WÜRTH

ANCHOR DESIGN MANUAL

IMPORTANT NOTICES

1. Construction materials as well as the service and environmental conditions vary on different sites. Therefore the present condition of the base material and the suitability must be checked by the user. If the user is in doubt, he should contact one of Würth's Representatives.

2. The information and recommendations given in this Design Manual are based on the principles, formulae and safety factors defined in approval guidelines, published research results and Würth's technical instructions, the operating manuals, the setting instructions, the installation manuals and other data sheets that are believed to be correct at the time of writing. The data and values are based on the respective average values obtained from tests under laboratory or other controlled conditions. It is the users responsibility to use the data given in the light of conditions on site and taking into account the intended use of the products concerned. The user has to check the listed prerequisites and that the criteria conform with the conditions actually existing on the job-site. Whilst Würth can give general guidance and advice, the nature of Würth products means that the ultimate responsibility for selecting the right product for a particular application must lie with the customer.

3. All products must be used, handled and applied strictly in accordance with all current instructions for use published by Würth, i.e. technical instructions, operating manuals, setting instructions, installation manuals and others.

4. Würth's aim is to always supply construction material with a quality and function of the latest state of technology. We therefore reserve the right to alter specifications, etc. without notice.

5. The given mean ultimate loads and characteristic data in the Design Manual reflect actual test results and are thus valid only for the indicated test conditions.

Due to variations in local base materials, on-site testing is required to determine performance at any specific site.

6. Würth is not obligated for direct, indirect, incidental or consequential damages, losses or expenses in connection with, or by reason of, the use of, or inability to use the products for any purpose. Implied warranties of merchantability or fitness for a particular purpose are specifically excluded.

CONTENTS

DESIGN PRINCIPLES

1. Design Principles

1.1. General

This chapter is intended to provide the reader with the design principles related to the anchorage of structural and non-structural elements to structural components through fasteners. Fasteners, mechanical or bonded, are designed to transmit actions to concrete by different mechanisms depending on their type and mode of action.

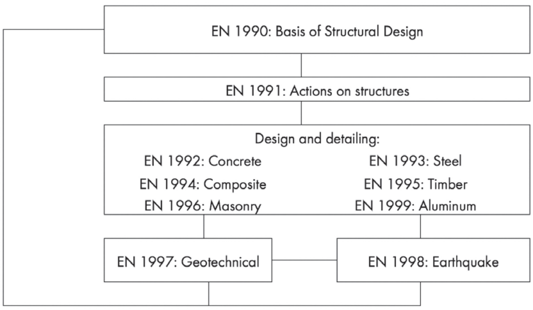


Figure 1: The Eurocodes

The design principles are primarily based on the European Standards of the Eurocode EN 1992-4, which is a European standard for the design of fastenings for use in concrete.

The Eurocode EN 1992-4 uses the fastener design theory, which applies to single fasteners and group of fasteners, on condition that the fasteners are of equal type and size and on the condition that they are joined through a common fixture.

1.2. Partial factor method

This design manual uses the partial factor method according to the European Norm EN 1990. When using the partial factor method, it shall be verified that, in all relevant design situations, no relevant limit state is exceeded when design values for actions (E_d) or effects of actions and resistances (R_d) are used in the design models.

$$E_d \leq R_d$$

For the selected design situations and the relevant limit states, the individual actions for the critical load cases should be combined.

Design values should be obtained by using the characteristic, or other representative values, in combination with partial and other factors (γ_f, γ_M) as defined in EN 1991 to EN 1999, the design guides for post-installed anchors and the relevant approval of the chosen anchor.

$$R_d = \frac{R_k}{\gamma_M}$$

The respective approval number is given in the relevant chapter of the anchor's design tables. Actual design requirements for post-installed anchors are published in the EN 1992-4. This Design Manual uses a simplification of these norms to allow manual verifications for anchorages.

The characteristic values and partial factors of the anchors are derived by assessments of the results of tests described in EN 1992-4. This guideline requires to meet the respective criteria of its suitability tests and tests for admissible service conditions.

1.3. Base material

The Würth anchor assortment is manufactured for a range of different base materials such as lightweight and normal weight concrete, masonry and plasterboards. The anchors presented in the following chapters are for use in normal weight concrete of different strength classes. The compressive strength is an important material property for calculating the load transmitting capacity. It is e.g. in Europe denoted by concrete strength classes which relate to the characteristic cylinder strength f_{ck} or the cube strength $f_{ck,cube}$ in accordance with EN 206. The suitable strength class for each individual anchor is given in the relative European Technical Assessment (ETA).

Table 1 shows the different concrete strength classes according to EN 206.

