MEMBER OF EOTA

European Technical Assessment ETA-14/0274 of 2022/03/11

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:	Würth hold downs type V Plus Lx90x65x3,0, V Plus Lx90x65x4,0, type HTA Lx60x60x3,0 and HTA Lx80x80x3,0 and Angle Bracket Type V, Type V-MH
Product family to which the above construction product belongs:	EC PAC 13: Three-dimensional nailing plate (Angle brackets and hold-downs for timber-to-timber or timber-to-concrete or steel connections)
Manufacturer:	Adolf Würth GmbH & Co. KG Reinhold Würth Strasse 12 – 17 D-74650 Künzelsau Tel. +49 7940 15 0 Fax +49 7940 15 1000 Internet www.wuerth.com
Manufacturing plant:	Adolf Würth GmbH & Co. KG Manufacturing plant II
This European Technical Assessment contains:	59 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 2020-11-30

Translations of this European Technical Assessment in other languages shall fully correspond to the original issued document and should be identified as such.

Communication of this European Technical Assessment, including transmission by electronic means, shall be in full (excepted the confidential Annex(es) referred to above). However, partial reproduction may be made, with the written consent of the issuing Technical Assessment Body. Any partial reproduction has to be identified as such.

II SPECIFIC PART OF THE EUROPEAN TECHNICAL ASSESSMENT

1 Technical description of product and intended use

Technical description of the product
Würth 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 mm to 4 mm are made from zinc-coated or zinc-magnesium-coated steel grade S235 and S355 according to EN 10346, or steel grade DX 51D according to EN 10111 with $R_e \geq 200$ N/mm², $R_m \geq 270$ N/mm² and $A_{80} \geq 22\%$ or steel grade DX51/DD11 according to EN 10111 with $R_e \geq 200$ N/mm², $R_m \leq 440$ N/mm² and $A_{80} \geq 23\%$ with tolerances according to EN 10143 and are available in various sizes.

The angle brackets are made from pre-galvanized steel S 250 GD + Z 275 according to EN 10346 or from steel DX51/DD 11 according to EN 10111 with a minimum yield strength of $R_{el} \geq 251$ N/mm² 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 wood members can be fulfilled by using timber or wood based material with a characteristic density from 290 kg/m³ to 420 kg/m³. 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/m³. 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/m³:

$$k_{dens} = \left(\frac{\rho_k}{350} \right)^{0,5}$$

For densities below 350 kg/m³:

$$k_{dens} = \left(\frac{\rho_k}{350} \right)^{0,8}$$

Where ρ_k is he characteristic density of the timber in kg/m³.

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 is

applied, or when stainless steel 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 and angle brackets 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*) (BWR1)	
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 (BWR2)	
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
3.8 General aspects related to the performance of the product	The angle brackets 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 γ_M for steel or timber, respectively, are also correctly 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_7 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 for Three-dimensional nailing plates. 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
3.6.1 Corrosion protection in service class 1 and 2.
The hold downs with a steel plate thickness of 3 mm to 4 mm are made from zinc-coated or zinc-magnesium-coated steel grade S350 and S355 according to EN 10025-2:2004, or steel grade DX 51D according to EN 10327:2004 with $R_e \geq 200$ N/mm², $R_m \geq 270$ N/mm² and $A_{80} \geq 22\%$ or steel grade DX51/DD11 according to EN 10111:2008 with $R_e \geq 200$ N/mm², $R_m \leq 440$ N/mm² and $A_{80} \geq 23\%$ with tolerances according to EN 10143:1993.

The angle brackets Type V 95, 135, 285 and V-MH 137 are made from steel DX51/DD 11 according to EN 10111 with a minimum yield strength of $R_{el} \geq 251$ N/mm².

3.6.2 Corrosion protection in service class 3.
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. In service class 1 and 2 the corrosion protection is given by hot-dip zinc coating Z275 according to EN 10147 or zinc coating according to EN1461 with a minimum thickness of 8 μm. In service class 3 the corrosion protection is given by hot-dip zinc coating Z350 according to EN 10147 or zinc coating according to EN1461 with a minimum thickness of 55 μm

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 A.

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 Commission1, as amended, the system(s) of assessment and verification of constancy of performance (see Annex V to Regulation (EU) No 305/2011) is 2+.

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

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited at ETA-Danmark prior to CE marking.

Issued in Copenhagen on 2022-03-11 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
V Plus Lx90x65x3,0	3,0	DX51D or DD11
V Plus Lx90x65x4,0	4,0	DX51D or DD11
HTA Lx60x60x3,0	3,0	S355
HTA Lx80x80x3,0	3,0	S355
HTA-2PH 95x155x60x3,0	3,0	S355
HTA-2PIL 195x95x60x3	3,0/5,0	S355
HTA-2PIL-L 255x95x60x3	3,0/5,0	S355
HTA-2PV 155x60x60x3,0	3,0	S355
V plus-2P Lx90x65x4,0	4,0	DX51D or DD11
Washer 30x3	3,0	S 235
Washer 37x3	3,0	S 235
Base plate HTA 58,5x50x10	10,0	S 235
Base plate HTA 79x70x20	20,0	S 235
BP Lx40x3,0	3,0	S350GD
BP Lx60x3,0	3,0	S350GD
Storey connector	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	Height (mm) vertical		Depth (mm) horizontal		Width (mm)	
V Plus Lx90x65x3,0	L – 2	L + 2	89	91	64	66
V Plus Lx90x65x4,0	L – 2	L + 2	89	91	64	66
HTA Lx60x60x3,0	L – 2	L + 2	59	61	39	41
HTA Lx80x80x3,0	L – 2	L + 2	79	81	82	84
HTA-2PH 95x155x60x3,0	93,4	96,6	153,4	156,6	58,8	61,2
HTA-2PIL 195x95x60x3,0	93,4	96,6	193,6	196,4	58,8	61,2
HTA-2PIL-L 255x95x60x3,0	93,4	96,6	253,6	256,4	58,8	61,2
HTA-2PV 155x60x60x3,0	153,4	156,6	58,8	61,2	58,8	61,2
V plus-2P Lx90x65x4,0	94	96	89	91	64	66
Washer 30x3	-	-	29	31	62	64
Washer 37x3	-	-	36	38	36	38
Base plate HTA 58,5x50x10	-	-	58	59	49	51
Base plate HTA 79x70x20	-	-	78	80	69	71
BP Lx40x3,0	L - 2	L + 2	-	-	39	41
BP Lx60x3,0	L - 2	L + 2	-	-	59	61
Storey connector	L - 2	L + 2	-	-	39	41
Vertical flange BPD	332,6	337,4	43,8	46,2	63,8	66,2
Vertical flange BPR or BPL 380	377,6	382,4	53,8	56,2	55,8	58,2
Vertical flange BPR or BPL 465	462,6	467,4	53,8	56,2	55,8	58,2

Table A.3 Materials specification – angle brackets

Bracket type	Thickness (mm)	Steel specification
V 95	4,0	DX51D or DD11
V 135	4,0	DX51D or DD11
V-MH 137	4,0	DX51D or DD11
V 285	4,0	DX51D or DD11
Timber-concrete flat steel anchor	Thickness (mm)	Steel specification
40 x 200 x 2,0	2,0	S 250 GD + Z 275
40 x 300 x 2,0	2,0	S 250 GD + Z 275
40 x 400 x 2,0	2,0	S 250 GD + Z 275
40 x 200 x 4,0	4,0	S 250 GD + Z 275
40 x 300 x 4,0	4,0	S 250 GD + Z 275
40 x 400 x 4,0	4,0	S 250 GD + Z 275

Table A.4 Range of sizes – angle brackets

Bracket type	Height (mm)		Width (mm)	
	Min	max	min	max
V 95	94	96	64	66
V 135	134	136	64	66
V-MH 137	136	138	64	66
V 285	284	286	64	66
Timber-concrete flat steel anchor	Length (mm)		Width (mm)	
	min	max	min	max
40 x 40 x 200	200	207	39	41
40 x 40 x 300	300	307	39	41
40 x 40 x 400	400	407	39	41
40 x 40 x 200	200	207	39	41
40 x 40 x 300	300	307	39	41
40 x 40 x 400	400	407	39	41

Table A.5 Fastener specification

Fastener	Size (mm)			Type	Finish
	Diameter	Length	Threaded Length		
Threaded nail	4,0 / 4,4	40, 50, 60	31, 40, 50	Ringed shank nail according to EN 14592	Electroplated zinc
Screw	5,0	35, 40, 50	30, 32, 42	Self-tapping ASSY screw according to ETA 11/0190	Electroplated zinc
Screw	8,0	80, 100	69, 89	Self-tapping ASSY screw according to ETA 11/0190	Electroplated zinc
Screw	10,0	60, 80, 100	50, 69, 89	Self-tapping ASSY screw according to ETA 11/0190	Electroplated zinc
Screw	6,3	19	11,5	ZEBRA Pias screws 6.3x19 according to ETA-10/0184	Electroplated zinc

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 1995-1-1:2004, paragraph 8.3.2 (head pull-through is not relevant):

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

Where:

$f_{ax,k}$ Characteristic value of the withdrawal parameter in N/mm^2

d Nail diameter in mm

t_{pen} Penetration depth of the profiled shank

      (4,0 x 40 mm $t_{pen} \geq 31$ mm; 4,0 x 50 mm $t_{pen} \geq 40$ mm; 4,0 x 60 mm $t_{pen} \geq 50$ mm)

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

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

| BOLT or METAL ANCHOR diameter	Correspondent Hole diameter	Bolt or metal anchor type

General:
     8.0 mm
     10.0 mm
     12.0 mm
 	
Hold downs type V 285
16.0 - 20.0 mm
	Max. 2 mm. larger than the bolt or anchor diameter
	
	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.
		Bolt according to EN 14592, Anchor according to ETA
		(see specification of the manufacturer)

Winkelverbinder V mit Langloch

Winkelverbinder V mit Rundloch
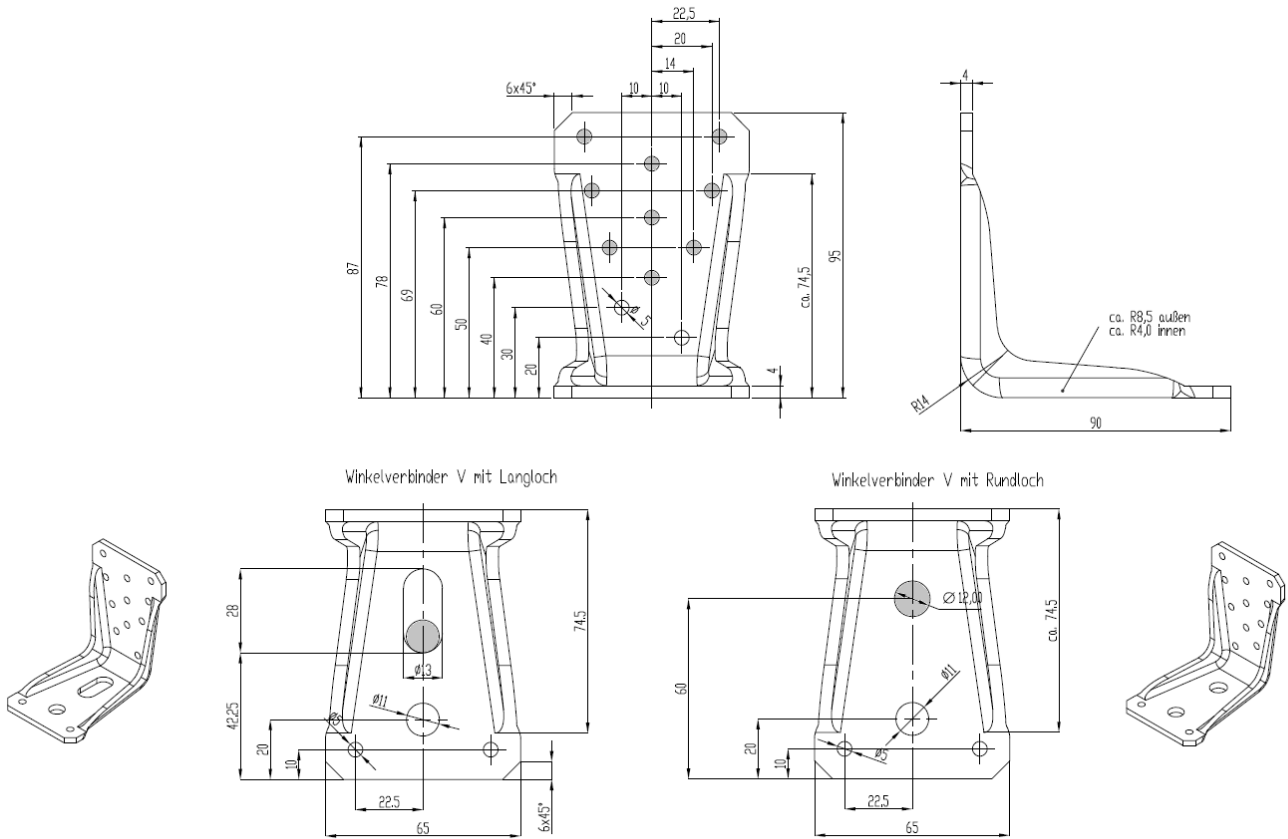
Figure A.1 Nail Patterns of Angle Bracket
V 95 – purlin connection

Winkelverbinder V mit Langloch

Winkelverbinder V mit Rundloch
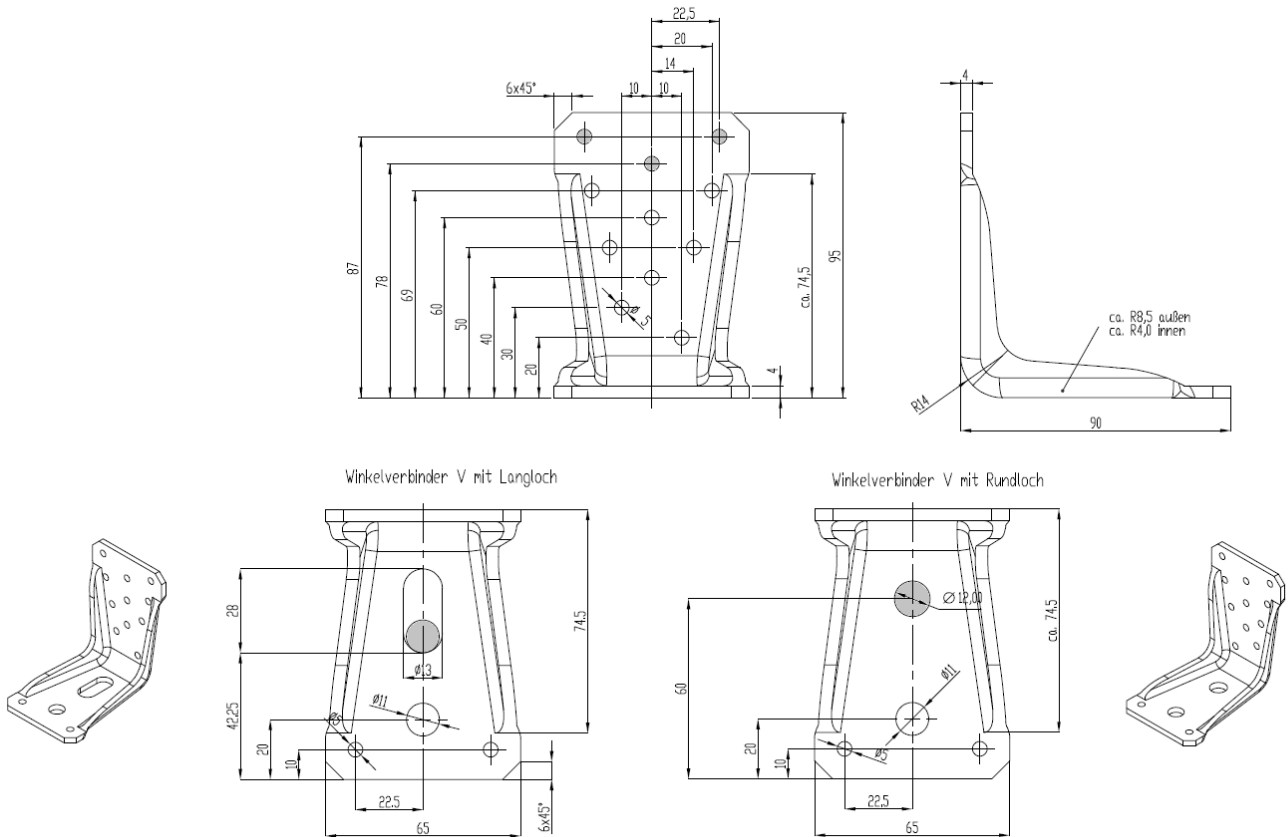
Figure A.1 Nail Patterns of Angle Bracket
V 95 – column connection

Winkelverbinder V mit Langloch

Winkelverbinder V mit Rundloch

Figure A.3 Nail Patterns of Angle Bracket
V 135 - purlin connection

Winkelverbinder V mit Langloch

Winkelverbinder V mit Rundloch

Figure A.4 Nail Patterns of Angle Bracket
V 135 - column connection
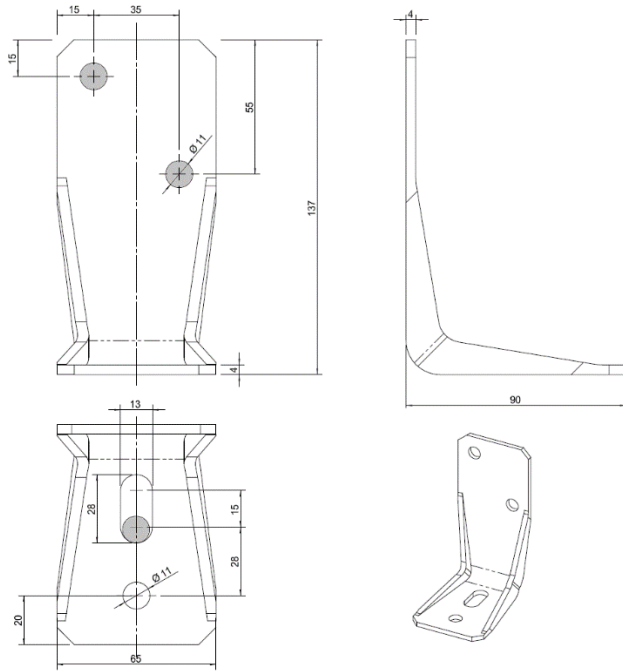
Figure A.5 Nail patterns of Angle Bracket V-MH 137 - Purlin
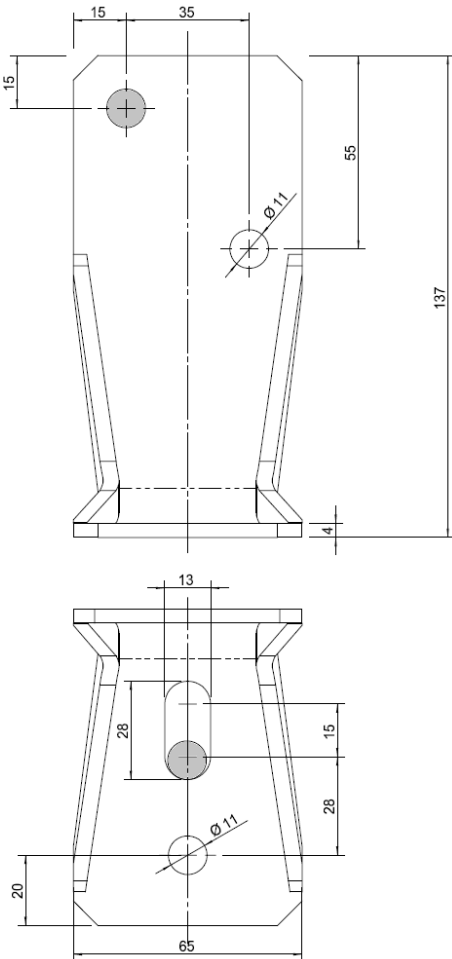
Figure A.6 Nail patterns of Angle Bracket V-MH 137 - Column

Winkelverbinder V mit Langloch

Winkelverbinder V mit Rundloch

Figure A.7 Nail Patterns of Angle Bracket V 285 - column connection

Annex B
Characteristic load-carrying capacities

Hold downs

Table B.1: Force F_1, 1 one-piece hold-down / connection timber-concrete / softwood[1] $\rho_k = 350$ kg/m³

Hold down type	capacity per nail in the vertical flange ($F_{v,Rk}$) [kN][2]			capacity per screw in the vertical flange ($F_{v,Rk}$) [kN][2]			concrete	steel[3] tensile ($F_{t,Rk}$) [kN]	bolt k_t
	4x40	4x50	4x60	5x35	5x40	5x50			
V Plus Lx90x65x3,0	1,57	1,87	1,93	1,88	2,14	2,29	see EN1992	36,2	1,0
V Plus Lx90x65x4,0	1,57	1,87	1,93	1,88	2,14	2,29		48,3	1,0
HTA Lx60x60x3,0*	1,57	1,87	1,93	1,88	2,14	2,29		32,5	1,1
HTA Lx60x60x3,0**	1,57	1,87	1,93	1,88	2,14	2,29		45,0	1,1
HTA Lx80x80x3,0***	1,57	1,87	1,93	1,88	2,14	2,29		60,0	1,1
HTA Lx80x80x3,0****	1,57	1,87	1,93	1,88	2,14	2,29		60,0	1,1
* with washer 30x3; ** with base plate t = 10 mm; *** with washer 37x3; **** base plate t = 20 mm									

[1] For other characteristic softwood densities, $F_{v,Rk}$ is multiplied by $k_{dens} = \left(\dfrac{\rho_k}{350}\right)^{0,5}$;

For hardwoods, $F_{v,Rk}$ is 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] 4,0 mm nails or 5,0 mm screws may be used

[3] Base plates/washers according to the engineering drawings are used

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

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

Where

$n_{ef,t}$ Effective number of nails or screws in the BP 60 or BP 40 vertical flange according to Table B.3 or B.4,

$F_{v,Rk}$ 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

Nt,Rk = 37,8 kN for e = 0 and hold-downs with vertical flange BPD, BPR or BPL

Nt,Rk = 16,4 kN for e = 10 mm and hold-downs with vertical flange BPD

Nt,Rk = 19,4 kN for e = 10 mm and hold-downs with vertical flange BPR or BPL

$N_{t,Rk}$ = 46,9 kN for hold-downs V plus-2P, HTA-2PV, HTA-2PIL, HTA-2PIL-L and HTA-2PH for e = 0 and BP 60 flange

$N_{t,Rk}$ = 34,1 kN for hold-downs V plus-2P, HTA-2PV, HTA-2PIL, HTA-2PIL-L and HTA-2PH for e = 10 mm and BP 60 flange

$N_{t,Rk}$ = 27,3 kN for hold-downs V plus-2P and HTA-2PIL, HTA-2PIL-L for e = 17,5 mm and BP 60 flange

$N_{t,Rk}$ = 31,3 kN for hold-downs V plus-2P, HTA-2PV, HTA-2PIL, HTA-2PIL-L and HTA-2PH for e = 0 and 40 mm flange or for storey connectors

$N_{t,Rk}$ = 19,3 kN for hold-downs V plus-2P, HTA-2PV and HTA-2PH for e = 10 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.5;

