



ETA-Danmark A/S
Göteborg Plads 1
DK-2150 Nordhavn
Tel. +45 72 24 59 00
Fax +45 72 24 59 04
Internet www.etadanmark.dk

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to Article 29 of the Regulation (EU)
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MEMBER OF EOTA



European Technical Assessment ETA-13/1060 of 2022/03/08

I General Part

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

Trade name of the construction product:

BB Stanz- und Umformtechnik GmbH Hold-Downs,
Angle Bracket KR and Concrete or timber Flat Steel
Anchor

Product family to which the above construction product belongs:

Three-dimensional nailing plate (Angle brackets and hold-downs for timber-to-timber or timber-to-concrete or steel connections)

Manufacturer:

BB Stanz- und Umformtechnik GmbH
Nordhäuser Str. 44
D-06536 Berga
Tel. +49 34651 2988 0
Fax +49 34651 2988 20
Internet www.bb-berga.de

Manufacturing plant:

BB Stanz- und Umformtechnik GmbH
Nordhäuser Str. 44
D-06536 Berga

This European Technical Assessment contains:

63 pages including 2 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:

EAD 130186-00-0603 for Three-dimensional nailing plates

This version replaces:

The ETA with the same number issued on 2019-12-13

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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

BB angle brackets and hold-downs are one-piece or two-piece (only hold-downs) welded or similarly joined face-fixed nailing plates to be used in timber to concrete or to steel or in timber to timber connections. They are connected to construction members made of timber or wood-based products with profiled (ringed shank) nails or screws according to EN 14592 or ETA and to concrete or steel members with bolts or metal anchors.

The hold-downs with a steel plate thickness of 3.0 mm to 4.0 mm are made from steel grade S235 and S355 according to EN 10025-2, or steel grade DX51D according to EN 10346 with $R_e \geq 200 \text{ N/mm}^2$, $R_m \geq 270 \text{ N/mm}^2$ and $A_{80} \geq 22\%$, or steel grade DD11 according to EN 10111 with $R_{eL} \geq 200 \text{ N/mm}^2$, $R_m \leq 440 \text{ N/mm}^2$ and $A_{80} \geq 23\%$ with tolerances according to EN 10143 and are available in various sizes.

The angle brackets are made from steel S250GD according to EN 10346, or from steel DX51D according to EN 10346 with a minimum yield strength of $R_{eL} \geq 251 \text{ N/mm}^2$, or from steel DD11 according to EN 10111 with a minimum yield strength of $R_{eL} \geq 251 \text{ N/mm}^2$ with tolerances according to EN 10143.

Dimensions, hole positions and typical installations are shown in Annex A and B.

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

The angle brackets and hold-downs are intended for use in making connections in load bearing timber structures, as a connection between a column and a concrete, steel or timber member, where requirements for mechanical resistance and stability and safety in use in the sense of the Basic Works Requirements 1 and 4 of Regulation (EU) 305/2011 shall be fulfilled.

The connection may be with a single angle bracket or with an angle bracket on each side of the fastened timber member (see Annex B).

The static and kinematical behaviour of the timber members or the supports shall be as described in Annex B.

The wood members may be of solid timber, glued laminated timber and similar glued members, or wood-based structural members. These requirements to the material of the softwood members can be fulfilled by using timber or wood-based material with a characteristic density from 290 kg/m^3 to 440 kg/m^3 . This is fulfilled for the following materials:

- Solid timber according to EN 14081,
- Glued solid timber according to EN 14080,
- Glulam according to EN 14080,
- LVL according to EN 14374,
- Parallam PSL,
- Intrallam LSL,
- Cross laminated timber according to EN 16351,
- Plywood according to EN 636

Annex B states the load-carrying capacities of the hold-down connections for a characteristic density of 350 kg/m^3 . For softwood timber or wood-based material with a different characteristic density the load-carrying capacities of the steel-to-timber connections shall be modified by the k_{dens} factor:

For densities above 350 kg/m^3 :

$$k_{\text{dens}} = \left(\frac{\rho_k}{350} \right)^{0.5}$$

For densities below 350 kg/m^3 :

$$k_{\text{dens}} = \left(\frac{\rho_k}{350} \right)^{0.8}$$

Where ρ_k is the characteristic density of the timber in kg/m^3 .

For hold-downs connected to hardwood members, the load-carrying capacity of the nailed or screwed steel-to-timber connection is calculated according to Eurocode 5.

The design of the connections shall be in accordance with Eurocode 5 or a similar national Timber Code. The wood members shall have a thickness which is larger than the penetration depth of the fasteners into the members.

The angle brackets and hold-downs are primarily for use in timber structures subject to the dry, internal conditions defined by service classes 1 and 2 of Eurocode 5 and for connections subject to static or quasi-static loading.

The angle brackets and hold-downs may also be used in outdoor timber structures, service class 3, when a corrosion protection in accordance with Eurocode 5, table 4.1 is applied, or when stainless steel according to

EN 10088-1 with similar or better characteristic yield and ultimate strength is employed. If a stainless steel with a lower characteristic yield or ultimate strength is employed, the load-carrying capacities $F_{t,Rk}$ in Table 1 (see annex B) are to be reduced proportionally.

The scope of the brackets regarding resistance to corrosion shall be defined according to national provisions that apply at the installation site considering environmental conditions.

The hold-downs may also be used for connections between a timber member and a member of concrete or steel.

The provisions made in this European Technical Assessment are based on an assumed intended working life of the hold-downs of 50 years.

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

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

Characteristic	Assessment of characteristic
3.1 Mechanical resistance and stability^{*)} (BWR 1)	
Joint Strength - Characteristic load-carrying capacity	See Annex B
Joint Stiffness	No performance assessed
Joint ductility	No performance assessed
Resistance to seismic actions	No performance assessed
Resistance to corrosion and deterioration	See section 3.6
3.2 Safety in case of fire (BR2)	
Reaction to fire	The angle brackets and hold downs are made from steel classified as reaction to fire Class A1 as provided for in the Delegated Regulation 2016/364/EC and EN 13501-1.
3.3 Related aspects of serviceability	
Durability	The angle brackets and hold-downs 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, 2 and 3.
Identification	See annex A

^{*)} See additional information in section 3.4 – 3.7.

3.4 Methods of verification

Safety principles and partial factors

The characteristic load-carrying capacities are based on the characteristic values of the nail or screw connections and the steel plates. 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 or screws subjected to shear or the withdrawal capacity of the most loaded nail or screw, 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 $\gamma_{M,H}$ for timber or $\gamma_{M,S}$ for steel, respectively, have to be taken into account.

3.5 Mechanical resistance and stability

See annex B for the characteristic load-carrying capacity in the direction F_1 for the hold-downs and F_1 to F_5 for the angle brackets.

The characteristic capacities of the hold-downs are determined by calculation assisted by testing as described in the EAD 130186-00-0603. They should be used for designs in accordance with Eurocode 5 or a similar national Timber Code.

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.

3.6 Aspects related to the performance of the product

The brackets are for use in timber structures subject to the service classes 1, 2 and 3 of Eurocode 5 and for connections subject to static or quasi-static loading.

3.6.1 Corrosion protection in service class 1 and 2.

In service class 1 and 2 the corrosion protection is given by hot-dip zinc coating Z275 according to EN 10346, or zinc coating Fe/Zn 12 according to EN ISO 2081, or zinc coating according to EN 1461 with a minimum thickness of 8 μm .

3.6.2 Corrosion protection in service class 3.

In service class 3 the corrosion protection is given by hot-dip zinc coating Z350 according to EN 10346, or zinc coating Fe/Zn 25 according to EN ISO 2081, or zinc coating according to EN 1461 with a minimum thickness of 55 μm , or stainless steel according to EN 10088-1.

3.7 General aspects related to the fitness for use of the product

The angle brackets and hold-downs are manufactured in accordance with the provisions of this European Technical Assessment using the manufacturing processes as identified in the inspection of the plant by the notified inspection body and laid down in the technical documentation

The nailing pattern used shall be either the maximum or the minimum pattern as defined in Annex B.

The following provisions concerning installation apply:

The structural members – the components 1 and 2 shown in the figure on page 12 - to which the brackets are fixed shall be:

- Restrained against rotation. At a load F_2/F_3 and F_4/F_5 , the timber component is allowed to be restrained against rotation by the angle brackets
- Strength class C14 or better,
- Free from wane under the bracket.
- The gap between the timber members does not exceed 3 mm.
- There are no specific requirements relating to preparation of the timber members.
- The execution of the connection shall be in accordance with the assessment holder's technical literature.

4 Attestation and verification of constancy of performance (AVCP)

4.1 AVCP system

According to the decision 97/638/EC of the European Commission, 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 2022-03-08 by



Thomas Bruun
Manager, ETA-Danmark

Annex A
Product details definitions

Table A.1: Materials specification – hold-downs

Hold-down type	Thickness (mm)	Steel specification
KR Lx90x65x3,0	3.0	DX51D or DD11
KR Lx90x65x4,0	4.0	DX51D or DD11
R Lx60x60x3,0	3.0	S355
R Lx80x80x3,0	3.0	S355
RL 95x155x60x3,0	3.0	S355
Washer 30x3	3.0	S235
Washer 37x3	3.0	S235
Base plate 58,5x50x10	10.0	S235
Base plate 79x70x20	20.0	S235
Vertical flange Lx40x3,0	3.0	S350GD
Storey connector	3.0	S350GD
Vertical flange Lx60x3,0	3.0	S350GD
Vertical flange BPD	2.0	S250GD
Vertical flange BPR or BPL	2.0	S250GD

Table A.2: Range of sizes – hold-downs

Hold-down type	Length vertical (mm)		Length horizontal (mm)		Width (mm)	
	min	max	min	max	min	max
KR 460x90x65x3,0	456,8	463,2	88,4	91,6	63,4	66,6
KR 560x90x65x3,0	556,8	563,2	88,4	91,6	63,4	66,6
KR 460x90x65x4,0	456,0	464,0	88,0	92,0	63,0	67,0
KR 560x90x65x4,0	556,0	564,0	88,0	92,0	63,0	67,0
R 340x60x60x3,0	337,6	342,4	61,8	64,2	58,8	61,2
R 440x60x60x3,0	436,8	443,2	61,8	64,2	58,8	61,2
R 540x60x60x3,0	536,8	543,2	61,8	64,2	58,8	61,2
R 620x80x80x3,0	616,8	623,2	81,4	84,6	78,4	81,6
RL 95x155x60x3,0	93,4	96,6	153,4	156,6	58,8	61,2
Washer 30x3	-	-	28,8	31,2	28,8	31,2
Washer 37x3	-	-	35,8	38,2	35,8	38,2
Base plate 58,5x50x10	-	-	57,0	61,0	48,0	52,0
Base plate 79x70x20	-	-	75,8	82,2	66,8	73,2
Vertical flange 340x40x3,0	337,6	342,4	-	-	38,8	41,2
Vertical flange 440x40x3,0	437,6	442,4	-	-	38,8	41,2
Vertical flange 540x40x3,0	537,6	542,4	-	-	38,8	41,2

Table A.3: Materials specification – angle brackets

Bracket type	Thickness (mm)	Steel specification
KR 95	4.0	DX51D or DD11
KR 135	4.0	DX51D or DD11
KR 137	4.0	DX51D or DD11
KR 285	4.0	DX51D or DD11

Table A.4: Range of sizes – angle brackets

Bracket type	Length vertical (mm)		Length horizontal (mm)		Width (mm)	
	min	max	min	max	min	max
KR 95	93,0	97,0	88,0	92,0	63,0	67,0
KR 135	133,0	137,0	88,0	92,0	63,0	67,0
KR 137	135,0	139,0	88,0	92,0	63,0	67,0
KR 285	282,6	287,4	88,0	92,0	63,0	67,0

Table A.5: Materials specification – concrete flat steel anchor

Concrete flat steel anchor	Thickness (mm)	Steel specification
200x40x40x2,0	2.0	S250GD
300x40x40x2,0	2.0	S250GD
400x40x40x2,0	2.0	S250GD
500x40x40x2,0	2.0	S250GD
200x40x40x4,0	4.0	S250GD
300x40x40x4,0	4.0	S250GD
400x40x40x4,0	4.0	S250GD
500x40x40x4,0	4.0	S250GD

Table A.6: Range of sizes – concrete flat steel anchor

Concrete flat steel anchor	Length vertical (mm)		Length horizontal (mm)		Width (mm)	
	min	max	min	max	min	max
200x40x40x2,0	203,6	208,4	40,8	43,2	38,8	41,2
300x40x40x2,0	304,6	309,4	40,8	43,2	38,8	41,2
400x40x40x2,0	403,8	410,2	40,8	43,2	38,8	41,2
500x40x40x2,0	503,8	510,2	40,8	43,2	38,8	41,2
200x40x40x4,0	206,6	211,4	40,4	43,6	38,4	41,6
300x40x40x4,0	306,6	311,4	40,4	43,6	38,4	41,6
400x40x40x4,0	405,0	413,0	40,4	43,6	38,4	41,6
500x40x40x4,0	505,0	513,0	40,4	43,6	38,4	41,6

Table A.7: Fastener specification

Bracket type	Fastener	Size (mm)			Type
		min diameter	min length	min threaded length	
KR 95, KR 135, KR 285, concrete flat steel anchor	Threaded nails	4.0	40	30	Ringed shank nail according to EN 14592
	Screws	5.0	30	25	Self-tapping screw with joist hanger head according to ETA-11/0190 or EN 14592
KR 137	Screws	10.0	60	50	Self-tapping screw according to ETA-11/0190 or EN 14592
KR Lx90x65x3,0, KR Lx90x65x4,0, R Lx60x60x3,0, R Lx80x80x3,0, RL 95x155x60x3,0, Vertical flange Lx40x3,0, Storey connector Lx40x3,0 Vertical flange Lx60x3,0, Vertical flange BPD, BPR 380, BPL 380 BPR 465, BPL 465	Threaded nails	4.0	40	31	Ringed shank nail according to EN 14592
		4.0	50	40	
		4.0	60	50	
	Screws	5.0	35	30	Self-tapping screw according to ETA-11/0190 with joist hanger head or EN 14592
		5.0	40	32	
		5.0	50	42	
Two-piece hold-downs	Self-tapping screws	6.3	19	11.5	ZEBRA Pias screws 6.3x19 according to ETA-10/0184

Above listed self-tapping screws according to EN 14592 have to fulfil the following requirements:

- min diameter 5.0 mm: $f_{ax,k} \geq 12.0 \text{ N/mm}^2$ and $M_{y,Rk} \geq 5,900 \text{ Nmm}$;
- min diameter 10.0 mm: $f_{ax,k} \geq 11.0 \text{ N/mm}^2$ and $M_{y,Rk} \geq 36,000 \text{ Nmm}$.

In the load-carrying-capacities of the connection 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 characteristic withdrawal capacity of the nails has to be determined by calculation in accordance with EN 1995-1-1, 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/mm^2
- d Nail diameter in mm
- t_{pen} Penetration depth of the profiled shank

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

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

Where:

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

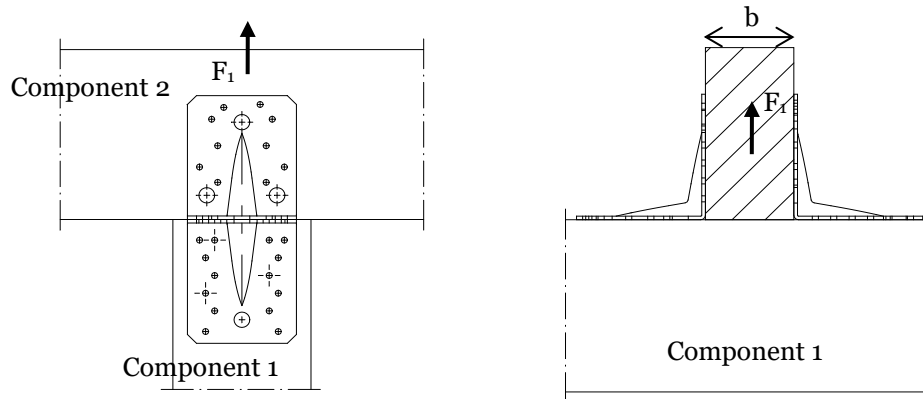
BOLT or METAL ANCHOR or SCREW diameter	Correspondent hole diameter	Bolt or screw or metal anchor type
8.0, 10.0, 12.0, 16.0, 18.0 and 20.0 mm	<p>Max. 2 mm. larger than the bolt or anchor or screw shank diameter</p> <p>Hold-downs only loaded by a force F1 may have larger hole diameters than d +2 mm, if an additional washer ensures the transfer of the tensile load into the hold-down.</p>	Bolt or screw according to EN 14592, metal anchor according to ETA (see specification of the manufacturer)

Annex B

Characteristic load-carrying capacities and product drawings

B.1 Hold-downs

Definitions of forces, their directions and eccentricity



Single hold-down per connection

Acting forces:

F_1 Lifting force acting in the central axis of the hold down. The component 2 shall be prevented from rotation.

Double hold-downs per connection

The hold-downs must be placed at each side opposite to each other, symmetrically to the component axis.

Acting forces:

F_1 Lifting force acting along the central axis of the joint. The load-carrying capacity is twice the load-carrying capacity of a connection with one hold-down

Wane

Wane is not allowed; the timber has to be sharp-edged in the area of the hold-downs.