Table 1: Concrete strength classes

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders of 150 mm diameter by 300 mm height at 28 days	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cubes of 150 mm side length at 28 days	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60

1.4. Partial safety factors

Table 2: Partial safety factors for post-installed fasteners according to EN 1992-4

Failure modes	**Partial factor**		
		Permanent and transient design situations	**Accidental design situation**
Steel failure - fasteners			
Tension	γ_{Ms}	$= 1.2 \cdot f_{uk}/f_{yk} \geq 1.4$	$= 1.05 \cdot f_{uk}/f_{yk} \geq 1.25$
Shear with and without level arm	γ_{Ms}	$= 1.0 \cdot f_{uk}/f_{yk} \geq 1.25$ when $f_{uk} \leq 800$ N/mm² and $f_{yk}/f_{uk} \leq 0.8$	$= 1.0 \cdot f_{uk}/f_{yk} \geq 1.25$ when $f_{uk} \leq 800$ N/mm² and $f_{yk}/f_{uk} \leq 0.8$
		$= 1.5$ when $f_{uk} > 800$ N/mm² or $f_{yk}/f_{uk} > 0.8$	$= 1.3$ when $f_{uk} > 800$ N/mm² or $f_{yk}/f_{uk} > 0.8$
Steel failure – supplementary reinforcement			
Tension	$\gamma_{Ms,re}$	= 1.15 [a]	= 1.0
Concrete related failure			
Concrete cone failure, concrete edge failure, concrete blow-out failure, concrete pry-out failure	γ_{Mc}	$= \gamma_c \cdot \gamma_{inst}$	$= \gamma_c \cdot \gamma_{inst}$
	γ_c	= 1.5 [a]	= 1.2 [a]
	γ_{inst}	≥ 1.0 for post-installed fasteners in tension, see relevant ETA	
		= 1.0 for post-installed fasteners in shear	
Concrete splitting failure	γ_{Msp}	$= \gamma_{Mc}$	
Pull-out and combined pull-out and concrete failure	γ_{Mp}	$= \gamma_{Mc}$	

[a] The values are in accordance with EN 1992-1-1. For seismic repair and strengthening of existing structures see EN 1998.

1.5. Würth simplified anchor design method

The Würth Simplified Anchor Design Method is based on the design concept of the EN 1992-4 and offers the engineer a convenient way of verifying the load capacity of a Würth anchor.

1.6. Failure modes

The following failure modes are considered:

Failure in Tension Loading
1. Steel failure
2. Concrete cone failure
3. Pull-out failure
4. Combined pull-out and concrete failure of bonded fasteners
5. Concrete splitting failure
Failure in Shear Loading
1. Steel failure without lever arm
2. Steel failure with lever arm
3. Concrete pry-out failure
4. Concrete edge failure

When both tension and shear are present, interaction effects are also considered. With above verifications and the interaction effects, it is sufficiently proven that the anchorage is able to transmit the acting loads into the concrete member.
Post-installed anchors do not always substitute e.g. falsely placed cast-in steel elements for which the load transmitting concrete member was already structurally verified.
In many cases, post-installed anchors are used to add attachments in order to refurbish even new construction as well as for repair and strengthening work. Therefore, it is strongly recommended to verify if the concrete member is able to transmit the additional concentrated loads.

1.6.1. Failure due to tension loading

1.6.1.1. Steel failure

Steel failure of a fastener in tension loading occurs when the tension load exceeds the characteristic steel resistance of the fastener. The resistance is directly proportional to the governing cross sectional area of the fastener and the ultimate steel strength f_{uk}. The characteristic resistance for steel failure can be found in the relevant European Technical Assessment ETA.

1.6.1.2. Concrete cone failure

Concrete cone failure occurs when the fastening system fails due to the failure of the concrete base material of the system. Concrete failure in this case takes up the shape of a conical breakout, and it is directly proportional to the effective anchorage depth of the fastener. The following is the concrete cone failure design resistance equation according to the Würth Simplified Method:

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

The figure below demonstrates a typical conical breakout in concrete:

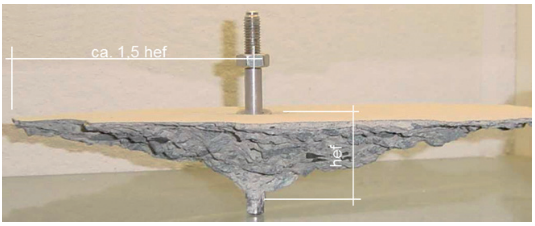


Figure 2: Concrete cone failure of a Fixanchor W-FAZ

1.6.1.3. Pull-out failure

Pull-out failure of a fastener occurs when the applied tension load exceeds the resistance induced by the expansion elements of a fastener on the wall of the drilled hole. In the case of torque-controlled expansion anchors, pull-out failure can occur when the follow-up expansion is not achieved. In case of displacement-controlled expansion anchors, this can occur when the expansion cone is not properly driven into the expansion sleeve. The following is the pull-out design resistance equation according to the Würth Simplified Method:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