$F_{t,Rk}$ 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 connectors

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 ($F_{c,Rk}$) [kN]	steel [2] tensile ($F_{t,Rk}$) [5] [kN]	bolt [3] k_t	bolt or screw [4] k_t
	4x40	4x50	4x60	5x35	5x40	5x50				
V plus-2P Lx90x65x4,0	1,57	1,87	1,93	1,88	2,14	2,29	see EN 1992	48,3	1,4	1,3
HTA-2PV Lx60x60x3,0*	1,57	1,87	1,93	1,88	2,14	2,29		32,5	1,2	1,2
HTA-2PH 95x155x60x3,0	1,57	1,87	1,93	1,88	2,14	2,29		35,0	1,5	1,5
HTA-2PIL 195x95x60x3,0 [3]	1,57	1,87	1,93	1,88	2,14	2,29		25,0	2,5	-
HTA-2PIL-L 255x95x60x3,0 [3]	1,57	1,87	1,93	1,88	2,14	2,29		28,0	1,8	-
HTA-2PIL 195x95x60x3,0 [4]	1,57	1,87	1,93	1,88	2,14	2,29	-	14,5	-	2,5
HTA-2PIL-L 255x95x60x3,0 [4]	1,57	1,87	1,93	1,88	2,14	2,29	-	27,0	-	1,8
* 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 BP 60 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 $n_{ef,s}$ of ZEBRA Pias screws 6.3x19 for V plus-2P, HTA-2PV and HTA-2PH

Screw arrangement		n_s	$n_{ef,s}$
1-2-3-4-5-6	only BP 60 flange	6	6
1-2-3-4	BP 40 or BP 60 flange or storey connectors	4	4
1-2-4-5 or 1-3-4-6	BP 40 or BP 60 flange or storey connectors	4	2,7
4-5-6	only BP 60 flange	3	3
3-4-6 or 2-4-5	BP 40 or BP 60 flange or storey connectors	3	1,6
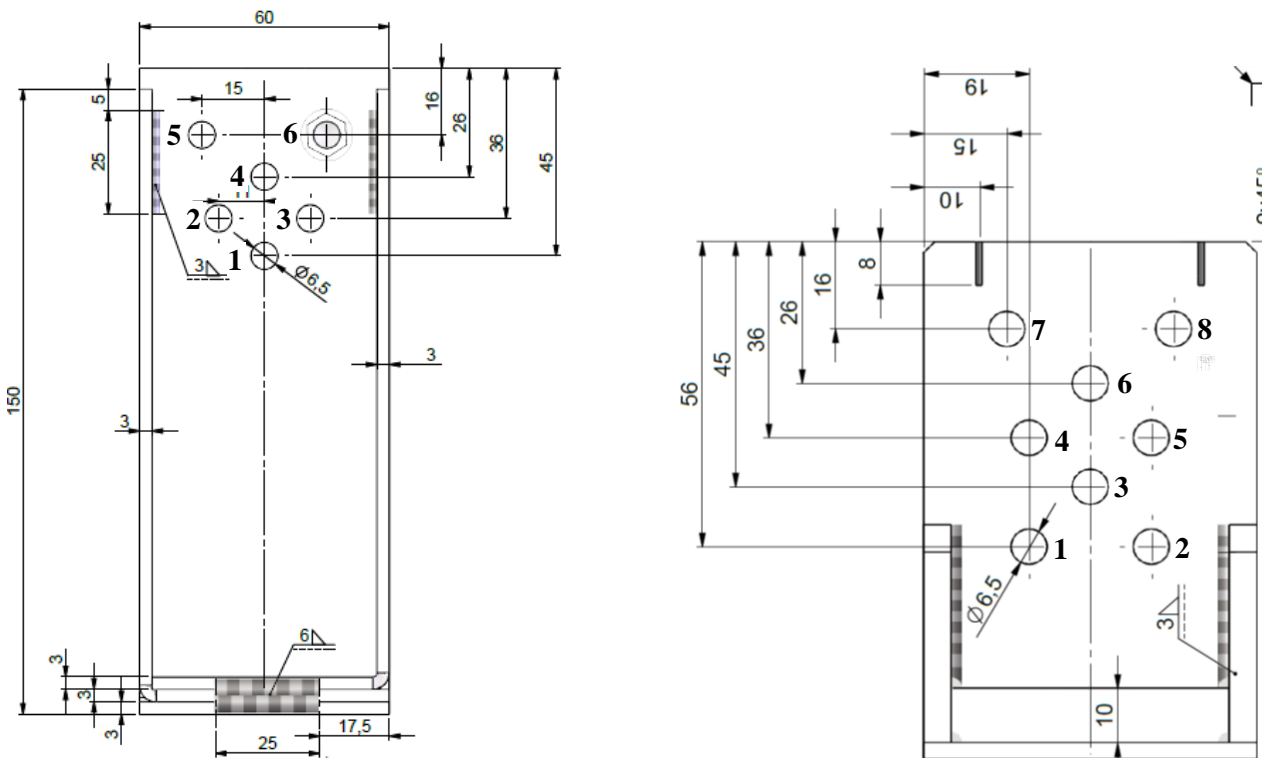
Figure B.1 Screw patterns of V plus-2P, HTA-2PV and HTA-2PH (left) and HTA-2PIL and HTA-2PIL-L (right)

Table B.6: Effective number $n_{ef,s}$ of ZEBRA Pias screws 6.3x19 for HTA-2PIL and HTA-2PIL-L

Screw arrangement		n_s	$n_{ef,s}$
1-2-3-4-5-6-7-8	only BP 60 flange	8	8
1-2-3-4-5-6 or 3-4-5-6-7-8	only BP 60 flange	6	6
3-4-5-6 or 1-2-3-6	BP 40 or BP 60 flange or storey connectors	4	4
3-4-6-7 or 3-5-6-8	BP 40 or BP 60 flange or storey connectors	4	2,7
1-2-3 or 3-4-5 or 4-5-6 or 6-7-8	only BP 60 flange	3	3
5-6-8 or 4-6-7	BP 40 or BP 60 flange or storey connectors	3	1,6

Table B.7: $F_{1,Rk}$ per storey connector / connection timber to timber

Screws see Table A.7	$F_{1,Rk} = \min\left\{ n \cdot F_{v,Rk} ; f_{y,k} \cdot A_{gross} ; f_{u,k} \cdot A_{net} \right\}$
$F_{v,Rk}$ is the characteristic lateral load-carrying capacity per screw according to Table B.9	

Table B.8:   F1,Rk per Plate connector / connection timber to concrete

Nails or screws see Table A.7	$F_{1,Rk} = \min\left\{ n \cdot F_{v,Rk} ; n_{anchor} \cdot V_{Rk} ; f_{y,k} \cdot A_{gross} ; f_{u,k} \cdot A_{net} \right\}$
$F_{v,Rk}$ is the characteristic lateral load-carrying capacity per nail or screw according to Table B.2 nanchor is the number of metal anchors V_{Rk} is the characteristic lateral load-carrying capacity per metal anchor	

Table B.9:   Characteristic capacities $F_{v,Rk}$ of laterally loaded ASSY plus VG 4 Combi screws in kN

d x L [mm]	$\sigma_k = 350$ kg/m³				$\sigma_k = 400$ kg/m³			
	8x80	8x100	10x80	10x100	8x80	8x100	10x80	10x100
ASSY plus VG 4 Combi	3,79	4,77	4,43	5,58	4,33	5,30	5,06	6,38

Pos.	Art. Nr.	L (mm)	B (mm)	S (mm)	Anzahl Löcher	Werkstoff / Oberfläche	Bemerkung
1		340			20		
2		440	60	3	30	S350 / Z275	
3		540			42		
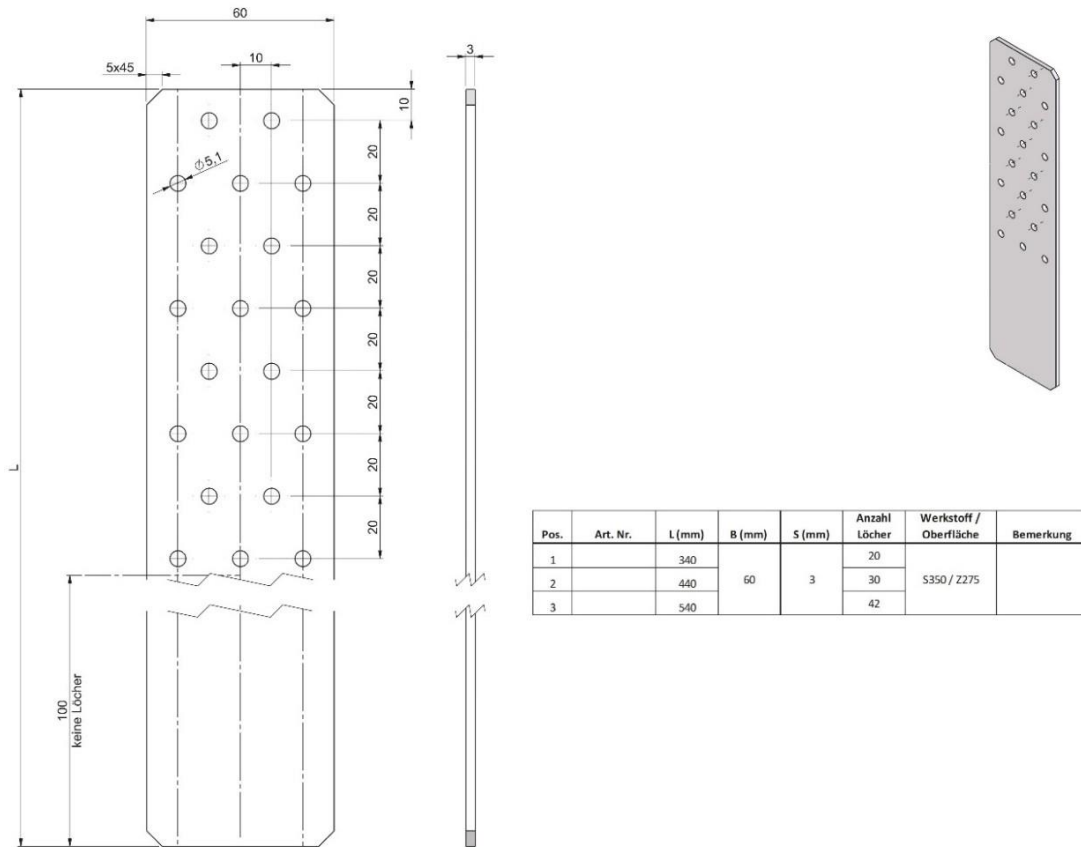
Figure B.2 Dimensions of 60 mm vertical flange BP 60 for two-piece hold-downs

Pos.	Art. Nr.	L (mm)	B (mm)	S (mm)	Anzahl Löcher	Werkstoff / Oberfläche	Bemerkung
1		340			18		
2		440	40	3	25	S350 / Z275	
3		540			33		
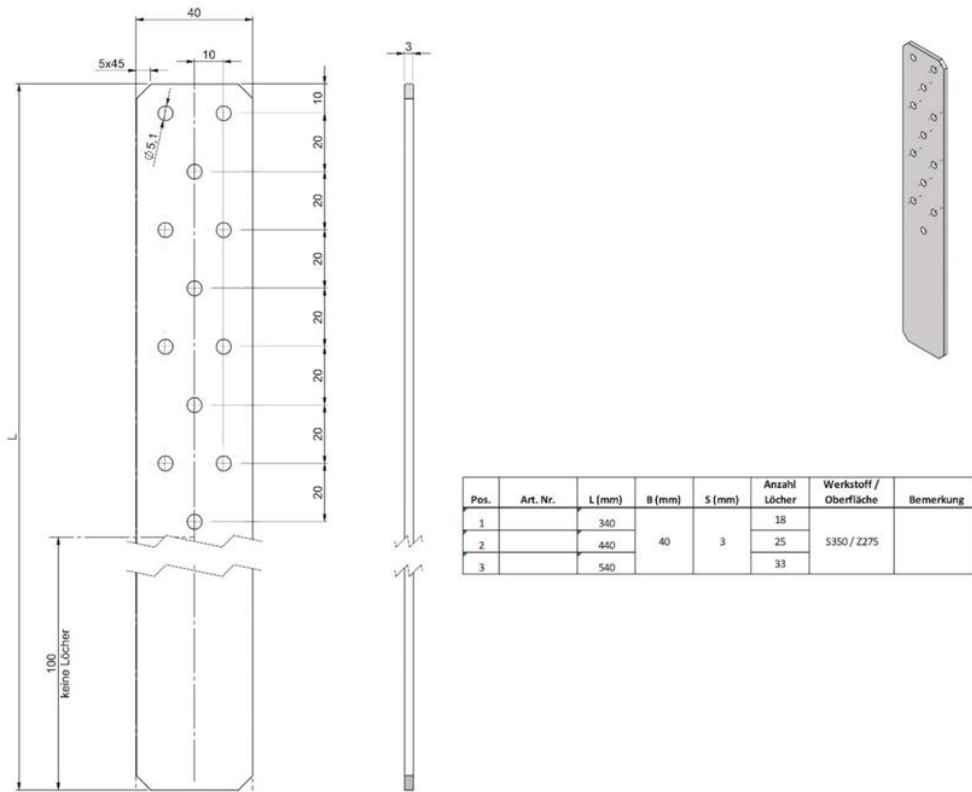
Figure B.3 Dimensions of 40 mm vertical flange BP 40 for two-piece hold-downs
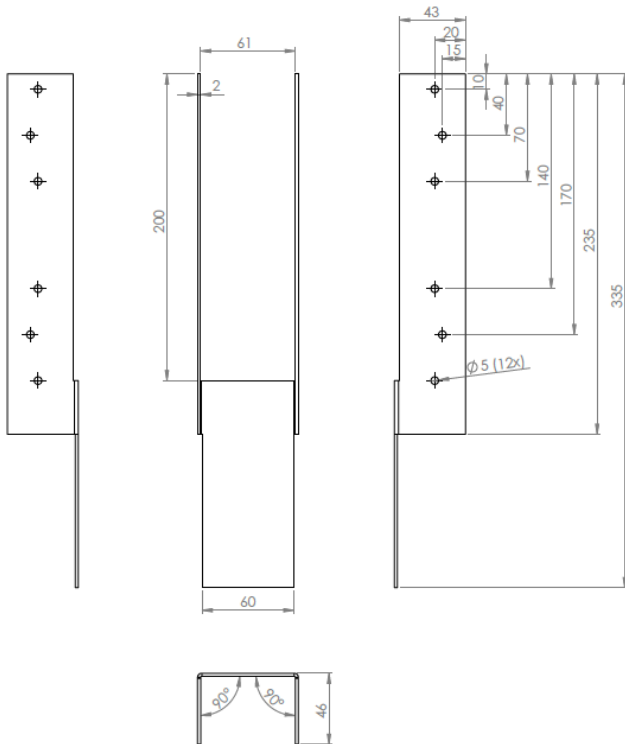
Figure B.4 Dimensions of vertical flange BPD S250 for two-piece hold-downs
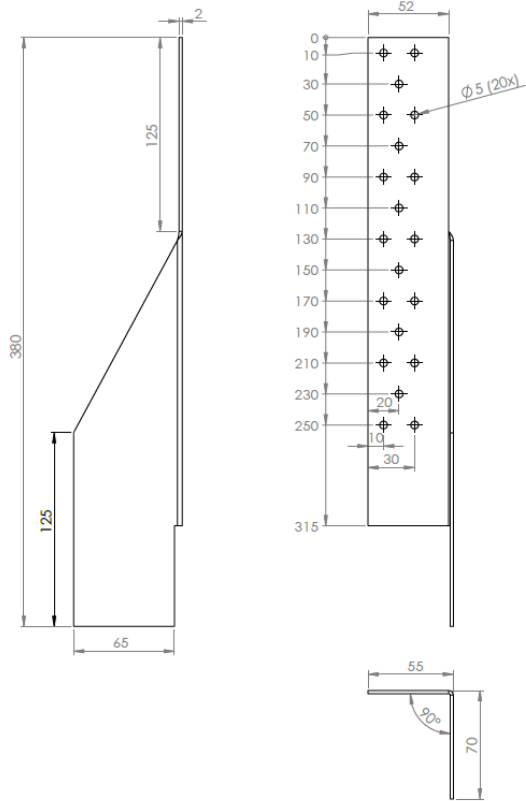
Figure B.5 Dimensions of vertical flange BPL380 S250 for two-piece hold-downs
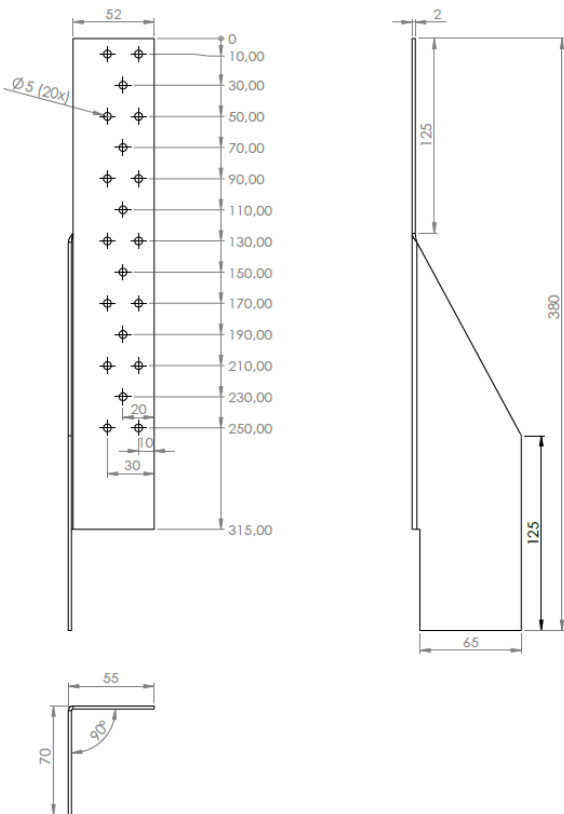
Figure B.6 Dimensions of vertical flange BPR380 S250 for two-piece hold-downs
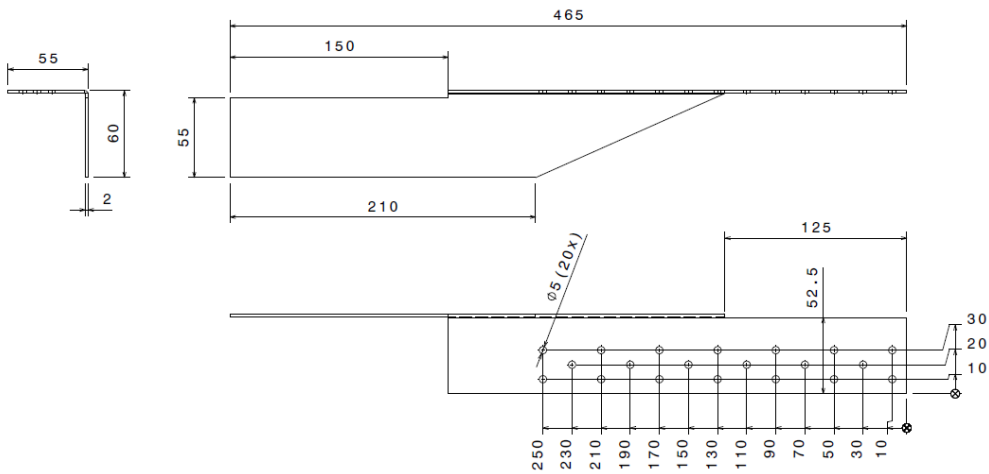
Figure B.7 Dimensions of vertical flange BPL S250 for two-piece hold-downs
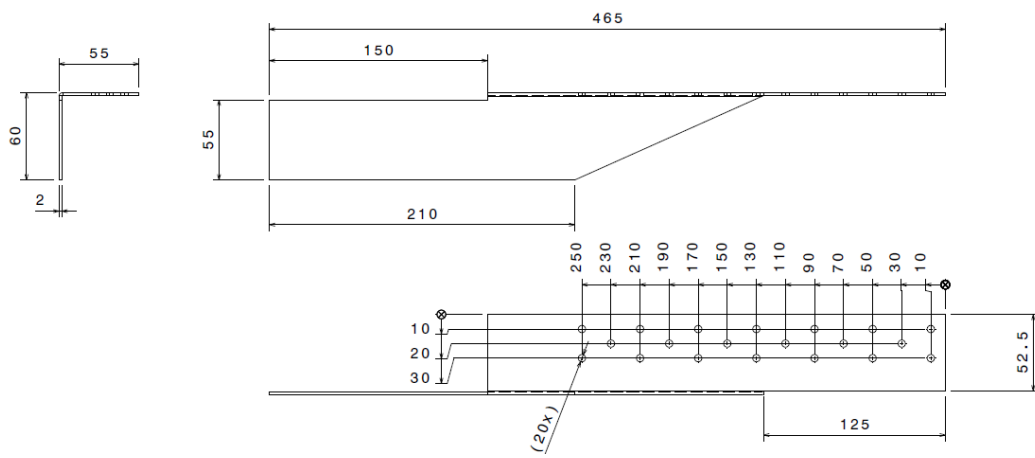
Figure B.8 Dimensions of vertical flange BPR465 S250 for two-piece hold-downs
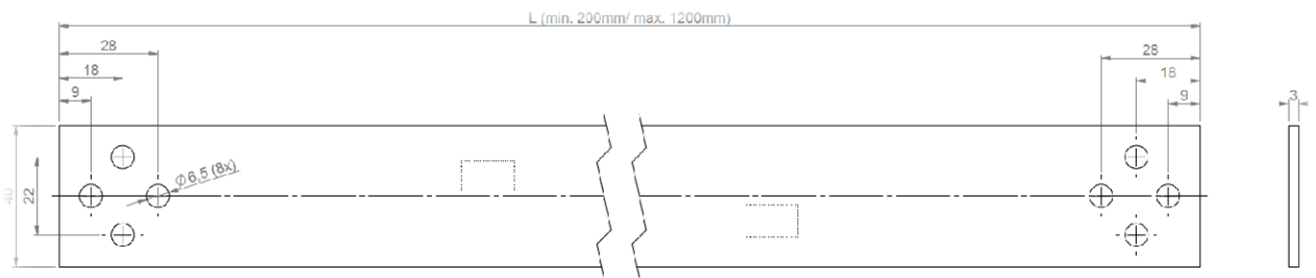
Figure B.9 Dimensions of storey connector Lx40x3 made of S350

Definitions of forces, their directions and eccentricity
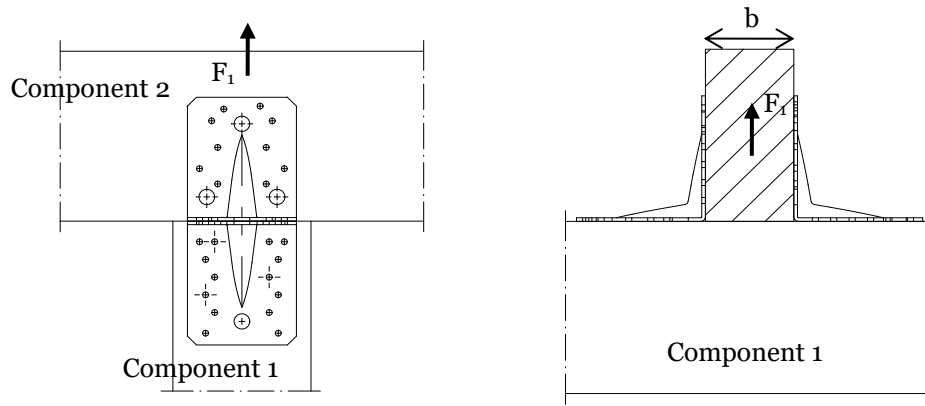
Single hold down per connection
Acting forces
F_1 Lifting force acting in the central axis of the hold down. The component 2 shall be prevented from rotation.