Connection to timber, concrete or steel with a bolt or metal anchor

The load $F_{B,t,Ed}$ for the design of a bolt or metal anchor is calculated as:

$$F_{B,t,Ed} = k_t \cdot F_{t,Ed} \quad \text{for tensile load} \quad (B.1.1)$$

Where:

$F_{B,t,Ed}$ Bolt tensile load in N
 k_t Coefficient taking into account the moment arm or hole tolerance, respectively
 $F_{t,Ed}$ Tensile load F_1 on vertical flap of the hold-down

Characteristic load-carrying capacities for connections with one hold-down per connection**Table B.1:** Force F_1 , 1 one-piece hold-down / connection timber-timber / concrete / steel

Hold-down type	capacity per nail in the vertical flange (F _{v,Rk}) ¹⁾ [kN]			capacity per screw in the vertical flange (F _{v,Rk}) ¹⁾ [kN]			concrete	steel ²⁾	bolt ³⁾	bolt or screw ⁴⁾
	4x40	4x50	4x60	5x35	5x40	5x50		tensile (F _{t,Rk}) ⁵⁾ [kN]	k _t	k _t
KR Lx90x65x3,0	1,57	1,87	1,93	1,88	2,14	2,29	see EN 1992	36,2	1,0	1,0
KR Lx90x65x4,0	1,57	1,87	1,93	1,88	2,14	2,29		48,3	1,0	1,0
R Lx60x60x3,0*	1,57	1,87	1,93	1,88	2,14	2,29		32,5	1,0	1,0
R Lx60x60x3,0**	1,57	1,87	1,93	1,88	2,14	2,29		45,0	1,0	1,0
R Lx80x80x3,0***	1,57	1,87	1,93	1,88	2,14	2,29		60,0	1,0	1,0
R Lx80x80x3,0****	1,57	1,87	1,93	1,88	2,14	2,29		60,0	1,0	1,0
* with washer 30x3; ** with base plate t = 10 mm; *** with washer 37x3; **** base plate t = 20 mm										

- 1) For hardwoods, $F_{v,Rk}$ has to be calculated according to EN 1995-1-1;
If a wood-based panel interlayer with a thickness of not more than 26 mm is placed between the connector plate and the timber member, the lateral load-carrying capacity of the nail or screw, respectively, has to take into account the effect of the interlayer.
- 2) Base plates/washers according to the engineering drawings are used
- 3) Bolt connection timber-concrete / steel
- 4) Bolt or screw connection timber-timber
- 5) Partial factor $\gamma_{M,S} = \gamma_{M2}$ for steel failure

Connections with one two-piece hold-down per connection or with storey connectors

$$F_{l,Rk} = \min \{ n_{ef,t} \cdot F_{v,Rk}; N_{t,Rk}; n_{ef,s} \cdot 5,5 \text{ kN}; F_{t,Rk}; F_{c,Rk} \} \quad (\text{B.1.2})$$

Where

- $n_{ef,t}$ Effective number of nails or screws in the 60 mm or 40 mm vertical flange according to Table B.3 or B.4, effective number of nails or screws in vertical flange BPD or BPR or BPL according to Table B.5,
- $F_{v,Rk}$ Load-carrying capacity per nail or screw in the vertical flange according to Table B.2
- $N_{t,Rk}$ Tensile capacity of the vertical flange
 $N_{t,Rk} = 37,8 \text{ kN}$ for $e = 0$ and hold-downs with vertical flange BPD, BPR or BPL
 $N_{t,Rk} = 16,4 \text{ kN}$ for $e = 10 \text{ mm}$ and hold-downs with vertical flange BPD
 $N_{t,Rk} = 19,4 \text{ kN}$ for $e = 10 \text{ mm}$ and hold-downs with vertical flange BPR or BPL
 $N_{t,Rk} = 46,9 \text{ kN}$ for hold-downs KR, R and RL for $e = 0$ and 60 mm flange
 $N_{t,Rk} = 34,1 \text{ kN}$ for hold-downs KR, R and RL for $e = 10 \text{ mm}$ and 60 mm flange
 $N_{t,Rk} = 27,3 \text{ kN}$ for hold-downs KR for $e = 17,5 \text{ mm}$ and 60 mm flange
 $N_{t,Rk} = 31,3 \text{ kN}$ for hold-downs KR, R and RL for $e = 0$ and 40 mm flange or for storey connectors
 $N_{t,Rk} = 19,3 \text{ kN}$ for hold-downs KR, R and RL for $e = 10 \text{ mm}$ and BP 40 flange
- e Horizontal eccentricity of the vertical flange with regard to the hold-down
- $n_{ef,s}$ Effective number of ZEBRA Pias screws 6.3x19 between the vertical flange and the hold-down according to Table B.6;
- $F_{t,Rk}$ Load-carrying capacity of the hold-down for load direction F_1 according to Table B.2;
- $F_{c,Rk}$ Load-carrying capacity of the concrete under the hold-down according to EN 1992;

Table B.2: Force F_1 , 1 two-piece hold-down / connection timber-timber / concrete / steel or storey connector

Hold-down type	capacity per nail in the vertical flange (F _{v,Rk}) ¹⁾ [kN]			capacity per screw in the verti- cal flange (F _{v,Rk}) ¹⁾ [kN]			Concrete (F _{c,Rk}) [kN]	steel ²⁾	bolt ³⁾	bolt or screw ⁴⁾
								tensile (F _{t,Rk}) ⁵⁾ [kN]	k _t	k _t
	4x40	4x50	4x60	5x35	5x40	5x50				
KR Lx90x65x4,0	1,57	1,87	1,93	1,88	2,14	2,29	see EN 1992	48,3	1,4	1,3
R Lx60x60x3,0*	1,57	1,87	1,93	1,88	2,14	2,29		32,5	1,2	1,2
RL 95x155x60x3,0	1,57	1,87	1,93	1,88	2,14	2,29		35,0	1,5	1,5
* with washer 30x3;										

- ¹⁾ For hardwoods, $F_{v,Rk}$ has to be calculated according to EN 1995-1-1;
If a wood-based panel interlayer with a thickness of not more than 26 mm is placed between the connector plate and the timber member, the lateral load-carrying capacity of the nail or screw, respectively, has to take into account the effect of the interlayer.
- ²⁾ Base plates/washers according to the engineering drawings are used
- ³⁾ Bolt connection timber-concrete / steel
- ⁴⁾ Bolt or screw connection timber-timber
- ⁵⁾ Partial factor $\gamma_{M,S} = \gamma_{M2}$ for steel failure

Table B.3: Effective number $n_{ef,t}$ of nails or screws for 60 mm vertical flange

Number of fasteners	e [mm]	$n_{ef,t}$	e [mm]	$n_{ef,t}$	e [mm]	$n_{ef,t}$
5	0	5	10	2,9	17,5	2,2
7	0	7	10	4,3	17,5	3,3
10	0	10	10	7,4	17,5	6,1
12	0	12	10	9,6	17,5	8,0
15	0	15	10	13,0	17,5	11,5
17	0	17	10	15,2	17,5	13,7
20	0	20	10	18,5	17,5	17,2
22	0	22	10	20,6	17,5	19,3
25	0	25	10	23,8	17,5	22,7
27	0	27	10	25,9	17,5	24,8
30	0	30	10	29,1	17,5	28,1
32	0	32	10	31,1	17,5	30,2
35	0	35	10	34,2	17,5	33,4
37	0	37	10	36,6	17,5	35,4
40	0	40	10	39,3	17,5	38,6
42	0	42	10	41,4	17,5	40,6

Table B.4: Effective number $n_{ef,t}$ of nails or screws for BP 40 vertical flange

Number of fasteners	e [mm]	$n_{ef,t}$	e [mm]	$n_{ef,t}$
3	0	3	10	1,6
5	0	5	10	3,7
6	0	6	10	4,5
8	0	8	10	6,8
9	0	9	10	7,7
11	0	11	10	10,0
12	0	12	10	10,9
14	0	14	10	13,1
15	0	15	10	14,1
17	0	17	10	16,2
18	0	18	10	17,2
20	0	20	10	19,3
21	0	21	10	20,3
23	0	23	10	22,4
24	0	24	10	23,4
26	0	26	10	25,4
27	0	27	10	26,4
29	0	29	10	28,5
30	0	30	10	29,5
32	0	32	10	31,6
33	0	33	10	32,6

Table B.5: Effective number $n_{ef,t}$ of nails or screws for BPD, BPR or BPL vertical flange

Vertical flange BPD		Vertical flange BPR or BPL	
Number of fasteners	$n_{ef,t}$	Number of fasteners	$n_{ef,t}$
4	1,9	3	0,8
6	3,4	6	2,8
8	3,4	9	3,4
10	5,8	12	5,4
12	8,1	15	7,9
		18	10,5
		20	12,6

Table B.6: Effective number $n_{ef,s}$ of ZEBRA Pias screws 6.3x19

Screw arrangement		n_s	$n_{ef,s}$
1-2-3-4-5-6	only BP 60 flange or BPD or BPR or BPL	6	6
1-2-3-4	BP 40 or BP 60 flange or BPD or BPR or BPL or storey connectors	4	4
1-2-4-5 or 1-3-4-6	BP 40 or BP 60 flange or BPD or BPR or BPL or storey connectors	4	2,7
4-5-6	only BP 60 flange or BPD or BPR or BPL	3	3
3-4-6 or 2-4-5	BP 40 or BP 60 flange or BPD or BPR or BPL or storey connectors	3	1,6

Product drawings hold-downs

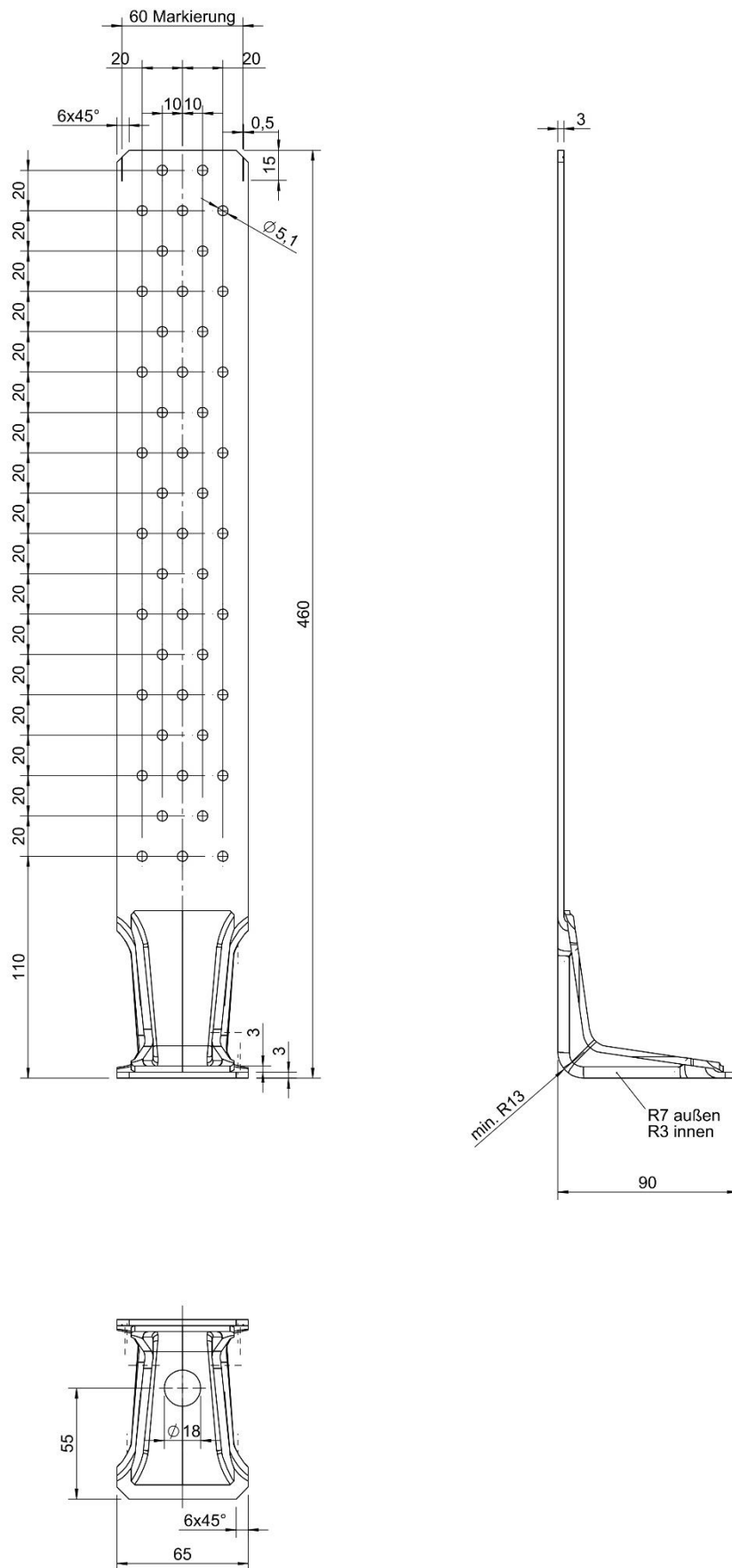


Figure B.1 Dimensions of type KR 460x90x65x3,0

Figure B.2 Dimensions of type KR 560x90x65x3,0

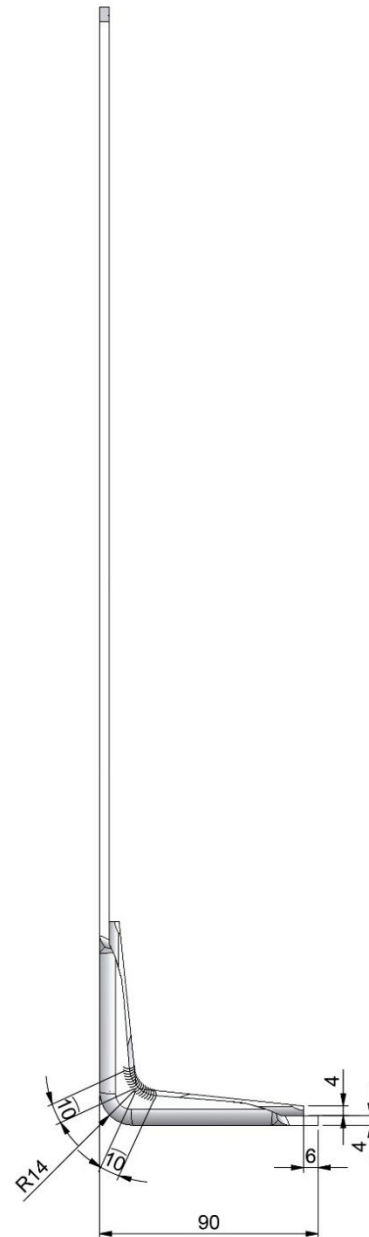
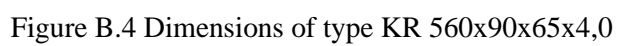


Figure B.3 Dimensions of type KR 460x90x65x4,0



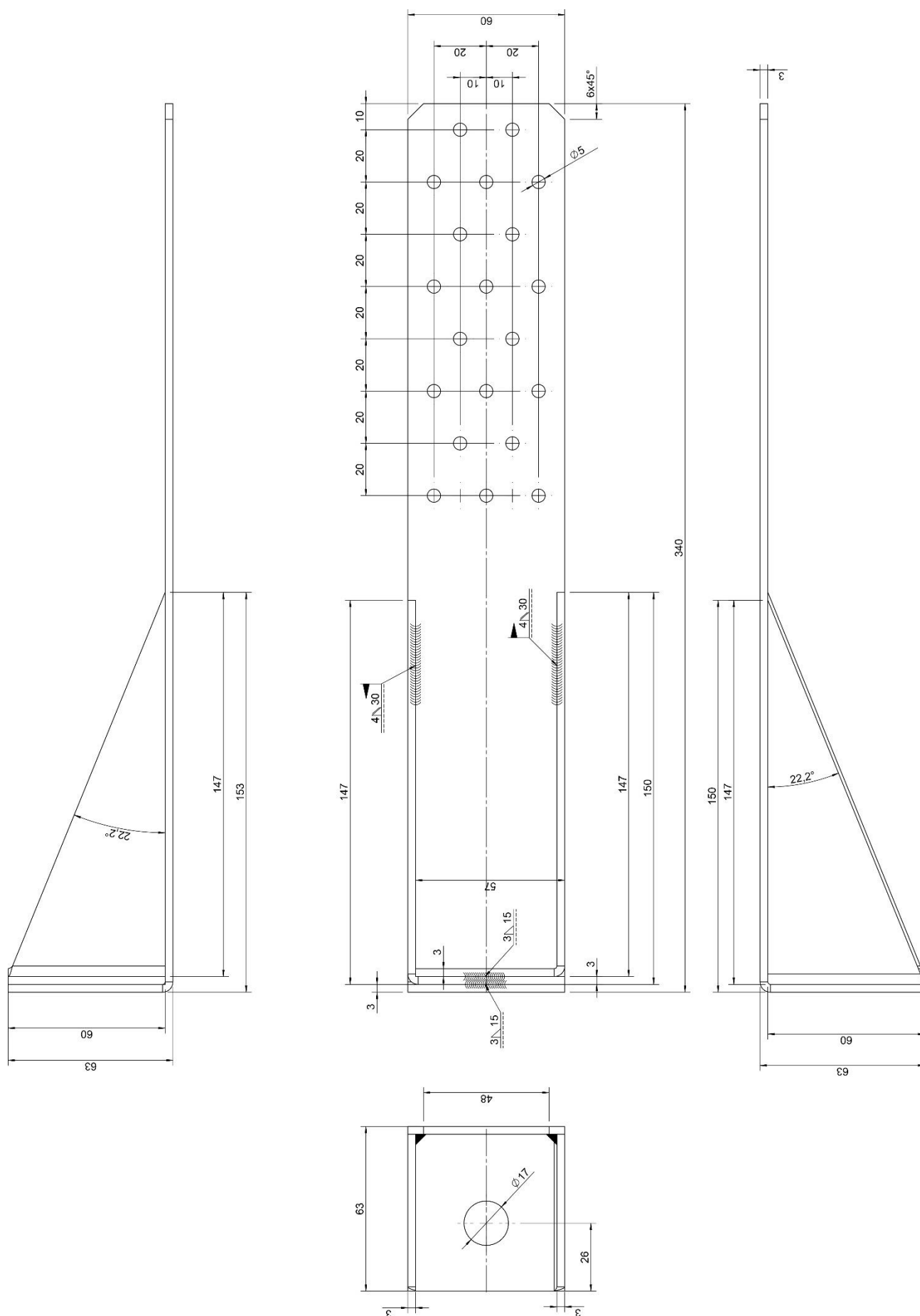


Figure B.5 Dimensions of type R 340x60x60x3,0 – alternative hole diameter 18 mm in bottom plate

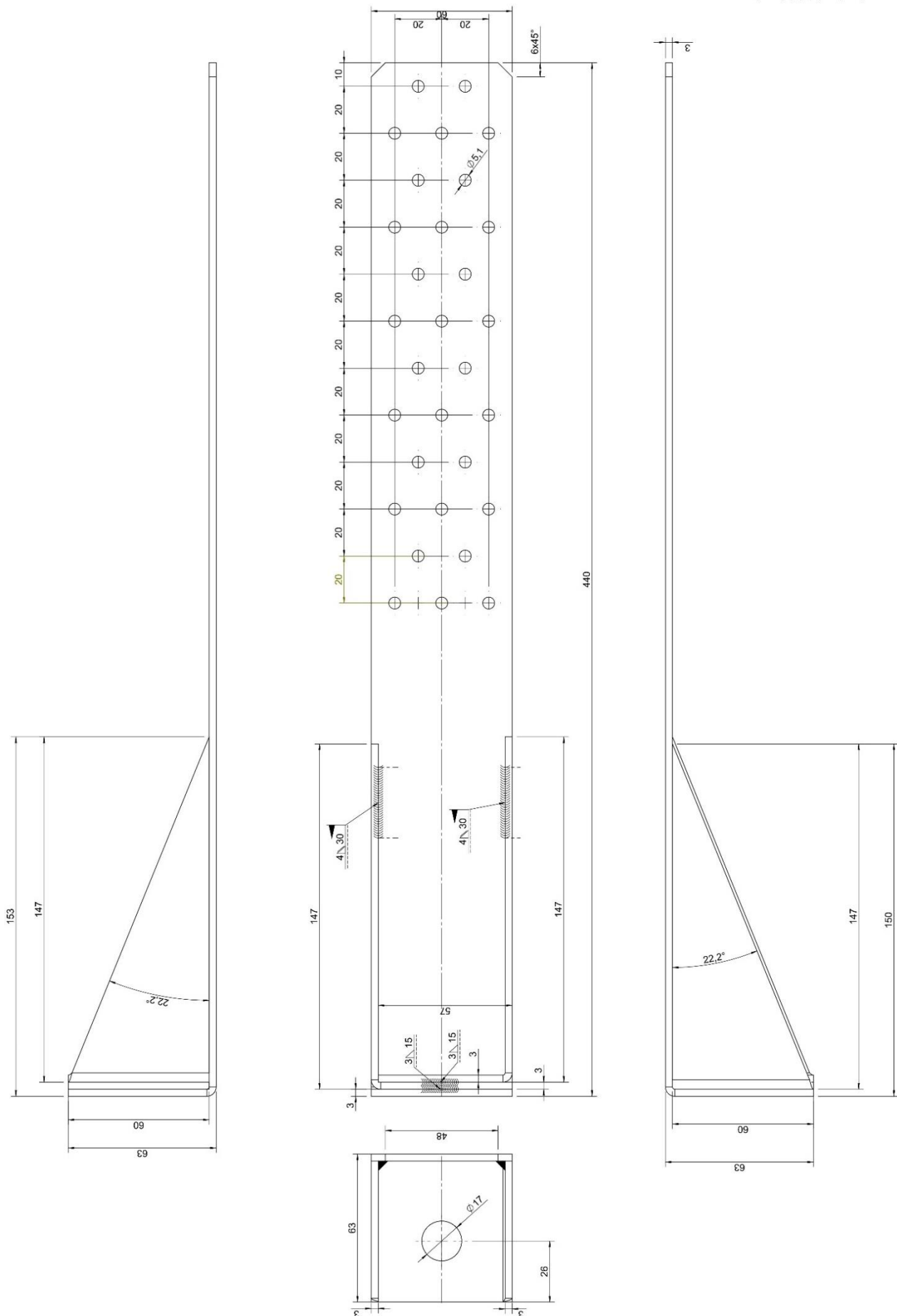


Figure B.6 Dimensions of type R 440x60x60x3,0 – alternative hole diameter 18 mm in bottom plate

