

TECHNICAL DOCUMENTATION



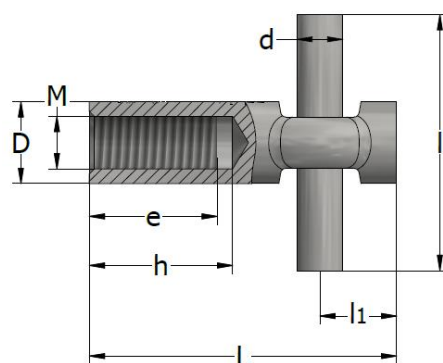
FIXING INSERTS | HBUS FIXING INSERT WITH CROSS-DRILLED HOLE AND CROSS-PIN



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FIXING INSERT WITH CROSS-DRILLED HOLE AND CROSS-PIN – HBUS



Fixing inserts HBUS are manufactured from steel bar 11SMnPb30 (W 1.0718) galvanised (EV) or from stainless steel bar A2 – 304 / 1.4305 (SS2) or A4-316Ti / 1.4571 (SS4). The cross-pin is made from steel bar S235JR. **Do not use these inserts for lifting.**

HBUS-EV	Product no.	Thread	Overall length	D	l1	e	h	Cross-pin		Admissible load
		M	[mm]	[mm]	[mm]	[mm]	[mm]	d	l	
HBUS M10x50-EV	45486	10	50	14	13	20	25	6	50	3.5
HBUS M10x60-EV	45462	10	60	14	13	20	25	6	50	4.0
HBUS M12x60-EV	45487	12	60	16	15	24	28	9	50	6.0
HBUS M12x70-EV	45463	12	70	16	15	24	28	9	50	7.0
HBUS M16x80-EV	45488	16	80	22	16	30	35	10	80	8.0
HBUS M16x85-EV	45489	16	85	22	16	30	35	10	80	9.0
HBUS M16x100-EV	45320	16	100	22	16	30	35	10	80	13.0
HBUS M20x100-EV	45490	20	100	26	24	35	40	12	80	14.0
HBUS M20x130-EV	45465	20	130	26	24	35	40	12	80	18.0
HBUS M24x120-EV	45491	24	120	32	32	40	45	15	100	18.0
HBUS M24x150-EV	45398	24	150	32	32	40	45	15	100	23.0

HBUS-SS2 (1.4305)	Product no.	Thread	Overall length	D	l1	e	h	Cross-pin		Admissible load
		M	[mm]	[mm]	[mm]	[mm]	[mm]	d	l	
HBUS M10x50-SS2	45321	10	50	14	13	20	25	6	50	3.5
HBUS M10x60-SS2	45498	10	60	14	13	20	25	6	50	4.0
HBUS M12x60-SS2	45374	12	60	16	15	24	28	9	50	6.0
HBUS M12x70-SS2	45499	12	70	16	15	24	28	9	50	7.0
HBUS M16x80-SS2	45376	16	80	22	16	30	35	10	80	8.0
HBUS M16x85-SS2	45500	16	85	22	16	30	35	10	80	9.0
HBUS M16x100-SS2	45501	16	100	22	16	30	35	10	80	13.0
HBUS M20x100-SS2	45378	20	100	26	24	35	40	12	80	14.0
HBUS M20x130-SS2	45502	20	130	26	24	35	40	12	80	18.0
HBUS M24x120-SS2	45380	24	120	32	32	40	45	15	100	18.0
HBUS M24x150-SS2	45503	24	150	32	32	40	45	15	100	23.0

HBUS-SS4 (1.4571)	Product no.	Thread	Overall length	D	l1	e	h	Cross-pin		Admissible load
		M	[mm]	[mm]	[mm]	[mm]	[mm]	d	l	
HBUS M10x50-SS4	45373	10	50	14	13	20	25	6	50	3.5
HBUS M10x60-SS4	45492	10	60	14	13	20	25	6	50	4.0
HBUS M12x60-SS4	45375	12	60	16	15	24	28	9	50	6.0
HBUS M12x70-SS4	45493	12	70	16	15	24	28	9	50	7.0
HBUS M16x80-SS4	45377	16	80	22	16	30	35	10	80	8.0
HBUS M16x85-SS4	45494	16	85	22	16	30	35	10	80	9.0
HBUS M16x100-SS4	45495	16	100	22	16	30	35	10	80	13.0
HBUS M20x100-SS4	45379	20	100	26	24	35	40	12	80	14.0
HBUS M20x130-SS4	45496	20	130	26	24	35	40	12	80	18.0
HBUS M24x120-SS4	45381	24	120	32	32	40	45	15	100	18.0
HBUS M24x150-SS4	45497	24	150	32	32	40	45	15	100	23.0

GENERAL INFORMATION

Fixing systems are used in the precast industry and are suitable for installation of precast concrete elements on site. Some of the advantages of this system include:

- a wide range of fixing sockets
- capability of establishing a connection in a safe, simple manner

Fixing insert designs and technical instructions are designed according to CEN/TS 1992-4:2009 (design of fastenings for use in concrete).