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

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

Where:

$F_{B,t,Ed}$ Bolt tensile load in N
k_t Coefficient taking into account the moment arm or hole tolerance, respectively
F_{Ed} Tensile load F_1 on vertical flap of the hold down
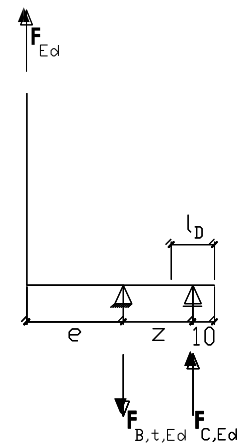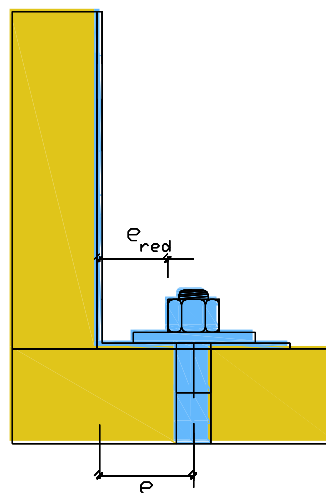
Angle brackets type V and V-MH: Load-carrying capacities with 1 or 2 angle brackets per connection

Table B.7: Characteristic values in the F1a - purlin, 1 angle bracket / connection

Angle Bracket	Number of nails	$F_{1a,k}$ in kN	k_t
V 95	9	13,7	
V 135	14	21,2	1,1
V-MH 137	2	10,9	

Table B.8: Characteristic values in the F1b - column, 1 angle bracket / connection

Angle Bracket	Number of nails	$F_{1b,k}$ in kN	k_t
V 95	3	4,6	
V 135	6	9,1	
V-MH 137	1	2,9	1,1
V 285	9	13,7	

Table B.9: Characteristic values in the F1a - purlin, 2 angle brackets / connection

Angle Bracket	Number of nails	$F_{1a,k}$ in kN	k_t
V 95	9	27,4	
V 135	14	42,4	1,1
V-MH 137	2	21,9	

Table B.10: Characteristic values in the F1b - column, 2 angle brackets / connection

Angle Bracket	Number of nails	$F_{1b,k}$ in kN	k_t
V 95	3	9,2	
V 135	6	18,3	
V-MH 137	1	11,5	1,1
V 285	9	27,5	
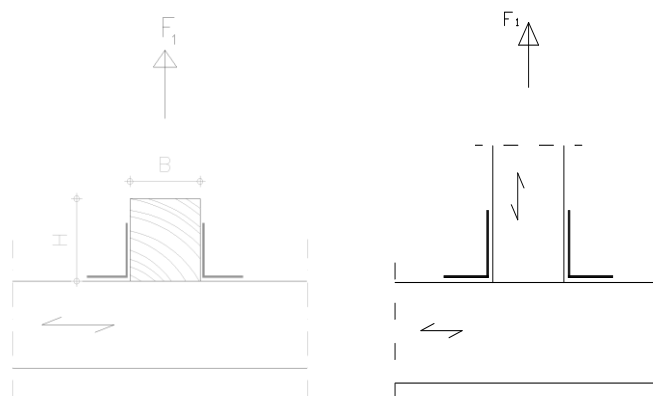
Figure B.2 Load F_1, purlin (left) and column (right)

Table B.11: Characteristic values in the F2 for V 95, 1 angle bracket / connection

	V 95		
	$F_{2,Rk}$ **in kN**		
	H in m		
B in m	**0,12**	**0,14**	**0,18**
0,06	4,29	4,58	4,68
0,10	3,72	3,81	3,98
0,14	3,56	3,61	3,70

Table B.12: Factor k_t for angle bracket V 95 force F2

	V 95		
	k_t		
	H in m		
B in m	**0,12**	**0,14**	**0,18**
0,06	2,16	2,24	2,44
0,10	2,05	2,08	2,15
0,14	2,01	2,03	2,07

Table B.13: Characteristic values F2 for V 135, 1 angle bracket / connection

	V 135		
	$F_{2,Rk}$ **in kN**		
	H in m		
B in m	**0,16**	**0,18**	**0,22**
0,06	4,45	4,94	5,03
0,10	3,91	3,98	4,06
0,14	3,73	3,77	3,83

Table B.14: Factor k_t for angle bracket V 135 force 2

	V 135		
	k_t		
	H in m		
B in m	**0,16**	**0,18**	**0,22**
0,06	1,94	2,82	4,50
0,10	2,02	2,06	2,04
0,14	1,94	1,97	2,02

Table B.15: Characteristic values F2 for V-MH 137, 1 angle bracket / connection

V-MH 137			
	$F_{2,Rk}$ in kN		
	H in m		
B in m	0,16	0,18	0,22
0,06	3,83	3,73	3,95
0,10	3,45	3,55	3,71
0,14	3,71	3,34	3,44

Table B.16: Factor k_t for angle bracket V-MH 137 force 2

V-MH 137			
	k_t		
	H in m		
B in m	0,16	0,18	0,22
0,06	1,70	1,73	2,04
0,10	1,61	1,63	1,65
0,14	1,65	1,59	1,61

Table B.17: Characteristic values F3 for V 95, 1 angle bracket / connection

V 95		
	$F_{3,Rk}$ in kN	
H in m	Steel	Timber
0,12	1,15	2,06
0,14	0,90	1,35
0,18	0,62	0,79

Table B.18: Characteristic values F3 for V 135, 1 angle bracket / connection

V 135	
	$F_{3,Rk}$ in kN
H in m	Steel
0,16	1,24
0,18	0,94
0,22	0,48

Table B.19: Characteristic values F3 for V-MH 137, 1 angle bracket / connection

V-MH 137	
	$F_{3,Rk}$ in kN
H in m	Steel
0,16	0,65
0,18	0,53
0,22	0,38
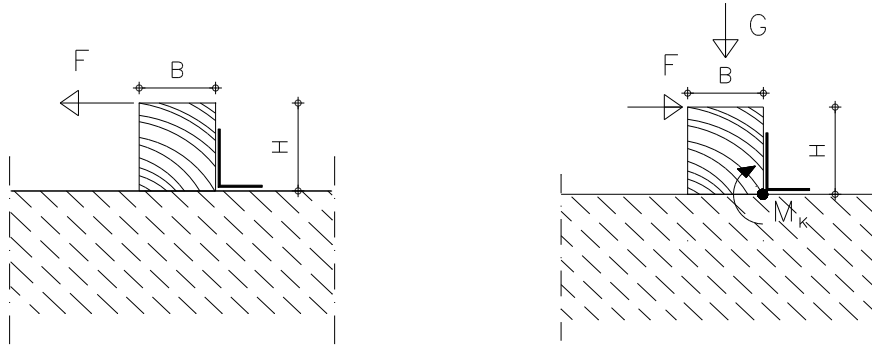
Figure B.3 Load F_2 (left) and Load F_3 (right)

Table B.20: Characteristic values for Force F4/F5

Angle Bracket	$F_{4/5,Rk}$ in kN
V 95	7,58
V 135	7,99
V-MH 137	8,57

For different purlin widths and depths, the interaction equations were evaluated. The results are given in the tables 15 and 16.

Table B.21: Characteristic values F4/F5 for V 95

V 95			
	$F_{4,5Rk}$ in kN		
	H in m		
B in 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.22: Characteristic values F4/F5 for V 135

V 135			
	$F_{4/5,Rk}$ in kN		
	H in m		
B in 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

$$F = (F_4/F_5) * H/B$$
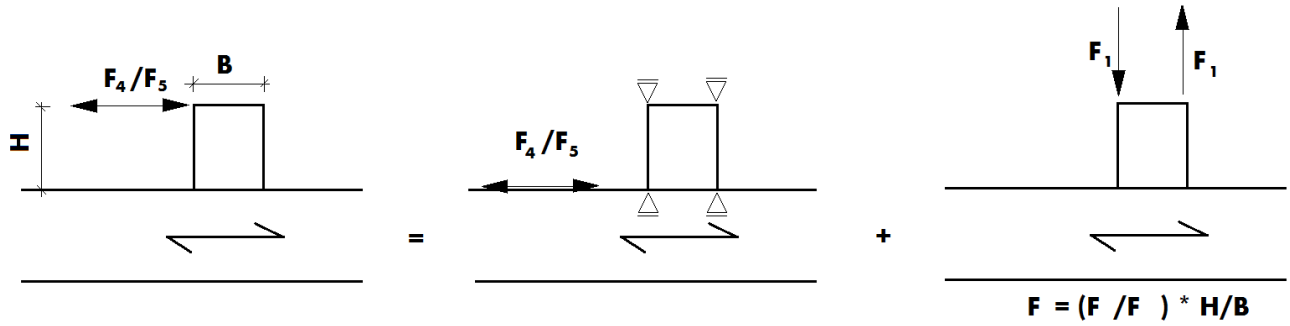
Figure B.4 Load Case F_4/F_5 reduced to two basic load cases

Table B.23: Characteristic values F6 (1 angle bracket / connection) and F7 (2 angle brackets / connection)

Angle Bracket	$F_{6,Rk}$ in kN	$F_{7,Rk}$ in kN
V 95	1,72	3,44
V 135	2,76	5,53
V-MH 137	2,14	4,28

Angle brackets Concrete flat steel anchor

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 as given in Annex A, beginning at the end of the timber-concrete steel anchor. The number constitutes at least 4 and follows from the static calculation.

Wane
Wane is not allowed; the timber-concrete steel anchor must seat solidly on timber.

Characteristic load-carrying capacities for connections with one timber-concrete steel anchor per connection
Table B.1: Characteristic load-carrying capacities Load F_1 – per timber-concrete steel anchor

Type	Timber ($F_{Rk,N}$)	Steel		Transverse tensile failure
		Bending ($F_{Rk,m}$)	Tension ($F_{Rk,t}$)	
2,0 mm	1,62 kN per nail	3,33 kN	17,8 kN	See chapter 3
4,0 mm	1,56 kN per nail	9,07 kN	35,6 kN	See chapter 3

Steel failure in bending is governing for timber-concrete steel anchors which are fixed with bolts and washers 43 mm x 4 mm. Steel failure in tension is governing for cast in concrete timber-concrete steel anchors.

Splitting
For a lifting force F_1 splitting has to be proved, when necessary, for the timber element. The capacity of a connection with timber-concrete steel anchors is calculated according to the general splitting design for connections with mechanical fasteners in EN 1995:2004.

$$F_{90,Rk} = 14 \cdot b \sqrt{\dfrac{h_e}{\left(1 - \dfrac{h_e}{h}\right)}} \tag{B.1}$$

Where:

$F_{90,Rk}$ the characteristic splitting capacity in N
b   the member thickness, in mm
h_e is the loaded edge distance to the centre of the most distant fastener in mm
h   the timber member height in mm

The design value of the force component perpendicular to the structural member's axis $F_{90,Ed}$ has to be lower than the design capacity $F_{90,Rd}$.

Würth Hold downs
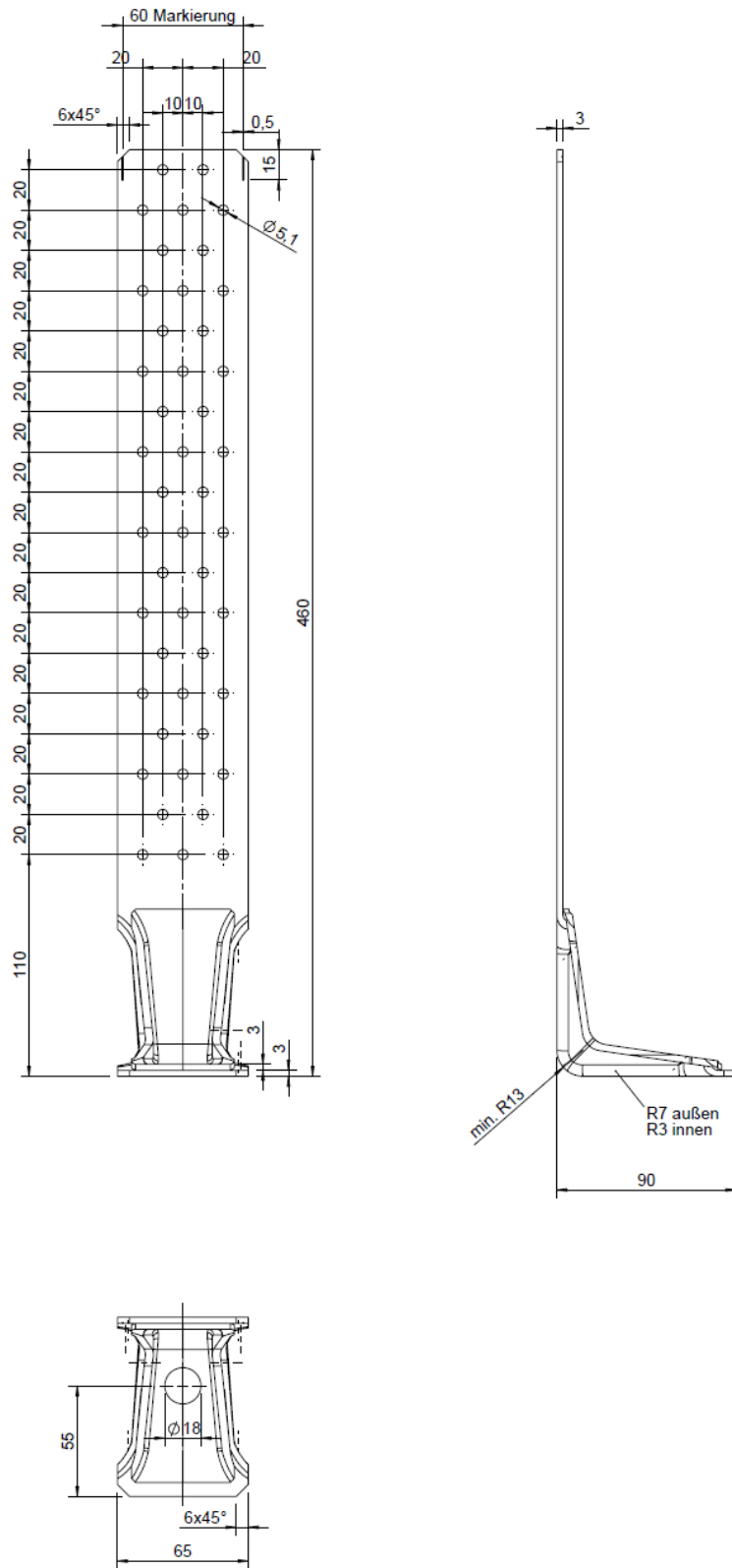
Figure B.1 Dimensions of type V Plus 460x90x65x3,0