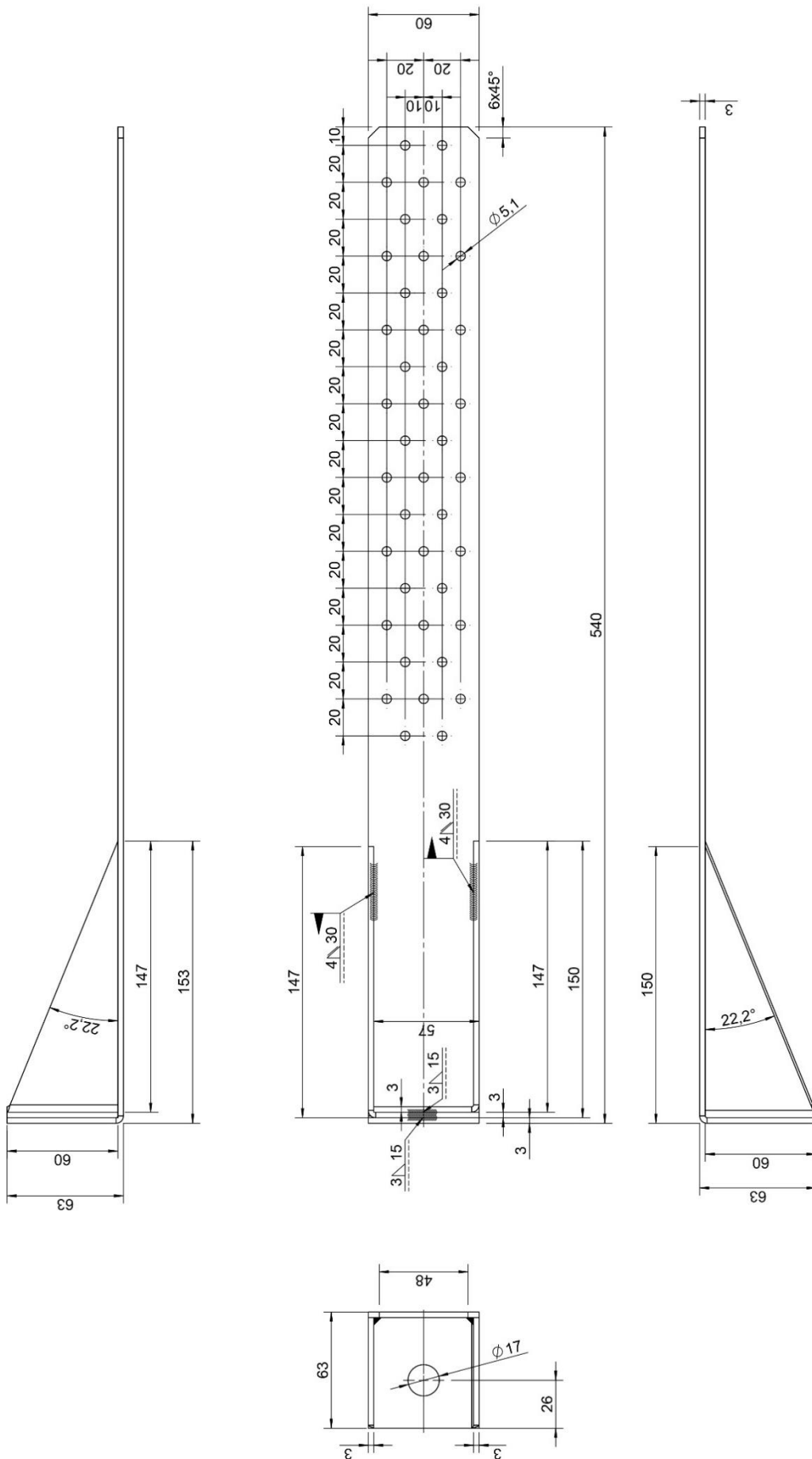


Figure B.7 Dimensions of type R 540x60x60x3,0 – alternative hole diameter 18 mm in bottom plate

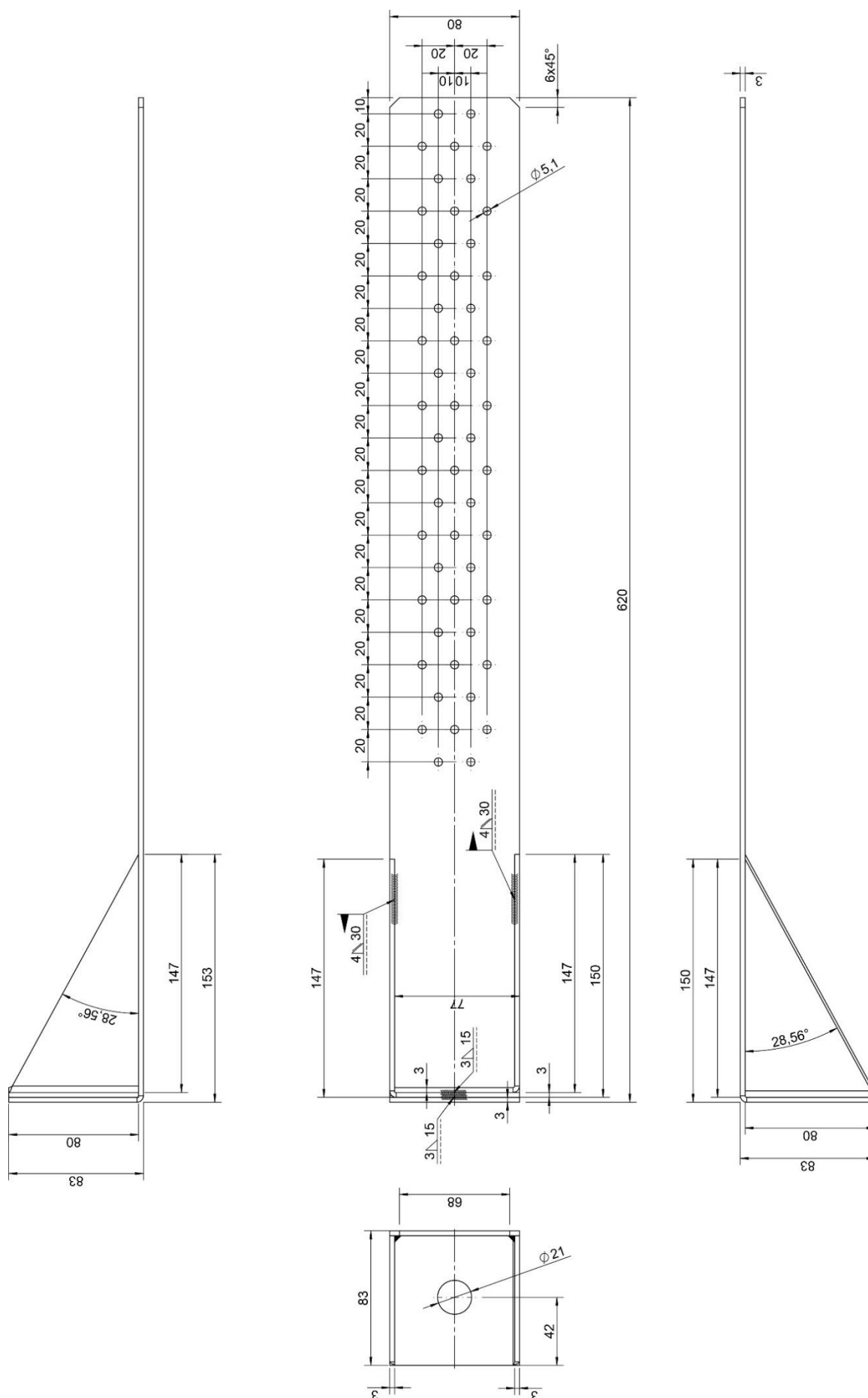


Figure B.8 Dimensions of type R 620x80x80x3,0

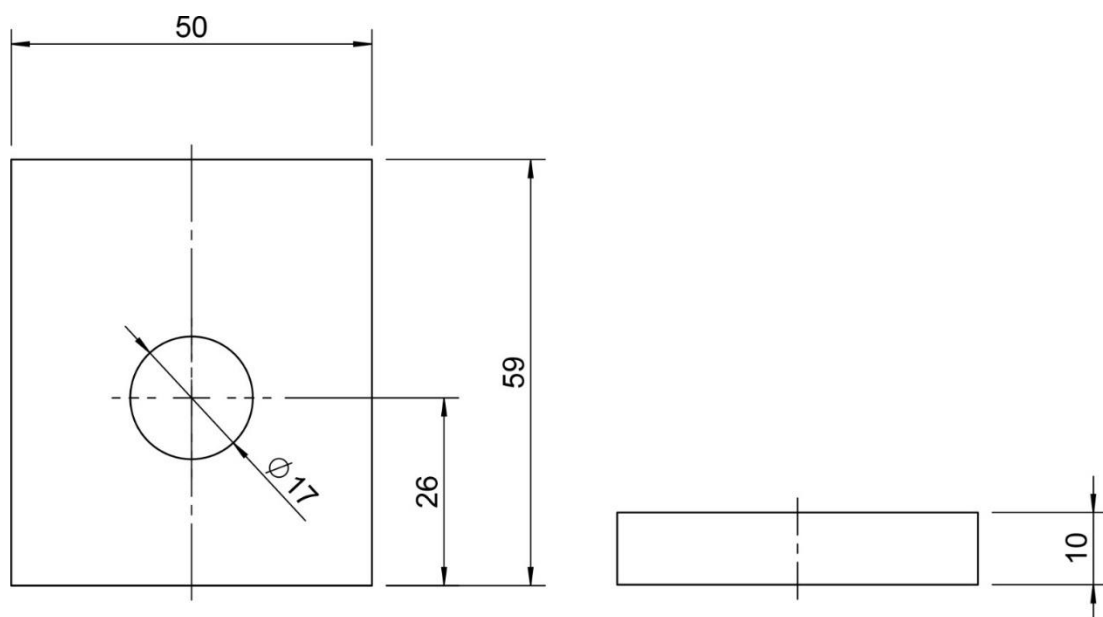


Figure B.9 Dimensions of base plates type R Lx59x50x10 Ø17 – alternative hole diameter 18 mm