FIXING SYSTEMS

- **FIXING INSERTS**
 - Fixing socket embedded in precast concrete unit.
 - Ready for mounting bolts.
- **CONNECTING ELEMENTS AND FIXING ACCESSORIES**
 - Thread connections
 - Fixing Accessories

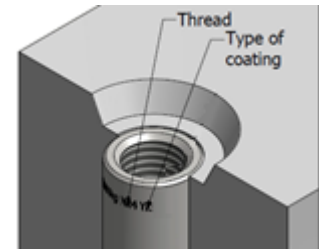
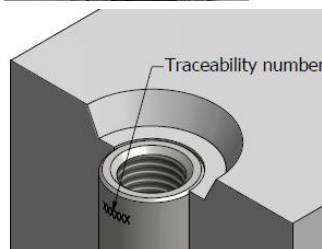
Quality

Terwa continuously controls the fixing insert production process from the perspective of strength, dimensional and material quality, and performs all of the required inspections for a superior quality system. All of the products are tracked from material acquisition to the final, ready to use product.



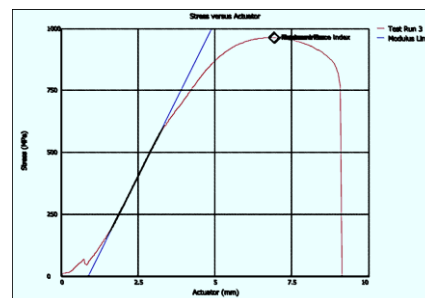
Marking and traceability

All systems have the CE marking and all data necessary for traceability, thread type and type of coating.



Anchor testing

Terwa ensures that all the fixing anchors and inserts comply with the admissible design loads.



FIXING INSERTS

TECHNICAL CONSIDERATIONS

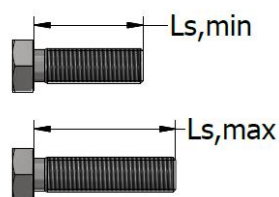
GENERAL GUIDANCE FOR FIXING INSERTS

The fixing inserts are easy, economical systems used for assembling concrete precast units.

Bolt length

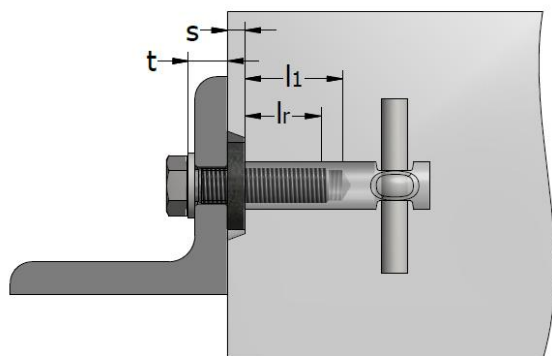
The bolt should be of sufficient length to ensure a minimum thread engagement of 1.5 times the bolt diameter.

Thread	Required thread engagement l_r mm
M8	12
M10	15
M12	18
M16	24
M20	30
M24	36



$$L_{s,max} = l_1 + s + t$$

$$L_{s,min} = l_r + s + t$$



l_1 – thread depth of the insert
 l_r – required thread engagement
 s – recess dimension (nailing plate)
 t – clamp thickness (includes washers)

SAFETY RULES AND ADMISSIBLE LOADS

The design of anchor shall be in accordance with the general guidelines in EN 1990.

The value of the design action is $S_d \leq R_d$; where S_d – value for design action, R_d – value for design resistance.

The design resistance is calculated using the formula: $R_d \leq R_k / \gamma_M$; where R_k – characteristic resistance of a single insert or an insert group, γ_M – partial safety factor for material.

The following failure modes must to be taken into consideration in the design of threaded fixing inserts:

- Steel failure of the bolt under tension
- Steel failure of the bolt in shear
- Combined steel failure of the bolt
- Steel failure of the threaded inserts under tension
- Concrete breakout failure under tension (concrete cone failure)
- Concrete edge failure in shear
- Concrete pry-out failure
- Combined concrete failure

Bolt capacities

The capacities of structural bolts grade 4.6 and 4.8 are presented in the table below.