Alle Schweißnähte

Figure B.2 Dimensions of type V Plus 460x90x65x4,0
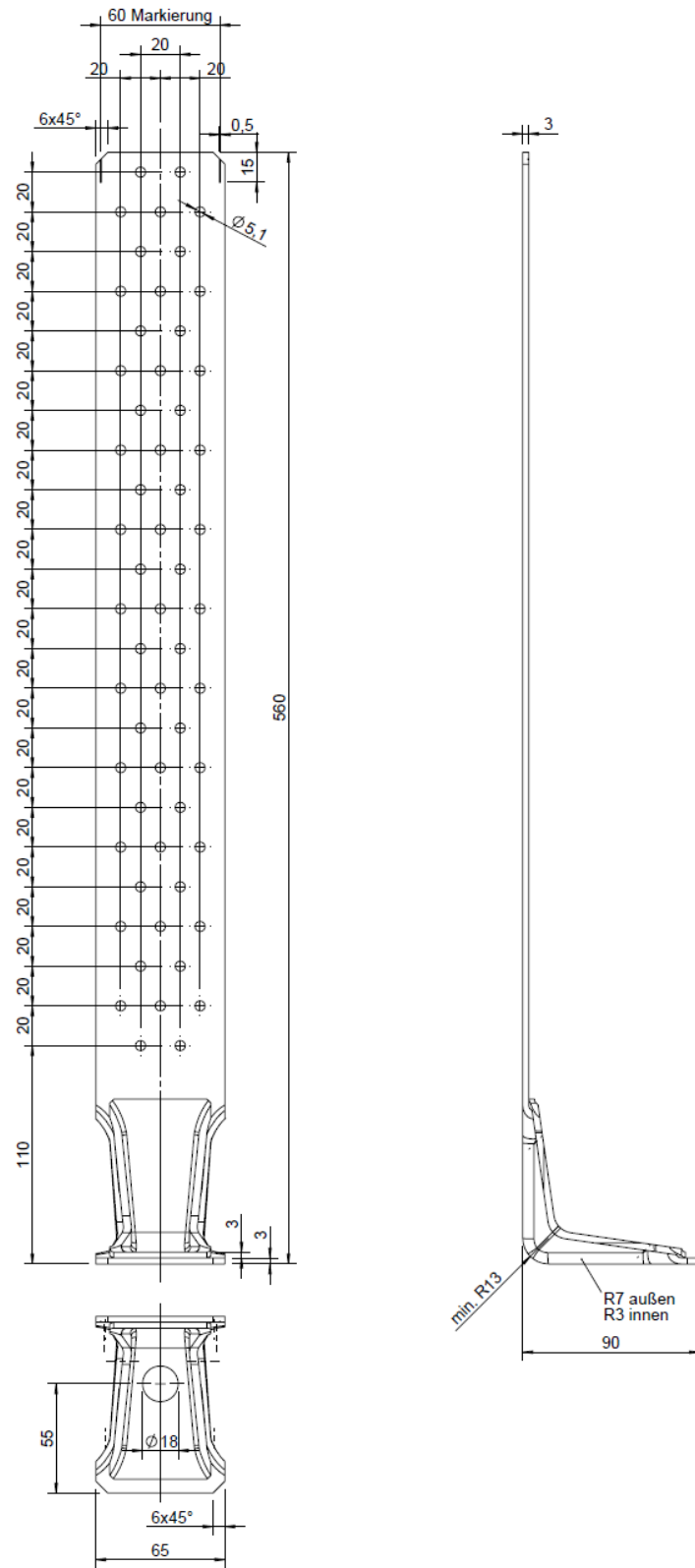
Figure B.3 Dimensions of type V Plus 560x90x65x3,0
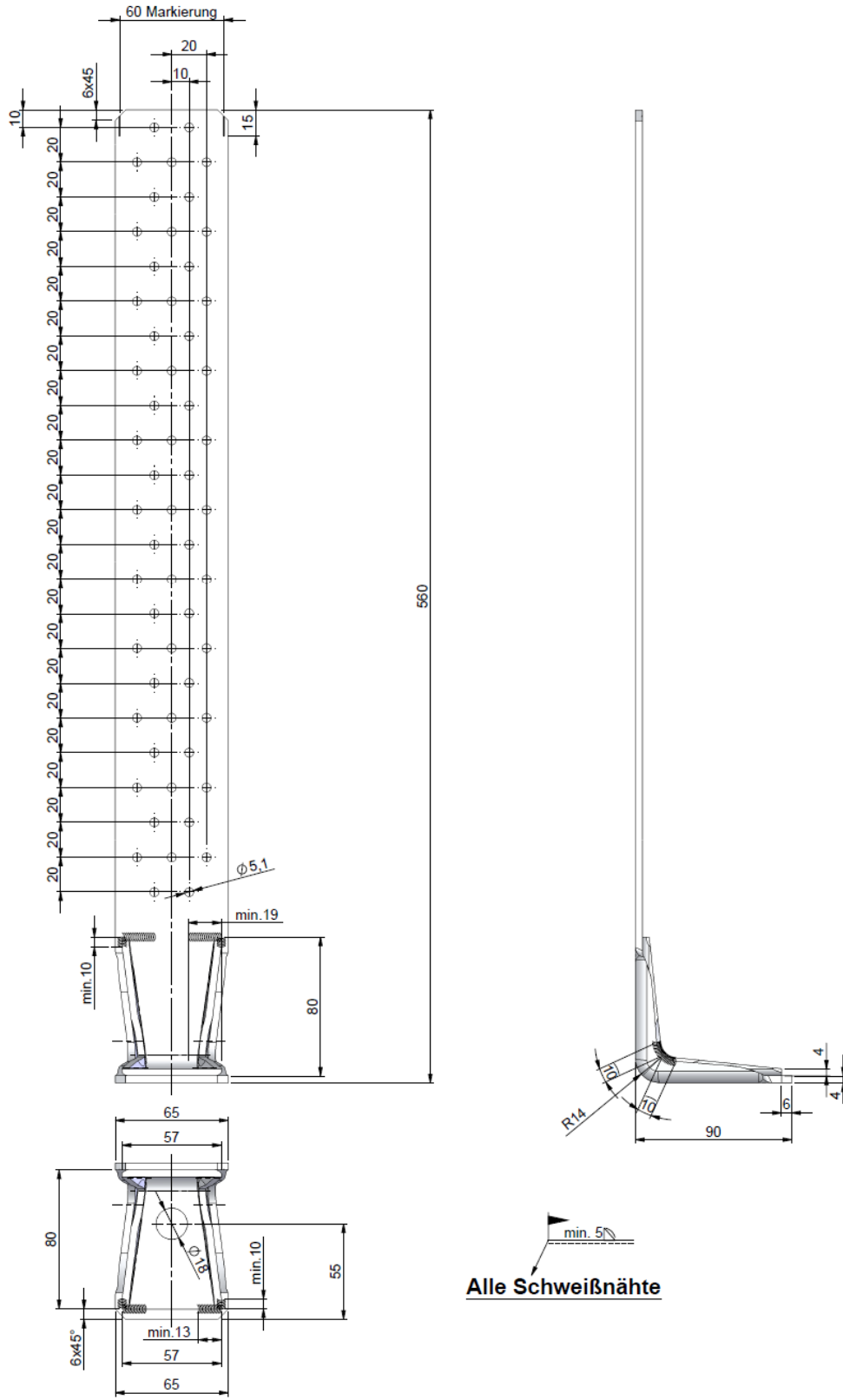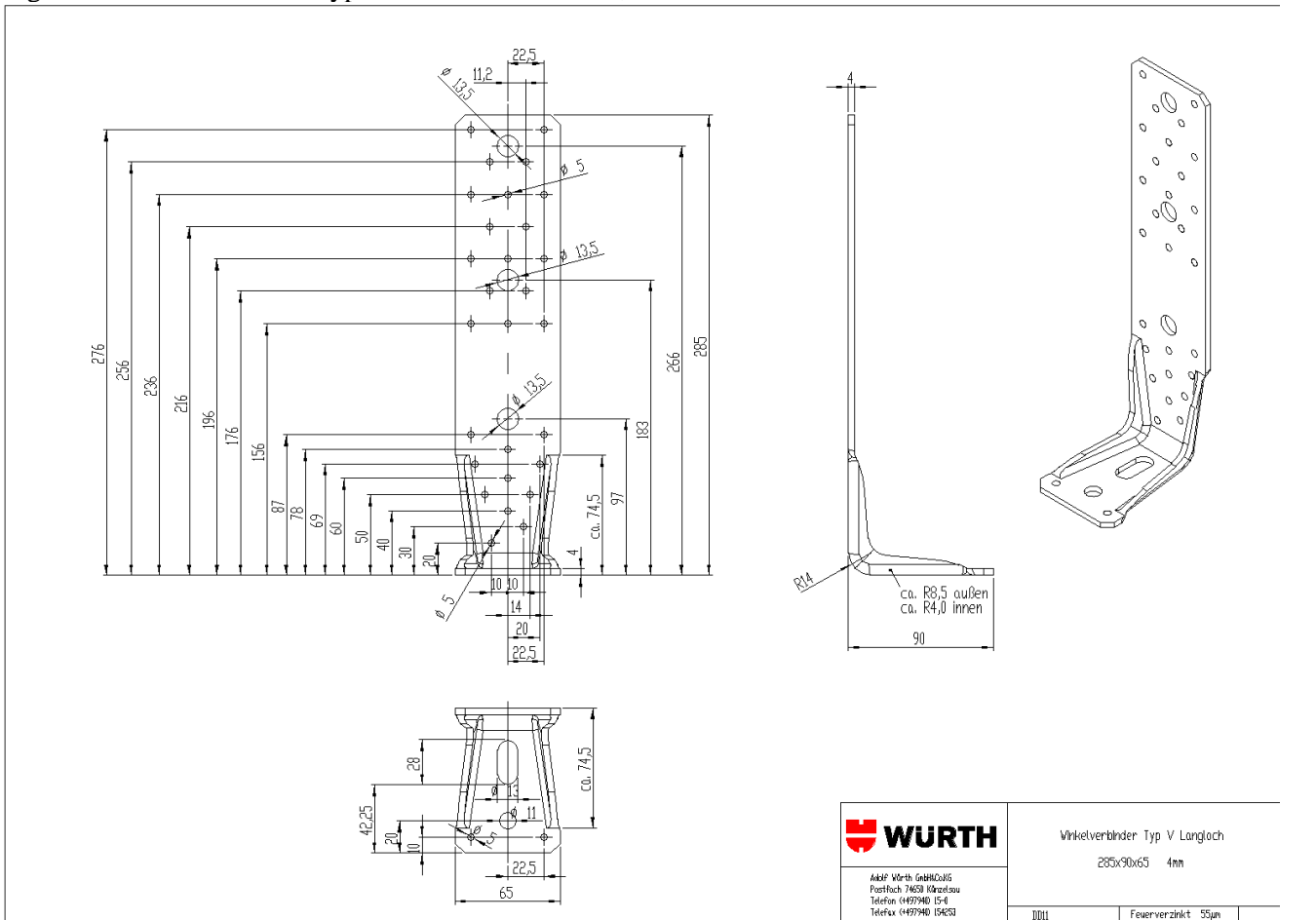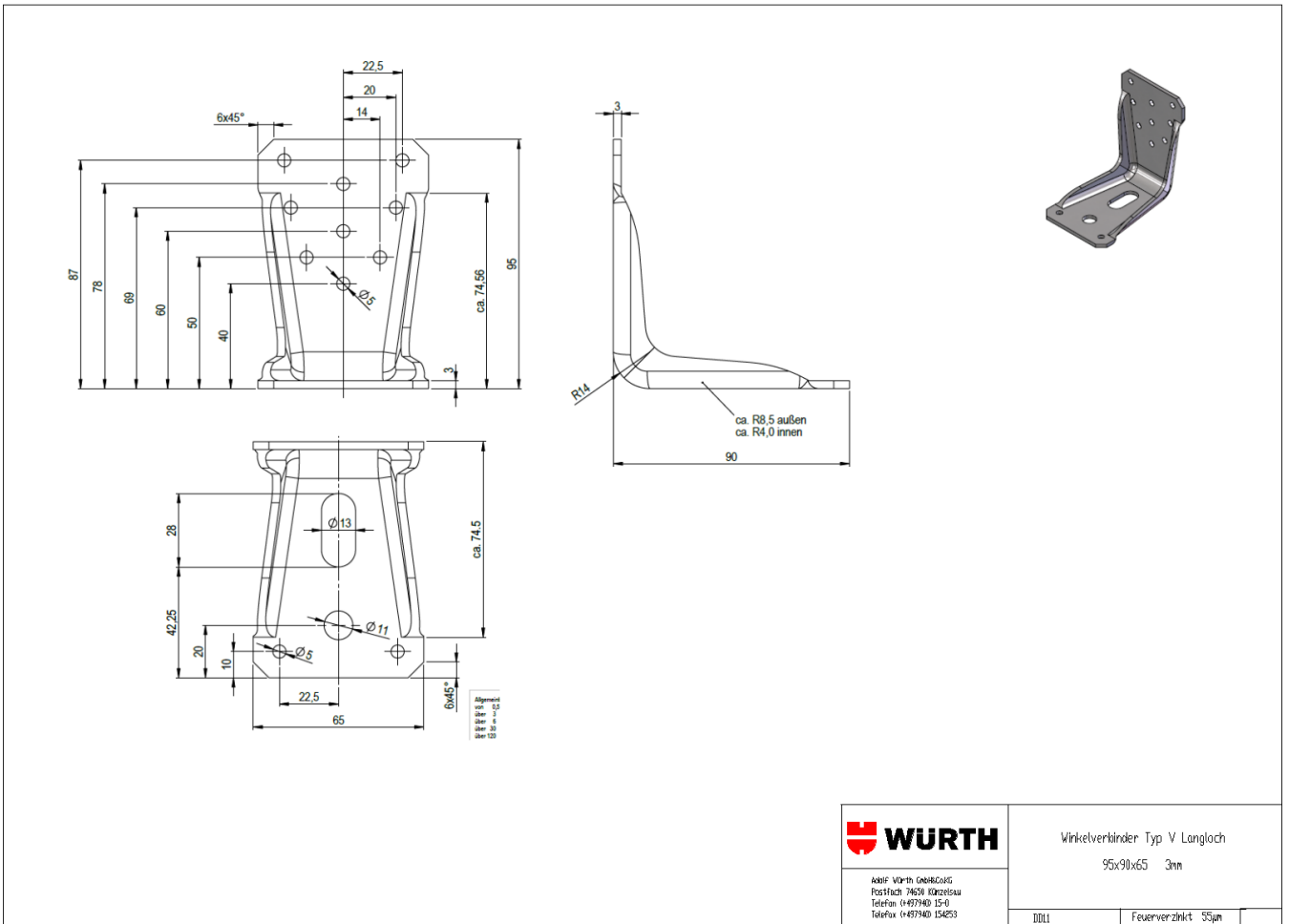
Figure B.4 Dimensions of type V Plus 560x90x65x4,0
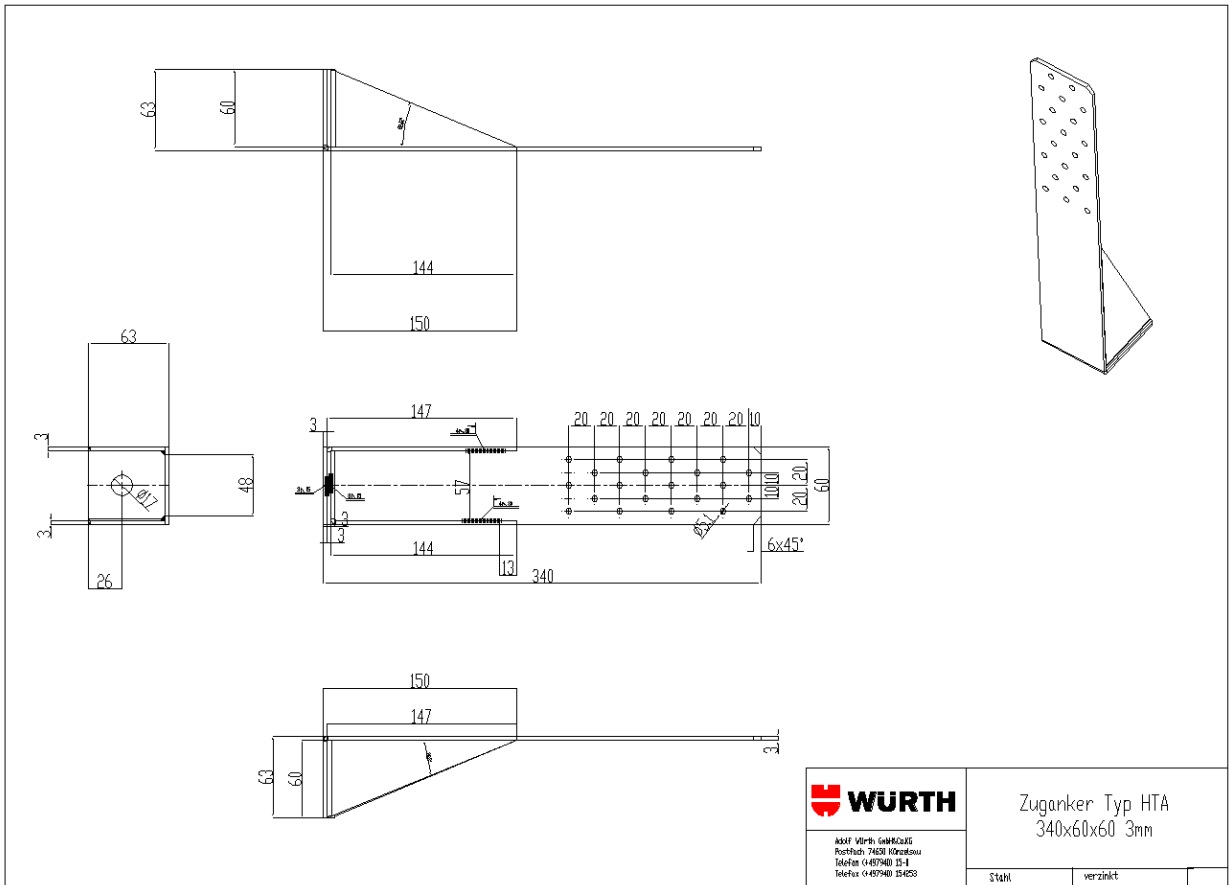
Figure B.5 Dimensions of type HTA 340x60x60x3,0 – alternative hole diameter 18 mm in bottom plate
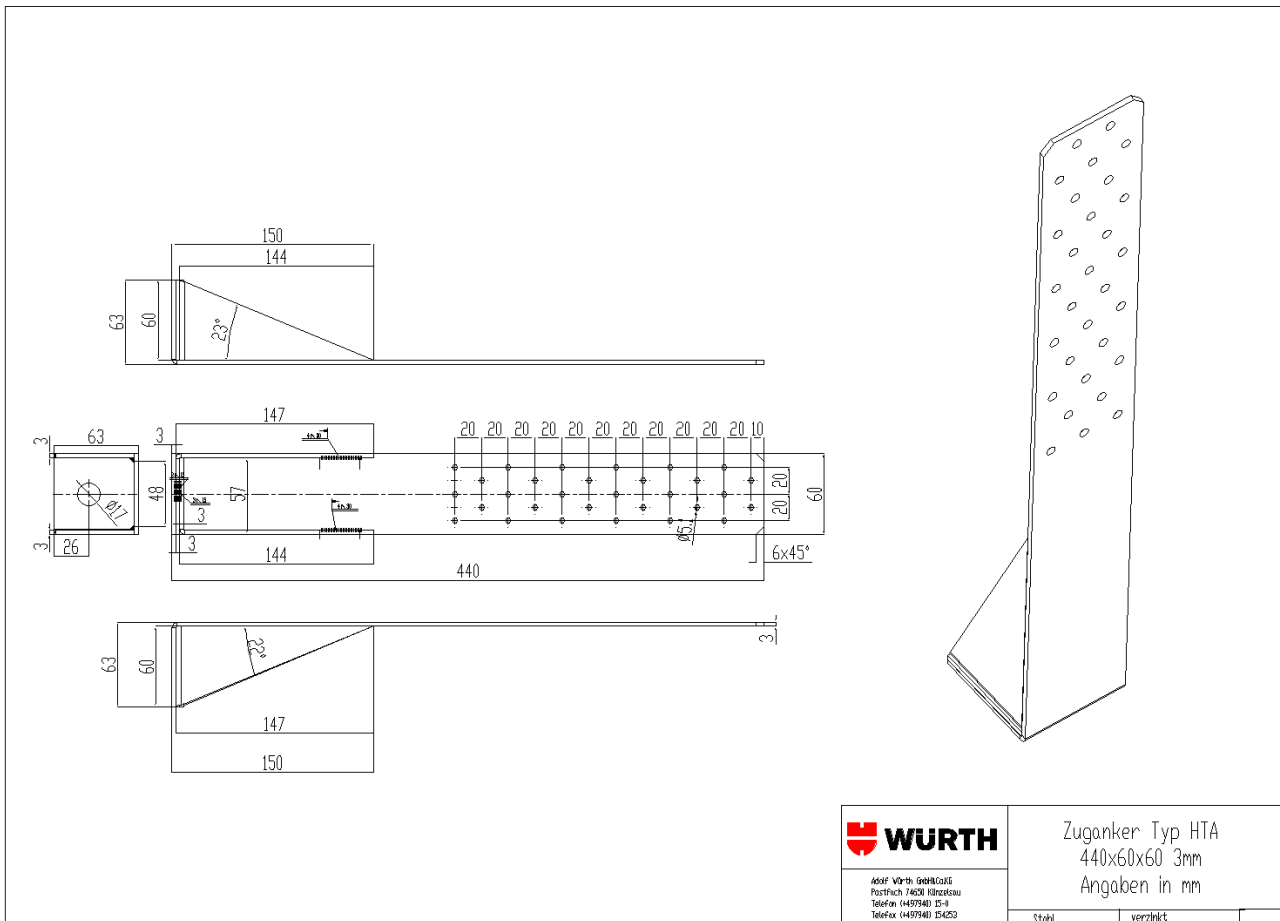
Figure B.6 Dimensions of type HTA 440x60x60x3,0– alternative hole diameter 18 mm in bottom plate
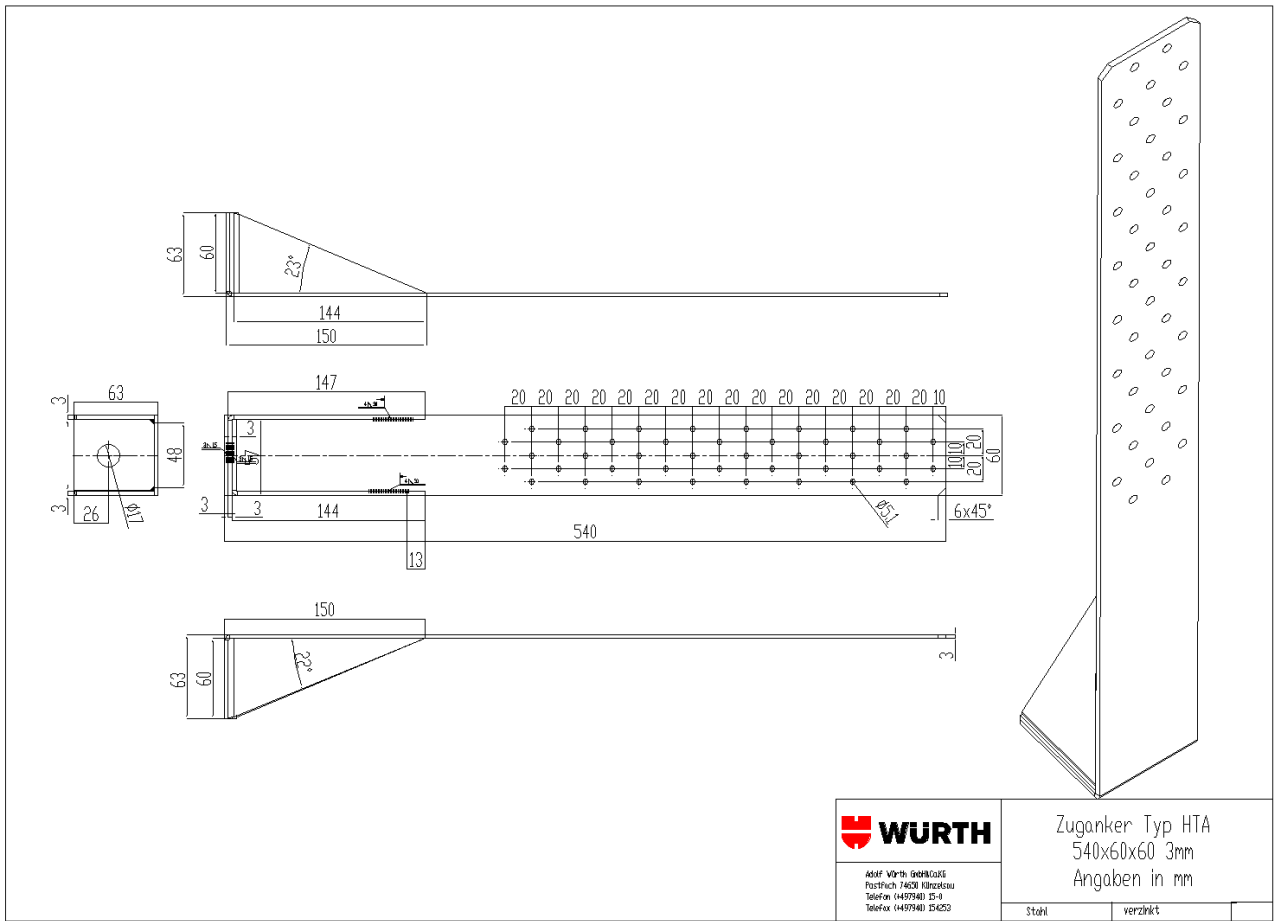
Figure B.7 Dimensions of type HTA 540x60x60x3,0 – alternative hole diameter 18 mm in bottom plate
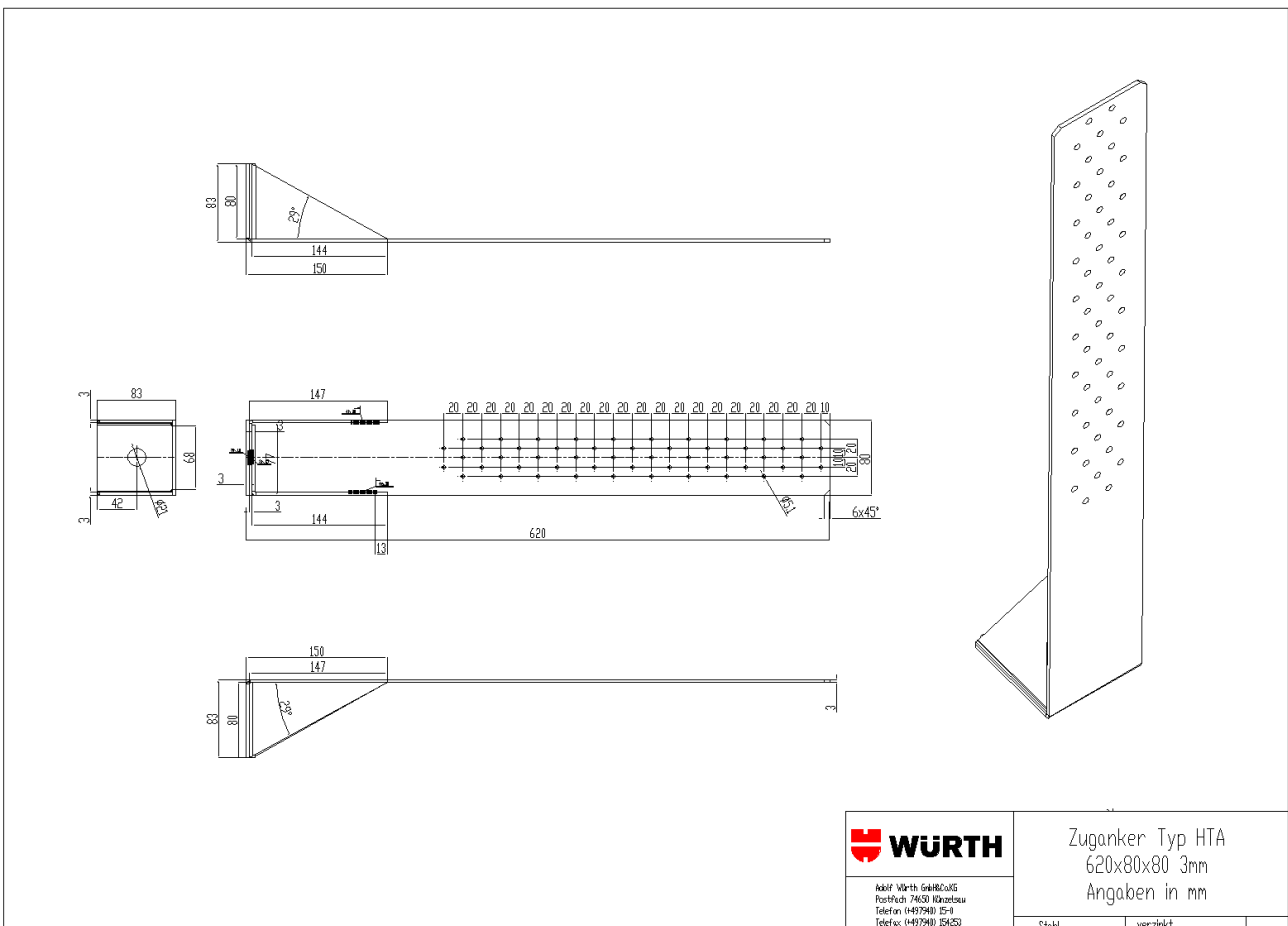
Figure B.8 Dimensions of type HTA 620x80x80x3,0
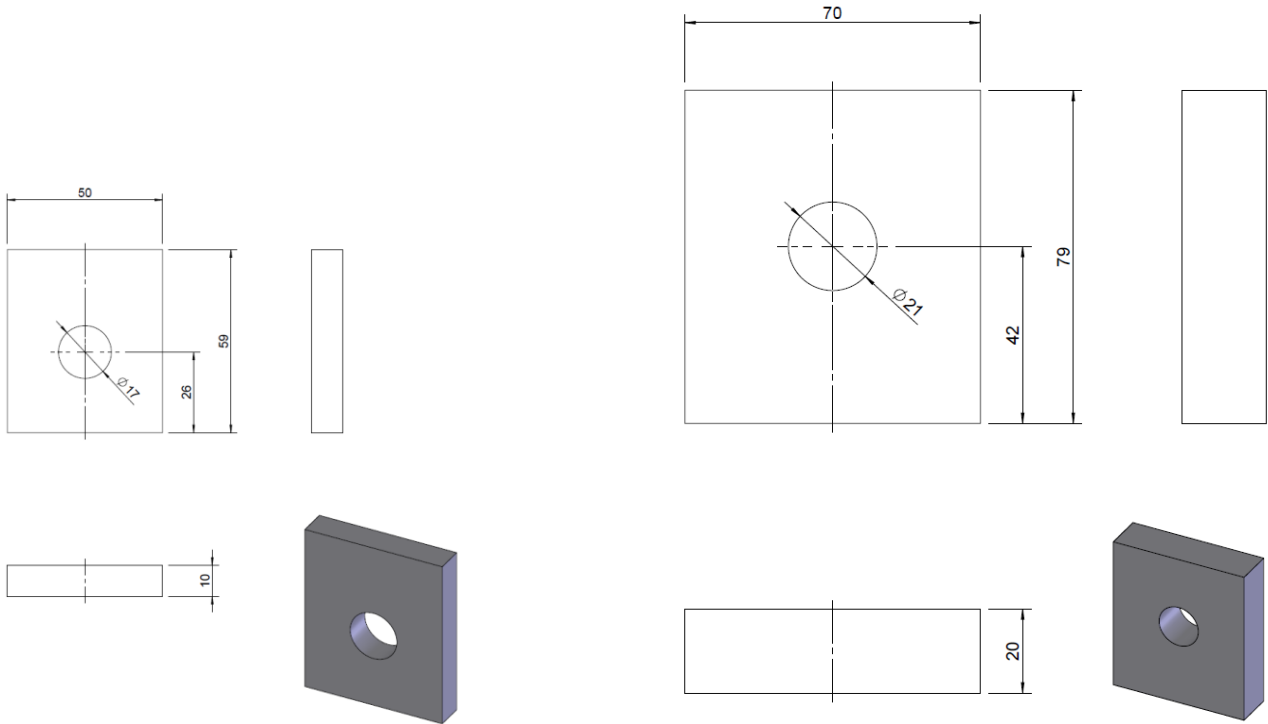
Figure B.9 Dimensions of base plates type HTA Lx60x60x3,0 (left) – alternative hole diameter 18 mm – and HTA Lx80x80x3,0 (right)
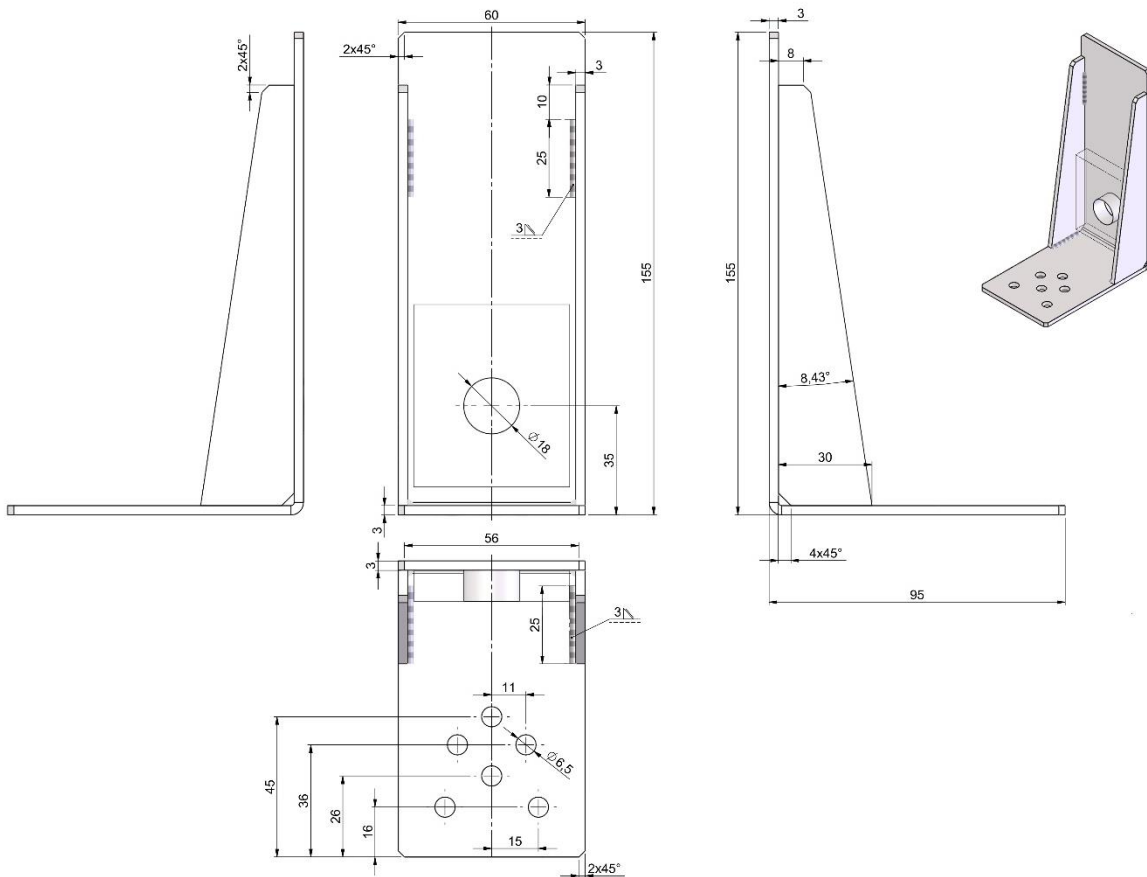
Figure B.10 Dimensions of two-piece hold-down type HTA-2PH 95x155x60x3,0
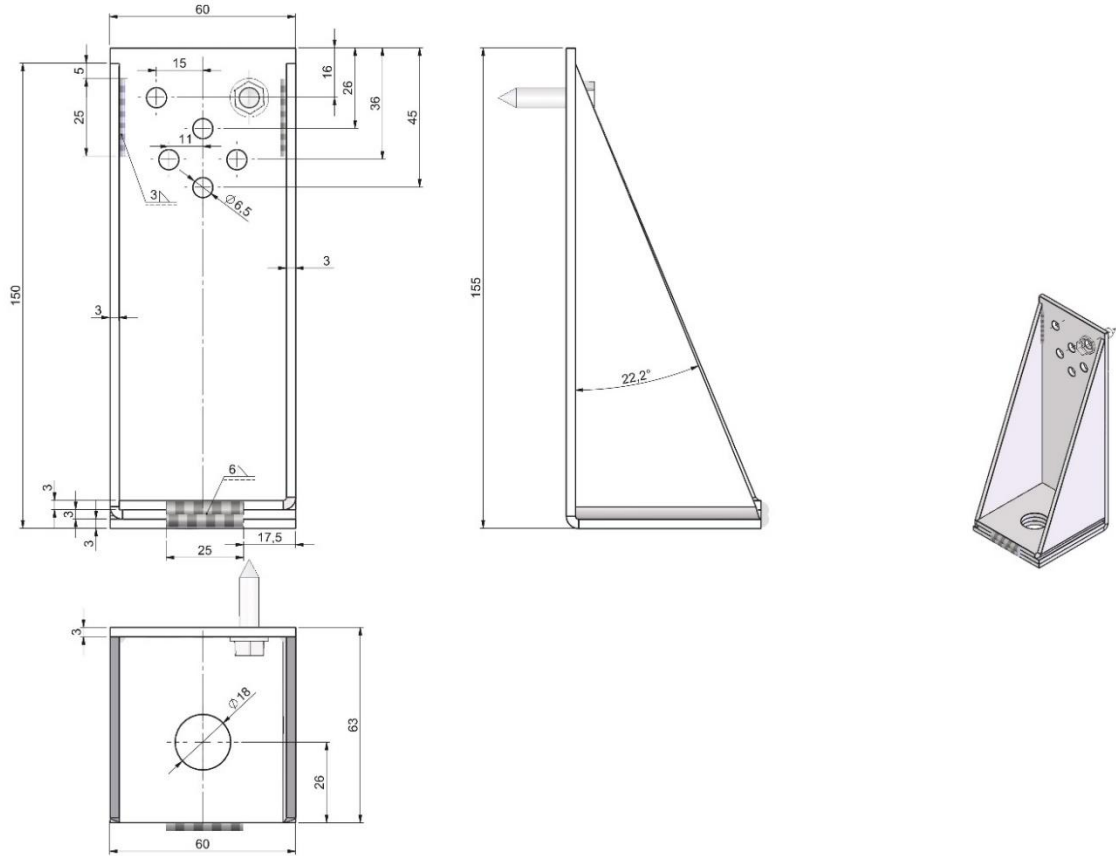
Figure B.111 Dimensions of two-piece hold-down type HTA-2PV 155x60x60x3,0
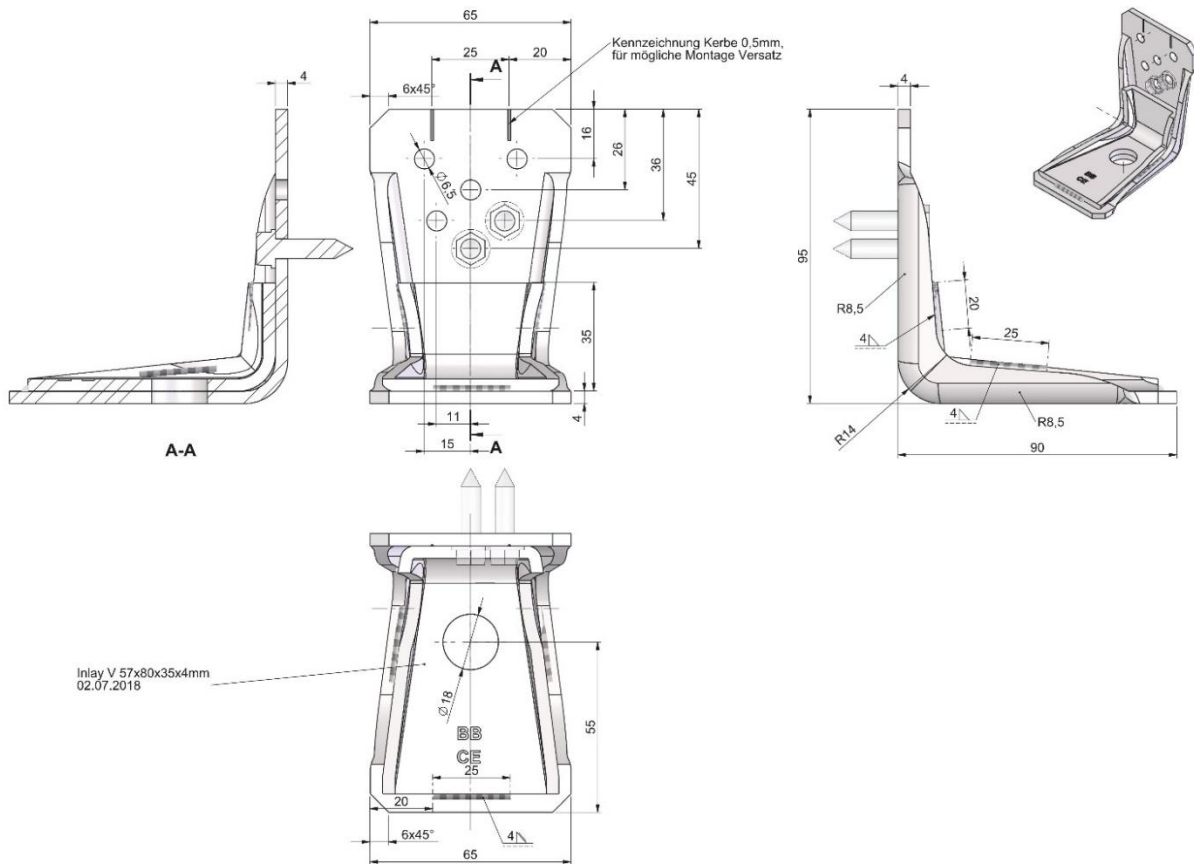
Figure B.12 Dimensions of two-piece hold-down type V Plus-2P 95x90x65x4,0
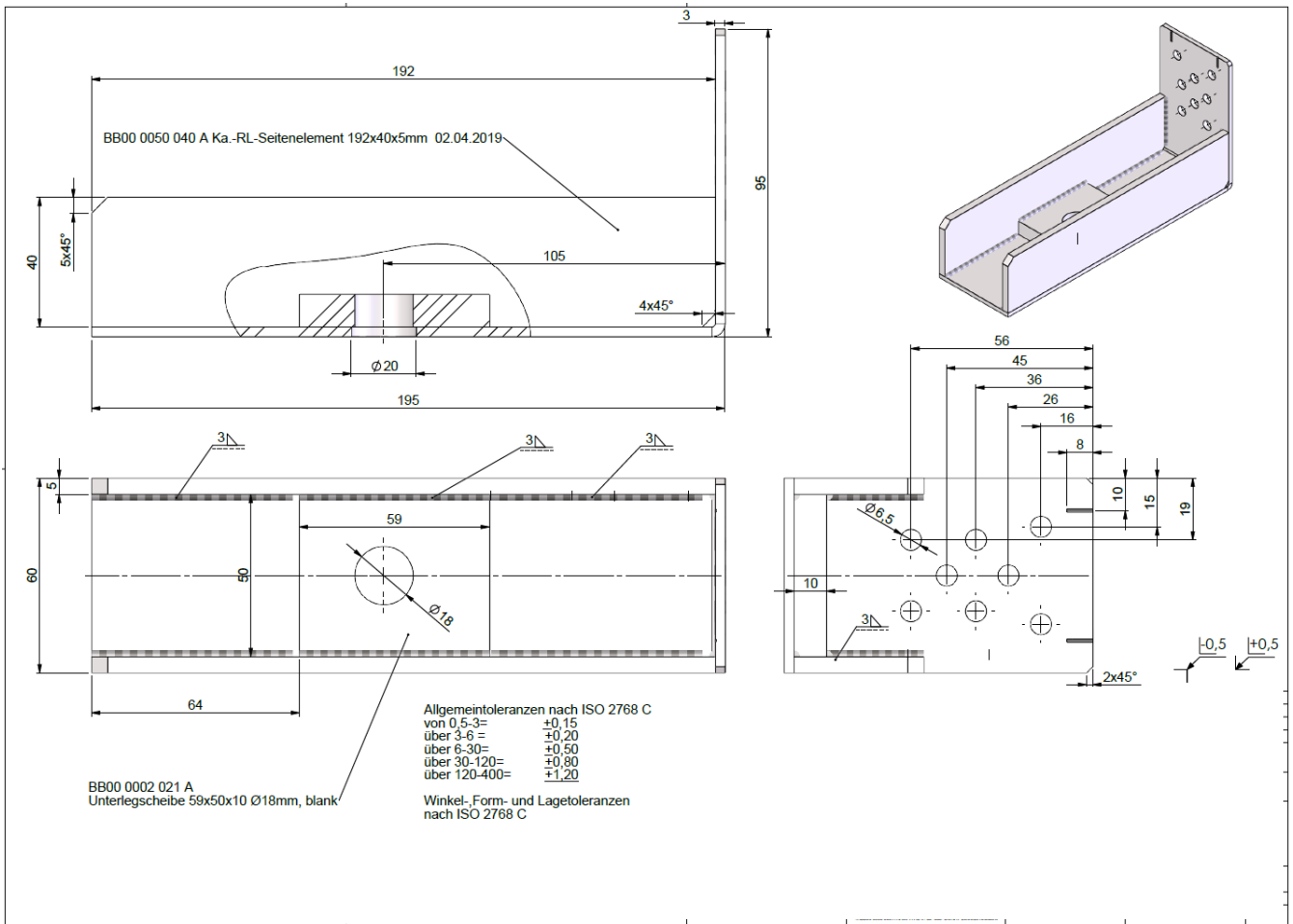
Figure B.13 Dimensions of two-piece hold-down type HTA-2PIL 195x90x65x4,0
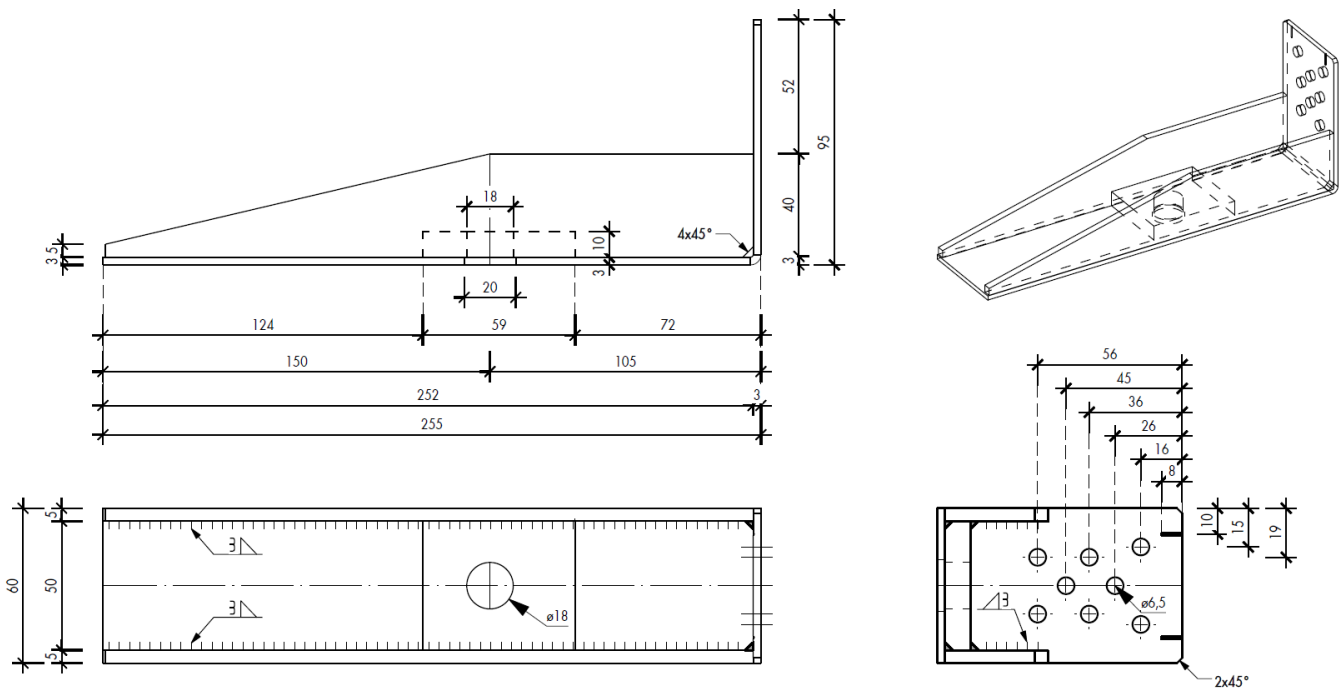
Figure B.14 Dimensions of two-piece hold-down type HTA-2PIL-L 255x90x65x4,0

