 x 140 x 1,5 (see Annex 4.1)
Threaded Nails	∅4,0mm x 50 mm; Full Nailing
	$F_{v,J,Rk} = F_{v,H,Rk} = 1967\,N; F_{ax,J,Rk} = F_{ax,H,Rk} = 1038\,N$

Force downward toward the bottom plate



Due to the minimum spacing of the nails, the distance from the uppermost header nails to the upper edge of the header must be $a_{4,c} \geq 5d$ = 20 mm.Otherwise the nails must be excluded from the calculation.

Determination of the polar moment of inertia of the header fastener group $I_{p,H,1,ax}$

Distances from the centre of rotation to the nails (outer column of nails)

$$(z_{H,i,o}) = \{125; 105; 85; 65; 45\}\,mm$$

Distances from the centre of rotation to the nails (inner column of nails)

$$(z_{H,i,i}) = \{115; 95; 75; 55; 35; 15\}\,mm$$

$$I_{p,H,1,ax} = 2 \bullet \sum z_{H,i}^2 = 2 \bullet 72475 = 144950\,mm^2$$

Determination of the form factor $k_{H,1}$

$$k_{H,1} = \frac{I_{p,H,1,ax}}{e_x \bullet z_{H,max}} = \frac{144950\,mm^2}{28\,mm \bullet 125\,mm} = 41{,}41$$

With

n_J = 12, t = 1,5mm, l = 70mm, ρ_k = 385 kg/m^3

and

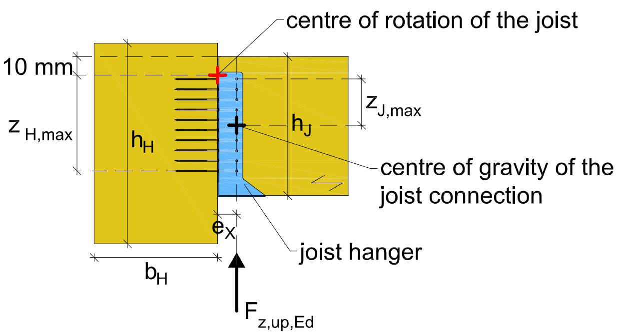
n_H = 22, $k_{H,1}$ = 41,41

BB joist hangers type 1, 2, 3 and 4	Annex 5.1
Example of calculation	

the load-carrying capacity $F_{Z,Rk}$ can be determined following EQ (A.3.1.1.1)

$$F_{Z,Rk} = \min\begin{cases} 12 \bullet 1967 + 3{,}24 \bullet 1{,}5 \bullet \sqrt{70 \bullet (70+30)} \bullet 385 \\ \dfrac{1}{\sqrt{\left(\dfrac{1}{22 \bullet 1{,}967}\right)^2 + \left(\dfrac{1}{41{,}41 \bullet 1{,}038}\right)^2}} \end{cases} = \min\begin{cases} 31{,}58 \\ 30{,}49 \end{cases} = 30{,}49\ \text{kN}$$

Force upward away from the bottom plate



Due to the minimum spacing of the nails, the distance from the uppermost header nails to the upper edge of the header must be $a_{4,t} \geq 7d = 28$ mm. Otherwise the nails must be excluded from the calculation.

Determination of the polar moment of inertia of the header fastener group $I_{p,H,2,ax}$

Distances from the centre of rotation to the nails (outer column of nails)

$$(z_{H,i,o}) = \{15; 35; 55; 75; 95\}\ \text{mm}$$

Distances from the centre of rotation to the nails (inner column of nails)

$$(z_{H,i,i}) = \{25; 45; 65; 85; 105; 125\}\ \text{mm}$$

$$I_{p,H,2,ax} = 2 \bullet \sum z_{H,i}^2 = 2 \bullet 59875 = 119750\ \text{mm}^2$$

Determination of the form factor $k_{H,2}$

$$k_{H,2} = \frac{I_{p,H,2,ax}}{e_x \bullet z_{H,max}} = \frac{119750\ \text{mm}^2}{28\ \text{mm} \bullet 125\ \text{mm}} = 34{,}21$$