Bolt strength and capacities in kN

Thread	Characteristic strength kN ISO 898-1:2009 Table 4 $N_{Rk,s}$		Tension capacity kN EN 1993-1-8:2005 $\varphi_s \times N_{Rk,s}$		Shear capacity kN EN 1993-1-8:2005 $\varphi_s \times V_{Rk,s} = 0.6 \times \varphi_s \times N_{Rk,s}$	
	Grade 4.6	Grade 4.6	Grade 4.6	Grade 4.6	Grade 4.6	Grade 4.6
M8	14.6	29.2	11.7	23.4	7.0	14.0
M10	23.2	46.4	18.6	37.1	11.2	22.3
M12	33.7	67.4	27.0	53.9	16.2	32.3
M16	62.8	125.0	50.2	100.0	30.1	60.0
M20	98.0	203.0	78.4	162.4	48.6	100.7
M24	141.0	293.0	112.8	234.4	67.7	140.6
M30	224.0	466.0	179.2	372.8	107.5	223.7
M36	327.0	678.0	261.6	542.4	157.0	325.4

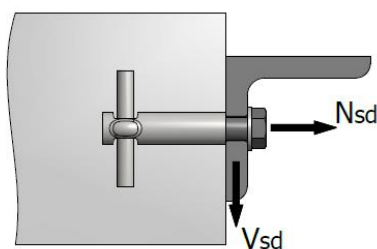
Note: $\varphi_s = 0.8$ (EN 1993-1-8 table 3.4: bolt under tension or in shear).

Combined loading for bolts under tension and in shear

If bolts are subject to combined tension and shear, they must be designed according to formula:

$$\left(\frac{N}{\varphi_s \cdot N_{Rk,s}}\right)^2 + \left(\frac{V}{\varphi_s \cdot V_{Rk,s}}\right)^2 \leq 1; \text{ where } N = \text{design tension load, } V = \text{design shear load}$$

If the threaded insert is installed using a recess former (nailing or magnetic plate), shear loads determine bending in the bolt, which must be taken into consideration.



ADMISSIBLE FORCES

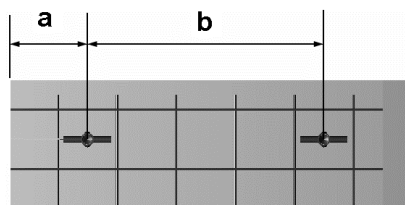
The admissible loads indicated in this catalogue refer to axial pull-out loads or shear loads. When these forces are combined, the result of these forces is obtained through the following formula:

$$\sqrt{N_{sd}^2 + V_{sd}^2}; \text{ where } N_{sd} - \text{pull-out load, } V_{sd} - \text{shear load.}$$

EDGE DISTANCE AND SPACING

The minimum edge distance depends on numerous factors such as: embedded depth, shear load directed towards the edge of the concrete unit, reinforcements near the inserts.

Note:
a = minimum 50mm



For short edge distance using long inserts, inserts with cross-pin or reinforcement of the next concrete edge are recommended.

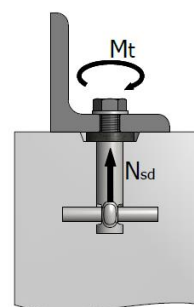
PROTECTION AGAINST CORROSION

Most of the fixing inserts are electrolytic galvanised. The thickness of the zinc layer is less than 10 µm. The corrosion resistance depends on the environmental circumstances. Hot-dipped galvanising is not possible for fixing inserts made of steel tubes with a flattened end. Some of the fixing inserts are manufactured from stainless steel bar X5CrNi18.10 (SS2) or X2CrNiMo17.13.3 (SS4) - SR EN 10088.3. The cast-in threaded elements (anchors or fixing inserts) can be cast flush or recessed for protection against corrosion. This recess is filled with fine concrete after use.

CONCRETE QUALITY

The loads indicated in tables are available for concrete with strength of 25 MPa. For other concrete strength values, applying the correction coefficients to the loads indicated is necessary, as shown below.

Concrete strength MPa	Correction coefficient
15	0.8
25	1.0
35	1.2
45	1.3
55	1.4



SPECIFIC CASES

If the fixing inserts are in recessed, we recommend using adequate filler (spacer) to load the insert properly without loading the concrete. If that is not possible, increase the real load applied to the insert by the value N shown below, then compare that with the admissible load from the catalogue.

$$N = M_a / 0.2 \times d_{nom}$$

N = additional force - daN

M_a = torque applied to the screw - daNm

d_{nom} = diameter of the inserts - m

Example:

For a fixing insert M12: $d_{nom} = 0.012$ m

Maximum torque 0.8 daNm

$$N = 0.8 / 0.2 \times 0.012 = 333 \text{ daN}$$

This means that, for fixing inserts BSR M12, after applying a torque, more than half of the load capacity is lost and major torque is prohibited.