Pos.	Art. Nr.	L (mm)	B (mm)	S (mm)	Anzahl Löcher	Werkstoff / Oberfläche	Bemerkung
1		340			20		
2		440	60	3	30	S350 / Z275	
3		540			42		
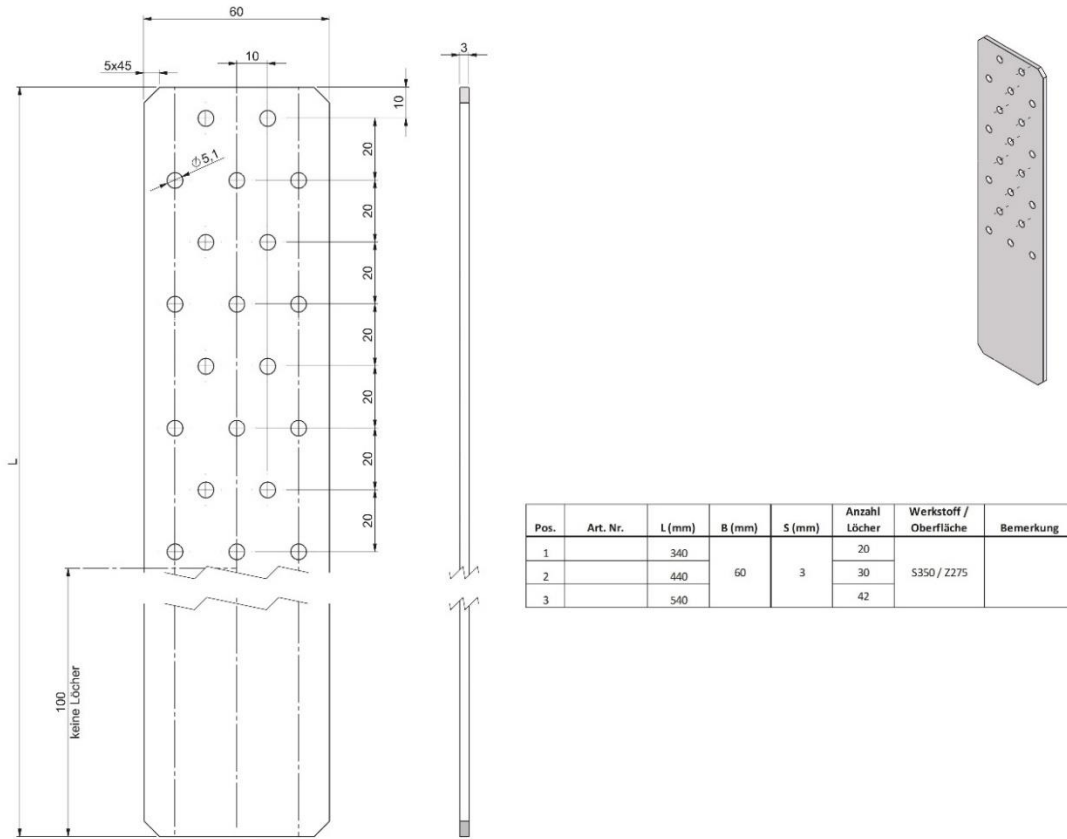
Figure B.15 Dimensions of BP 60 vertical flange for two-piece hold-downs