1.6.1.4. Combined pull-out and concrete failure of bonded fasteners

Combined pull-out and concrete failure occurs when the tension load is higher than the resistance created by the bond between the mortar or bonding agent and the concrete. As a result of this failure, the anchor rod is pulled out from the concrete and consequently pulls out a small concrete cone in the process. The bond resistance is directly proportional to the bond strength τ_{Rk} of the selected chemical mortar. Additionally, and after the introduction of the new EN 1992-4, an additional influence factor fsus has been introduced to the combined pull-out and concrete failure of bonded fasteners to take into account long-term loading and creep effects on the bonded anchor. The following is the combined pull-out and concrete cone design resistance equation according to the Würth Simplified Method:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$$

1.6.1.5. Concrete splitting failure

Splitting failure occurs typically under tension loading when the fastener or group of fasteners are located near an edge or a corner and when the minimum edge distance, spacing, and concrete thickness requirements are not met. The following is the concrete splitting failure design resistance equation according to the Würth Simplified Method:

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

1.6.2. Failure due to shear loading

1.6.2.1. Steel failure with/without lever arm

When the building components are sufficiently large (edge distance, spacing, and material thickness), steel failure occurs when the loading of the fastener in shear exceeds maximum resistance capacity. Steel failure resistance values are taken from the relevant fastener ETA.

1.6.2.2. Concrete pry-out

Concrete pry-out failure usually occurs in fasteners or group of fasteners with a small embedment depth in concrete. The following is the concrete pry-out design resistance equation according to the Würth Simplified Method:

$$V_{Rd,c} = N_{Rd,c} \cdot k$$

1.6.2.3. Concrete edge failure

Concrete edge failure occurs when the fastener or group of fasteners are located near an edge or corner and loaded in the direction of the edge. The following is the concrete edge failure design resistance equation according to the Würth Simplified Method:

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

1.7. Influence factors

The following is a table of the general influence factors in the design resistance equations above. Tables for specific values are found in the anchor selection chapter.

DESIGN PRINCIPLES

Table 3: Influence factors

Factor	Description
f_b	Influence of concrete strength
f_{sx}, f_{sy}	Influence of spacing
f_{cx}, f_{cy}	Influence of edge distances
f_h	Influence of concrete member thickness
f_{hef}	Influence of the effective anchorage depth
f_a	Influence of load direction on edge resistance
f_{sus}	Influence of sustained loads for bonded anchors

1.8. Required verifications

1.8.1. In tension

Table 4: Required verifications for post-installed fasteners in tension

	Failure mode	Single fastener	Group of fasteners	
			Most loaded fastener	Group
1	Steel failure of fastener	$N_{Ed} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms}}$	$N_{Ed}^h \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms}}$	
2	Concrete cone failure	$N_{Ed} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{Mc}}$		$N_{Ed}^g \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{Mc}}$
3	Pull-out failure of fastener [a]	$N_{Ed} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}}$	$N_{Ed}^h \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}}$	
4	Combined pull-out and concrete failure [b]	$N_{Ed} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}}$		$N_{Ed}^g \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}}$
5	Concrete splitting failure	$N_{Ed} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{Msp}}$		$N_{Ed}^g \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{Msp}}$

[a] Not required for post-installed bonded fasteners

[b] Not required for post-installed mechanical fasteners

1.8.2. In shear

Table 5: Required verifications for post-installed fasteners in shear

	Failure mode	Single fastener	Group of fasteners	
			Most loaded fastener	Group
1	Steel failure of fastener without lever arm	$V_{Ed} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{Ms}}$	$V_{Ed}^{h} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{Ms}}$	
2	Steel failure of fastener with lever arm	$V_{Ed} \leq V_{Rd,s,M} = \frac{N_{Rk,s,M}}{\gamma_{Ms}}$	$V_{Ed}^{h} \leq V_{Rd,s,M} = \frac{N_{Rk,s,M}}{\gamma_{Ms}}$	
3	Concrete pry-out failure	$V_{Ed} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{Mc}}$		$V_{Ed}^{g} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{Mc}}$
4	Concrete edge failure	$V_{Ed} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{Mc}}$		$V_{Ed}^{g} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{Mc}}$

1.8.3. Combined tension and shear loading

In the new EN 1992-4, combined tension and shear are separately evaluated for steel and concrete. This gives the designer a better and more accurate estimation of the interaction effects on the materials.