Use of a torque wrench is recommended to prevent unexpected high loads on the fixing inserts. Torque values and forces can be found in the table below.

No.	Fixing insert diameter	Torque [Nm]	Force [kN]
	[mm]		
1	M6	1	0.83
2	M8	2	1.25
3	M10	4	2.0
4	M12	8	3.3
5	M16	17	5.3
6	M20	35	8.7
7	M24	53	11.0
8	M30	96	16.0

REINFORCEMENTS

The cross-pin of the fixing inserts BSRS, BSRFS, HBUS do not increase the admissible load, but must be regarded as an extra safety measure if there are voids or air pockets.

The fixing inserts with cross-drilled holes permit an increase of admissible load by 10% when a “U” shape anchor of sufficient length (approximately 50 x diameter) is added in the cross-hole.

TERWA FIXING INSERTS

1. FIXING INSERTS WITHOUT CROSS-PIN: BSR, BSRF, HBU, BSH
2. FIXING INSERTS WITH CROSS-PIN: BSRS, BSRFS, HBUS
3. FIXING BOLTS ANCHORS: BBB / BBB-SS, BBP / BBP-SS
4. FIXING AND LIFTING ANCHOR TRL, TGK, TGL.

Group 1 and 2

The admissible pull-out load can be used with a minimum:

- edge distance of: $a=1.5 \times$ total length of the anchor
- centre to centre distance of: $b = 3 \times$ total length of the anchor

The admissible shear load can be used with a minimum:

- edge distance of: $a=2.5 \times$ total length of the anchor
- centre to centre distance of: $5 \times$ total length of the anchor

Reduction factors for small edge distances

Edge distance	Admissible pull-out force N _{adm}	Edge distance	Admissible shear load force V _{adm}	Y = 1.2	Y = 1.2
2.5 x L	100%	2.5 x L	100%	100%	100%
2.0 x L	100%	2.0 x L	85%	100%	100%
1.5 x L	100%	1.5 x L	65%	78%	91%
1.0 x L	75%	1.0 x L	40%	48%	56%
0.5 x L	50%	0.5 x L	15%	18%	21%

The reduced admissible shear loads in the direction towards the edge can be increased by using additional reinforcement.

-for straight reinforcement Y = 1.2

-for “U” bent reinforcement Y = 1.4

The loads mentioned for inserts are valid for concrete quality B25 (25 MPa); for a higher quality of concrete, use the factors as indicated in the table.

Concrete quality	B25	B35	B45	B55	B65
Factor	1.00	1.18	1.34	1.48	1.61

The load must meet the following requirements:

- $N_{sd} \leq N_{Rd}$; where N_{sd} apparent pull-out load, N_{Rd} admissible pull-out load
- $V_{sd} \leq V_{Rd}$; where V_{sd} apparent shear load, V_{Rd} admissible shear load

Group 3

The international standards (CEB Bulletin 233 and Technical Approval of Metal Anchor for Use in Concrete 1997) are valid for the concrete qualities B25–B65. Terwa Bolt anchors BBB, BBB-SS, BBP and BBP-SS meet the requirement mentioned in the standards and can be calculated without any additional tests.

Group 4

The fixing and lifting anchors TGK, TGL are especially suited for use in thin prefab panels and where anchors must bear high pull-out loads. These items are a subject for another technical manual.

Ultimate limit state

The design of anchor shall be in accordance with the general guidelines in EN 1990. It must be shown that the design value of the action S_d is equal to or smaller than the design value of the resistance R_d .

$$S_d \leq R_d$$

Spacing, edge distance as well as thickness of concrete element should not remain below the given minimum values.

The spacing between the outer insert of adjoining groups or the distance to single inserts should be $a > S_{cr,N}$

Actions to be used in design may be obtained from national regulations or, in their absence, from the relevant sections in EN 1991. The partial safety factors for actions may be taken from national regulations or, in their absence, from CEN/TS 1992-4-2.

The design resistance is calculated as: $R_d \leq R_k/\gamma_M$.

