TERWA

TECHNICAL DOCUMENTATION

FIXING INSERTS | BSX
FIXING INSERTS WITH WAVE END

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FIXING INSERTS WITH WAVE END – BSX

Fixing inserts BSX are manufactured from steel precision tube S235JR NBK hot dip galvanized (TV), electrolytic galvanised EV or from stainless steel tube 1.4404 (SS4). **Do not use these inserts for lifting.**

BSX-TV	Product no.	Thread	Overall Length L	D	e	h	Admissible load
		M	[mm]	[mm]	[mm]	[mm]	[kN]
BSX M10x55-TV	49102	10	55	13	10	20	4.0
BSX M10x75-TV	49104	10	75	13	10	20	5.0
BSX M12x95-TV	49106	12	95	17.2	21	45	6.0
BSX M12x135-TV	45204	12	135	17.2	21	45	7.0
BSX M16x100-TV	49081	16	100	22	30	45	10.0
BSX M16x125-TV	49083	16	125	22	30	45	11.0
BSX M16x135-TV	48894	16	135	22	21	45	12.0
BSX M20x100-TV	49085	20	100	27	30	45	16.0
BSX M20x125-TV	49087	20	125	27	30	45	16.0
BSX M24x120-TV	49108	24	120	32	33	55	16.0
BSX M30x145-TV	49114	30	145	38	36	65	16.0

BSX-EV	Product no.	Thread	Overall Length L	D	e	h	Admissible load
		M	[mm]	[mm]	[mm]	[mm]	[kN]
BSX M12x95-EV	49410	12	95	17.2	21	45	6.0
BSX M12x135-EV	49411	12	135	17.2	21	45	7.0
BSX M16x135-EV	48893	16	135	22	21	45	12.0

BSX-SS4 (W 1.4301)	Product no.	Thread	Overall Length L	D	e	h	Admissible load
		M	[mm]	[mm]	[mm]	[mm]	[kN]
BSX M10x55-SS4	49103	10	55	13	10	20	4.0
BSX M10x75-SS4	49105	10	75	13	10	20	5.0
BSX M12x95-SS4	49107	12	95	17.2	21	45	6.0
BSX M12x135-SS4	45285	12	135	17.2	21	45	7.0
BSX M16x100-SS4	49082	16	100	22	30	45	10.0
BSX M16x125-SS4	49084	16	125	22	30	45	11.0
BSX M16x135-SS4	48892	16	135	22	21	45	12.0
BSX M20x100-SS4	49086	20	100	27	30	45	16.0
BSX M20x125-SS4	49088	20	125	27	30	45	16.0
BSX M24x120-SS4	49109	24	120	32	33	55	16.0
BSX M30x145-SS4	49115	30	145	38	36	65	16.0

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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.
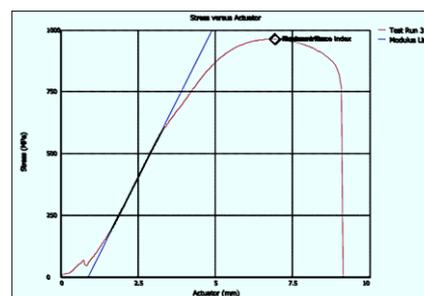
Marking and traceability
All systems have the CE marking and all data necessary for traceability, thread type and type of coating.
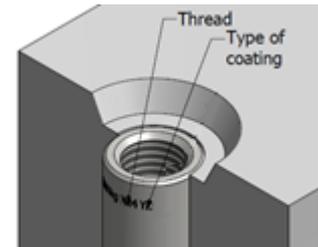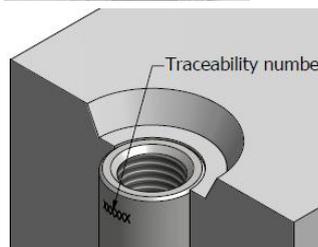
Anchor testing
Terwa ensures that all the fixing anchors and inserts comply with the admissible design loads.