Table 6: Required verifications for post-installed fasteners without supplementary reinforcement subjected to a combined tension and shear load

	Failure mode	Verification
1	Steel failure of fastener [a]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[a] This verification is not required in case of shear load with lever arm

DESIGN PRINCIPLES

1.9. Geometry of anchorage

When installing post-installed anchors, the consideration of geometrical constraints is very important. The thickness of the concrete member in which the anchor has to be post-installed to later decides how deep the installer can drill a hole into the concrete, and finally the maximum effective anchorage depth of the anchor. As the anchor's pull-out resistance depends on the effective anchorage depth, the thickness of the concrete member determines the maximum load which can be transferred in almost all cases. On the other hand, the projecting length of the anchor has to be selected in order to cover tolerances of the construction and the thickness of the attachment itself.

1.9.1. The effective anchorage depth

The effective anchorage depth h_{ef} is one of the most important dimensions as it determines the so called concrete capacity of each anchor.

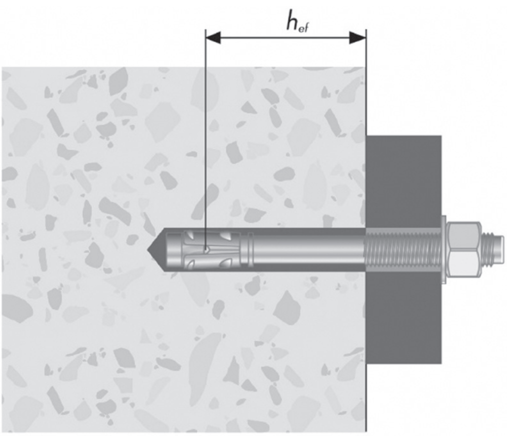


Figure 3: Effective anchorage depth of fastener

Advanced anchors normally generate concrete cone failure as this failure is the limit of each post-installed fastening system. The concrete cone failure depends on the compressive strength of concrete and on the anchorage depth h_{ef}:

$$N^0_{Rk,c} = k_1 \cdot \sqrt{f_{ck}} \cdot h^{1.5}$$

With $k_9 = k_{cr,N} = 7.7$ for cracked concrete and $k_9 = k_{ucr,N} = 11$ for verified non-cracked concrete

The engineer is responsible to verify if the acting tensile load is smaller than the concrete cone capacity of the anchor. From a structural design point of view, the engineer has to mention the anchor's effective anchorage depth in his or her detailed drawings. Only this value guarantees that suppliers provide anchors with the respective performance.

1.9.2. Anchor diameter

The diameter is important for calculating the steel capacity due to shear loading, but gives also information on the required diameter d_0 of the drill hole in the concrete member and on the maximum clearance hole diameter d_f in the fixtures.

1.9.3. Fixture thickness

The thickness of the fixture has to be verified by the structural engineer for adequate load capacity. Minimum values can be found in the relevant product ETA. Considering the stand-off fixture below, the projecting length of the anchor rod has to cover the gap between concrete surface and anchor plate, the thickness of the anchor plate itself and in addition have to exceed the anchor plate by the thickness of washer and nut.

Figure 4: Column fixing with stand-off fixture

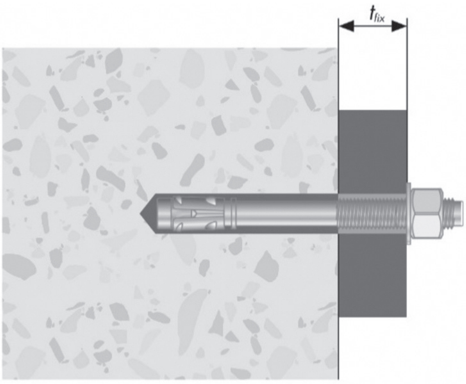


Figure 5: Fixture thickness

The maximum fixture thickness t_{fix} which represents the maximum useful length is difficult to decide during the designing stage, because the real conditions on building site differ mostly from the drawings. Most suppliers provide anchors with a wide range of useful lengths at same effective anchorage depth. This allows the installer to select a proper anchor in agreement with the responsible structural engineer.

1.9.4. Anchor length

The anchor length l depends on the effective anchorage depth and the useable length. In general, the anchor is longer than the sum of both, because it should consider additional length for the washer and nut. For safety reasons, the anchor should project at least one pitch of the threaded bolt. On the other hand, that part which exceeds the effective anchorage depth depends on the manufacturers developing ability to provide economic fastening systems.

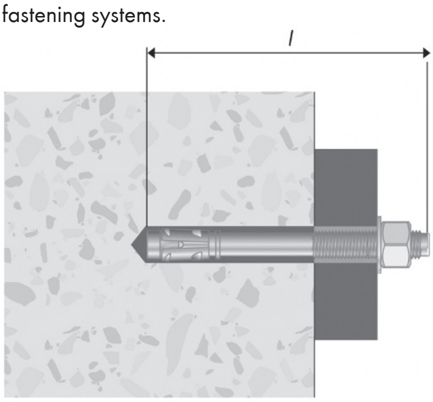


Figure 6: Anchor length

1.9.5. Concrete member thickness and the drill hole depth

The drill hole depth depends on the type of anchor. Figure 7 below shows the depth of the drill hole h_1 in case of a through fixing. This means that the anchor is installed through the bracket into the concrete. The sufficient depth of the drill hole is important to generate the correct functioning of the anchors in order to achieve the designed performance on the one hand, but on the other hand it determines the minimum concrete member thickness.