Design method

Resistance to tension loads

Required verifications

- Steel failure: $N_{Sd} \leq N_{Rk,s}/\gamma_{Ms}$
- Combined pull-out and concrete cone failure: $N_{Sd} \leq N_{Rk,p}/\gamma_{Mp}$
- Concrete cone failure: $N_{Sd} \leq N_{Rk,c}/\gamma_{Mc}$
- Splitting failure: $N_{Sd} \leq N_{Rk,sp}/\gamma_{Msp}$

The partial safety factors γ_{Ms} for steel failure are determined as a function of the type of loading:

- Tension loading

$$\gamma_{Ms} = \frac{1.2}{f_{yk}/f_{uk}} \geq 1.4$$

- Shear loading

$$\gamma_{Ms} = \frac{1.0}{f_{yk}/f_{uk}} \geq 1.25 \quad f_{uk} \leq 800 \text{ MPa}, f_{yk}/f_{uk} \geq 0.8$$

$$\gamma_{Ms} = 1.5 \quad f_{uk} > 800 \text{ MPa}, f_{yk}/f_{uk} > 0.8$$

The partial safety factors for concrete failure, pry-out failure and edge failure (γ_{Mc}), splitting failure (γ_{Msp}), and pull-out failure (γ_{Mp}) are given in CEN/TS 1992-4-2.

$\gamma_{Mc} = \gamma_c \times \gamma_2$; γ_c – partial safety factor for concrete = 1.5, γ_2 – partial safety factor taking into account the installation safety of an anchor system.

The partial safety factor γ_2 is evaluated based on the installation safety test results:

- Tension loading

= 1.0 for systems with high installation safety

$\gamma_2 = 1.2$ for systems with normal installation safety

$\gamma_2 = 1.4$ for systems with low but still acceptable installation safety

- Shear loading

$\gamma_2 = 1.0$

For partial safety factors γ_{Msp} and γ_{Mp} , the value γ_{Mc} must be taken into account.

Steel failure

The characteristic resistances of an insert in case of steel failure $N_{Rk,s}$ are

$$N_{Rk,s} = A_s \times f_{uk} [N]$$

Where: $N_{Rk,s}$ – is specified in CEN/TS 1992-4-2
 A_s – stress on cross-section of steel
 f_{uk} – characteristic ultimate tensile strength for steel (nominal value)

Combined pull-out and concrete cone failure

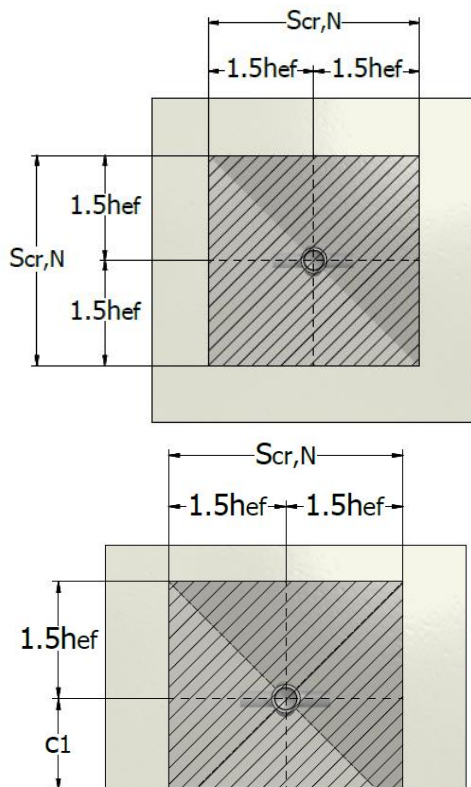
The characteristic resistance for combined pull-out and concrete cone failure is

$$N_{Rk,p} = N_{Rk,p}^0 \times (A_{p,N}/A_{p,N}^0) \times \psi_{s,Np} \times \psi_{G,Np} \times \psi_{ec,Np} \times \psi_{re,Np} [N]$$

The different factors in the above-mentioned equation for inserts according to current experience are given in CEN/TS 1992-4-2.

$$N_{Rk,p}^0 = \pi \times d \times h_{ef} \times \tau_{Rk} [N] \text{ where } \tau_{Rk} \text{ in } N/mm^2, d \text{ and } h_{ef} \text{ in mm.}$$

The geometric effect of spacing and edge distance on the characteristic resistance is taken into account by the value $A_{p,N}/A_{p,N}^0$



$$A_{p,N}^0 = S_{cr,Np} \times S_{cr,Np}$$

$$A_{p,N} = (c1 + 0.5S_{cr,Np}) \times S_{cr,Np} \text{ if } c1 \leq c_{cr,Np}$$

$$S_{cr,Np} = 20 \times \left(\frac{\tau_{Rk,ucr}}{7.5} \right)^{0.5} \leq 3 \times h_{ef} [mm]$$

$$c_{cr,Np} = S_{cr,Np}/2 [mm]$$

Concrete break (cone) failure

The characteristic resistance of an insert or a group of inserts, respectively, for concrete cone failure is:

$$N_{Rk,c} = N_{Rk,c}^0 \times (A_{c,N}/A_{c,N}^0) \times \psi_{s,N}$$

$N_{Rk,c}$ – characteristic concrete cone failure resistance for an insert.