Pos.	Art. Nr.	L (mm)	B (mm)	S (mm)	Anzahl Löcher	Werkstoff / Oberfläche	Bemerkung
1		340			18		
2		440	40	3	25	S350 / Z275	
3		540			33		
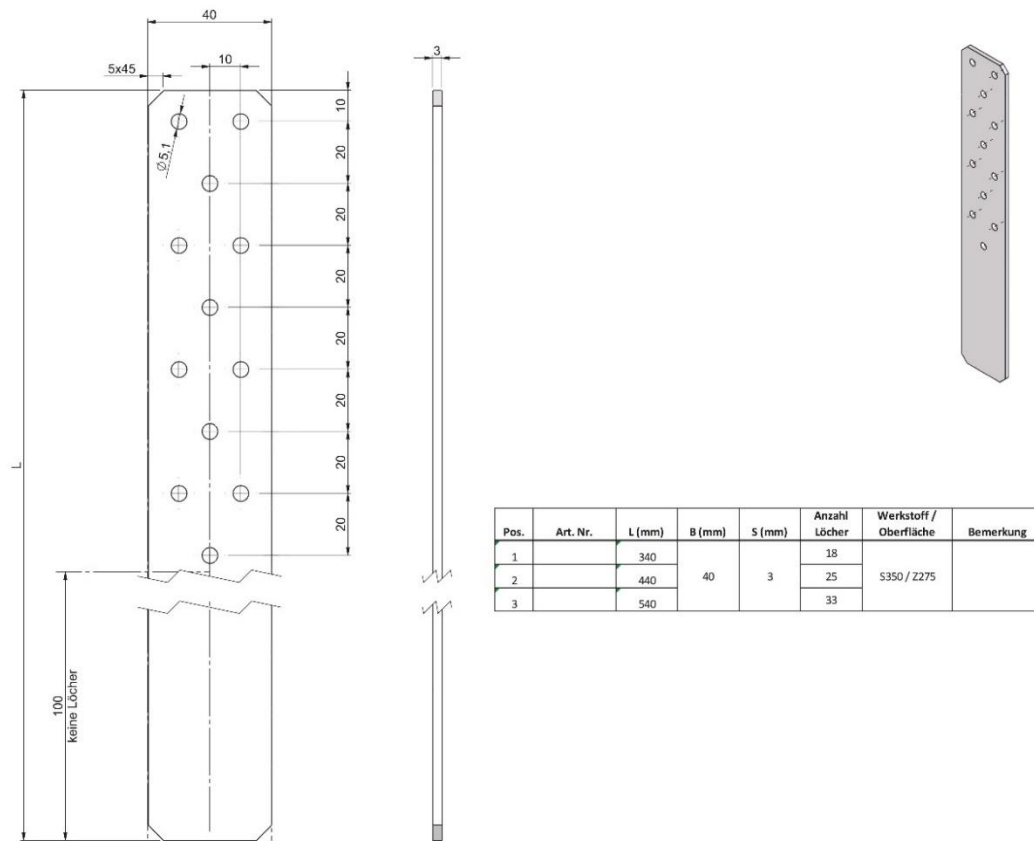
Figure B.16 Dimensions of BP 40 vertical flange for two-piece hold-downs
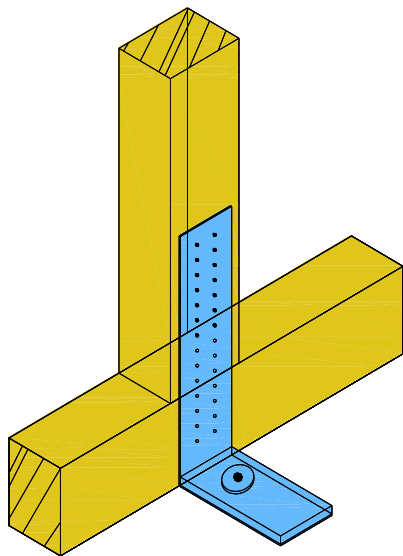
Figure B.17 Typical installation
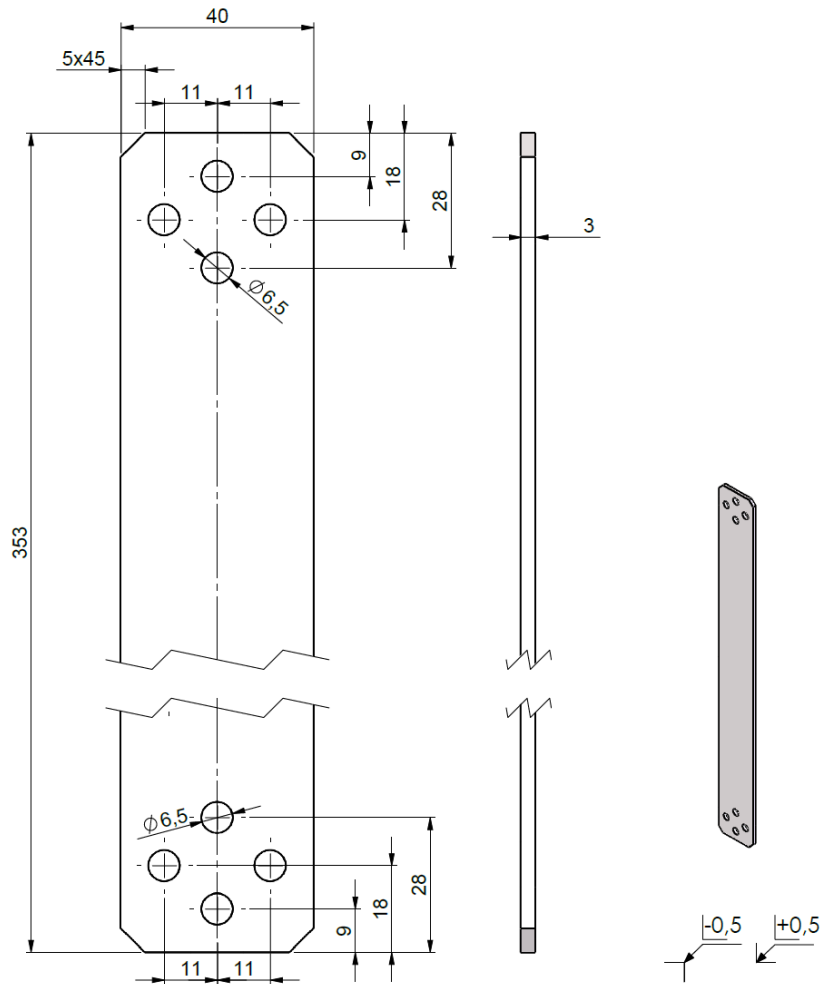
Figure B.18 Dimensions of storey connector 353x40x3 made of S350

Angle Brackets
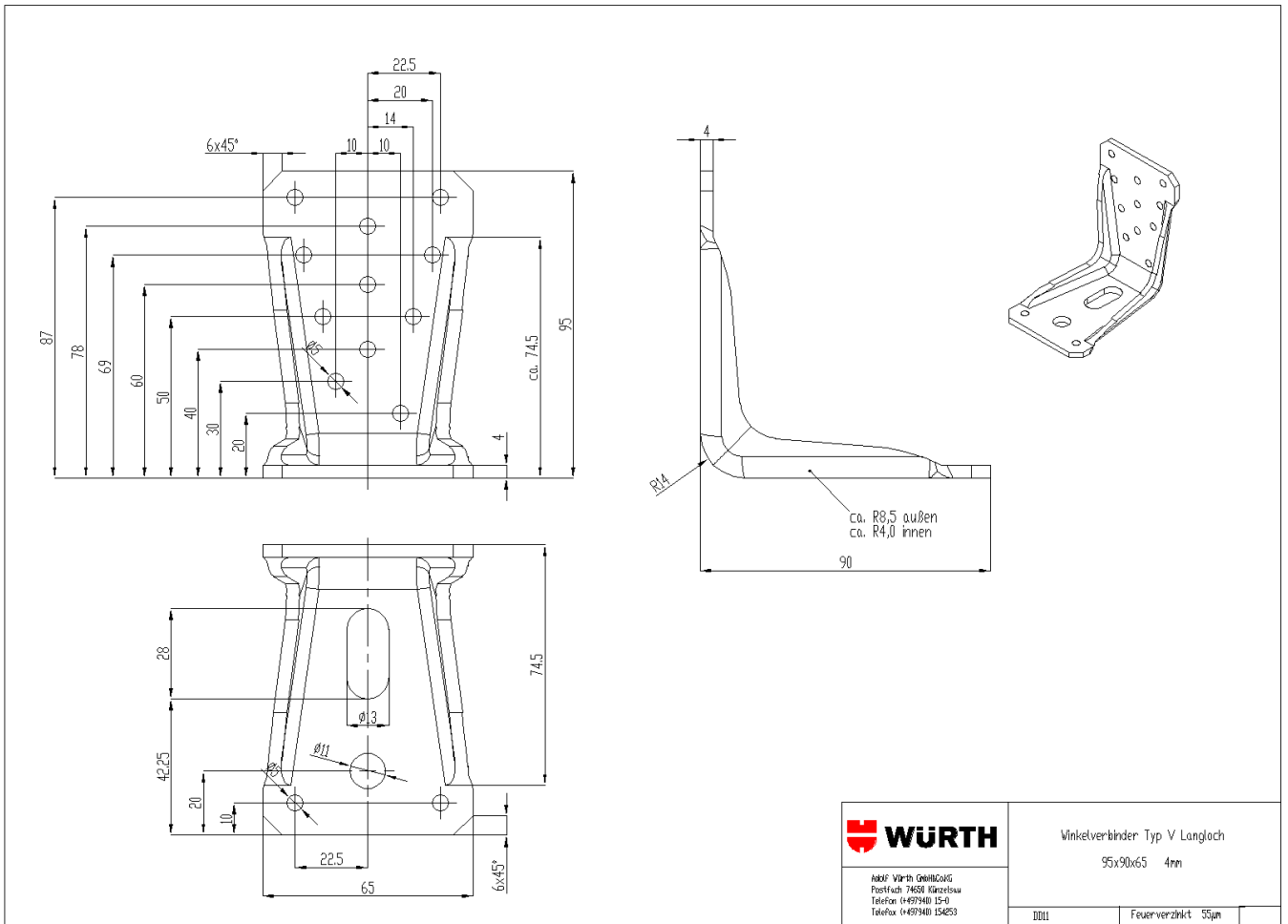
Figure B.19 Dimensions of type V Langloch 95x90x65x4,0
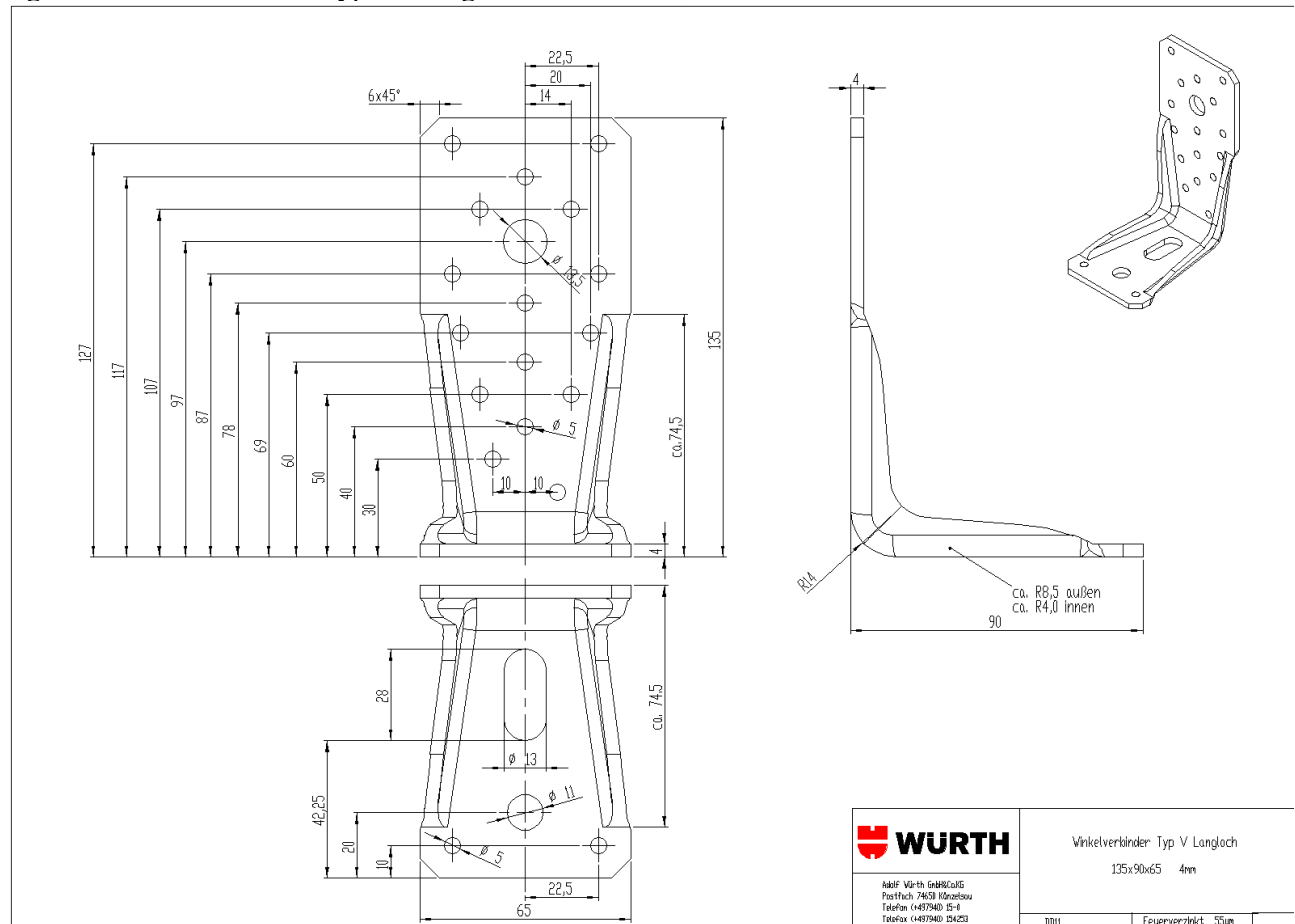
Figure B.20 Dimensions of type V Langloch 135x90x65x4,0
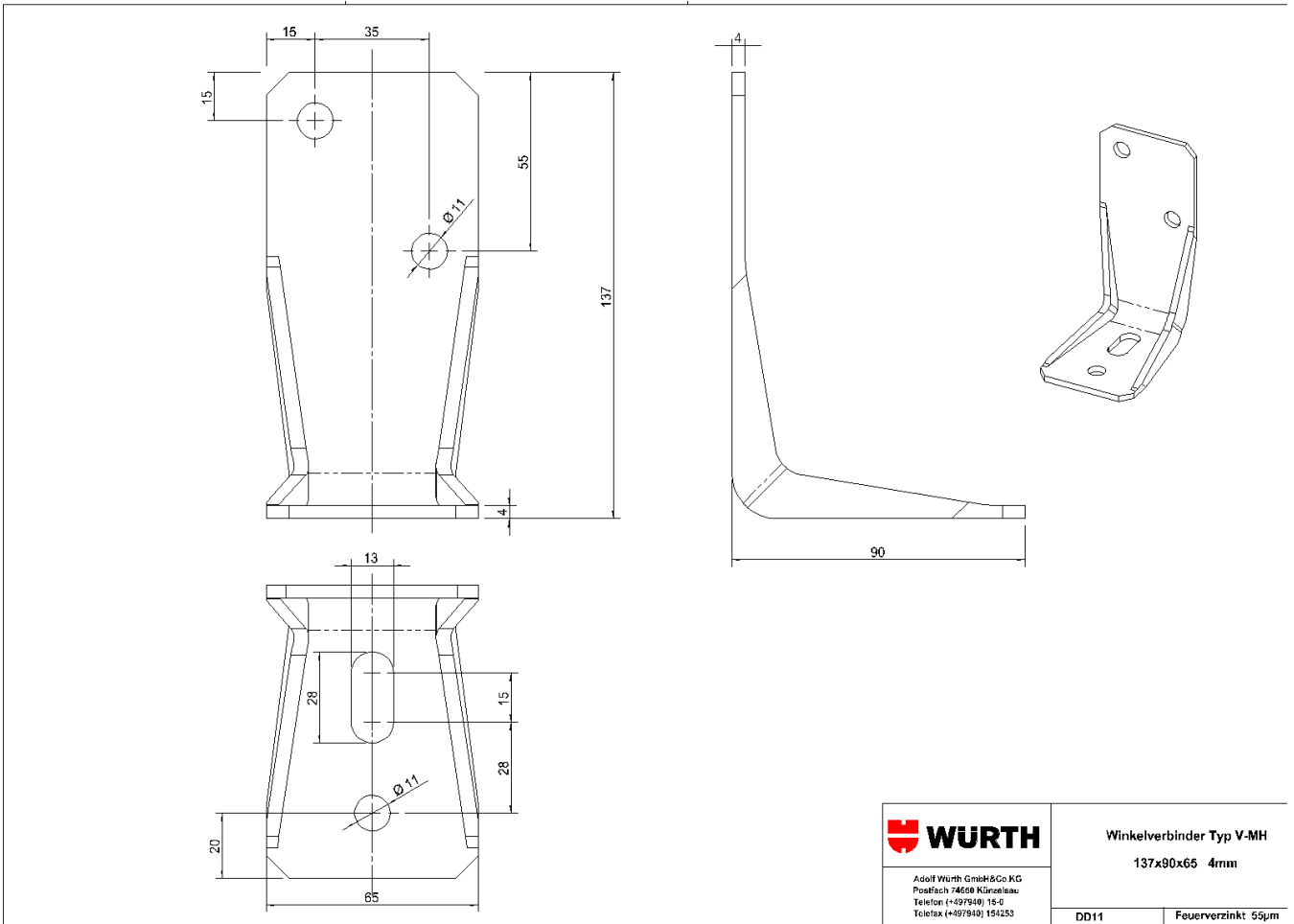
Figure B.21 Dimensions of type V-MH 137x90x65x4,0