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**FIXING INSERTS**

TECHNICAL CONSIDERATIONS

GENERAL GUIDANCE FOR FIXING INSERTS

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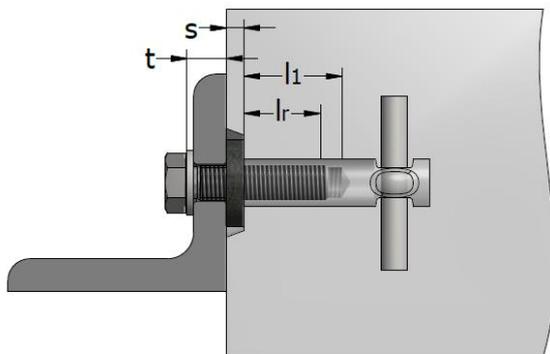
Bolt length

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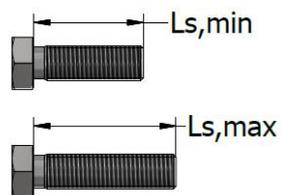
$$L_{s,max} = l_1 + s + t$$

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

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

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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: φ_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:

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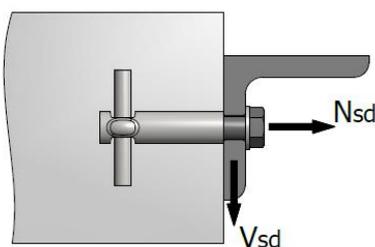
ADMISSIBLE FORCES

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:

$$\sqrt{N_{sd}^2 + V_{sd}^2}$$; where N_{sd} – pull-out load, V_{sd} – 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
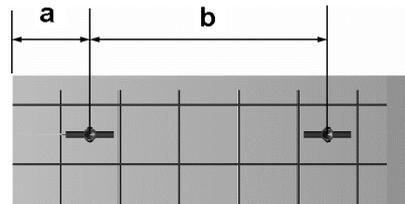
For short edge distance using long inserts, inserts with cross-pin or reinforcement of the next concrete edge are recommended.

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
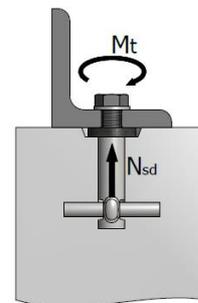
SPECIFIC CASES

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 x 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 x 0.012 = 333 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 [mm]	Torque [Nm]	Force [kN]
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 x total length of the anchor
- centre to centre distance of: b = 3 x total length of the anchor

The admissible shear load can be used with a minimum:
- edge distance of: a=2.5 x total length of the anchor
- centre to centre distance of: 5 x total length of the anchor

Reduction factors for small edge distances

Edge distance	Admissible pull-out force Nadm	Edge distance	Admissible shear load force Vadm	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.

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

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*

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

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

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

γ_2 = 1.2 for systems with normal installation safety

γ_2 = 1.4 for systems with low but still acceptable installation safety

- Shear loading

γ_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)
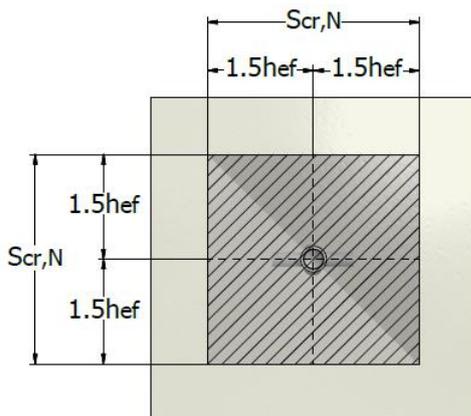
Combined pull-out and concrete cone failure

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 $A_{p,N}/A_{p,N}^0$

$$A_{p,N}^0 = s_{cr,Np} \times s_{cr,Np}$$
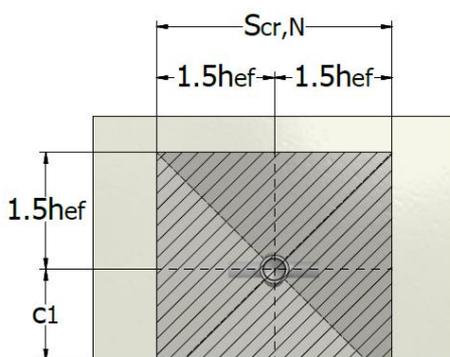
$$A_{p,N} = (c1 + 0.5s_{cr,Np}) \times s_{cr,Np}$$
$$\text{If } c_1 \leq c_{cr,Np}$$