According to guidelines, the minimum component thickness in which anchors are installed is $h \geq 80$ mm.

If the thickness of the concrete member is smaller than required above, then the resistance can be reduced because of a premature splitting failure or a reduction of the shear resistance for anchorages at the edge. Furthermore, the minimum values for edge distance and spacing might not be sufficient because a splitting failure can occur during installation. Therefore, a smaller thickness of the concrete member is allowed only if the above-mentioned effects are taken into account in the design and installation of the anchorage.
The minimum member thickness is given in the relevant product European Technical Approval.

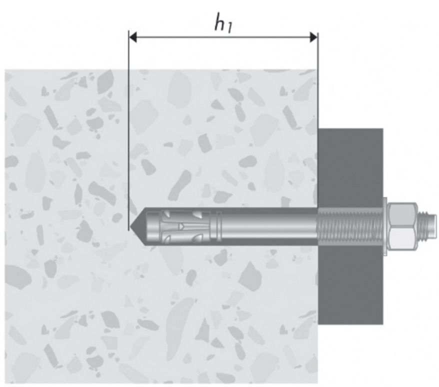


Figure 7: Drill-hole depth

DESIGN PRINCIPLES

DESIGN PRINCIPLES

The used symbols are listed below:

Symbol	Description
	European Technical Assessment Key document for the calculation. It contains the performance parameters of the anchor
	International Code Council ICC Evaluation Service Inc. (ICC ES) issues evaluation reports based on the Uniform Building Code and related codes in the USA and Canada.
	The anchor may also be used under seismic action according to ETA and/or ICC-ESR
	Fire resistance classification
	LEED certified The system looks at numerous factors that were divided into five categories, which relate to and include the health of humans and the environment
	VOC Emissions class label In the context of analyzing the air a group of pollutants is analyzed, which can have serious health effects on humans. The term VOC (volatile organic compounds) is grouped together, a plurality of volatile organic compounds
	NSF International The National Sanitation Foundation (NSF) is a nonprofit organization that ensures the safety of public health and environmental protection. It ensures that the materials and additives used in food, water or air are not harmful to health
	An EPD (Environmental Product Declaration) is a multipage document that serves to provide transparency to the public regarding the environmental influences of building products. It is the basis for the ecological evaluation of buildings
	For sprinkler systems

2. Seismic and accidental fire design situation

2.1. General

In many countries around the world, fire and seismic considerations are becoming increasingly important, as fire events and earthquakes are causing severe damages to buildings and a high number of casualties. Post-installed anchors have to be fit for those extraordinary events as they are incorporated in the structural and non-structural elements of a building, and are used to fix the services and essential lifelines of a building.

Post-installed anchors are assessed based on the valid European Assessment Documents (EAD). The different product behaviour of mechanical, bonded and concrete screw anchors, is incorporated in their specifically related EADs. This relates also to the tests for the assessment of the product behaviour under accidental loads. In this Design Manual, we give information based on the European guidelines. Information based on American guidelines would be equivalent. Only post-installed anchors that are qualified for cracked concrete and seismic applications are considered in this chapter.

Chapter 9 of the EN 1992-4 provides the requirements for the design of post-installed fasteners under seismic actions. Annex C of the same code provides more detailed information on the design method and requirements. The design explanations of part 2.5 of this chapter are primarily based on the EN 1992-4 and its annexes.

A manufacturer of post-installed anchors is not responsible for the structural verifications of an anchorage, but should provide information about the relevant and related topics to design and establish safe anchorage. Therefore, and as we consider the topic about combination of actions important, we start here with a short summary.

2.2. Design values of actions

The design concept and the required verification considering a limit state of rupture or excessive deformation based on EN 1990 clause 6.4 was briefly explained in our previous chapter. This chapter elaborates on the combinations of actions as a matter of principle. It is assumed that the structural engineer will detail particular verifications with the relevant National Standard.

2.2.1. Combinations of actions for persistent or transient design situations (fundamental combinations)

For each critical load case, the design values of the effects of actions E_d shall be determined by combining the values of actions that are considered to occur simultaneously.

$$E_d = \sum_{j\geq 1} \gamma_{G,j}\, G_{k,j} + \gamma_{Q,1} Q_{k,1} + \sum_{i>1} \gamma_{Q,i}\, \psi_{o,i} Q_{k,i}$$

Effects of actions that cannot exist simultaneously due to physical or functional reasons should not be considered together in combinations of actions. Depending on its uses and the form and the location of a building, the combinations of actions may be based on not more than two variable actions.