Figure B.22 Dimensions of type V Langloch 285x90x65x4,0

Figure B.23 Dimensions of type V Langloch 95x90x65x3,0
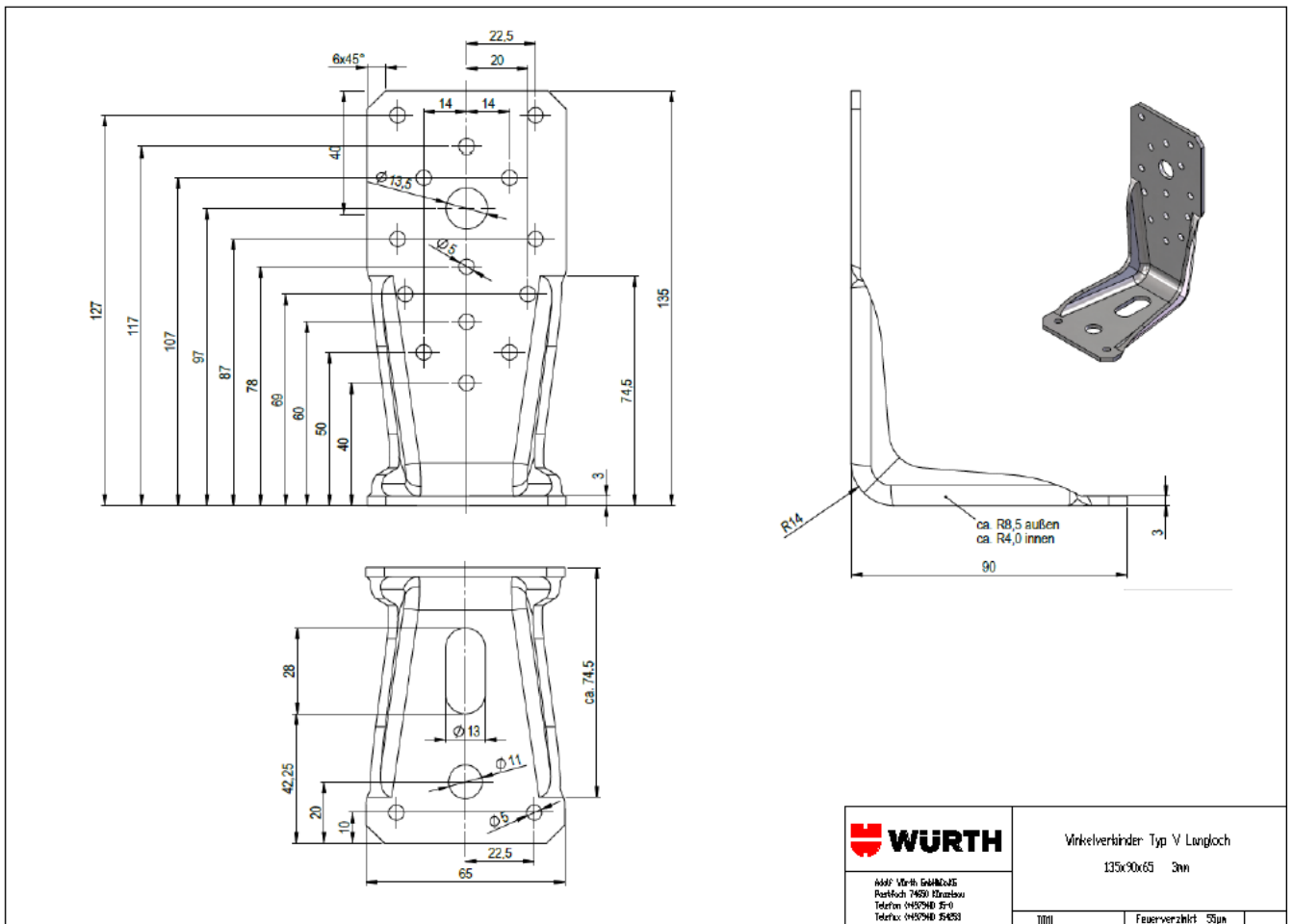
Figure B.24 Dimensions of type V Langloch 135x90x65x3,0
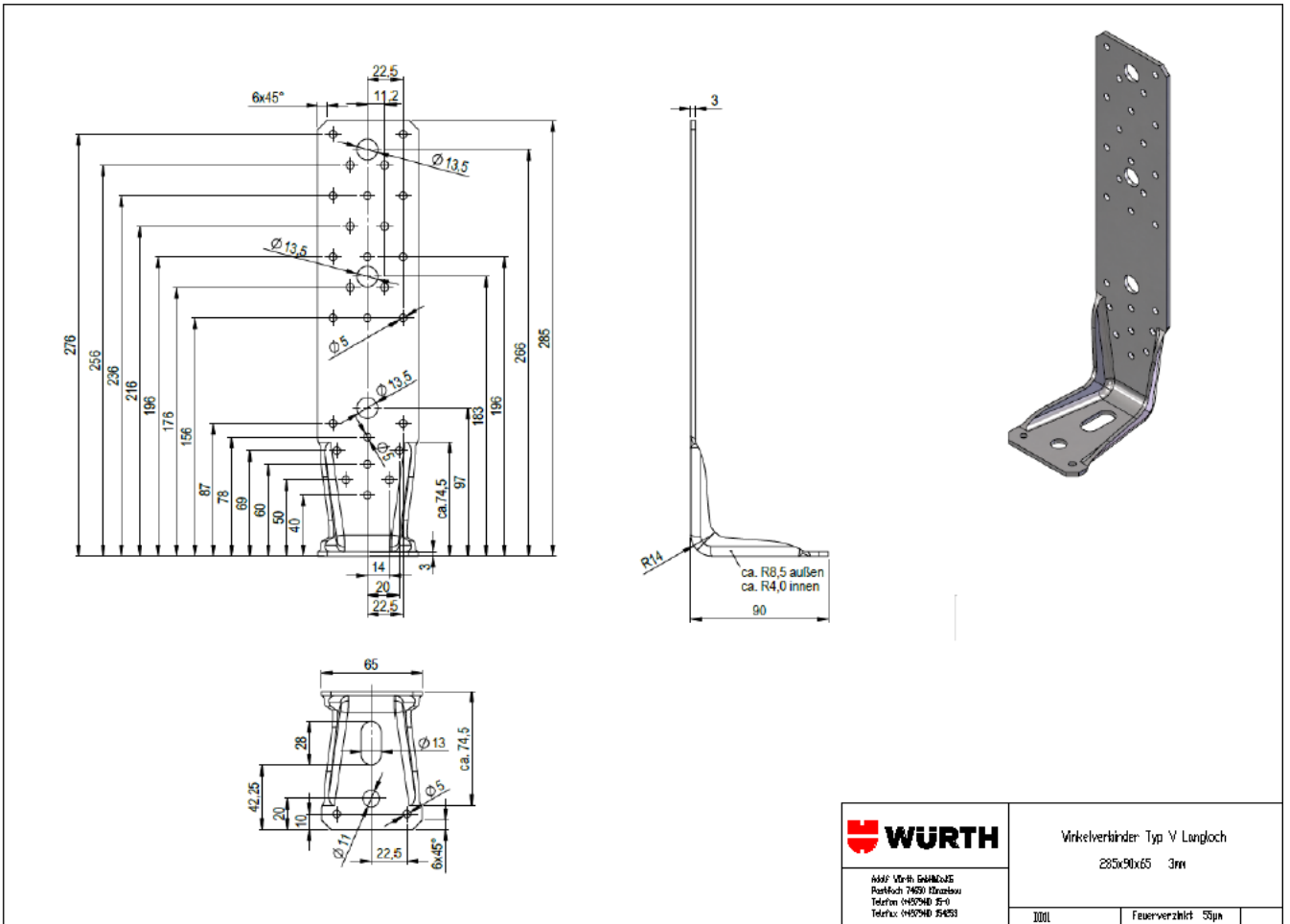
Figure B.25 Dimensions of type V Langloch 285x90x65x3,0
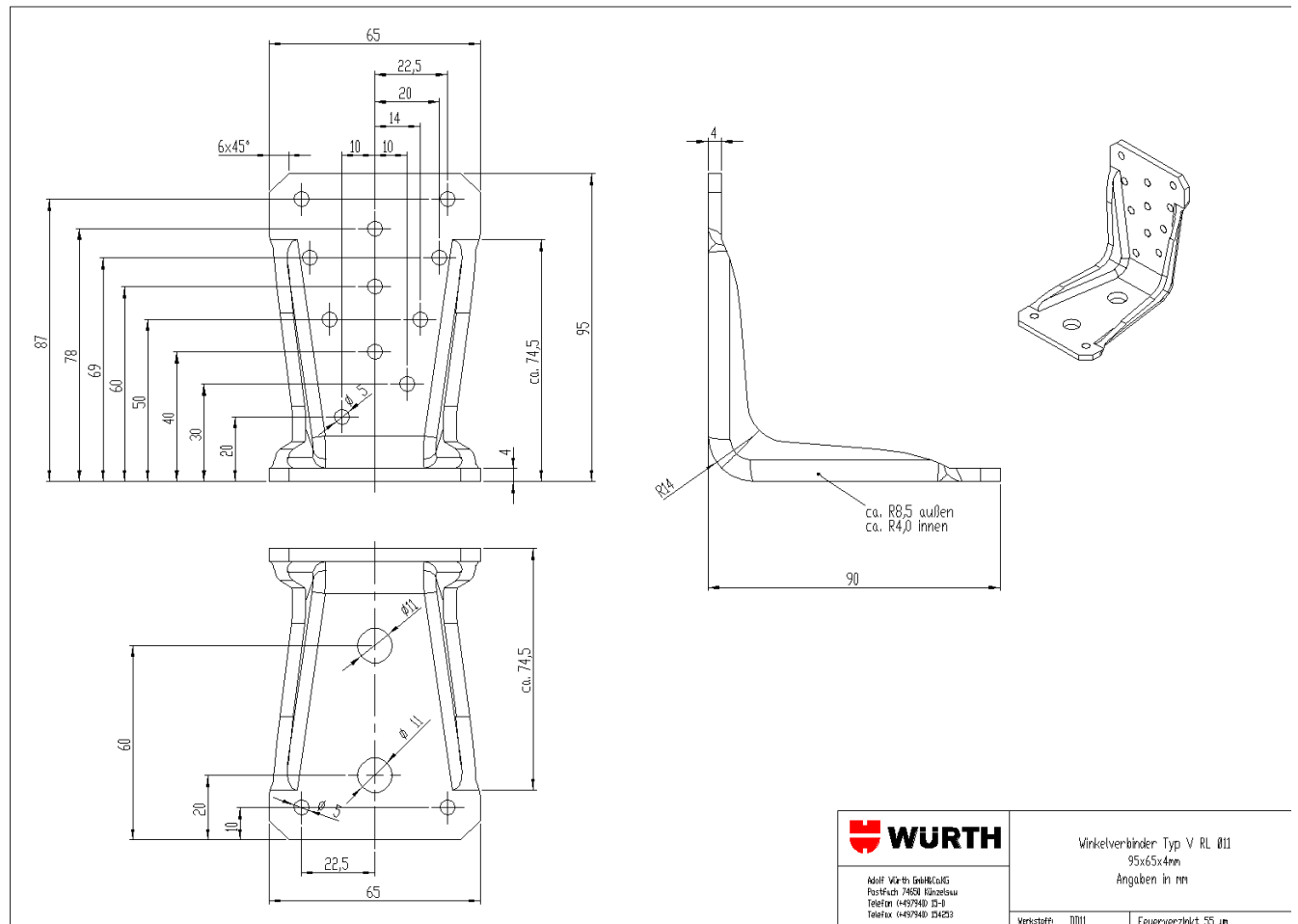
Figure B.26 Dimensions of type V RL11 95x65x4,0
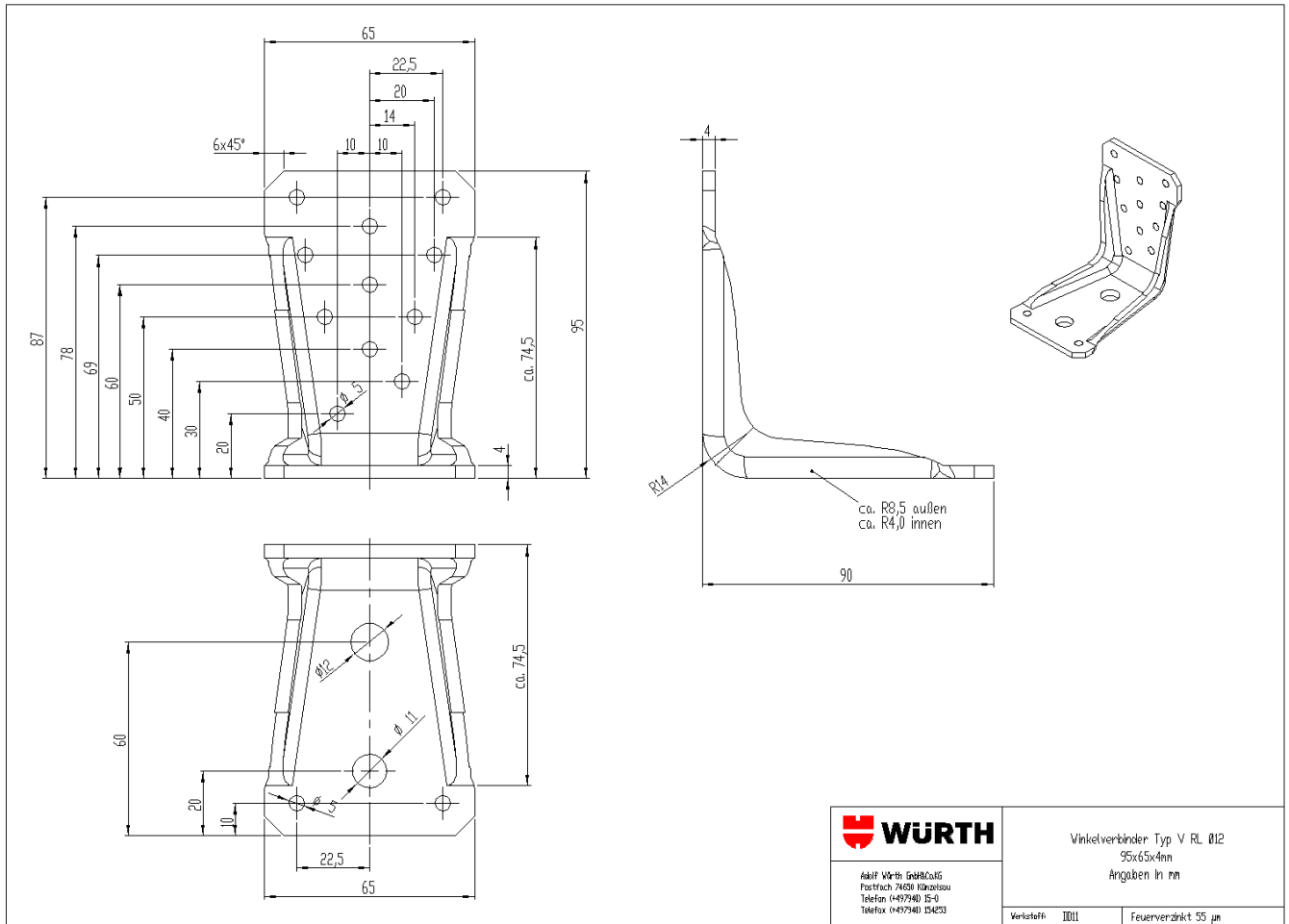
Figure B.27 Dimensions of type V RL12 95x65x4,0
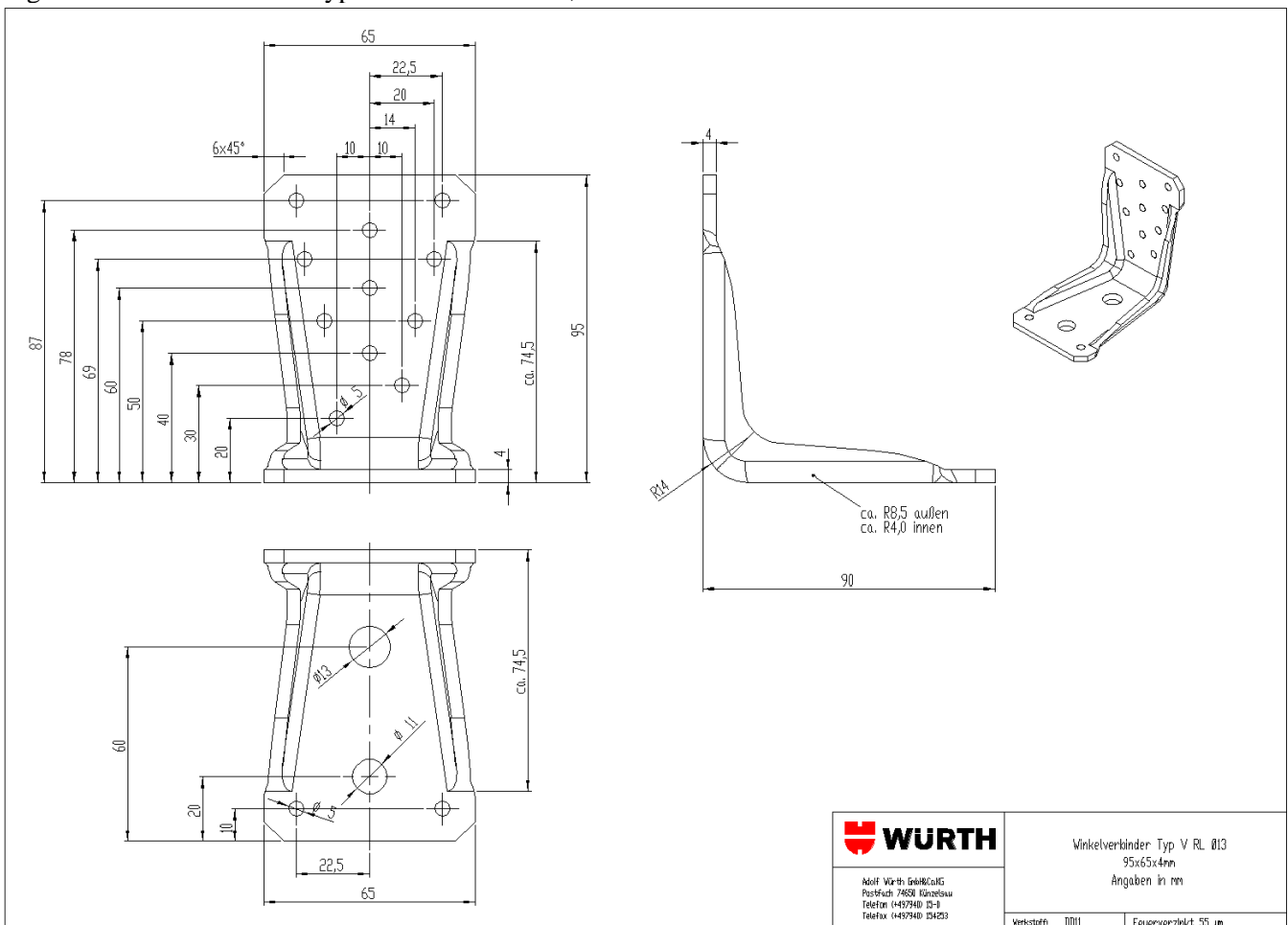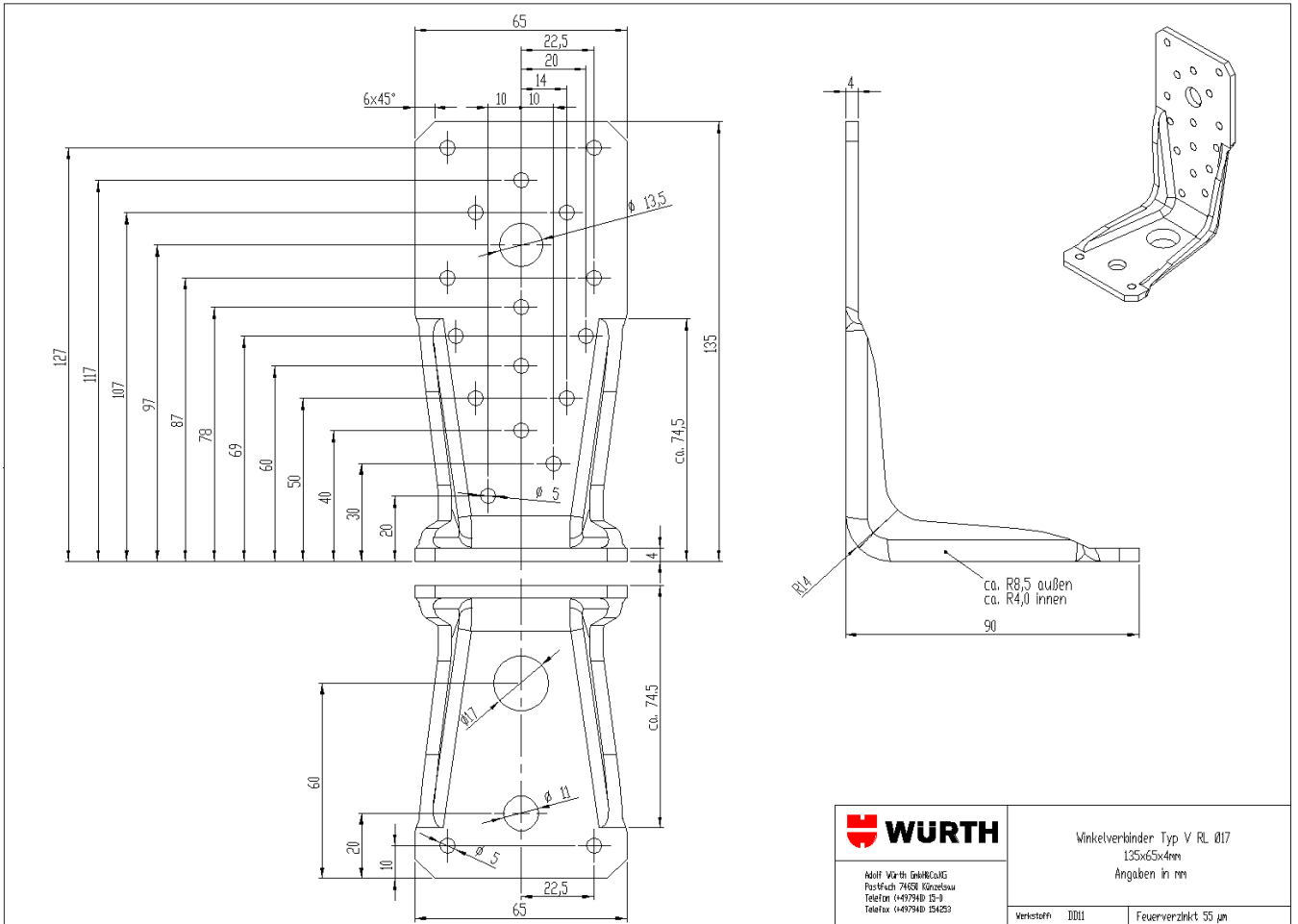