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

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

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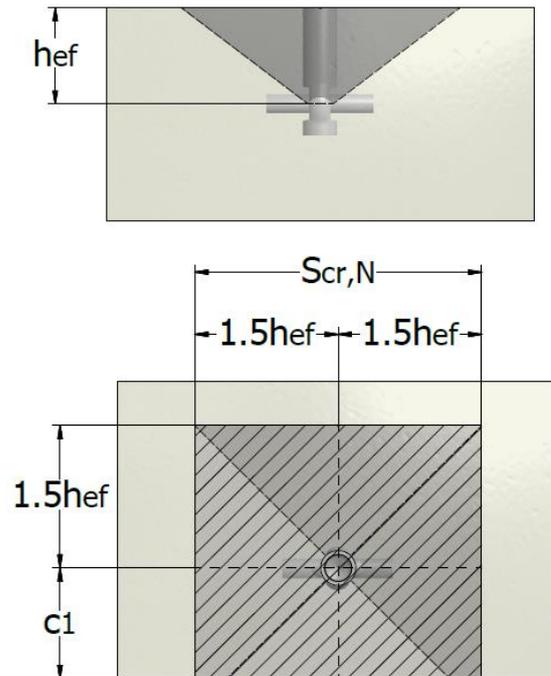
$\psi_{s,N}$ – stress disturbance factor dependent on the proximity of edges.

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

c_i – smallest edge distance

If c1 < 1.5hef
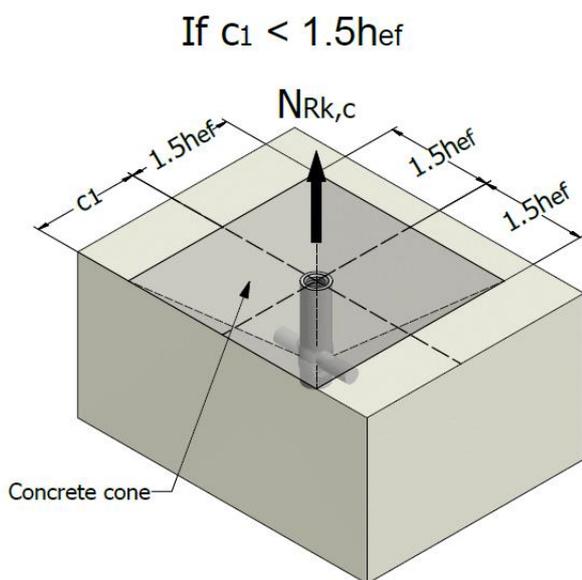
$$A_{c,N} = 3h_{ef}(1.5h_{ef} + c_1)$$

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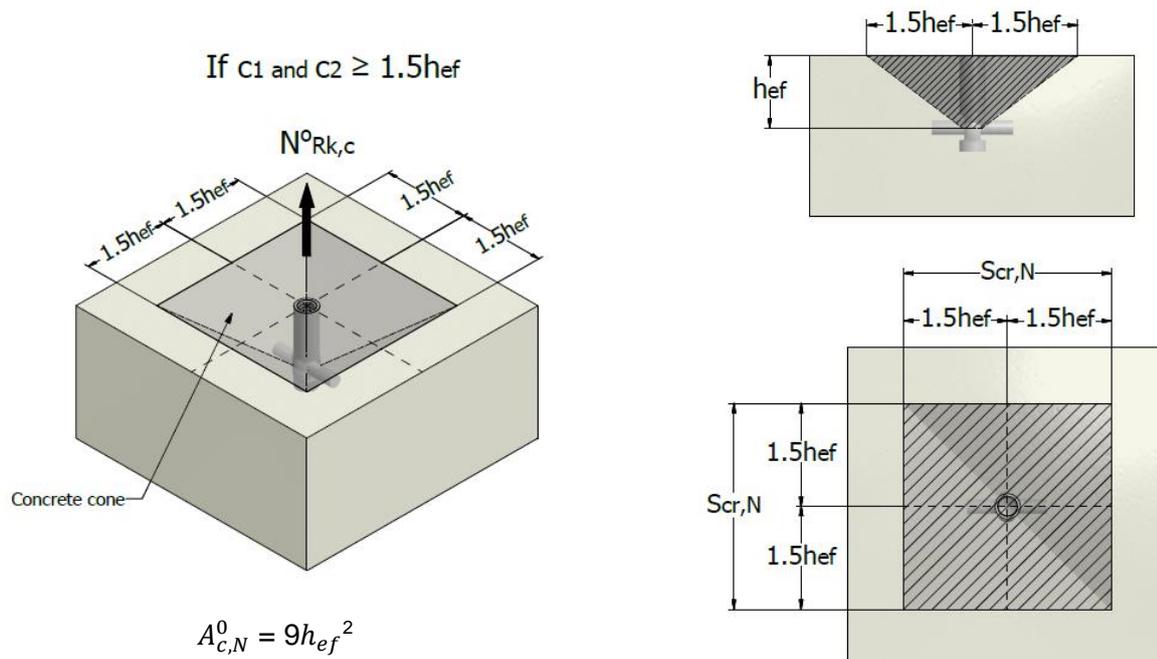$A_{c,N}^0$ – reference projected area of a single insert