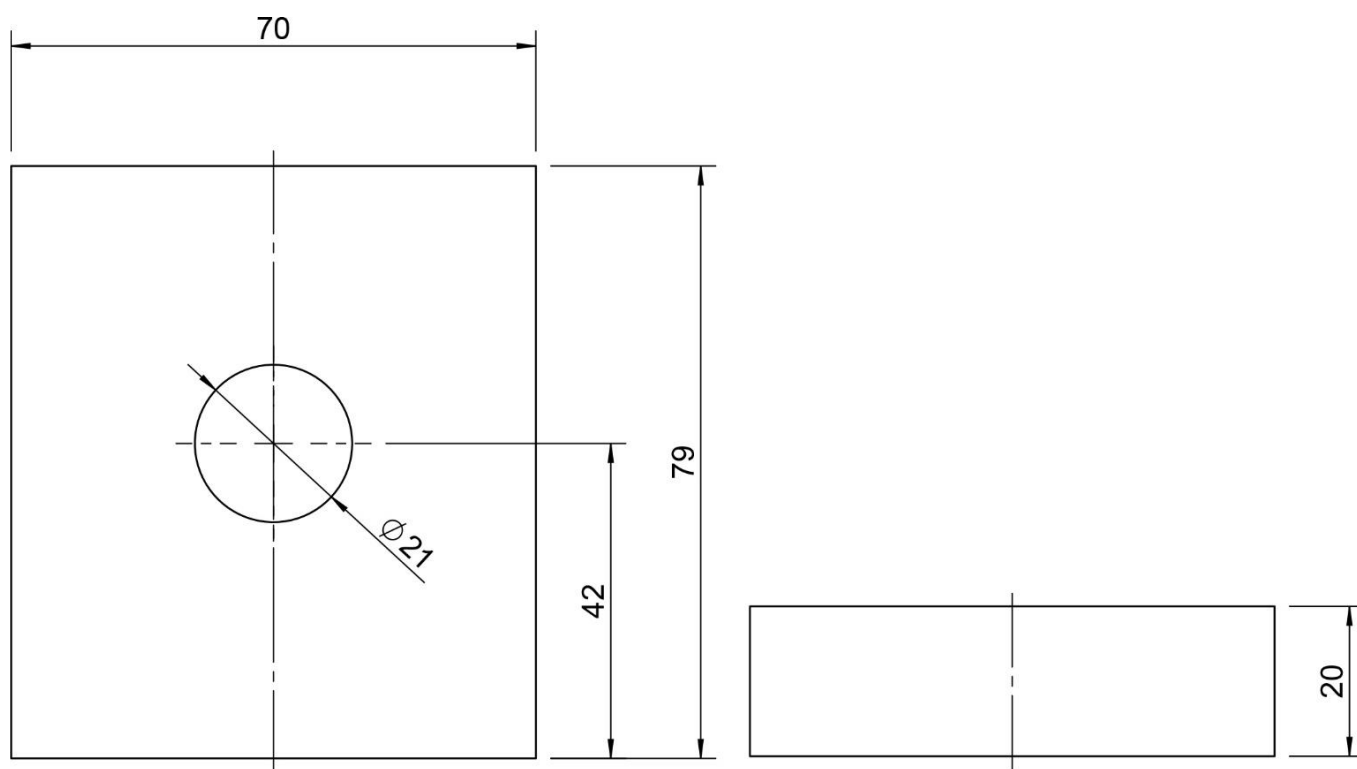


Figure B.10 Dimensions of base plates type R Lx79x70x20 Ø21

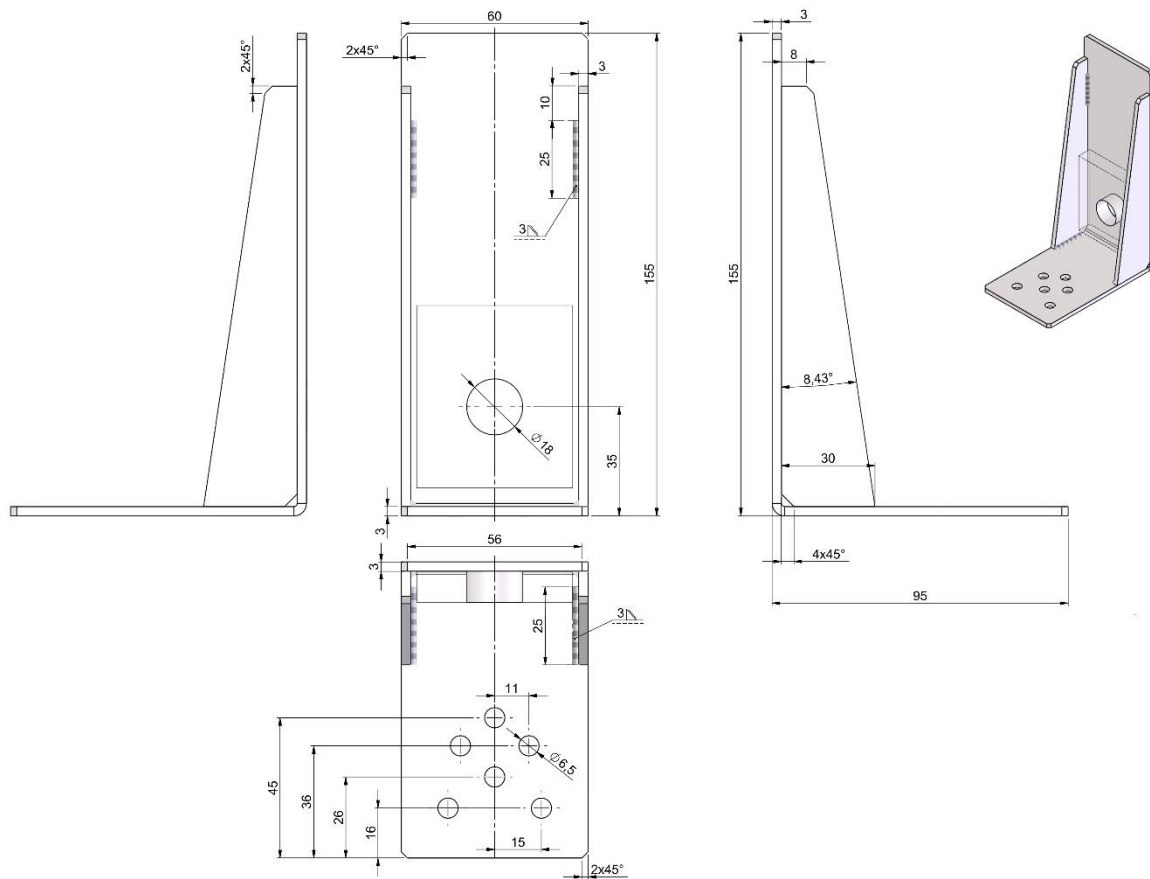


Figure B.11 Dimensions of two-piece hold-down type RL 95x155x60x3,0

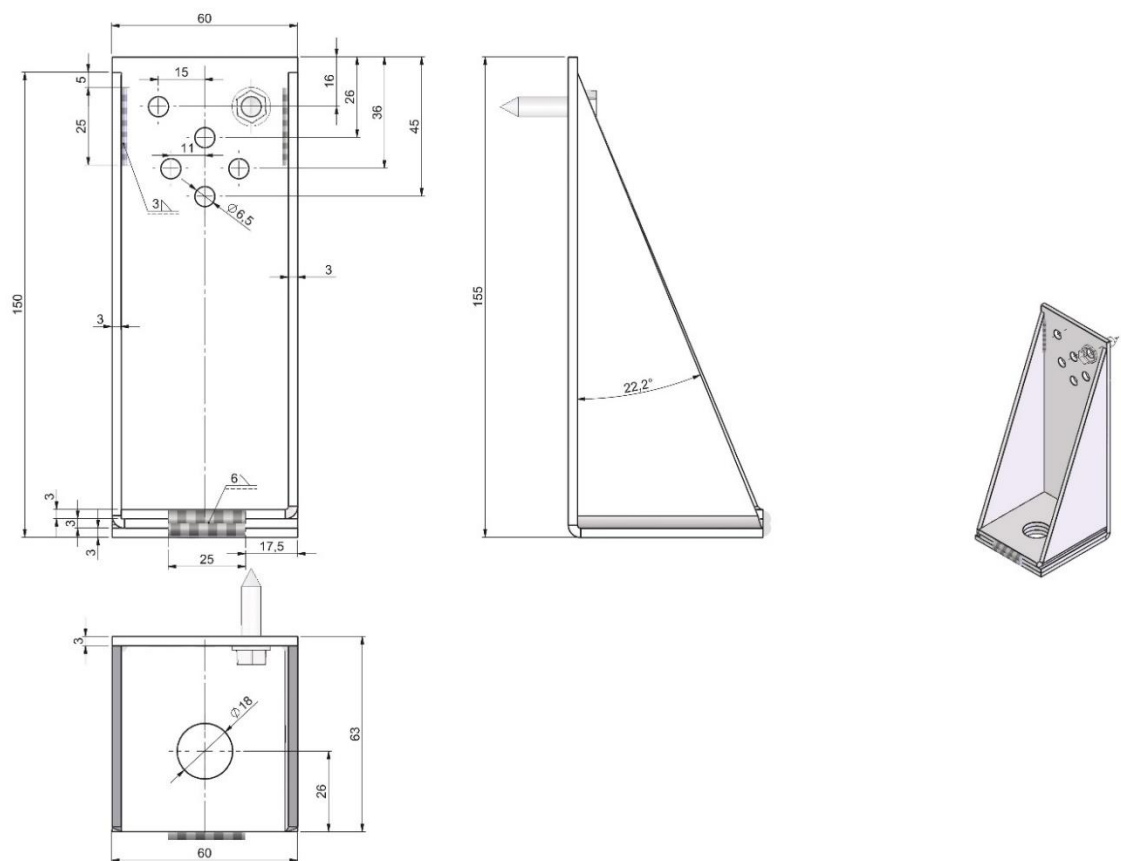


Figure B.12 Dimensions of two-piece hold-down type R 155x60x60x3,0

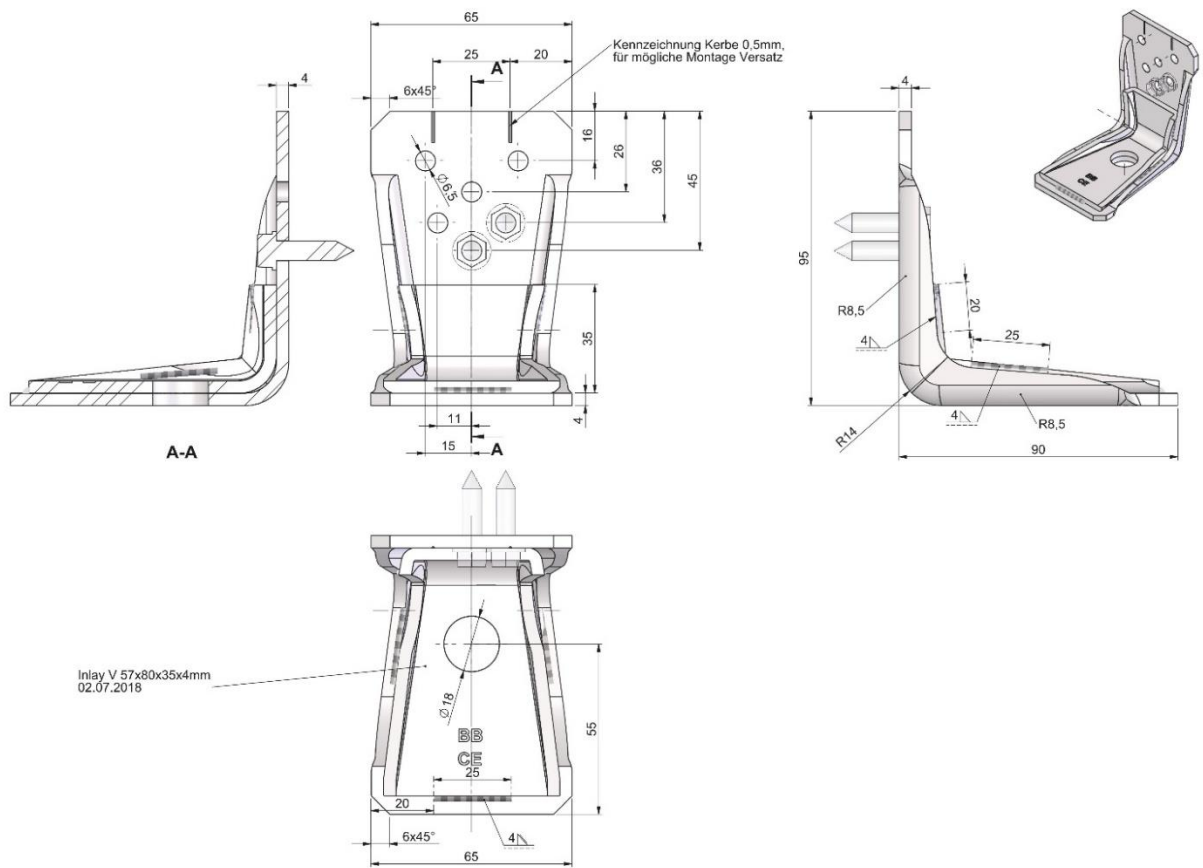


Figure B.13 Dimensions of two-piece hold-down type KR 95x90x65x4,0

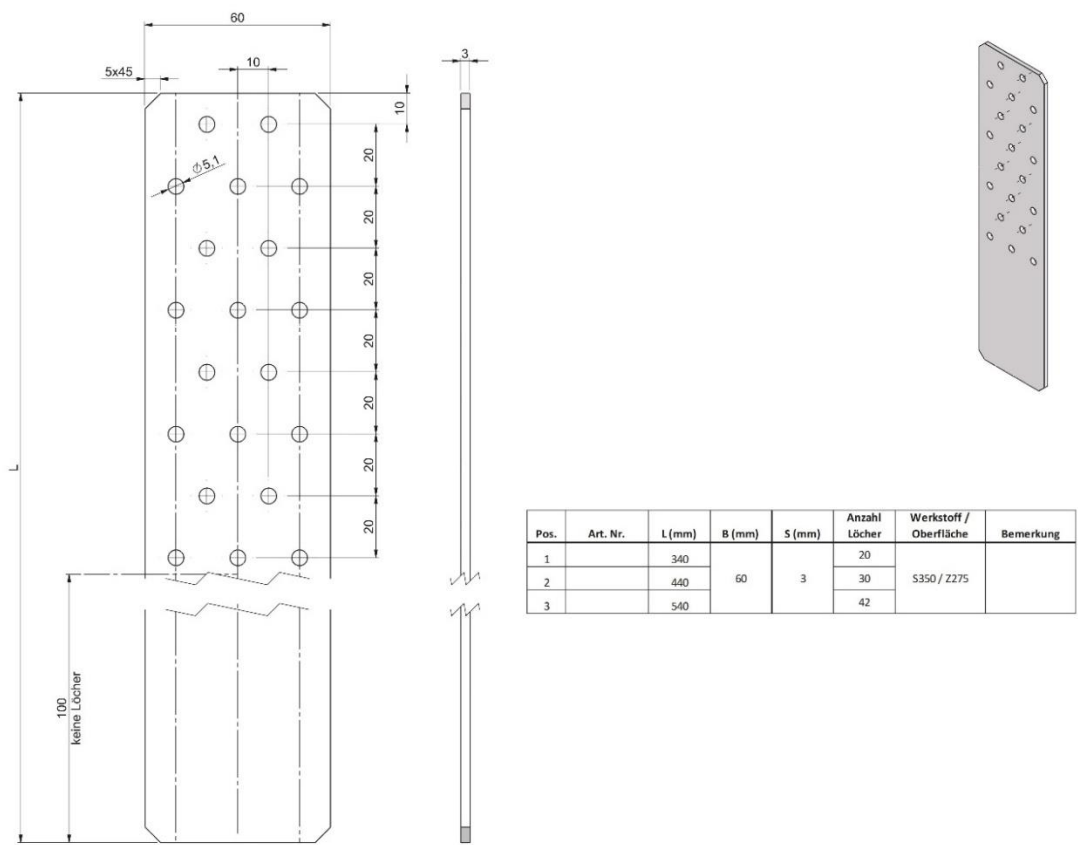


Figure B.14 Dimensions of 60 mm vertical flange for two-piece hold-downs

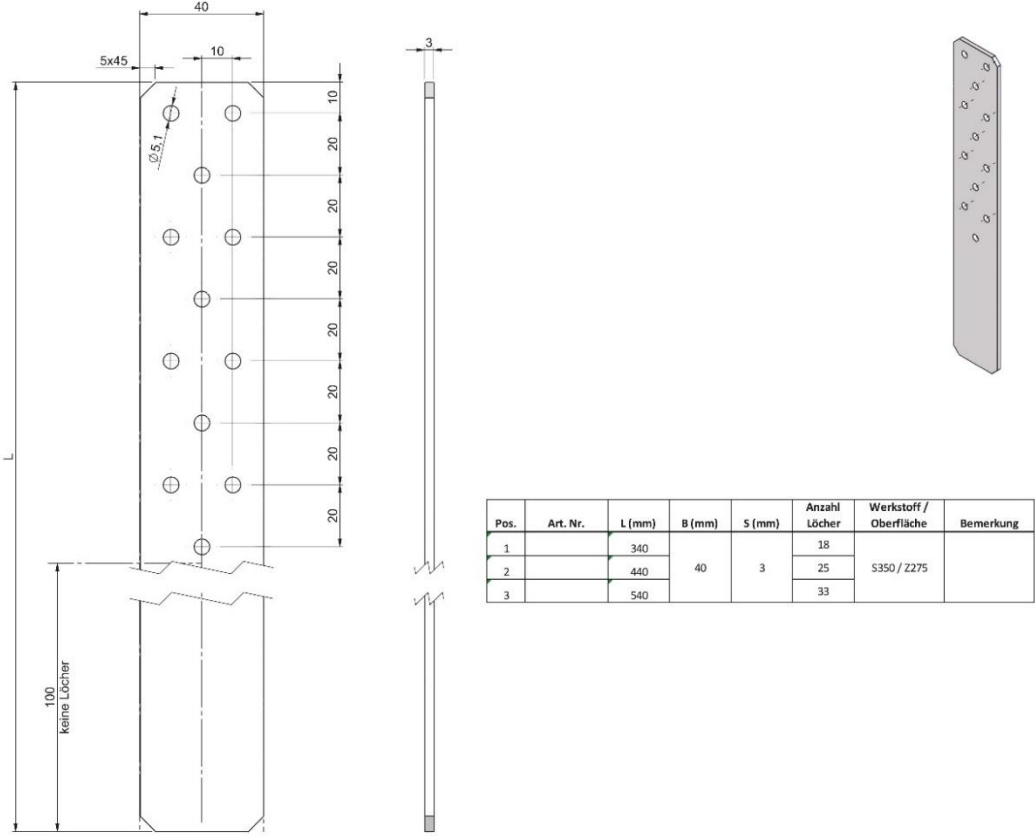


Figure B.15 Dimensions of 40 mm vertical flange for two-piece hold-downs

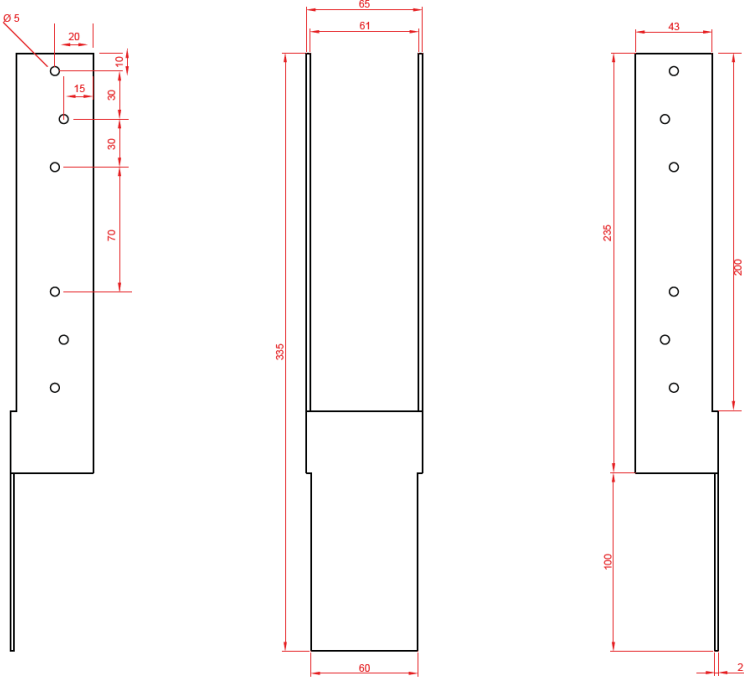


Figure B.16 Dimensions of vertical flange BPD S250 for two-piece hold-downs

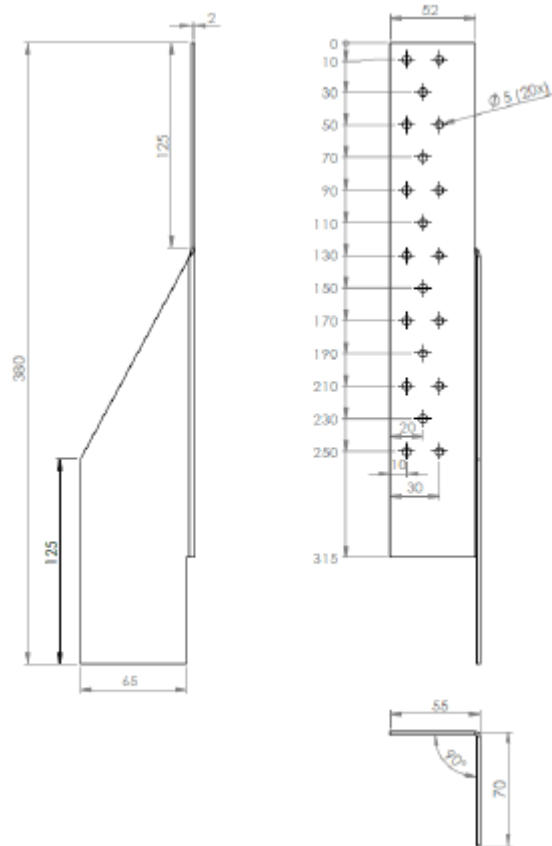


Figure B.17 Dimensions of vertical flange BPL380 S250 for two-piece hold-downs

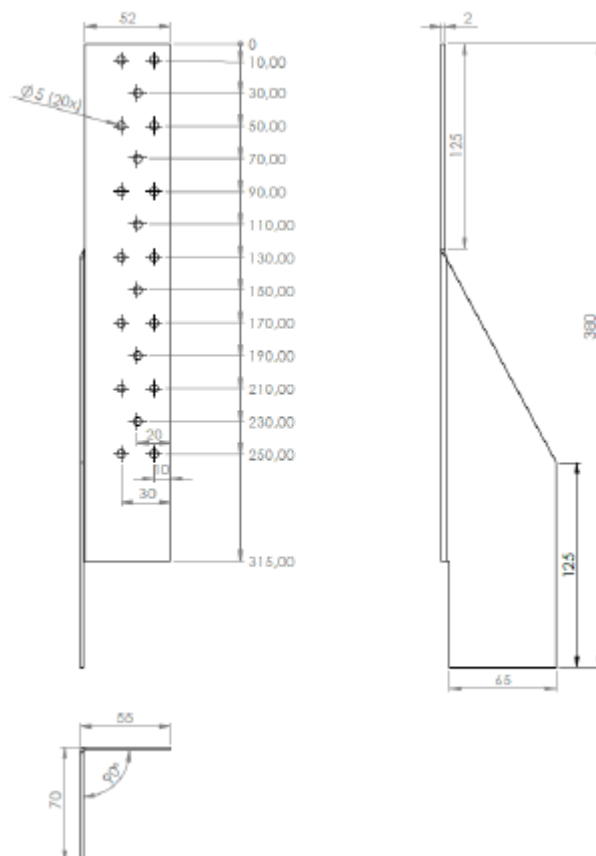


Figure B.18 Dimensions of vertical flange BPR380 S250 for two-piece hold-downs

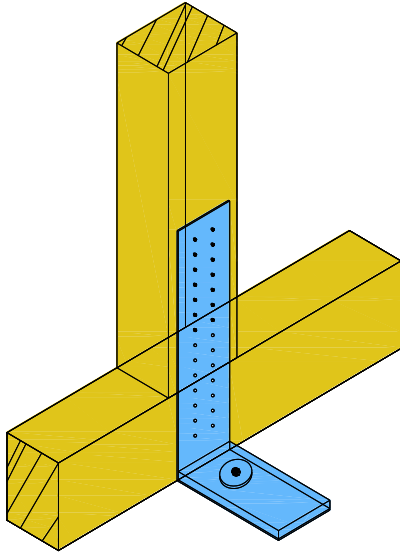


Figure B.19 Typical installation

B.2 Angle brackets type KR

Definitions of forces, their directions and eccentricity

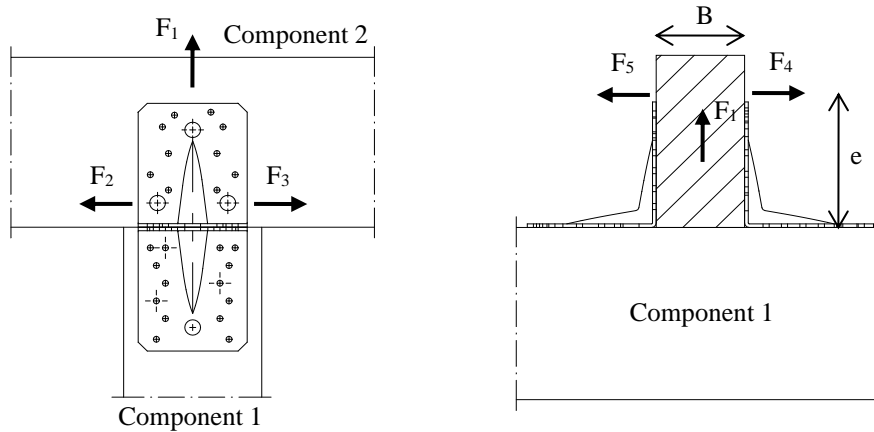


Figure B.20: Load directions and eccentricity e

Fastener specification

Holes are marked with numbers referring to the nailing pattern in Annex B.2. Load case F_4 / F_5 is only valid for angle brackets without slotted hole in the horizontal flange.

Double angle brackets per connection

The angle brackets must be placed at each side opposite to each other, symmetrically to the component axis.

Acting forces:

- F_1 Centrical lifting force acting in component 2.
 - F_2 and F_3 Centrical lateral force acting in component 2 in axial direction of component 2.
 - F_4 and F_5 Centrical lateral force acting in component 2 in axial direction of component 1.
- If the load is applied with an eccentricity e, a design for combined loading is required (see equation B.2.2 and B.2.3).

Single angle bracket per connection

Acting forces:

- F_1 Lifting force acting in component 2. The component 2 shall be prevented from rotation.
- F_2 and F_3 Lateral force acting in component 2 in axial direction of component 2. The component 2 shall be prevented from rotation.
- F_4 and F_5 Lateral force acting in component 2 in axial direction of component 1. F_4 is the lateral force towards the angle bracket; F_5 is the lateral force away from the angle bracket. The component 2 shall be prevented from rotation.

Wane

Wane is not allowed, the timber has to be sharp-edged in the area of the angle brackets.

Timber splitting

It must be checked in accordance with Eurocode 5 or a similar national Timber Code that splitting will not occur.

Connection to timber, concrete or steel with a bolt or metal anchor

The load $F_{B,t,Ed}$ for the design of the maximal loaded bolt or metal anchor in a bolt or metal anchor group is calculated as:

$$F_{B,t,Ed} = k_t \cdot F_{t,Ed} \quad \text{for tensile load} \quad (\text{B.2.1})$$

Where:

$F_{B,t,Ed}$ Bolt tensile load in N

k_t Coefficient taking into account the moment arm or hole tolerance, respectively
 $F_{t,Ed}$ Tensile load F_1 on vertical flap of the angle bracket in N

Combined forces

If the forces F_1 and F_2 / F_3 or F_4 / F_5 act at the same time, the following inequality shall be fulfilled:

$$\left(\frac{F_{1,Ed}}{F_{1,Rd}} \right)^2 + \left(\frac{F_{2,Ed}}{F_{2,Rd}} \right)^2 + \left(\frac{F_{3,Ed}}{F_{3,Rd}} \right)^2 + \left(\frac{F_{4,Ed}}{F_{4,Rd}} \right)^2 + \left(\frac{F_{5,Ed}}{F_{5,Rd}} \right)^2 \leq 1 \quad (B.2.2)$$

The forces F_2 and F_3 or F_4 and F_5 are forces with opposite direction. Therefore, only one force F_2 or F_3 , and F_4 or F_5 , respectively, is able to act simultaneously with F_1 , while the other shall be set to zero.