The combination factors ψ are given in Annexes of EN 1990.

Table 1: $\gamma_{G,j}$ & $\gamma_{Q,1}$ factors for permanent and variable actions

Persistent and transient design situations	Permanent action	Variable action
favourable	$\gamma_{G,j} = 1.00$	$\gamma_{Q,1} = \gamma_{Q,i} = 0$
unfavourable	$\gamma_{G,j} = 1.35$	$\gamma_{Q,1} = \gamma_{Q,i} = 1.50$

2.2.2. Combinations of actions for accidental design situations

Combinations of actions for accidental design situations should either involve an explicit accidental action A_d (fire or impact), or refer to a situation after an accidental event ($A_d = 0$).

$$E_d = \sum_{j\geq 1} G_{k,j} + A_d + \psi_{1,1} Q_{k,1} + \sum_{i>1} \psi_{2,i} Q_{k,i}.$$

2.2.3. Combinations of actions for seismic design situations

$$E_d = \sum_{j\geq1} G_{k,j} + P_{Ed} + \sum_{i>1} \psi_{2,i} Q_{k,i}.$$

2.3. Structural verifications under seismic design situations and design values of the anchor resistances for the respective failure modes

Anchors are assessed for their seismic performance characteristics according to the product relevant EAD. Only anchors, which proved their suitability for the use in cracked concrete, are accepted and qualified in seismic performance categories C1 and/or C2.

The two seismic performance categories C1/C2 are distinguished by the stringency of the tests, with C2 qualification being the more demanding. The recommended use of the C1/C2 is given in the EN 1992-4.

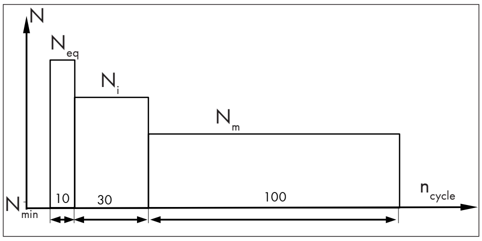
The performance category C1 provides fastener capacities in terms of strength (forces), while C2 in terms of both strength (forces) and displacements. Both cases take into consideration concrete cracking. In the case of C1, the maximum crack width is taken as $\triangle w = 0.5$ mm and in C2 as $\triangle w = 0.8$ mm. For C2, the performance is assessed with a test where cracks open and close (see figure 5) in addition.

The following table provides the reader with the qualification tests for each performance category:

Table 2: Seismic Qualification Tests of Fasteners

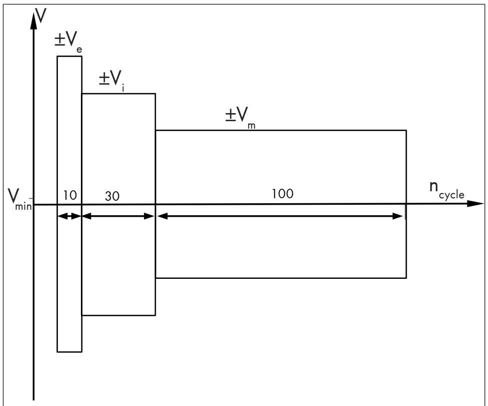
C1 Category	C2 Category
1. Pulsating tension load 2. Alternating shear loads	1 Tests up to failure 2. Pulsating tension load 3. Alternating shear load 4. Crack cycling

2.3.1. Qualification of anchors for category C1



N_{eq} = $0.5 \cdot N_{u,m,ref}$
N_i = $0.375 \cdot N_{u,m,ref}$
N_m = $0.25 \cdot N_{u,m,ref}$
$N_{u,m,ref}$ = normalized mean tension capacity for C20/25, $\Delta w = 0.5$mm

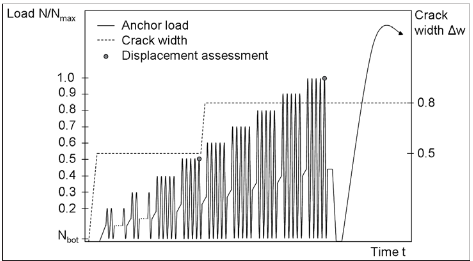
Figure 1: Tests under pulsating tension load



V_{eq} = $0.5 \cdot V_{u,m,ref}$
V_i = $0.375 \cdot V_{u,m,ref}$
V_m = $0.25 \cdot V_{u,m,ref}$
$V_{u,m,ref}$ = normalized mean shear capacity for C20/25, $\Delta w = 0.5$mm