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

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

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

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

If C1 and C2 ≥ 1.5hef

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

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: $V_{Sd} \leq V_{Rk,cp}/\gamma_{Mc}$
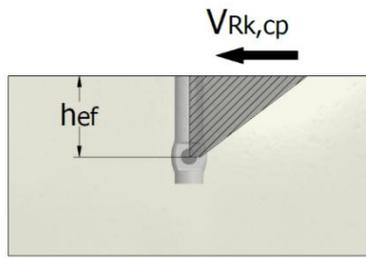
Steel failure

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

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

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

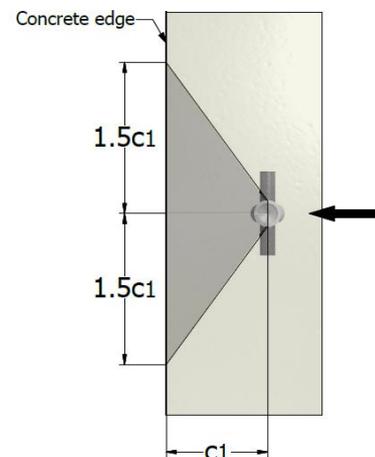$\psi_{s,V}$, $\psi_{h,V}$ and $\psi_{re,V}$ according CEN/TS 1992-4-2.
$$V_{Rk,c}^0 = k_1 \times d^\alpha \times h_{ef}^\beta \times \sqrt{f_{ck,cube}} \times c_1^{1.5} \ \text{[N]}$$

- 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 $\leq 60mm$, $h_{ef} \leq 8 \times d$
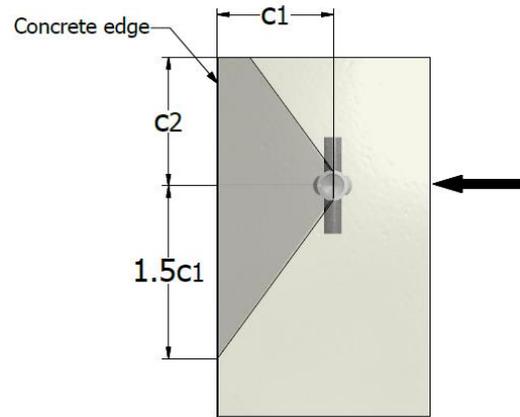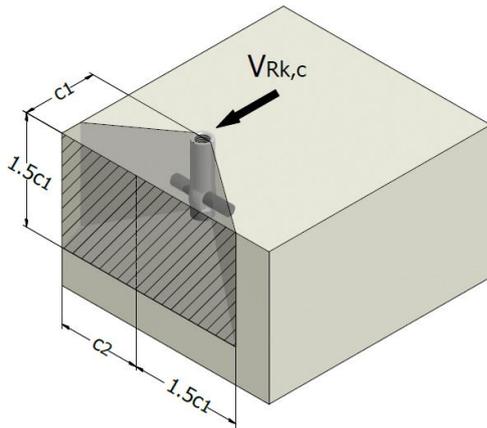- $\beta = 0.1 \times (d/c_1)^{0.2}$

Idealised concrete cone and area $A_{c,V}^0$ of concrete cone for a single insert
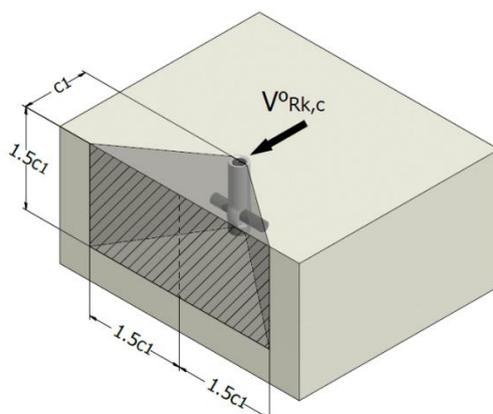
$$A_{c,V}^0 = 1.5c_1(3c_1) = 4.5c_1^2$$

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

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

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.

CONTACT

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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