If the load F_4 / F_5 is applied with an eccentricity e , a design for combined loading **for connections with double angle brackets** is required. Here, an additional force ΔF_1 has to be added to the existing force F_1 .

$$\Delta F_{1,Ed} = F_{4/5,Ed} \cdot \frac{e}{B} \quad (B.2.3)$$

B is the width of component 2. For different purlin widths and depths, the interaction equations were evaluated, given in the tables B.16 to B.21.

Characteristic load-carrying capacities for connections with one or two angle brackets per connection

B.2.1 Results angle brackets force F_1

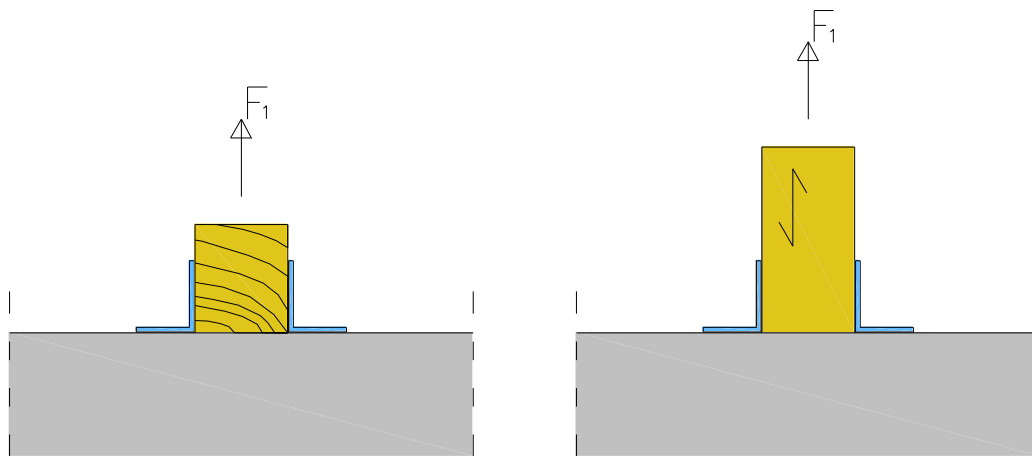


Figure B.21: Load F_1 , purlin (left) and column (right)

Table B.10: Force F_1 Purlin, 1 angle bracket / connection, timber-timber / concrete / steel

Angle bracket type	Number of fasteners	$F_{1,k}$ [kN]	k_t ¹⁾	k_t ²⁾
KR 95	9	13,7	1,1	1,1
KR 135	14	21,2		
KR 137	2	10,9		

¹⁾ Bolt connection timber-concrete / steel; with washer $t = 2.5$ mm

²⁾ Bolt or screw connection timber-timber; with washer $t = 2.5$ mm

Table B.11: Force F_1 Column, 1 angle bracket / connection, timber-timber / concrete / steel

Angle bracket type	Number of fasteners	$F_{1,k}$ [kN]	$k_t^{1)}$	$k_t^{2)}$
KR 95	3	4,6	1,1	1,1
KR 135	6	9,1		
KR 137	1	2,9		
KR 285	9	13,7		

1) Bolt connection timber-concrete / steel

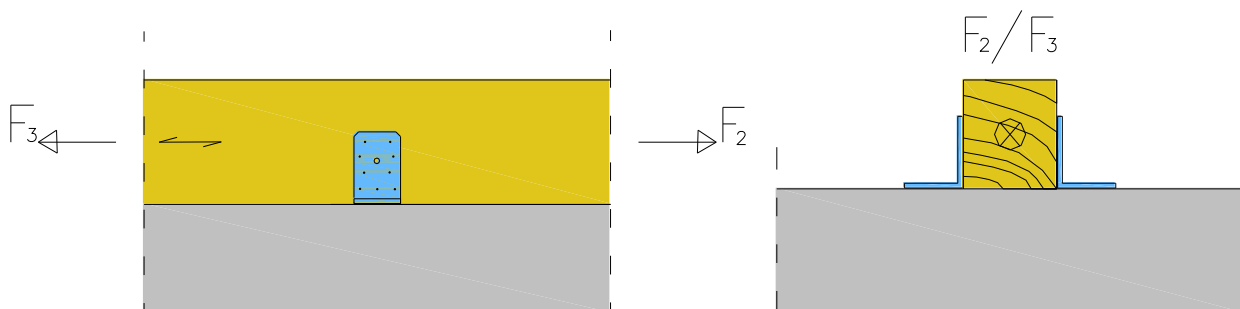
2) Bolt or screw connection timber-timber

Table B.12: Force F_1 Purlin, 2 angle brackets / connection, timber-timber / concrete / steel

Angle bracket type	Number of fasteners	$F_{1,k}$ [kN]	$k_t^{1)}$	$k_t^{2)}$
KR 95	9	27,4	1,1	1,1
KR 135	14	42,4		
KR 137	2	21,9		

1) Bolt connection timber-concrete / steel; with washer $t = 2.5$ mm2) Bolt or screw connection timber-timber; with washer $t = 2.5$ mm**Table B.13:** Force F_1 Column, 2 angle brackets / connection, timber-timber / concrete / steel

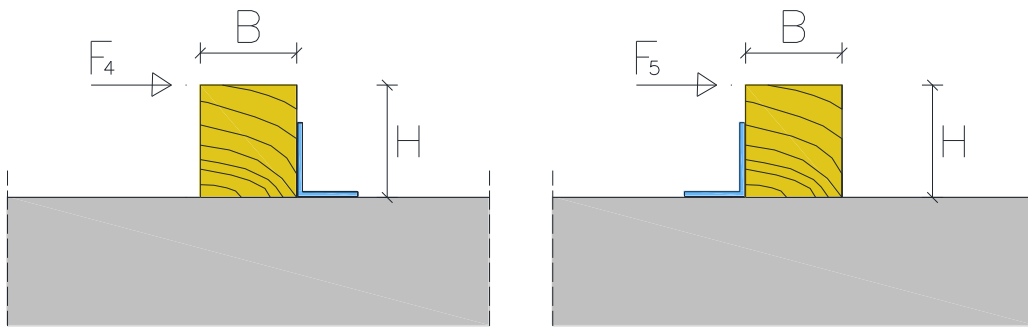
Angle bracket type	Number of fasteners	$F_{1,k}$ [kN]	$k_t^{1)}$	$k_t^{2)}$
KR 95	3	9,2	1,1	1,1
KR 135	6	18,3		
KR 137	1	11,5		
KR 285	9	27,5		

1) Bolt connection timber-concrete / steel; with washer $t = 2.5$ mm2) Bolt or screw connection timber-timber; with washer $t = 2.5$ mm**B.2.2 Results angle brackets force F_2 / F_3** Figure B.22: Load F_2 / F_3 , purlin**Table B.14:** Force $F_{2/3}$ Purlin, 1 angle bracket / connection, timber-timber / concrete / steel

Angle bracket type	$F_{2/3,Rk}$ [kN]
KR 95	1,72
KR 135	2,76
KR 137	2,14

Table B.15: Force $F_{2/3}$ Purlin, 2 angle brackets / connection, timber-timber / concrete / steel

Angle bracket type	$F_{2/3,Rk}$ [kN]
KR 95	3,44
KR 135	5,53
KR 137	4,28

B.2.3 Results angle brackets force F_4 / F_5 with single angle bracket per connectionFigure B.23: Load F_4 (left) and Load F_5 (right)**Table B.16:** Force F_4 Purlin, 1 angle bracket type KR 95 / connection, timber-timber / concrete / steel

KR 95		
H [m]	$F_{4,Rk}$ [kN]	
	Steel ¹⁾	Timber
0,12	1,15	2,06
0,14	0,90	1,35
0,18	0,62	0,79

¹⁾ Partial factor $\gamma_{M,S} = \gamma_{M0}$ for steel failure**Table B.17:** Force F_4 Purlin, 1 angle bracket type KR 135 / connection, timber-timber / concrete / steel

KR 135		
H [m]	$F_{4,Rk}$ [kN]	
	Steel ¹⁾	
0,16	1,24	
0,18	0,94	
0,22	0,48	

¹⁾ Partial factor $\gamma_{M,S} = \gamma_{M0}$ for steel failure**Table B.18:** Force F_4 Purlin, 1 angle bracket type KR137 / connection, timber-timber / concrete / steel

KR 137		
H [m]	$F_{4,Rk}$ [kN]	
	Steel ¹⁾	
0,16	0,65	
0,18	0,53	
0,22	0,38	

¹⁾ Partial factor $\gamma_{M,S} = \gamma_{M0}$ for steel failure

Table B.19: Force F_5 Purlin, 1 angle bracket type KR 95 / connection, timber-timber / concrete / steel

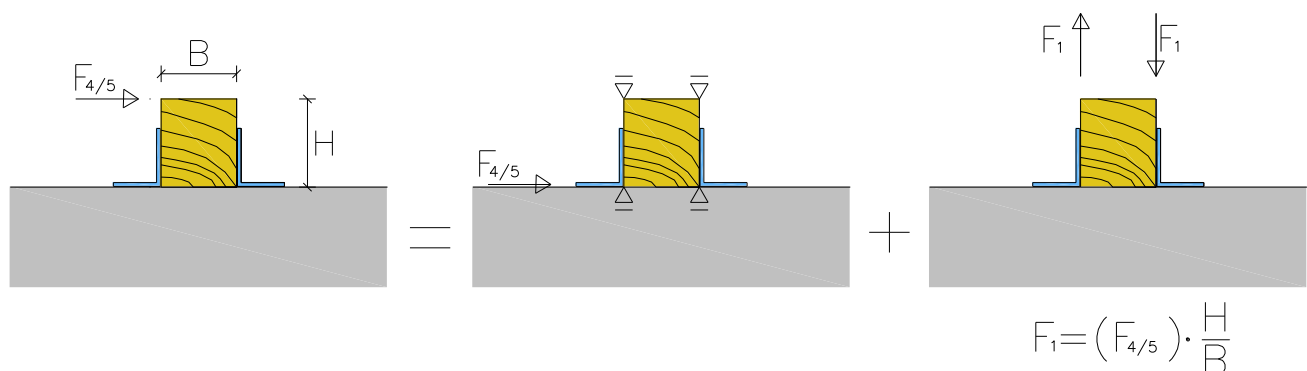
KR 95	H [m]					
	0,12		0,14		0,18	
B [m]	$F_{5,Rk}$ [kN]	k_t	$F_{5,Rk}$ [kN]	k_t	$F_{5,Rk}$ [kN]	k_t
0,06	4,29	2,16	4,58	2,24	4,68	2,44
0,10	3,72	2,05	3,81	2,08	3,98	2,15
0,14	3,56	2,01	3,61	2,03	3,70	2,07

Table B.20: Force F_5 Purlin, 1 angle bracket type KR 135 / connection, timber-timber / concrete / steel

KR 135	H [m]					
	0,16		0,18		0,22	
B [m]	$F_{5,Rk}$ [kN]	k_t	$F_{5,Rk}$ [kN]	k_t	$F_{5,Rk}$ [kN]	k_t
0,06	4,45	1,94	4,94	2,82	5,03	4,50
0,10	3,91	2,02	3,98	2,06	4,06	2,04
0,14	3,73	1,94	3,77	1,97	3,83	2,02

Table B.21: Force F_5 Purlin, 1 angle bracket type KR 137 / connection, timber-timber / concrete / steel

KR 137	H [m]					
	0,16		0,18		0,22	
B [m]	$F_{5,Rk}$ [kN]	k_t	$F_{5,Rk}$ [kN]	k_t	$F_{5,Rk}$ [kN]	k_t
0,06	3,83	1,70	3,73	1,73	3,95	2,04
0,10	3,45	1,61	3,55	1,63	3,71	1,65
0,14	3,71	1,65	3,34	1,59	3,44	1,61

B.2.4 Results angle brackets force F_4 / F_5 with double angle brackets per connectionFigure B.24: Load Case F_4 / F_5 reduced to two basic load cases**Table B.22:** Basic Force $F_{4/5}$ Purlin, 2 angle brackets / connection, timber-timber / concrete / steel.

The purlin has to be prevented from rotation. The resulting force F_1 (equation B.2.3) has to be considered.

Angle bracket type	$F_{4/5,Rk}$ [kN]
KR 95	7,58
KR 135	7,99
KR 137	8,57

For different purlin widths and depths, the interaction equations were evaluated. The results are given in the tables B.23 to B.24.

Table B.23: Force $F_{4/5}$ Purlin, 2 angle brackets type KR 95 / connection, timber-timber / concrete / steel

KR 95	$F_{4,5Rk}$ [kN]		
	H [m]		
B [m]	0,12	0,14	0,18
0,06	6,63	6,37	5,83
0,10	7,19	7,07	6,79
0,14	7,38	7,31	7,14

Table B.24: Force $F_{4/5}$ Purlin, 2 angle brackets type KR 135 / connection, timber-timber / concrete / steel

KR 135	$F_{4/5,Rk}$ [kN]		
	H [m]		
B [m]	0,16	0,18	0,22
0,06	7,14	6,96	6,57
0,10	7,65	7,57	7,38
0,14	7,81	7,77	7,66

Product drawings angle brackets type KR

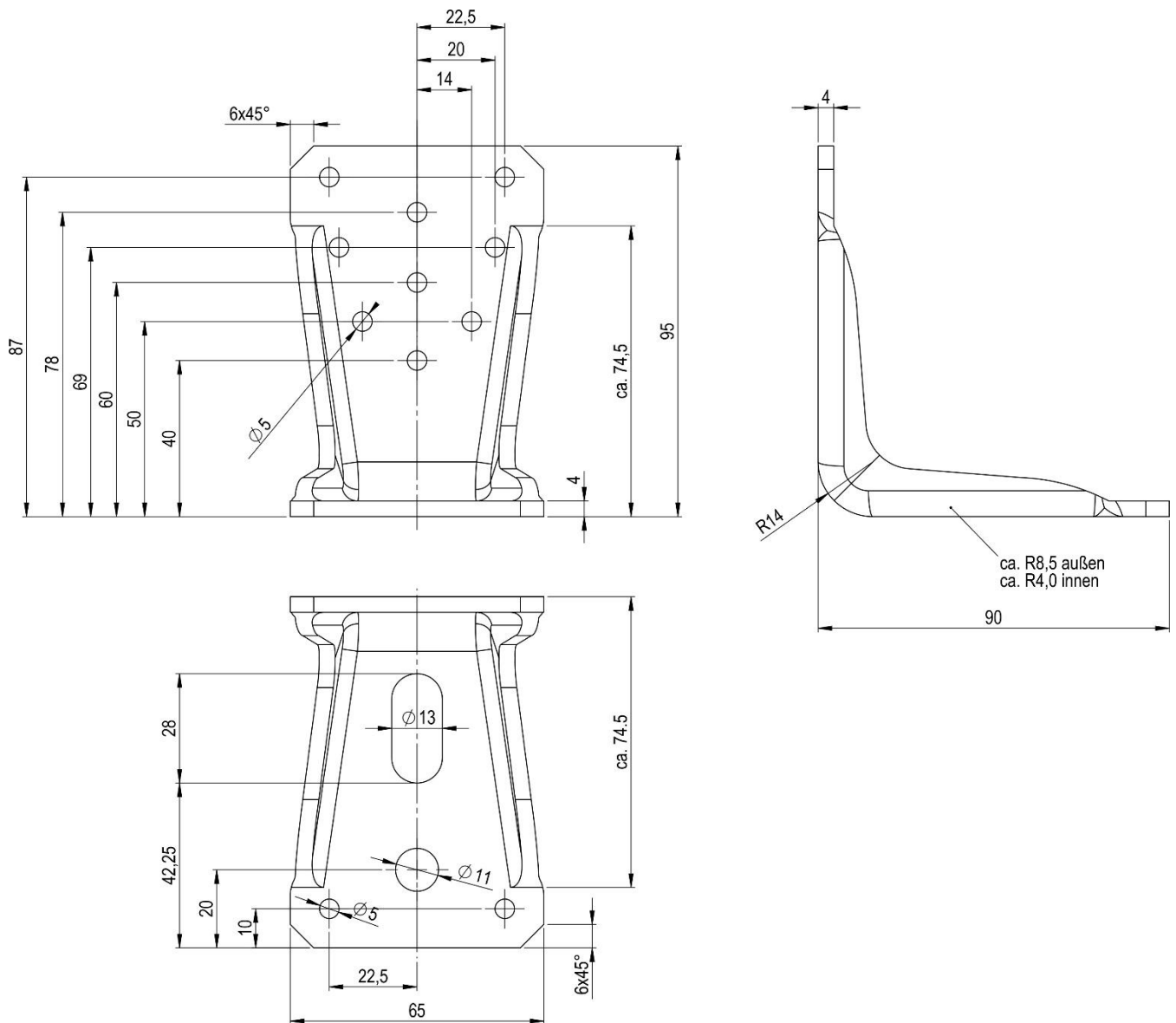
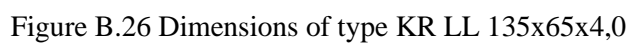