Figure B.28 Dimensions of type V RL13 95x65x4,0
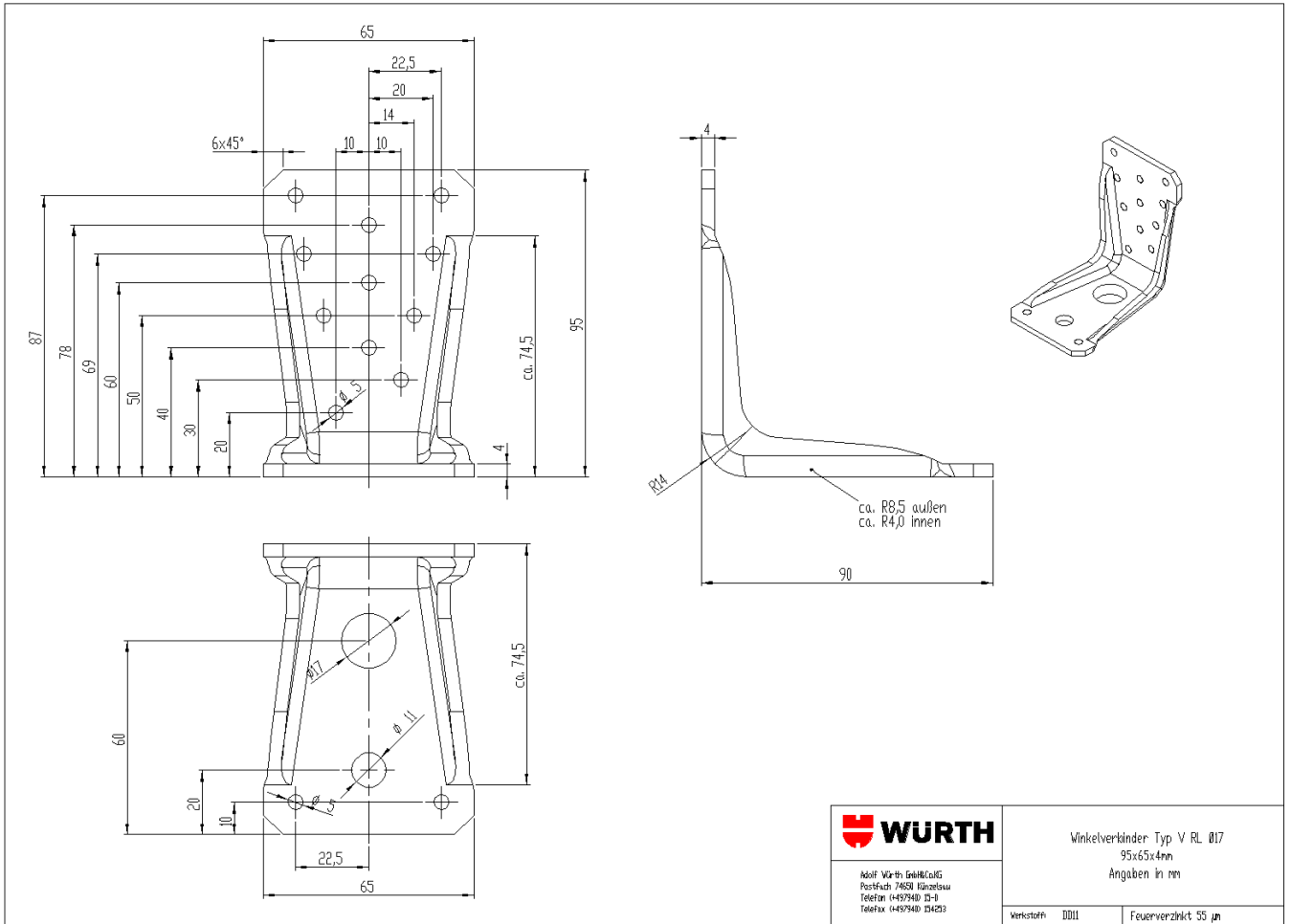
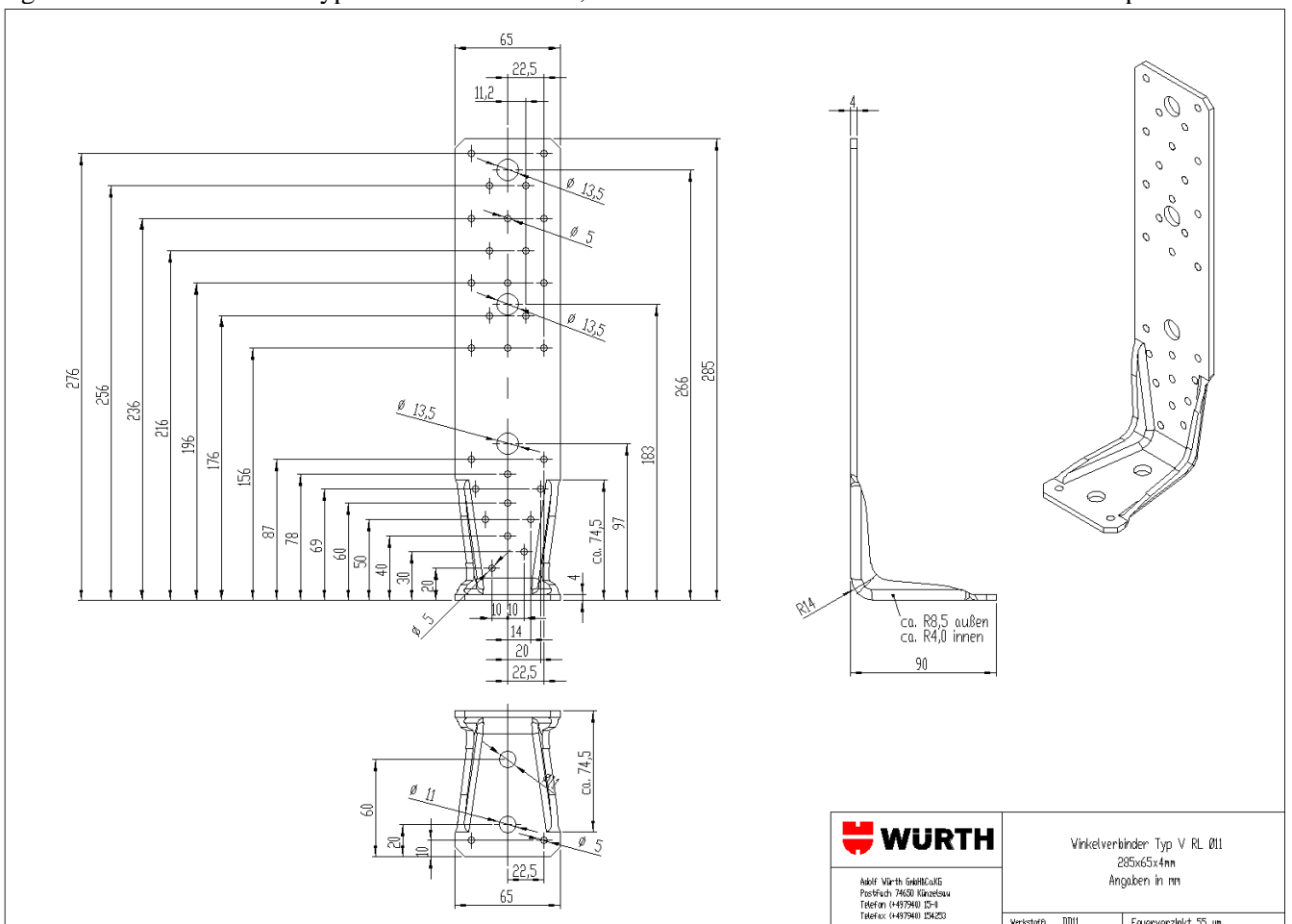Figure B.29 Dimensions of type V RL17 95x65x4,0 – alternative hole diameter 18 mm in bottom plate
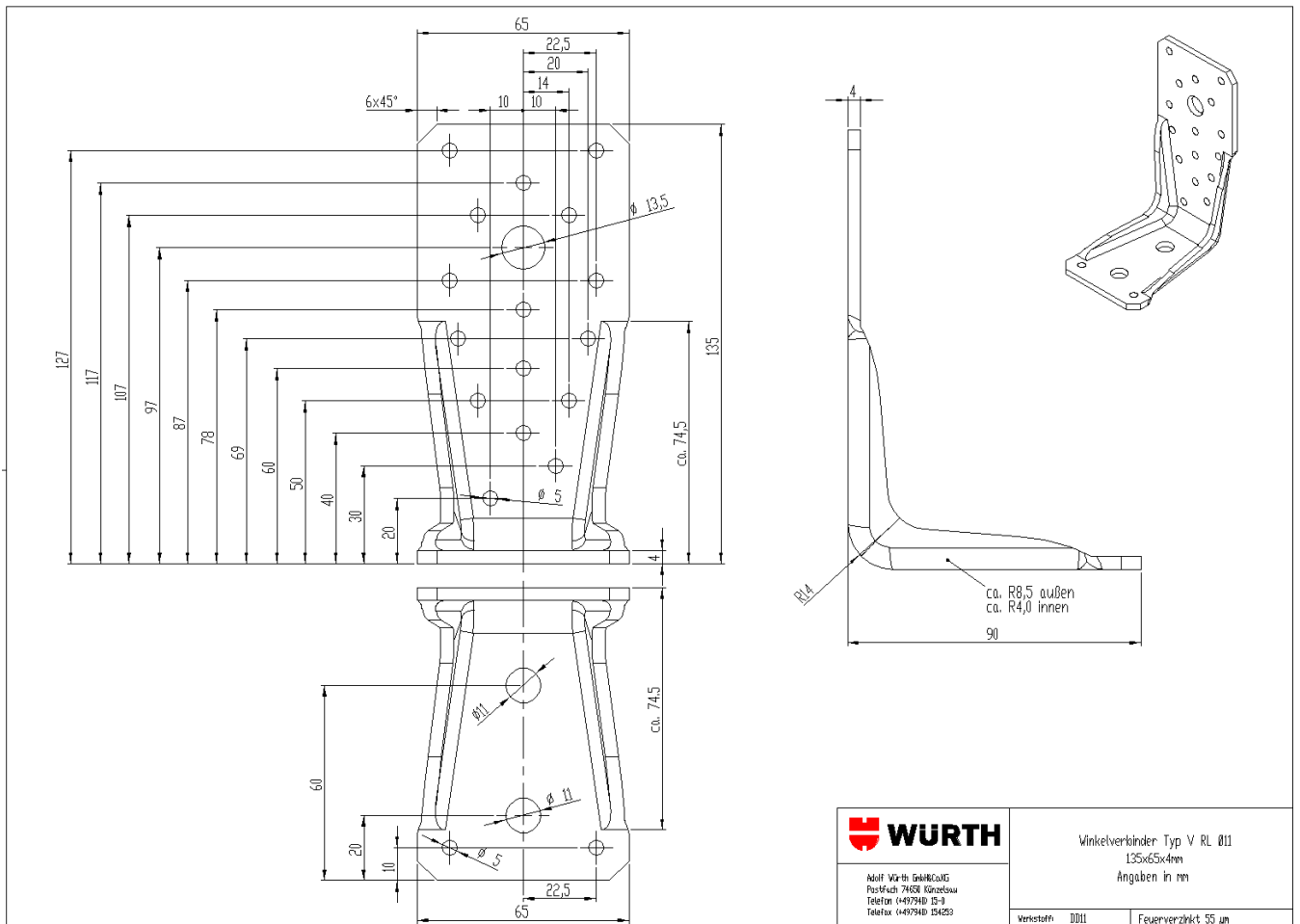
Figure B.30 Dimensions of type V RL11 135x65x4,0
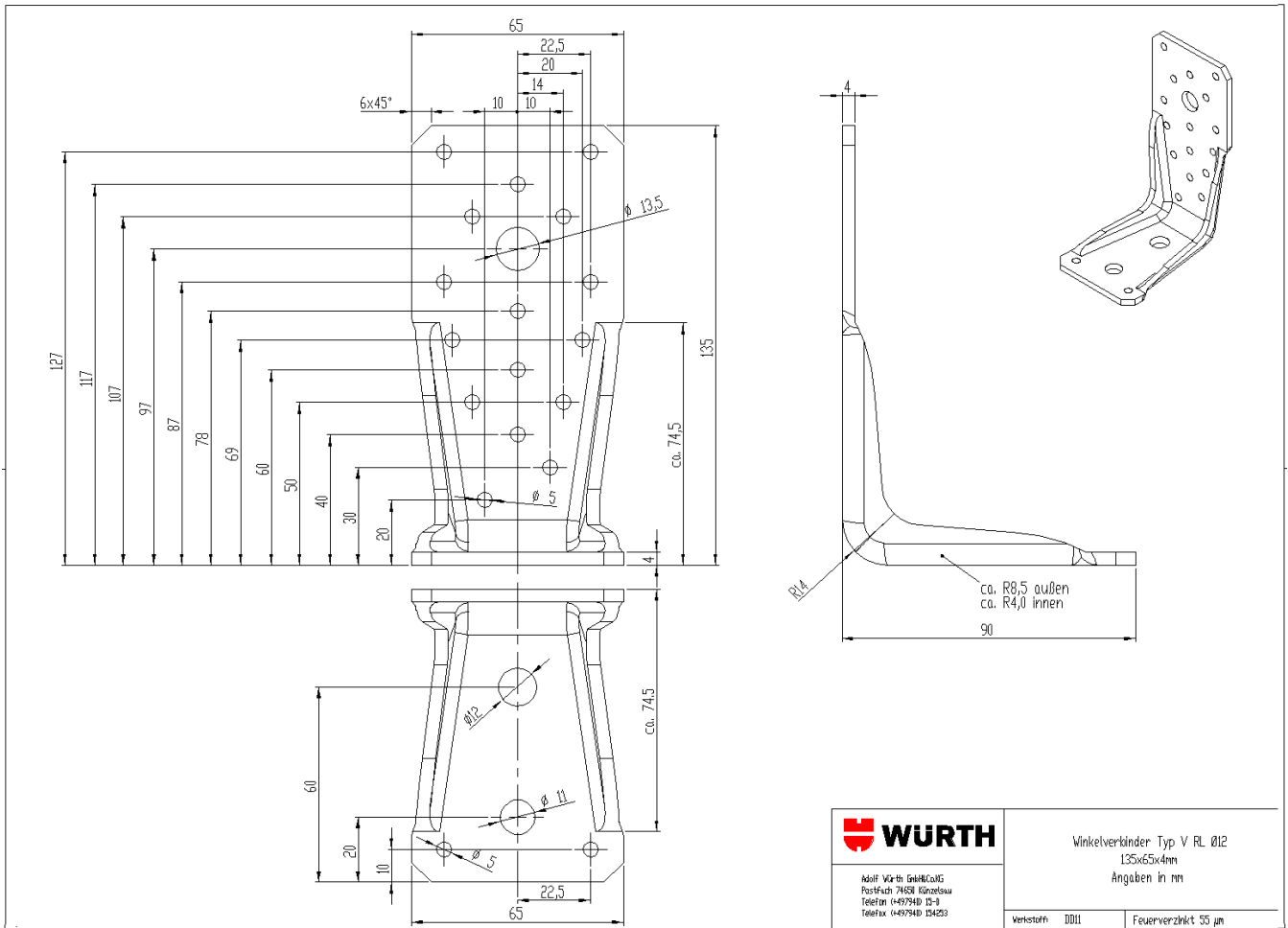
Figure B.31 Dimensions of type V RL12 135x65x4,0
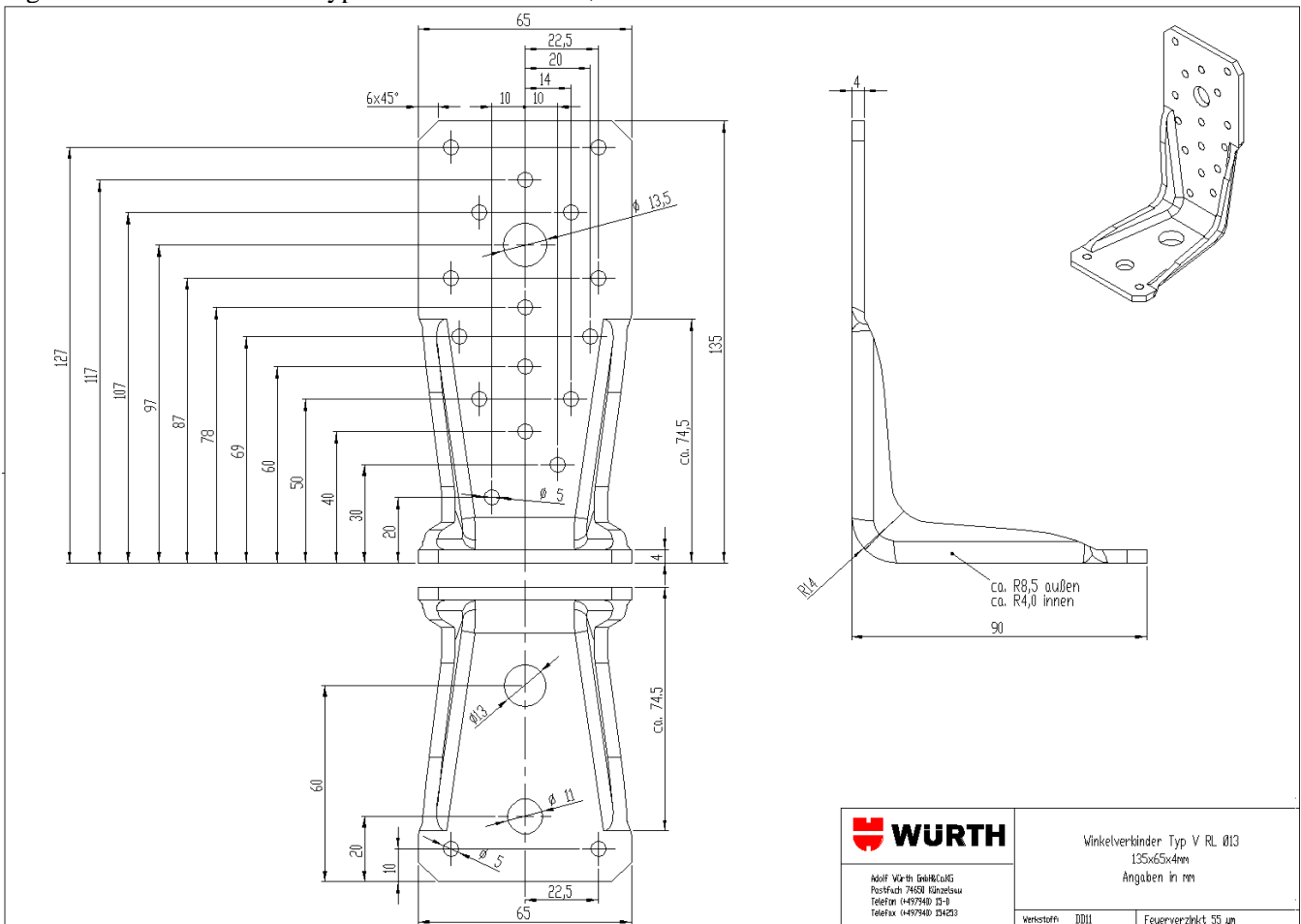
Figure B.32 Dimensions of type V RL13 135x65x4,0

Figure B.33 Dimensions of type V RL17 135x65x4,0 – alternative hole diameter 18 mm in bottom plate

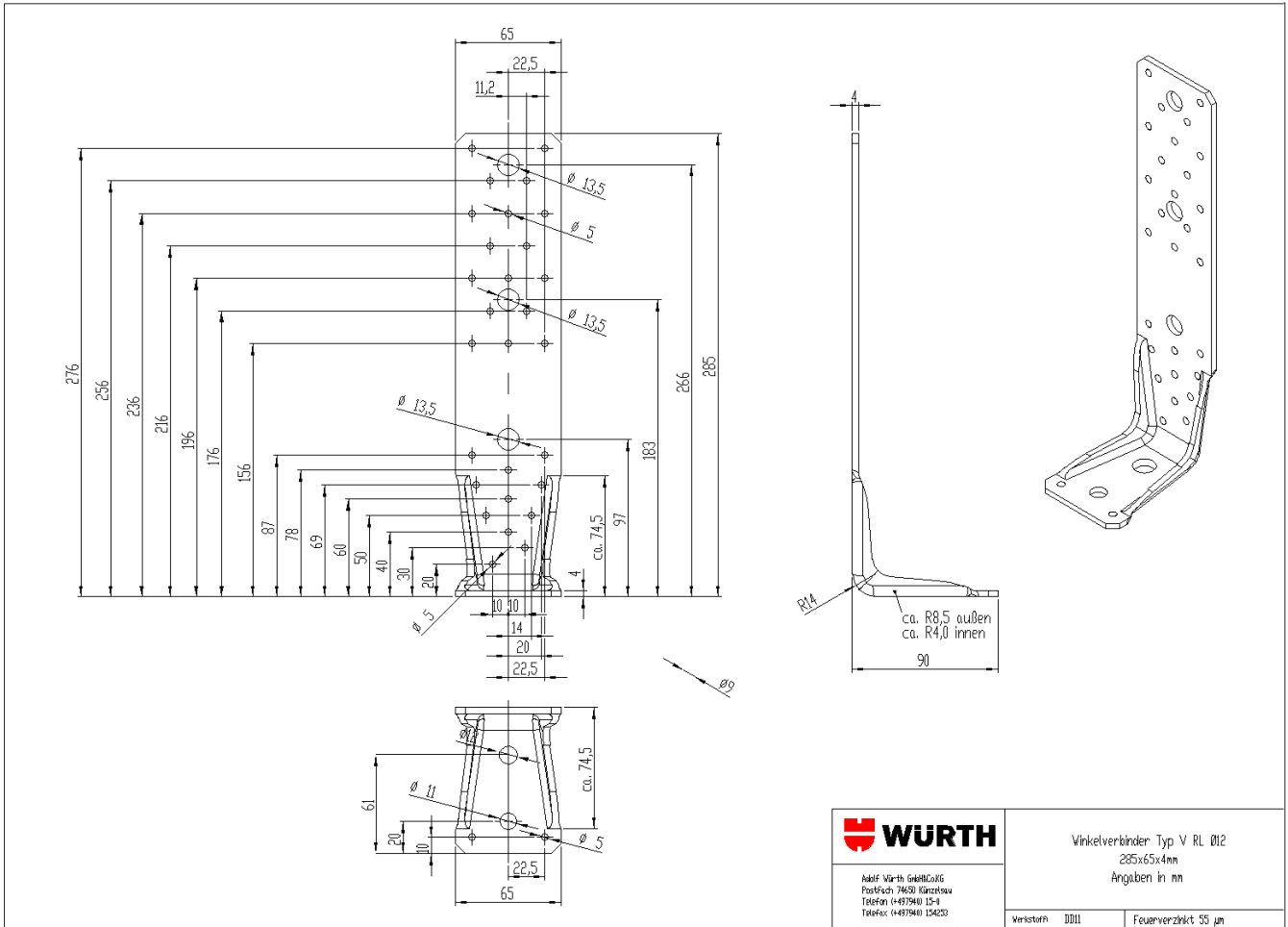Figure B.34 Dimensions of type V RL11 285x65x4,0

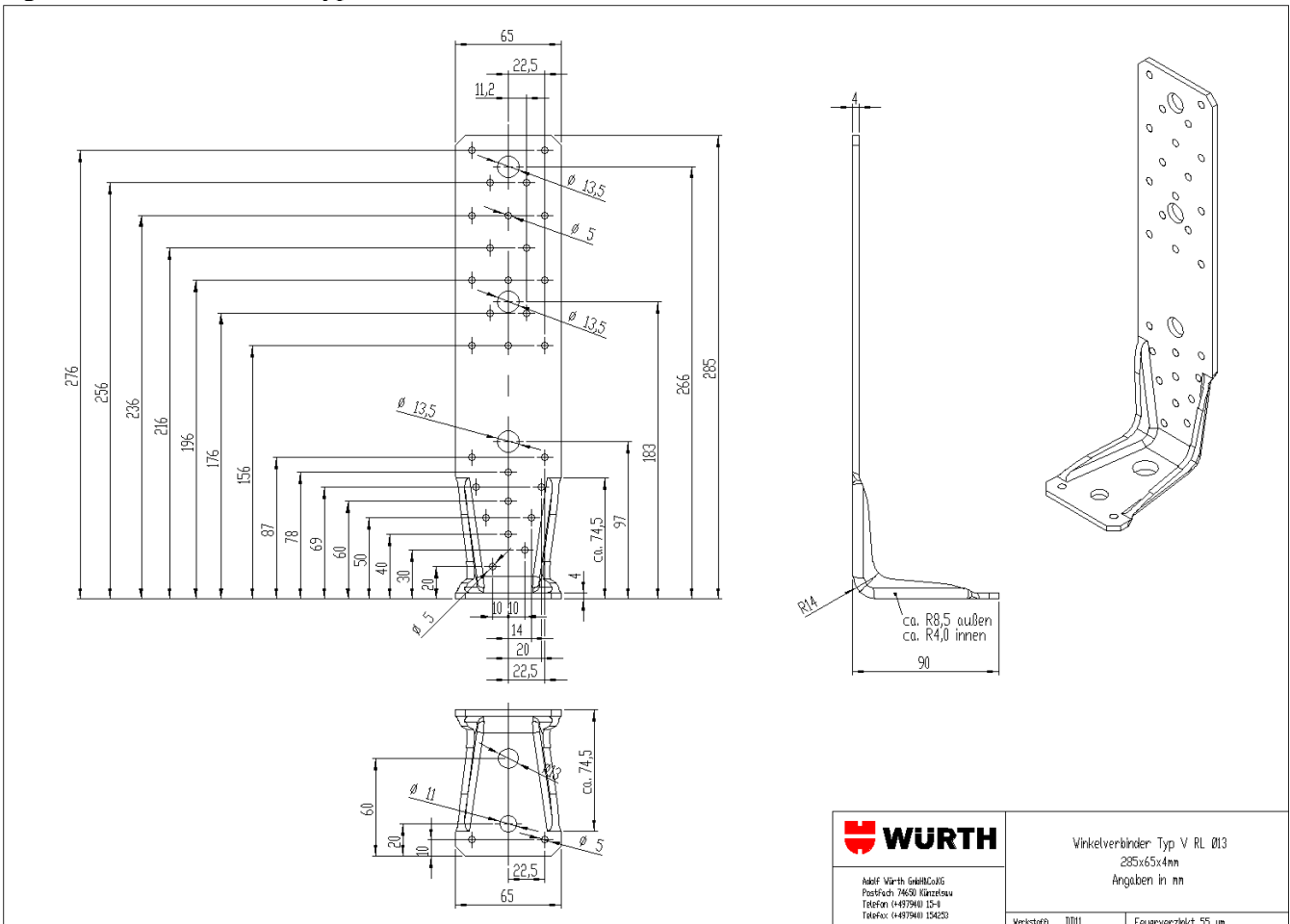Figure B.35 Dimensions of type V RL12 285x65x4,0
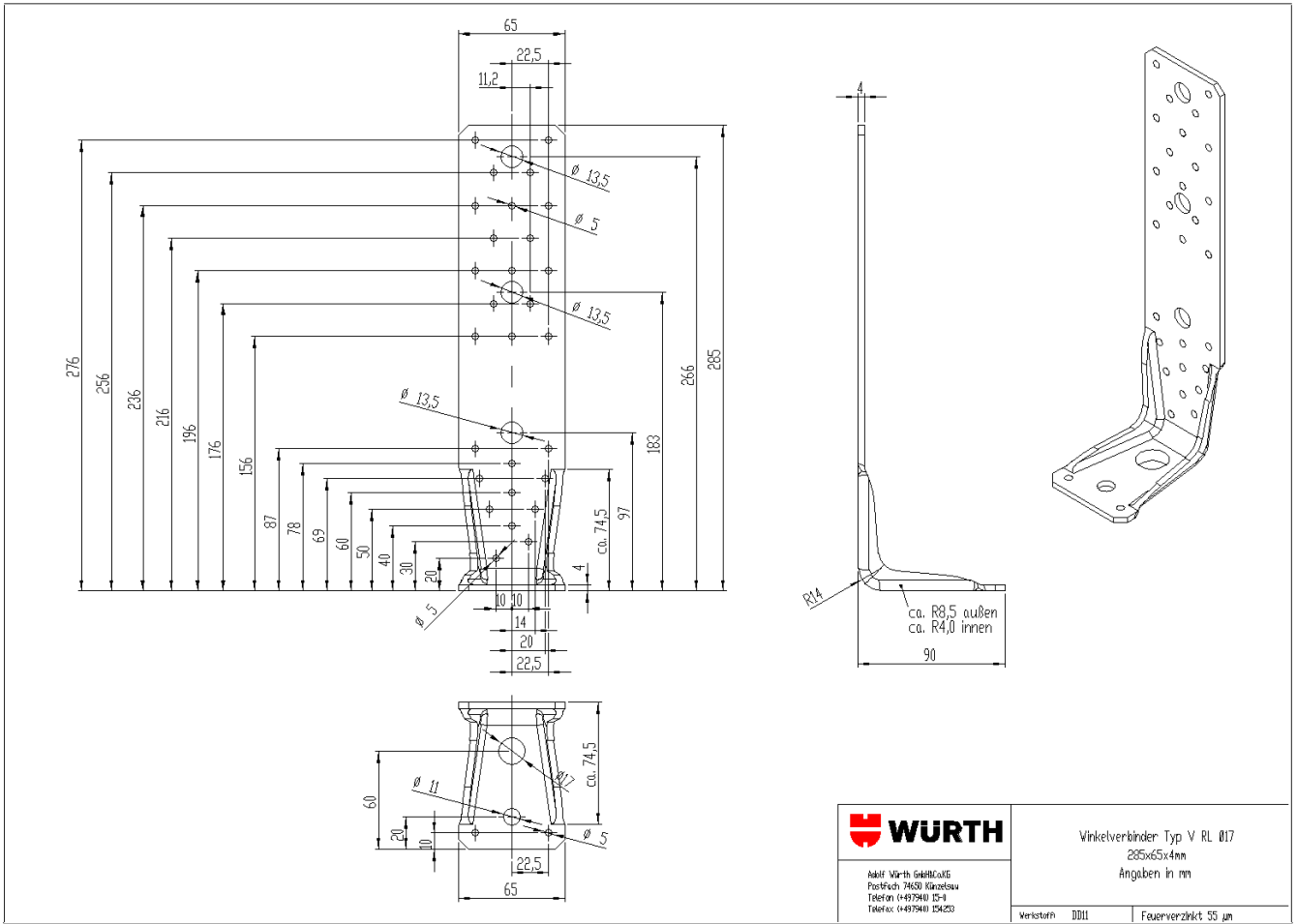

Figure B.36 Dimensions of type V RL13 285x65x4,0

Figure B.37 Dimensions of type V RL17 285x65x60x4,0 – alternative hole diameter 18 mm in bottom plate

Concrete flat steel anchors