$N_{Rk,c}^0$ – characteristic concrete cone failure resistance for an insert located far from the edges of the concrete element or adjacent inserts

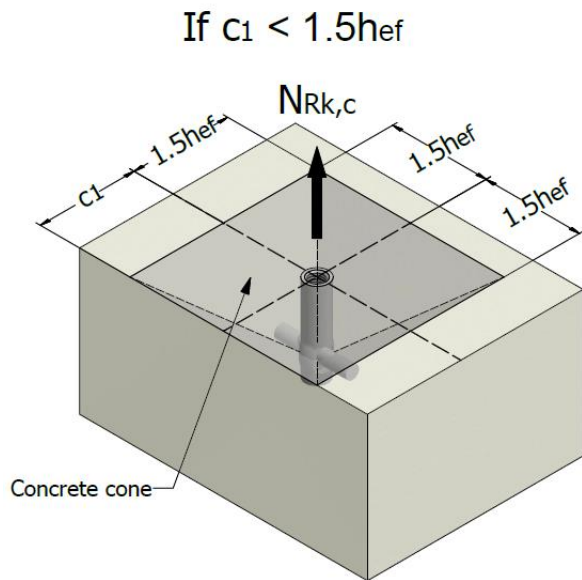
$A_{c,N}$ – Actual projected area of the idealised concrete cone developed by the insert on the concrete surface

$A_{c,N}^0$ – Area of the idealised concrete breakout cone on the surface, of an individual insert located far from the edges of the concrete element or adjacent inserts.

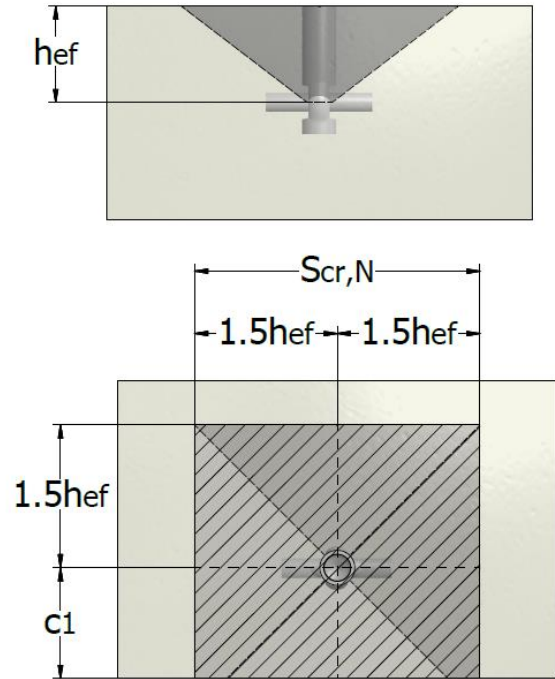
$\psi_{s,N}$ – stress disturbance factor dependent on the proximity of edges.

$$\psi_{s,N} = 0.7 + 0.3 \times \left(\frac{c_i}{1.5h_{ef}} \right) \leq 1$$

c_i – smallest edge distance



$$A_{c,N} = 3h_{ef}(1.5h_{ef} + c_1)$$



The characteristic resistance to concrete cone failure for a single insert, placed a minimum distance $1.5h_{ef}$ from any edge is

$$N_{Rk,c}^0 = k_{cr} \times \sqrt{f_{ck,cube}} \times h_{ef}^{1.5}$$

k_{cr} - 13 for inserts in uncracked concrete, 10 for insert in cracked concrete.

$f_{ck,cube}$ - characteristic compressive strength of the concrete [MPa]

h_{ef} – effective embedded depth of the insert [mm]

Effect of insert spacing and edge distance

$A_{c,N}$ – Actual projected area limited by overlapping concrete cones of adjacent inserts