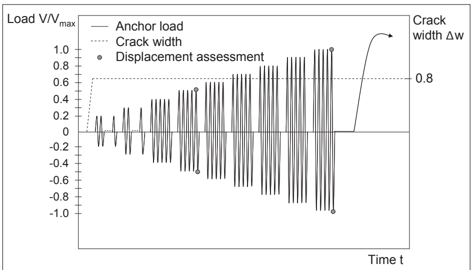
Figure 2: Tests under alternating shear load

2.3.2. Qualification of anchors for category C2



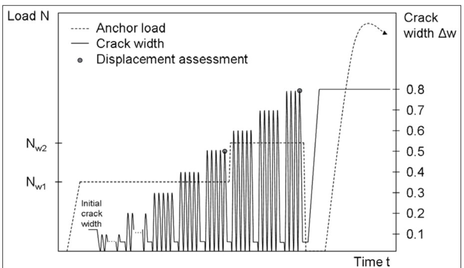
N_{max} = $0.75 \cdot N_{u,m,ref}$
$N_{u,m,ref}$ = normalized mean tension capacity for C20/25, $\Delta w = 0.8mm$

Figure 3: Tests under pulsating tension load



V_{max} = $0.85 \cdot V_{u,m,ref}$
$V_{u,m,ref}$ = normalized mean shear capacity for C20/25, $\Delta w = 0.8mm$

Figure 4: Tests under alternating shear load



N_{w1} = $0.4 \cdot N_{u,m,ref}$
N_{w2} = $0.5 \cdot N_{u,m,ref}$
$N_{u,m,ref}$ = normalized mean shear capacity for C20/25, $\Delta w = 0.8mm$

Figure 5: Tests under crack cycling

2.4. Recommended seismic performance categories for anchors

The seismic performance of anchors subjected to seismic loading is categorized by the performance categories C1 and C2. Seismic performance category C1 provides anchor capacities only in terms of resistances at ultimate limit state, while seismic performance category C2 provides anchor capacities in terms of both resistances at ultimate limit state and displacements at damage limitation state and ultimate limit state. The following tables relate to the seismic performance categories C1 and C2 to the seismicity level and building importance class. The level of seismicity is defined as a function of the product $a_g \cdot S$, where a_g is the design ground acceleration on Type A ground and S the soil factor both in accordance with EN 1998-1.

Table 3: Importance classes for buildings

Importance class	Buildings
I	Buildings of minor importance for public safety, e.g. agricultural buildings, etc.
II	Ordinary buildings, not belonging in the other categories.
III	Buildings whose seismic resistance is of importance in view of the consequences associated with a collapse, e.g. schools, assembly halls, cultural institutions etc.
IV	Buildings whose integrity during earthquakes is of vital importance for civil protection, e.g. hospitals, fire stations, power plants, etc.

Note: Importance classes I, II, III or IV correspond roughly to consequences classes CC1, CC2, CC3, respectively, defined in EN 1990:2002, Annex B.

2.5. Connections between structural elements of primary and/or secondary seismic members

Table 4: Recommended seismic performance categories for fasteners

	Seismicity level [a]		Importance class acc. to EN 1998-1:2004, 4.2.5			
1	Class	$a_{g.}S^{c}$	I	II	III	IV
2	Very low [b]	$a_{g.}S \leq 0.05$ g	No seismic performance category required			
3	low [b]	0.05 g $< a_{g.}S \leq 0.1$ g	C1	C1[d] or C2[e]		C2
4	> low	$a_{g.}S > 0.1$ g	C1	C2		

[a] The values defining the seismicity levels are subject to a National Annex. The recommended values are given here.
[b] Definition according to EN 1998-1:2004. 3.2.1.
[c] a_g = design ground acceleration on type A ground (see EN 1998-1:2004, 3.2.1),
S = soil factor (see EN 1998-1:2004, 3.2.2).
[d] C1 for fixing non-structural elements to structures
[e] C2 for fixing structural elements to structures

2.6. Design options and criteria

In the design of fastenings one of the following options shall be satisfied:

a1) Capacity design
a2) Elastic design
b) Design with requirements on the ductility of the anchors

2.6.1. Design without requirements on the ductility of the anchors.

It shall be assumed that anchors are non-dissipative elements and they are not able to dissipate energy by means of ductile hysteretic behaviour and that they do not contribute to the overall ductile behaviour of the structure.

a1) Capacity design

The anchor or group of anchors is designed for the maximum tension and/or shear load that can be transmitted to the fastening based on either the development of a ductile yield mechanism in the fixture or the attached element taking into account strain hardening and material over-strength or the capacity of a non-yielding attached element. For both connections between structural elements of primary and/or secondary seismic members and attachments of non-structural elements, the fastening is designed for the maximum load that can be transmitted to the fastening based either on the development of a ductile yield mechanism in the attached steel component (see Figure 6) or in the steel base plate (see Figure 7) taking into account material over-strength effects, or on the capacity of a non-yielding attached component or structural element (see Figure 8). The assumption of a plastic hinge in the fixture (Figure 7) requires to take into account specific aspects including e.g. the redistribution of loads to the individual anchors of a group, the redistribution of the loads in the structure and the low cycle fatigue behaviour of the fixture.