Figure B.25 Dimensions of type KR LL 95x65x4,0



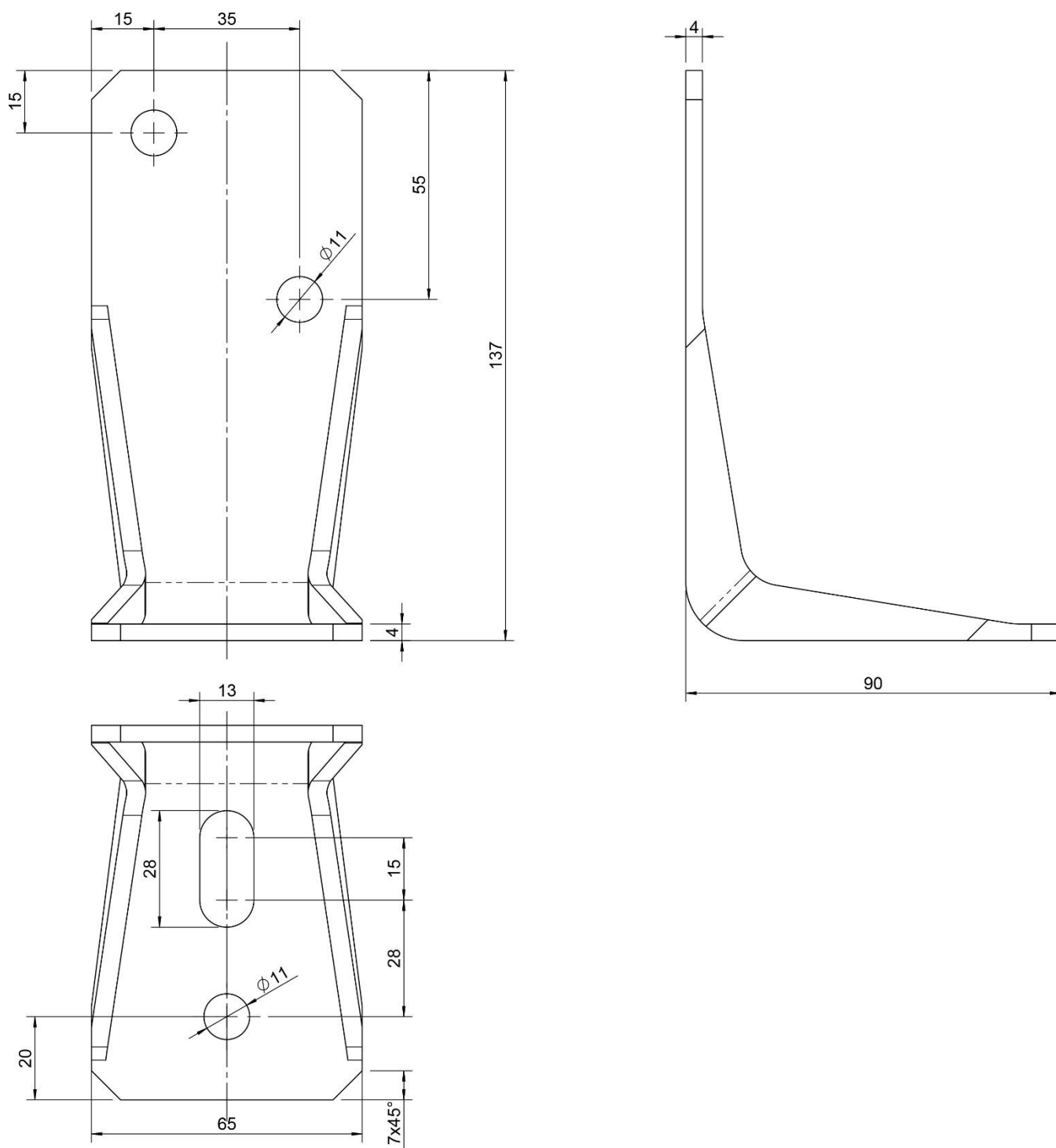


Figure B.27 Dimensions of type KR LL 137x65x4,0

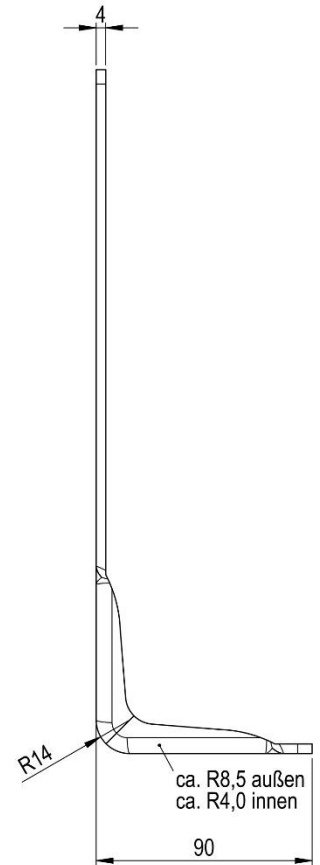


Figure B.28 Dimensions of type KR LL 285x65x4,0

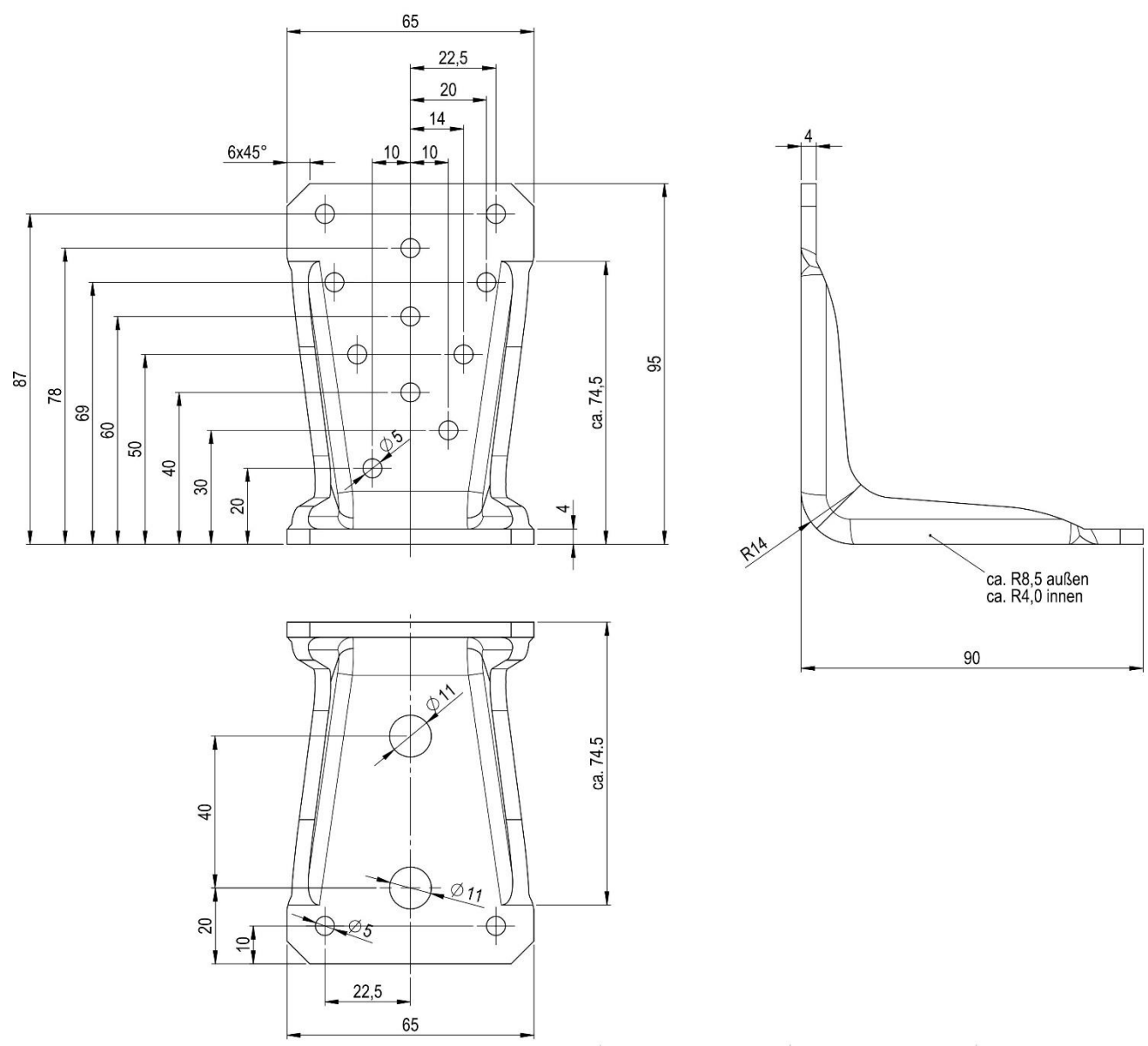


Figure B.29 Dimensions of type KR RL 95x65x4,0_Ø11

Figure B.30 Dimensions of type KR RL 95x65x4,0_Ø12

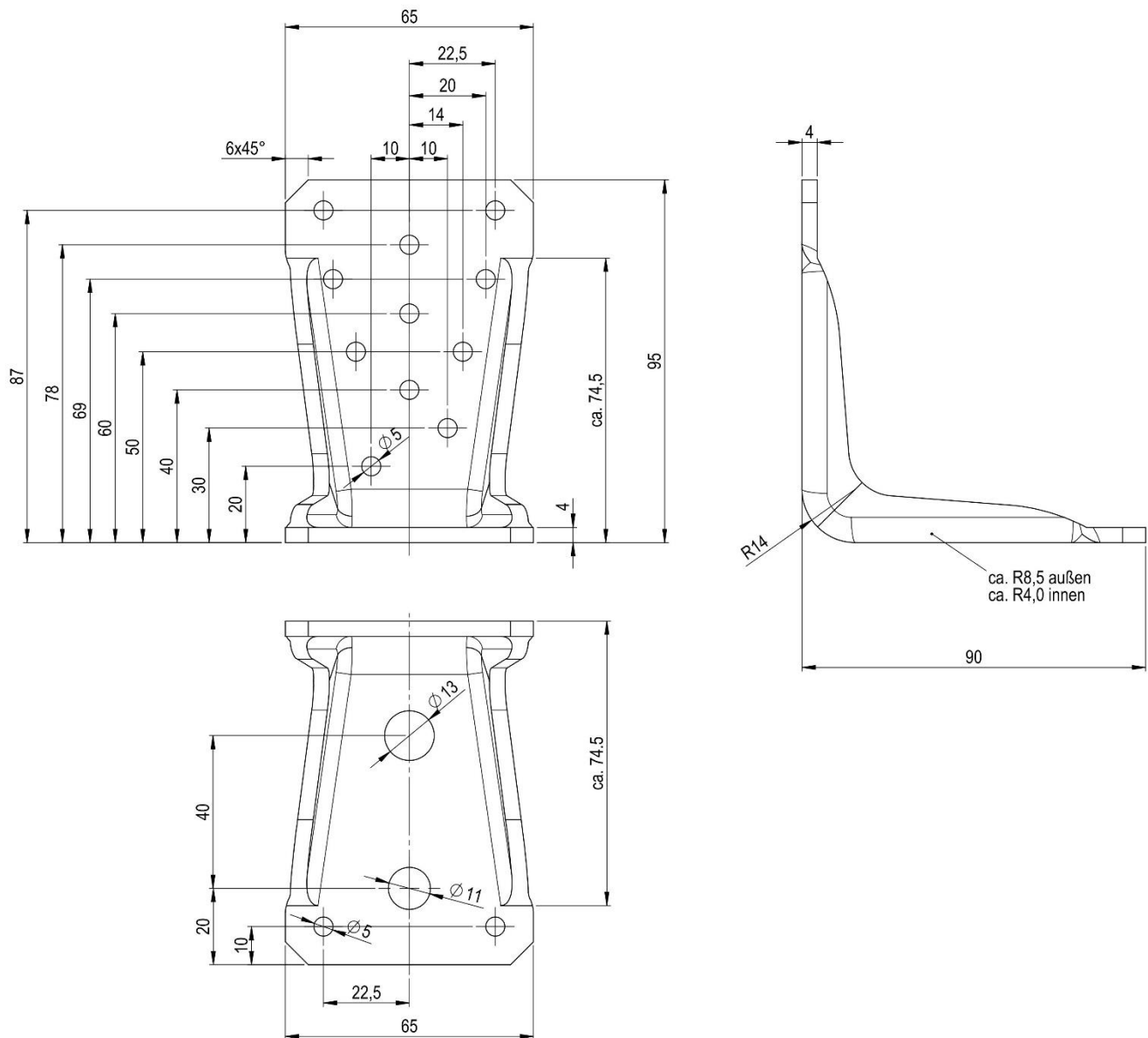


Figure B.31 Dimensions of type KR RL 95x65x4,0_Ø13

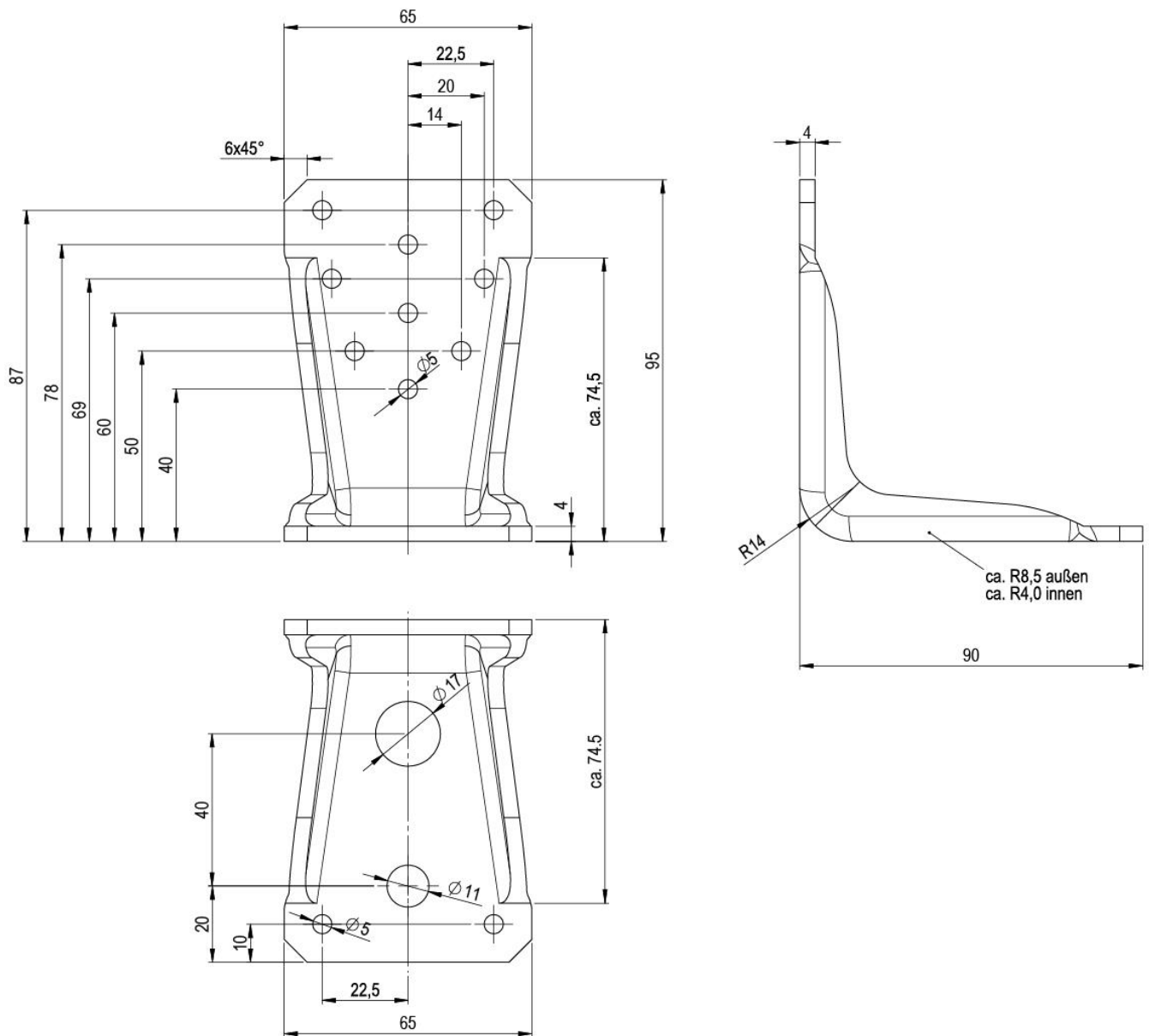


Figure B.32 Dimensions of type KR RL 95x65x4,0_Ø17

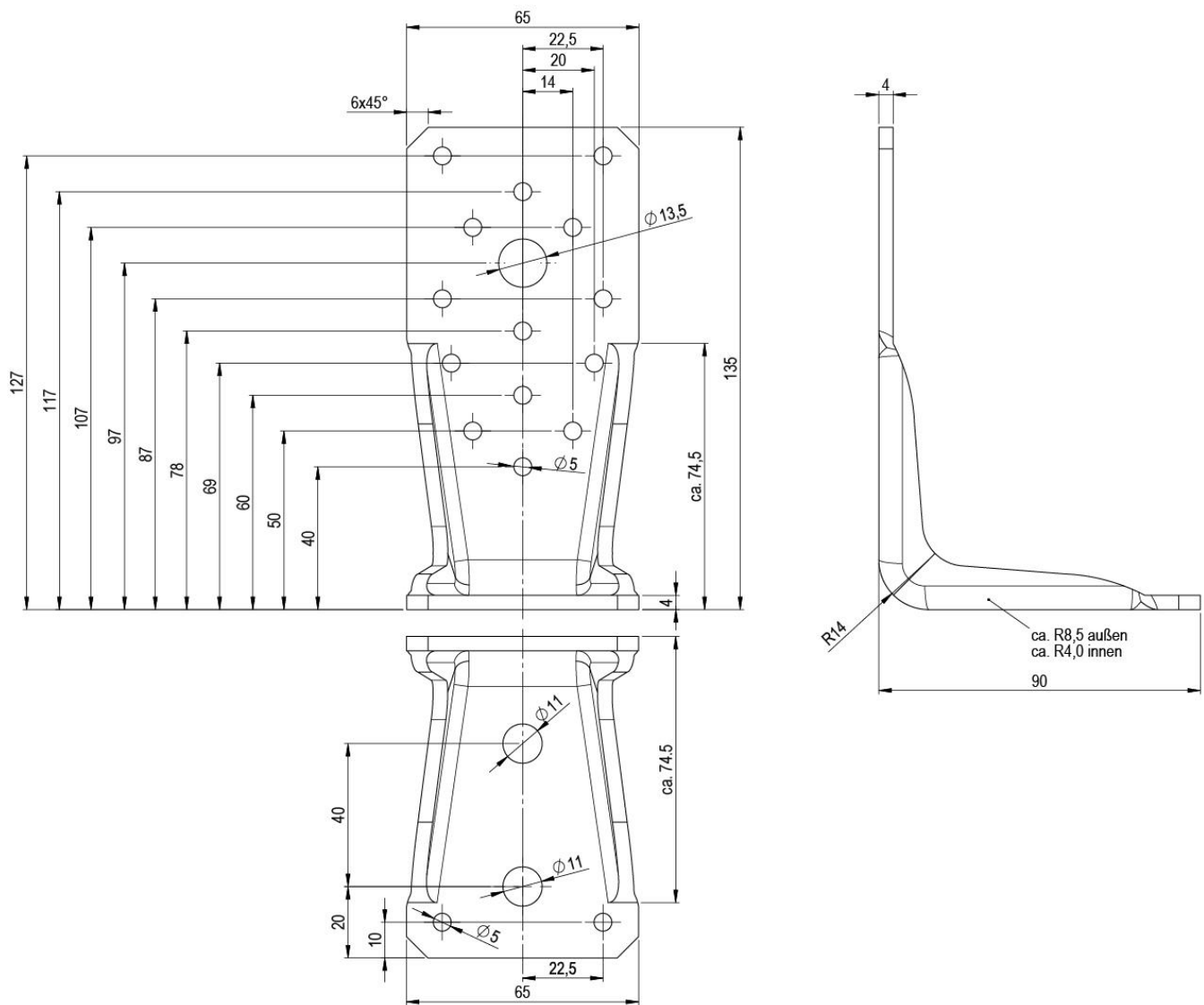


Figure B.33 Dimensions of type KR RL 135x65x4,0_Ø11

Figure B.34 Dimensions of type KR RL 135x65x4,0_Ø12

Figure B.35 Dimensions of type KR RL 135x65x4,0_Ø13

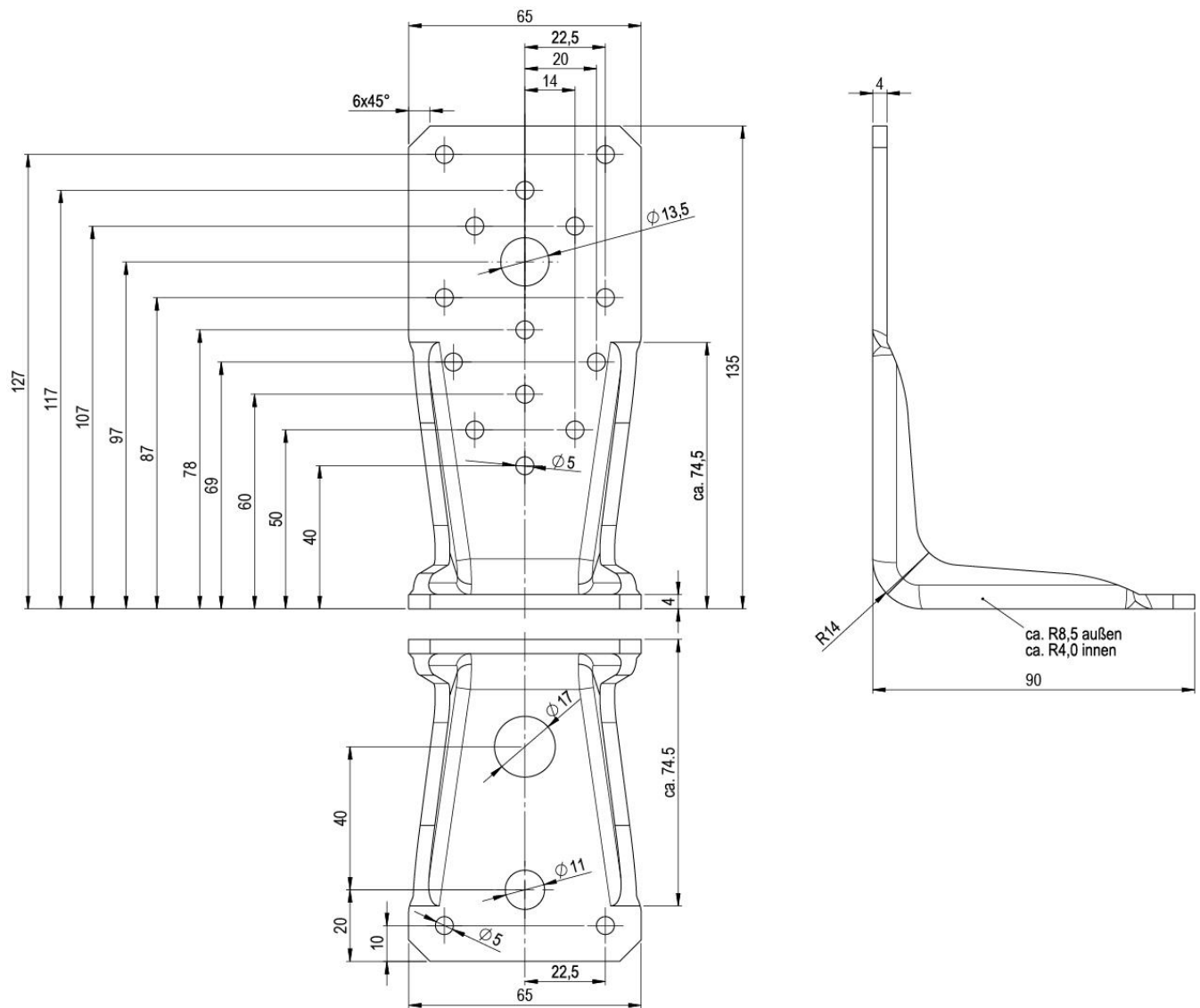


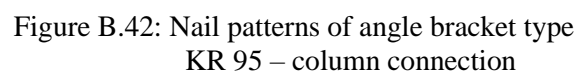
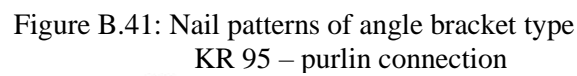
Figure B.36 Dimensions of type KR RL 135x65x4,0_Ø17