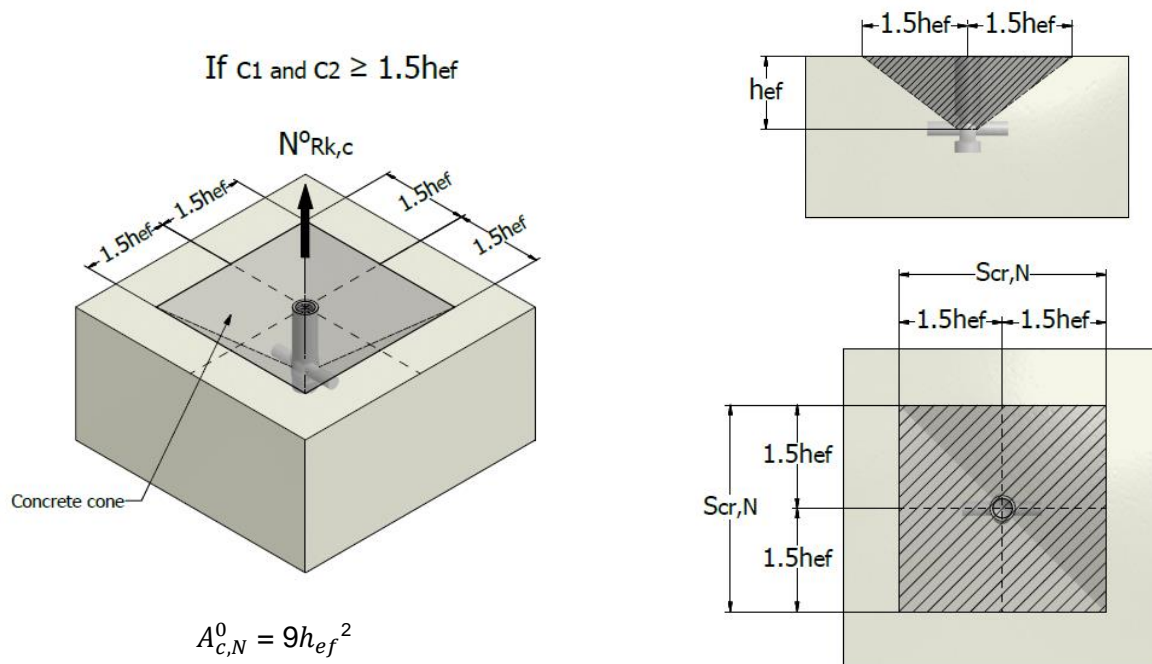
$A_{c,N}^0$ – reference projected area of a single insert

$$A_{c,N}^0 = s_{cr,N} \times s_{cr,N}$$

$$s_{cr,N} = 2c_{cr,N}$$

$$c_{cr,N} = 1.5h_{ef}$$

$$A_{c,N}^0 = 9h_{ef}^2$$



Resistance to shear loads

Required verification

- Steel failure, shear load without lever arm: $V_{Sd} \leq V_{Rk,s}/\gamma_{Ms}$
- Steel failure, shear load with lever arm: $V_{Sd} \leq V_{Rk,s}/\gamma_{Ms}$
- Concrete pry-out failure: $V_{Sd} \leq V_{Rk,cp}/\gamma_{Mc}$

Steel failure

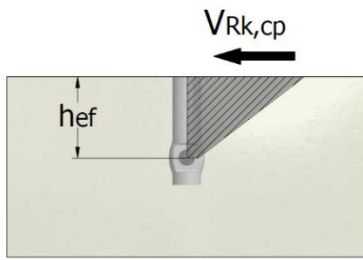
The characteristic resistances of an insert for steel failure $V_{Rk,s}$ (shear load without lever arm) is

$$V_{Rk,s} = 0.5 A_s \times f_{uk} [N]$$

Where:

- $V_{Rk,s}$ – is specified in CEN/TS 1992-4-2
- A_s – stress cross-section of steel
- f_{uk} – characteristic ultimate tensile strength for steel (nominal value)

Concrete pry-out failure



$$V_{Rk,cp} = k \times N_{Rk,c}$$

$$k = 1 \text{ for } h_{ef} < 60 \text{ mm}$$

$$k = 2 \text{ for } h_{ef} \geq 60 \text{ mm}$$

Concrete edge failure

The characteristic resistance for an insert for concrete edge failure corresponds to:

$$V_{Rk,c} = V_{Rk,c}^0 \times (A_{c,V}/A_{c,V}^0) \times \psi_{s,V} \times \psi_{h,V} \times \psi_{re,V}$$

$V_{Rk,c}$ – Characteristic resistance of a single insert in shear

$V_{Rk,c}^0$ – Characteristic resistance of an insert loaded perpendicular to the edge in cracked concrete

$A_{c,V}$ – Projected area of the idealised concrete breakout area of an insert directed towards an edge

$A_{c,V}^0$ – area of the idealised concrete breakout cone on the lateral concrete surface, of an insert located far from edges parallel to the loading direction, or adjacent inserts, with a thickness greater than the embedded depth of the insert, with the shape of the fracture area idealised as a half pyramid with an equal height c_1 and a base length of $1.5c_1$ and $3c_1$.