With

$n_J = 12$

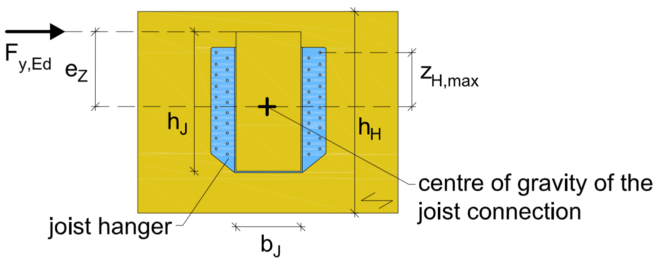
and

$n_H = 22$, $k_{H,2} = 34{,}21$

the load-carrying capacity $F_{Z,Rk}$ can be determined following EQ (A.3.1.1.2)

$$F_{Z,Rk} = \min\left\{\begin{array}{l} 12 \bullet 1{,}967 \\ \dfrac{1}{\sqrt{\left(\dfrac{1}{22 \bullet 1{,}967}\right)^2 + \left(\dfrac{1}{34{,}21 \bullet 1{,}038}\right)^2}} \end{array}\right. = \min\left\{\begin{array}{l} 23{,}60 \\ 27{,}45 \end{array}\right. = 23{,}60\ \text{kN}$$

Lateral Force



Due to the minimum spacing of the nails, the distance from the uppermost header nails to the upper edge of the header must be $a_{4,c} \geq 5d$ = 20 mm. Otherwise the nails must be excluded from the calculation.

Determination of the polar moment of inertia of the header fastener group $I_{p,H,v}$

The centre of gravity of the nails in the header is

$\bar{z}_H = \dfrac{\sum z_{H,i}}{n_H} = 55{,}91\,\text{mm}$ below the upper end of the joist hanger

The distances from the centre of gravity to the nails are

$$\begin{pmatrix} y_{H,i,s} \\ z_{H,i,s} \end{pmatrix} = \left\{\begin{array}{c} \pm 62; \pm 62; \pm 62; \pm 62; \pm 62; \pm 62; \pm 80; \pm 80; \pm 80; \pm 80; \pm 80 \\ 40{,}91; 20{,}91; 0{,}91; -19{,}09; -39{,}09; -59{,}09; 50{,}91; 30{,}91; 10{,}91; -9{,}09; -29{,}09 \end{array}\right\}\text{mm}$$

$$\sum y_{H,i,s}^2 = 2 \bullet (6 \bullet 62^2 + 5 \bullet 80^2) = 110128\ \text{mm}^2$$

$$\sum z_{H,i,s}^2 = 2 \bullet (40{,}91^2 + 20{,}91^2 + 0{,}91^2 + (-19{,}09)^2 + (-39{,}09)^2 + (-59{,}09)^2 + 50{,}91^2 + 30{,}91^2 + 10{,}91^2 + (-9{,}09)^2 + (-29{,}09)^2 = 24182\ \text{mm}^2$$

$$I_{p,H,v} = \sum\left(z_{H,i,s}^2 + y_{H,i,s}^2\right) = 134310\ \text{mm}^2$$

BB joist hangers type 1, 2, 3 and 4 Example of calculation	Annex 5.3

The centre of gravity of the nails in the joist is

$\bar{z}_J = \frac{\sum z_{J,i}}{n_J}$ =60,0 mm below the upper end of the joist hanger

With

n_J = 12, e_x = 28mm, $e_{z,J}$ = 160-140+65 = 85mm, b_J = 100mm

and

n_H = 22, $e_{z,H}$ = 160-140+55,91 = 75,91 mm, H* = 110 mm, W = 160 mm

the load-carrying capacity $F_{Y,Rk}$ can be determined following EQ (A.3.1.1.3)

$$F_{Y,Rk} = \min \begin{cases} \dfrac{12 \bullet 1{,}967}{\sqrt{\left(\dfrac{2 \bullet \sqrt{28^2 + 80^2}}{100}\right)^2 + \left(\dfrac{1{,}967}{1{,}038}\right)^2}} \\ \dfrac{1{,}967}{\sqrt{\left(\dfrac{1}{22} + \dfrac{75{,}91 \bullet 110}{2 \bullet 134310}\right)^2 + \left(\dfrac{75{,}91 \bullet 160}{2 \bullet 134310}\right)^2}} \end{cases} = \min \begin{cases} 9{,}28 \\ 22{,}13 \end{cases} = 9{,}28 \text{ kN}$$

BB joist hangers type 1, 2, 3 and 4	Annex 5.4
Example of calculation	