Figure B.37 Dimensions of type KR RL 285x65x4,0_Ø11

Figure B.38 Dimensions of type KR RL 285x65x4,0_Ø12

Figure B.39 Dimensions of type KR RL 285x65x4,0_Ø13

Figure B.40 Dimensions of type KR RL 285x65x4,0_Ø17



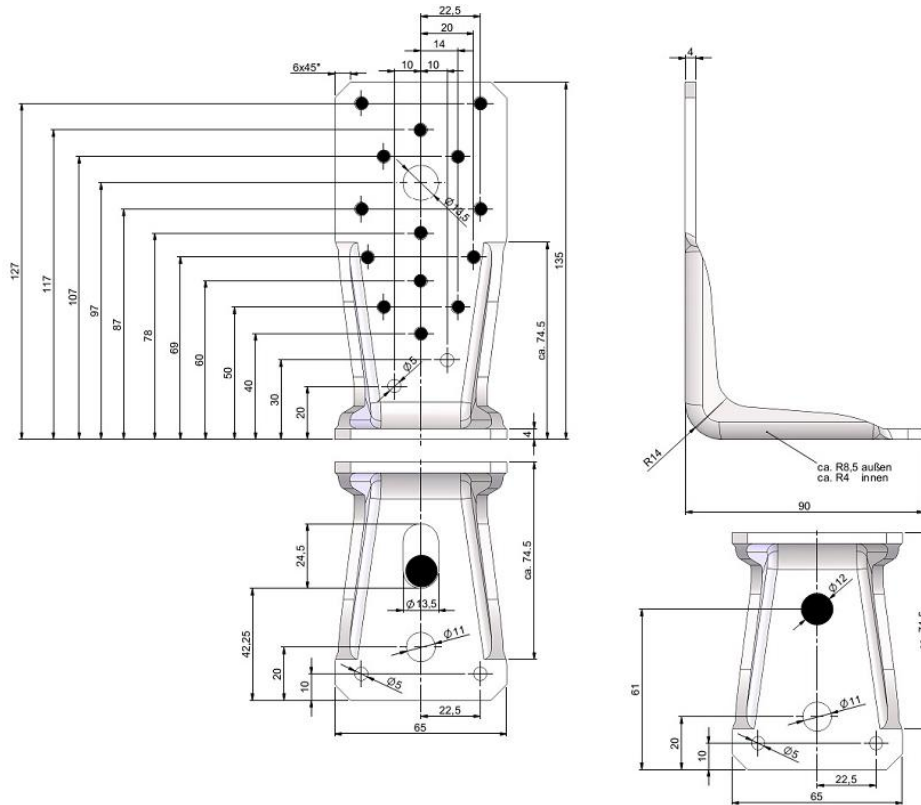


Figure B.43: Nail patterns of angle bracket type
KR 135 - purlin connection

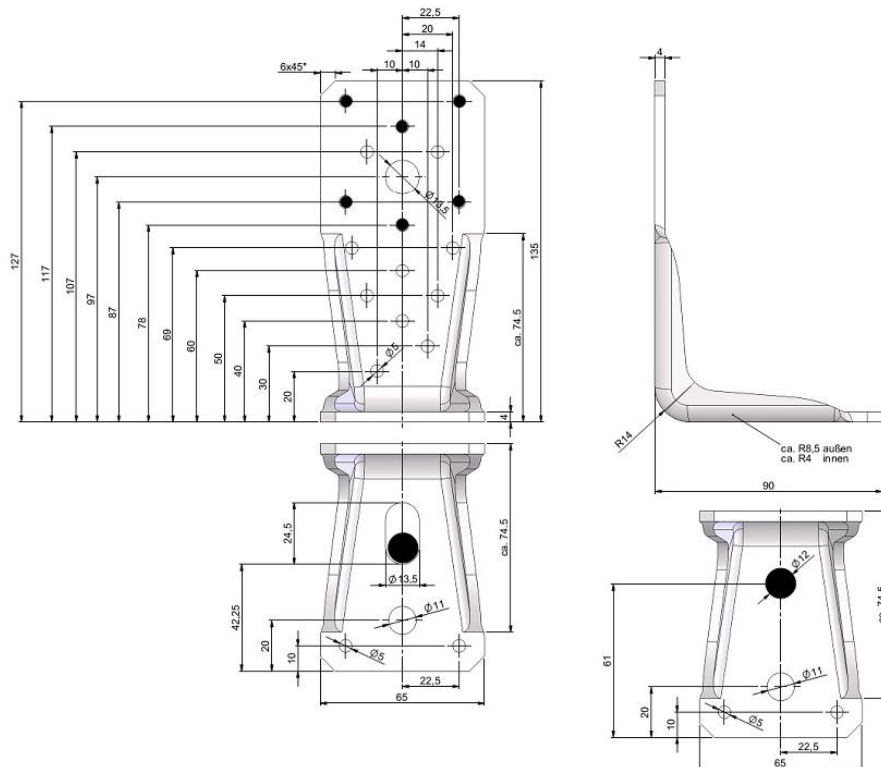


Figure B.44: Nail patterns of angle bracket type
KR 135 - column connection

Technical drawing of a mechanical part, showing two views: a front view (top) and a side view (bottom).

Front View (Top):

- Overall width: 65 (split into 15 and 35)
- Overall height: 55
- Top flange thickness: 4
- Central hole diameter: Ø11

Side View (Bottom):

- Overall width: 65
- Overall height: 20
- Top flange thickness: 15
- Central hole diameter: Ø11
- Internal dimensions: 13 (width of top flange), 28 (height of side wall), 28 (height of base)

Technical drawing of a lamp post (Lampenmast) showing front, side, and top views with dimensions in mm.

Front View (Top): Shows the overall height and mounting details. Key dimensions include:

- Total height: 276 mm
- Mounting arm length: 256 mm
- Arm offset: 236 mm
- Arm offset: 216 mm
- Arm offset: 196 mm
- Arm offset: 176 mm
- Arm offset: 156 mm
- Arm offset: 87 mm
- Arm offset: 78 mm
- Arm offset: 69 mm
- Arm offset: 60 mm
- Arm offset: 50 mm
- Arm offset: 40 mm
- Arm offset: 30 mm
- Arm offset: 20 mm
- Arm offset: 10 mm
- Arm offset: 14 mm
- Arm offset: 20 mm
- Arm offset: 22,5 mm
- Arm offset: 4 mm
- Arm offset: ca. 74,5 mm
- Arm offset: 97 mm
- Arm offset: 183 mm
- Arm offset: 266 mm
- Arm offset: 285 mm

Side View (Bottom Left): Shows the profile of the lamp post. Key dimensions include:

- Height: 61 mm
- Width: 20 mm
- Width: 10 mm
- Width: 22,5 mm
- Width: 65 mm
- Width: ca. 74,5 mm

Top View (Bottom Right): Shows the base of the lamp post. Key dimensions include:

- Height: 42,25 mm
- Height: 24,5 mm
- Height: 20 mm
- Height: 10 mm
- Width: 22,5 mm
- Width: 65 mm
- Width: ca. 74,5 mm

Figure B.47: Nail patterns of angle bracket type KR 285 - column connection

B.3 Concrete flat steel anchors

Support conditions

The distance between the timber elements and the concrete member in the area of the connection must not exceed 3 mm.

Fastener specification

The holes have to be nailed, beginning at the end of the concrete flat steel anchor. The number constitutes at least 4 and follows from the static calculation.

Wane

Wane is not allowed, the concrete flat steel anchor must seat solidly on timber.

Splitting

It must be checked in accordance with Eurocode 5 or a similar national Timber Code that splitting will not occur.

Characteristic load-carrying capacities for connections with one concrete flat steel anchor per connection

Table B.25: Force F_1 , 1 concrete flat steel anchor / connection, timber-concrete

Type	Timber	Steel	
	capacity per nail in the vertical flange ($F_{v,Rk}$) ¹⁾ [kN]	Bending ($F_{Rk,m}$) ²⁾ [kN]	Tension ($F_{Rk,t}$) ³⁾ [kN]
2,0 mm	1,62	3,33	17,8
4,0 mm	1,56	9,07	35,6

- ¹⁾ Screws as given in table A.5 may be used alternatively. For hardwoods, $F_{v,Rk}$ has to be calculated according to EN 1995-1-1.
- ²⁾ Partial factor $\gamma_{M,S} = \gamma_{M0}$ for steel failure. Steel failure in bending is governing for concrete flat steel anchor which are fixed with bolts and washers 43 mm x 4 mm according to EN ISO 7094.
- ³⁾ Partial factor $\gamma_{M,S} = \gamma_{M2}$ for steel failure. Steel failure in tension is governing for concrete flat steel anchor which are encased in concrete.

Product drawings concrete flat steel anchors

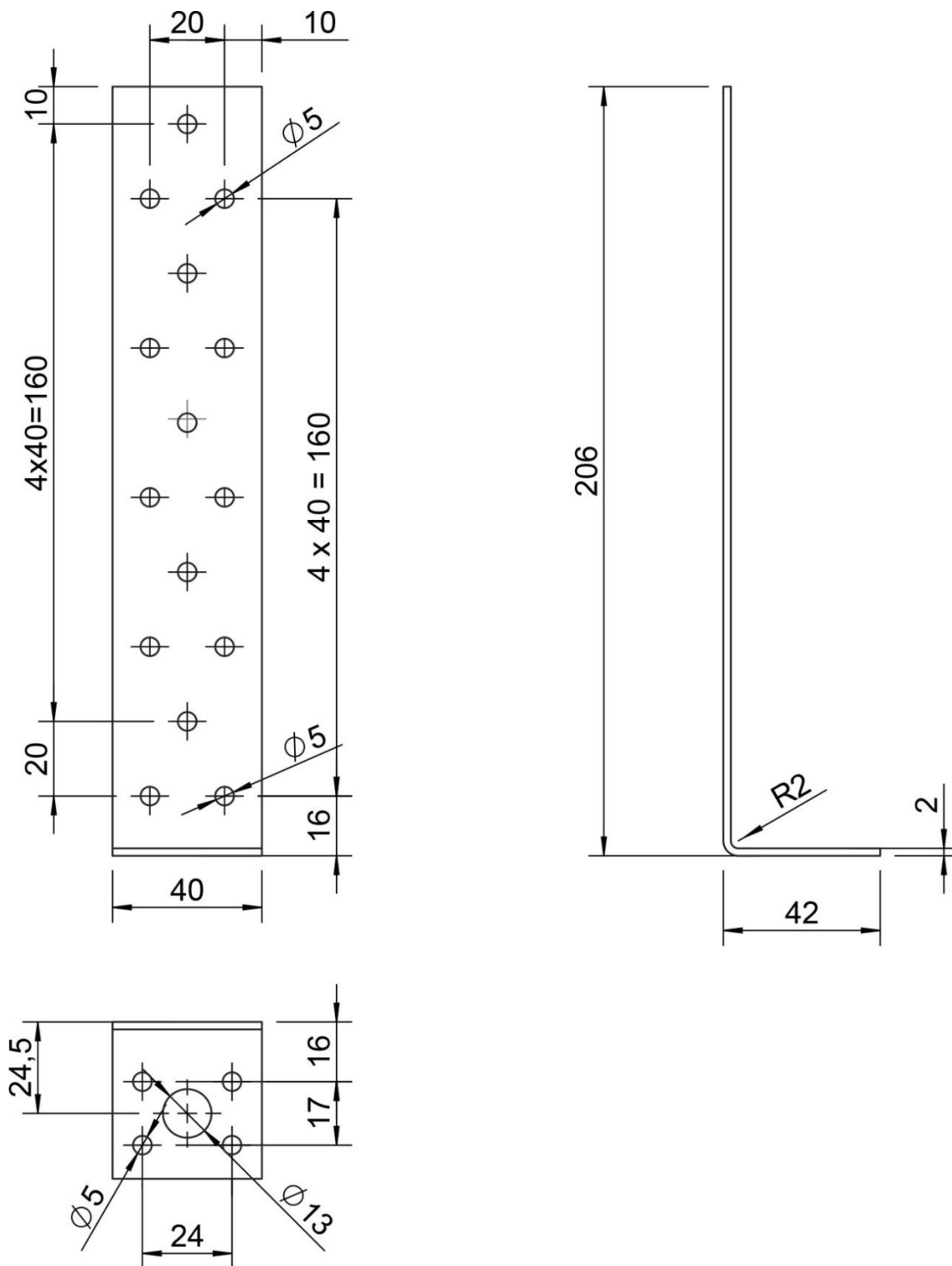
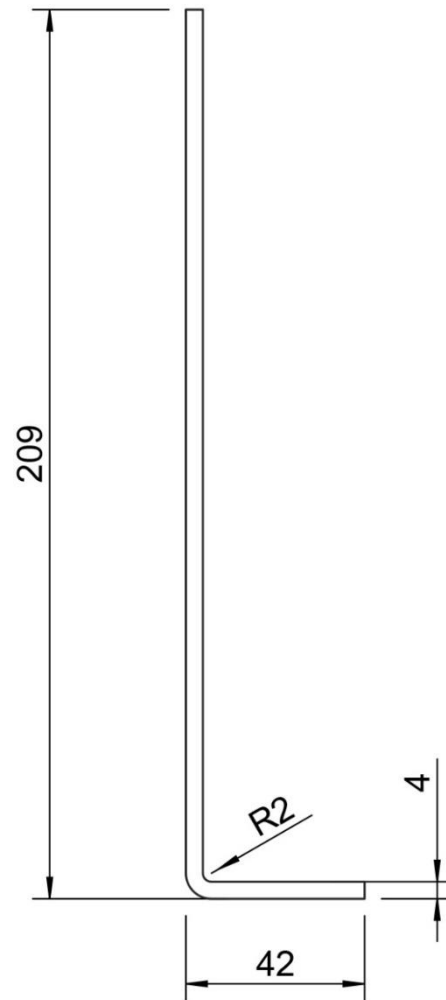