$\psi_{s,V}$ – factor which accounts for the disturbance of the stress distribution

$\psi_{h,V}$ – thickness of the structural component disturbance factor

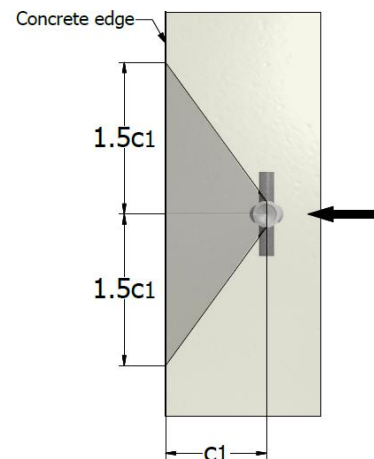
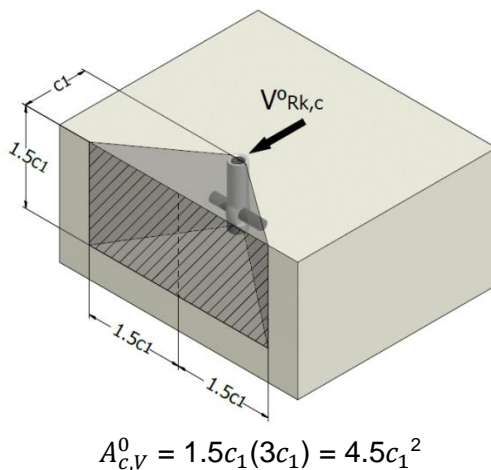
$\psi_{re,V}$ – position of the fastening disturbance factor

$\psi_{s,V}$, $\psi_{h,V}$ and $\psi_{re,V}$ according CEN/TS 1992-4-2.

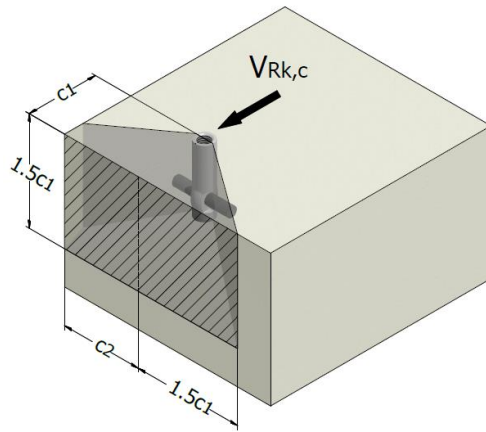
$$V_{Rk,c}^0 = k_1 \times d^\alpha \times h_{ef}^\beta \times \sqrt{f_{ck,cube}} \times c_1^{1.5} \text{ [N]}$$

- $k_1 = 1.7$ for applications in cracked concrete
- $k_1 = 2.4$ for applications in uncracked concrete
- $\alpha = 0.1 \times (h_{ef}/c_1)^{0.5}$ d outer diameter of inserts $\leq 60\text{mm}$, $h_{ef} \leq 8 \times d$
- $\beta = 0.1 \times (d/c_1)^{0.2}$

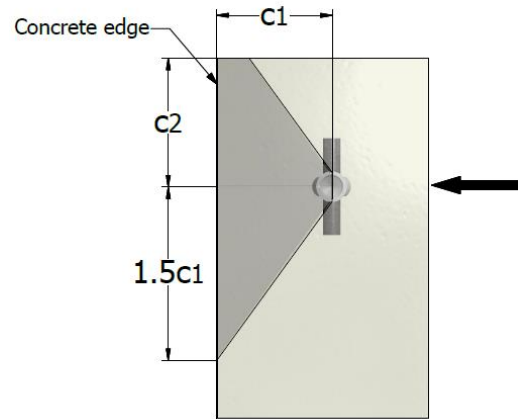
Idealised concrete cone and area $A_{c,V}^0$ of concrete cone for a single insert



Actual area of concrete cone of anchorage on the lateral concrete surface. $A_{c,V}$ of concrete cone for an insert anchor



$$A_{c,V} = 1.5c_1(1.5c_1 + c_2), c_2 \leq 1.5c_1$$



The admissible static tensile loads are determined after combining the data from numerous tests for pure pull or shear load. The data obtained from these tests take into account multiple factors such as: composition, uniformity, strength, age of concrete and the circumstances that arise at installation. The admissible static loads for Terwa fixing inserts, embedded completely in concrete, are valid for pull-out or shear load and have a safety factor of 3 to 4 x the average breaking load of concrete with strength of 25 MPa.

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TERWA is the global supplier for precast and construction solutions with multiple offices around the world. With all our staff, partners and agents, we are happy to provide all construction and precast companies who work in the building industry with full service and 100% support.

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