Figure B.48 Dimensions of concrete flat steel anchor 200x40x40x2,0



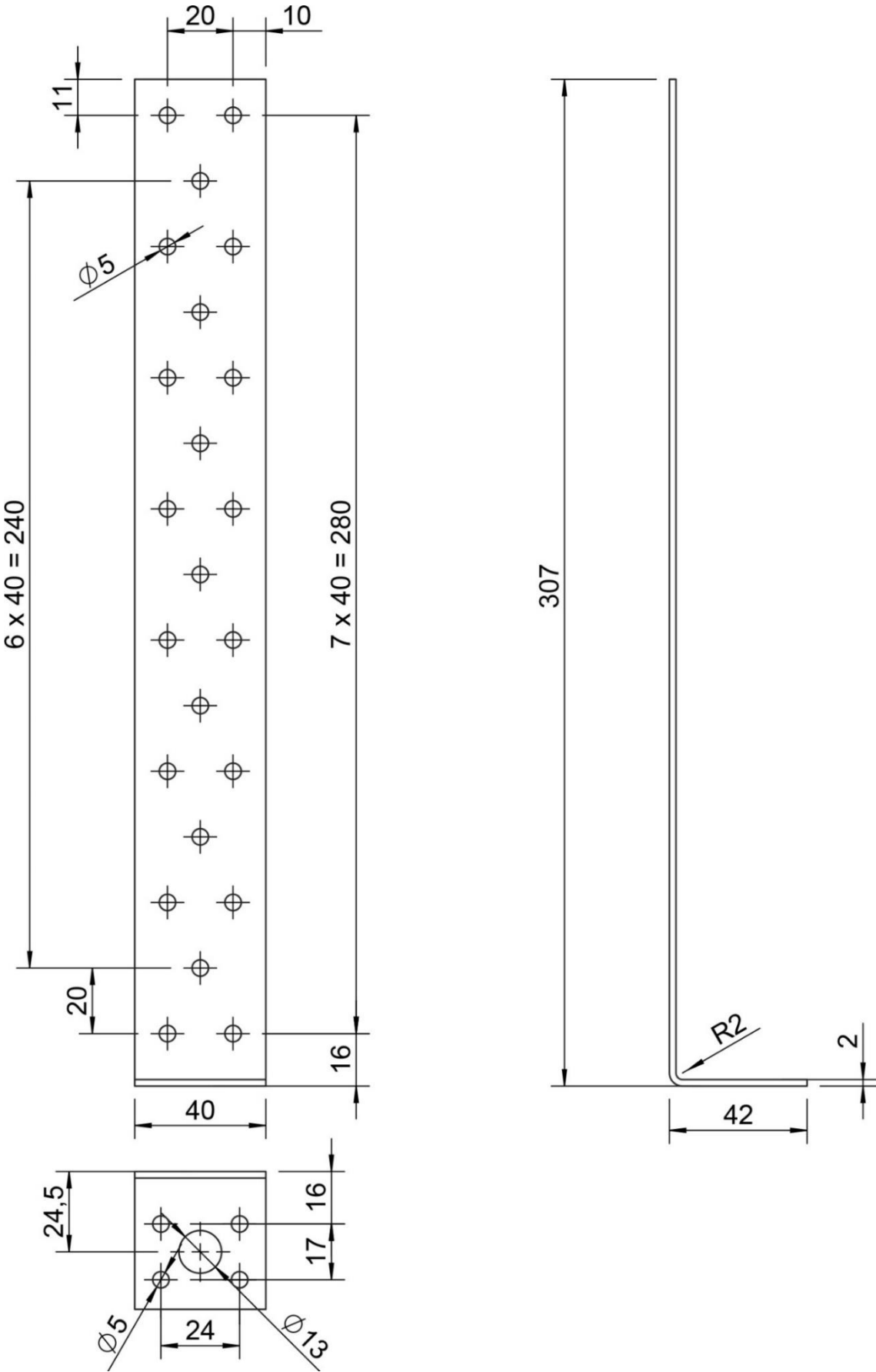


Figure B.50 Dimensions of concrete flat steel anchor 300x40x40x2,0

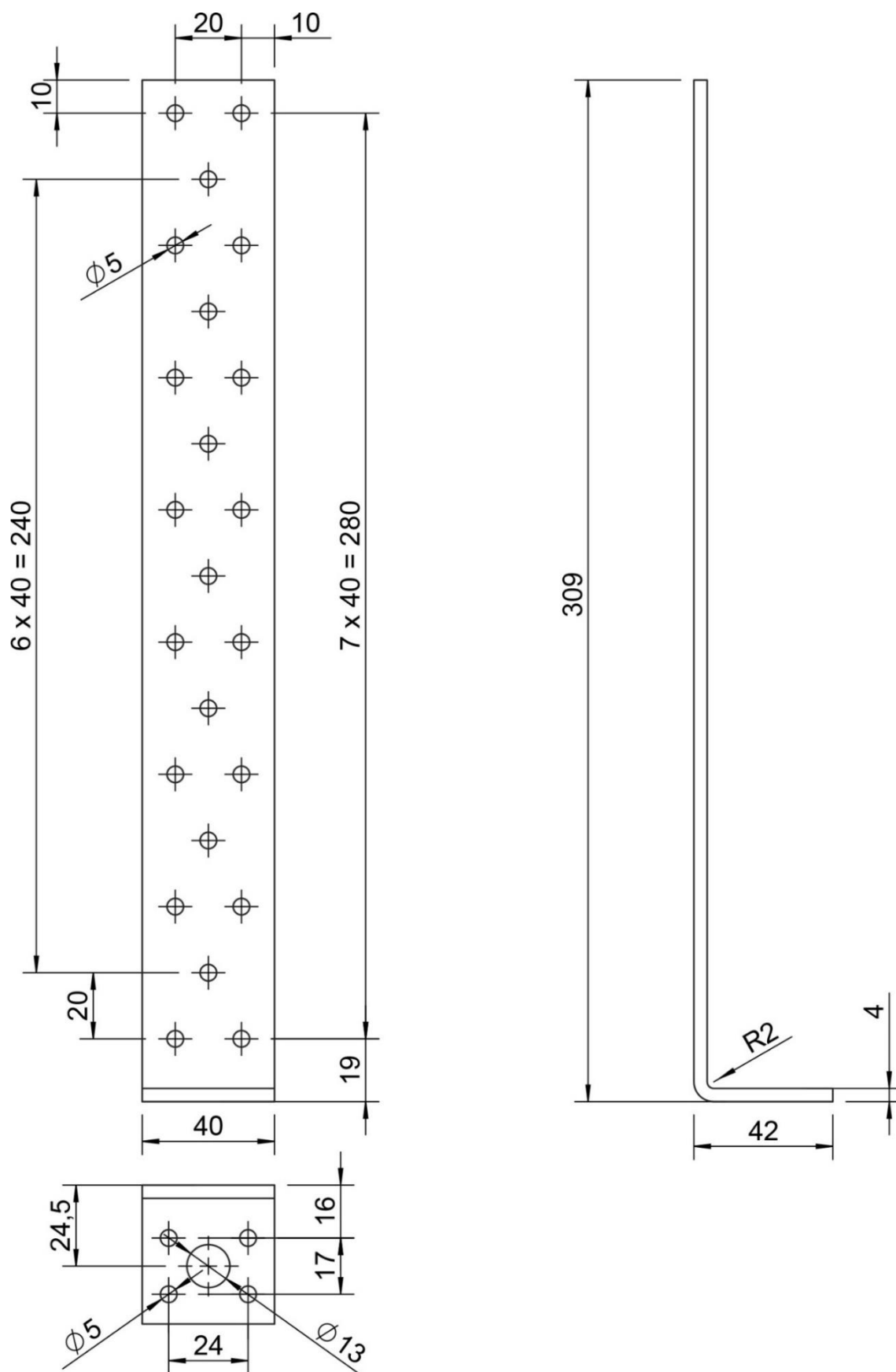


Figure B.51 Dimensions of concrete flat steel anchor 300x40x40x4,0

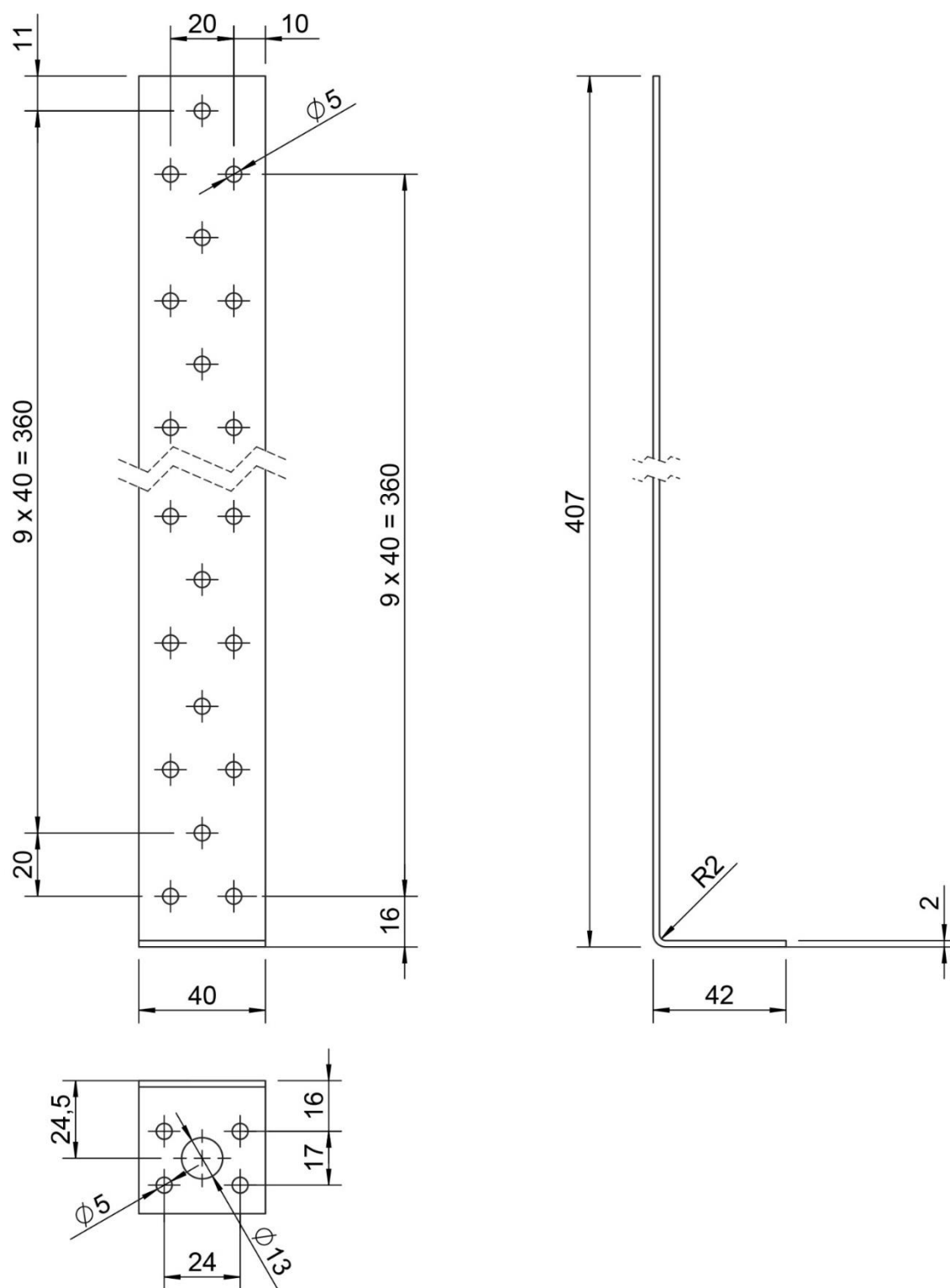


Figure B.52 Dimensions of concrete flat steel anchor 400x40x40x2,0

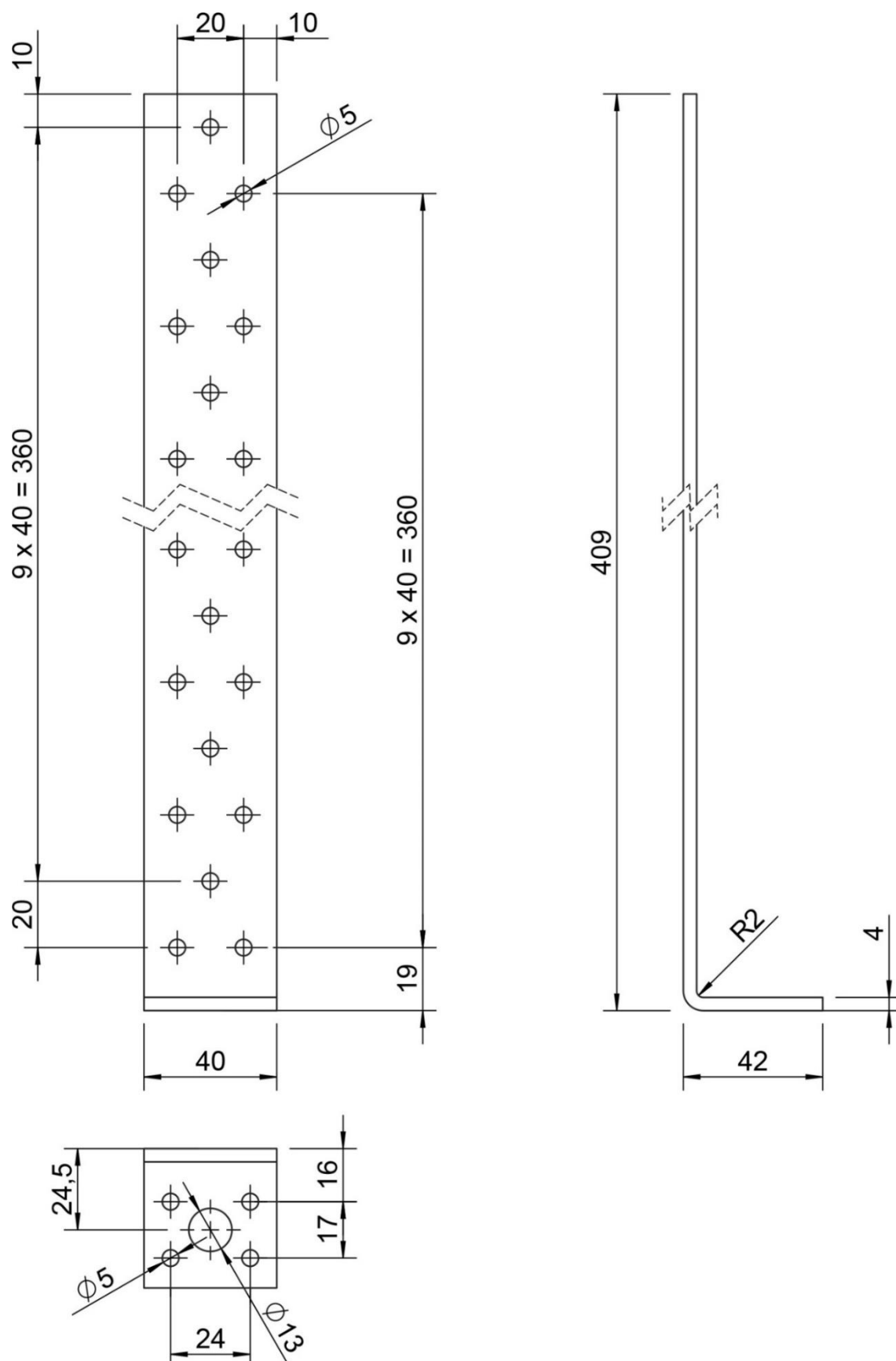


Figure B.53 Dimensions of concrete flat steel anchor 400x40x40x4,0

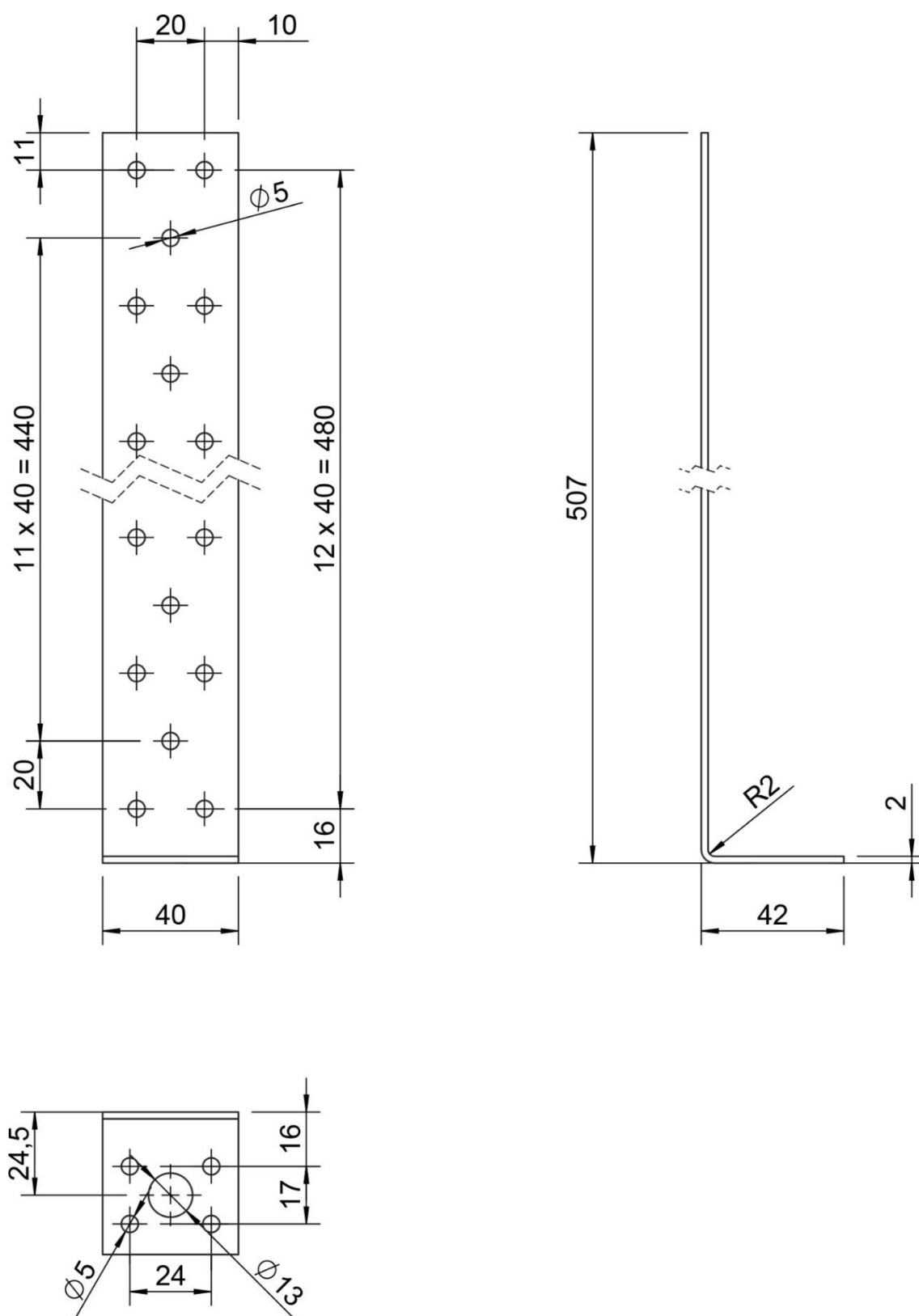


Figure B.54 Dimensions of concrete flat steel anchor 500x40x40x2,0

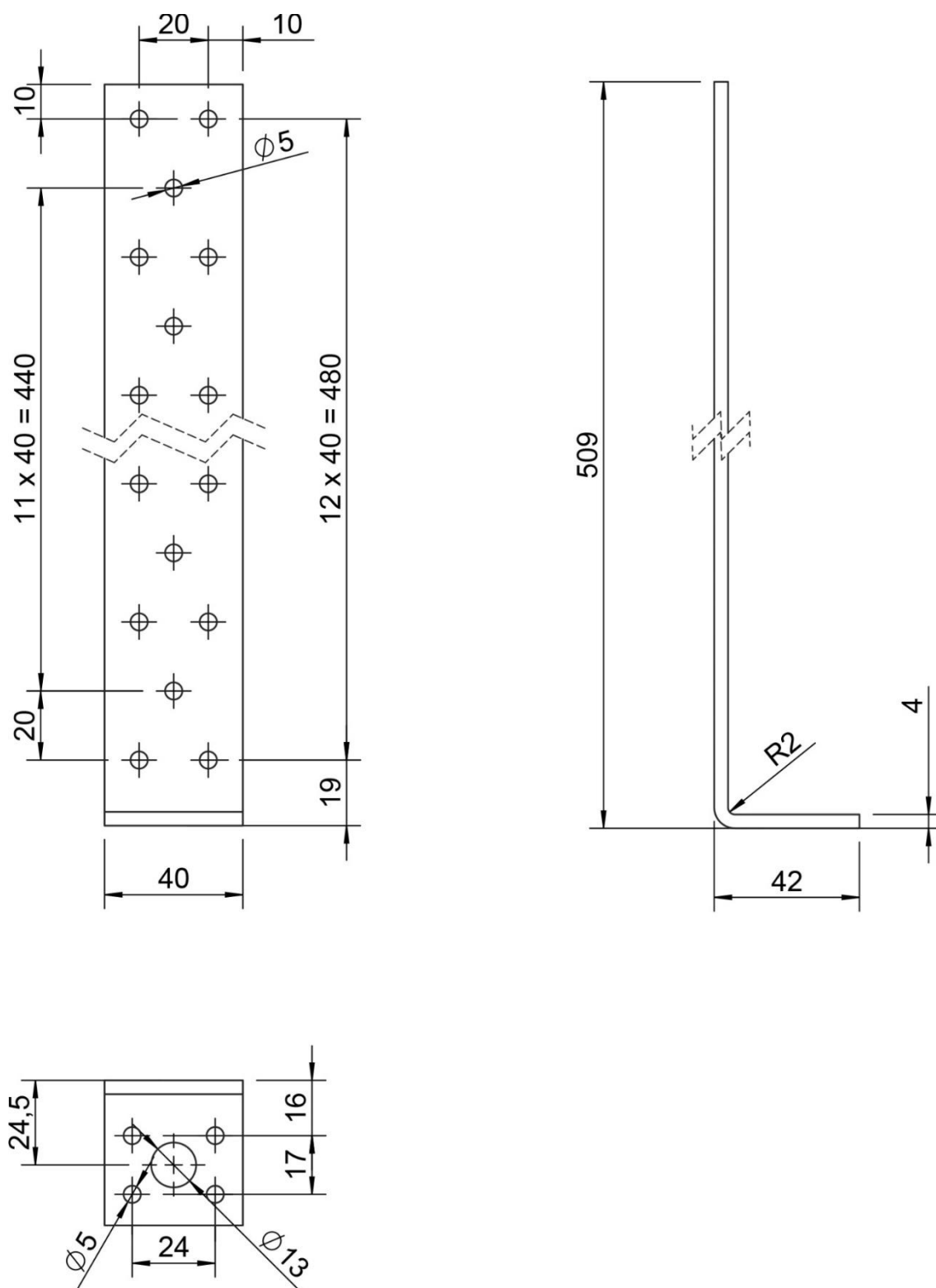


Figure B.55 Dimensions of concrete flat steel anchor 500x40x40x4,0