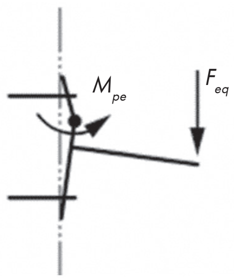


Figure 6: Yielding in attached element

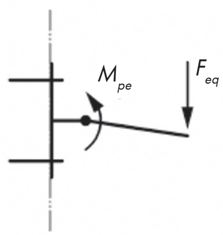


Figure 7: Yielding in baseplate

SEISMIC AND FIRE CONSIDERATIONS

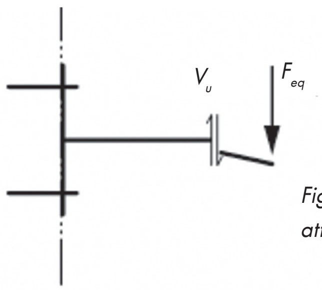


Figure 8: Capacity of attached element

a2) Elastic design

The fastening is designed for the maximum load obtained from the design load combinations that include seismic actions $A_{E,d}$ corresponding to the ultimate limit state (EN 1998-1) assuming an elastic behaviour of the fastening and of the structure. Furthermore uncertainties in the model to derive seismic actions on the fastening shall be taken into account.

The action effects for connections between structural elements of primary and/or secondary seismic members shall be derived according to EN 1998-1 with a behaviour factor q = 1.0.

For attachments of non-structural elements the action effects shall be derived with a behaviour factor q_a = 1.0 for the attached element.

If action effects are derived in accordance with the simplified approach given in EN 1998-1:2004, 4.3.5, those types with a behaviour factor q_a = 1.0 shall be multiplied by an amplification factor equal to 1.5. If the action effects are derived from a more precise model this further amplification may be omitted.

In the design of fastenings for non-structural elements subjected to seismic actions, any beneficial effects of friction due to gravity loads should be ignored.

The horizontal effects of the seismic action of non-structural elements are determined according to Equation (4.24) of EN 1998-1.

$$F_a = \frac{S_a \cdot W_a \cdot \gamma_a}{q_a}$$

F_a = horizontal seismic force, acting at the centre of mass of the non-structural element in the most unfavourable direction,
W_a = weight of the element,
S_a = seismic coefficient pertinent to non-structural elements,
γ_a = importance factor of the element.
For the following non-structural elements the importance factor γa shall not be chosen less than 1.5:
- Anchorage of machinery and equipment required for life safety systems.
- Tanks and vessels containing toxic or explosive substances considered to be hazardous to the safety of the general public.

In all other cases the importance factor γ_a of a non-structural element may be assumed γ_a = 1.0.
q_a = behaviour factor of the element

The seismic coefficient may be calculated as follows:

$$S_a = \alpha \cdot S \cdot \left[\left(1 + \frac{z}{H}\right) \cdot A_a - 0.5\right]$$

α = ratio of the design ground acceleration on type A ground, a_g, to the acceleration of gravity g,
S = soil factor,
A_a = Amplification factor

$$A_a = \frac{3}{(1 + (1 - T_a/T_1)^2)}$$

or taken from Table below if one of the fundamental vibration periods is not known,
T_a = fundamental vibration period of the non-structural element,
T_1 = fundamental vibration period of the building in the relevant direction,
z = height of the non-structural element above the level of application of the seismic action,
H = height of the building from the foundation or from the top of a rigid basement.

The behaviour factor q_a and seismic amplification factor A_a may be taken from the following table:

Table 5: behaviour factor q_a and seismic amplification factor A_a

Type of non-structural element	q_a	A_a
Cantilevering parapets or ornamentations	1.0	3.0
Signs and billboards		3.0
Chimneys, masts and tanks on legs acting as unbraced cantilevers along more than one half of their total height		3.0
Hazardous material storage, hazardous fluid piping		3.0
Exterior and interior walls	2.0	1.5
Partitions and facades		1.5
Chimneys, masts and tanks on legs acting as unbraced cantilevers along less than one half of their total height, or braced or guyed to the structure at or above their centre of mass		1.5
Elevators		1.5
Computer access floors, electrical and communication equipment		3.0
Conveyors		3.0
Anchorage elements for permanent cabinets and book stacks supported by the floor		1.5
Anchorage elements for false (suspended) ceilings and light fixtures		1.5
High pressure piping, fire suppression piping		3.0
Fluid piping for non-hazardous materials		3.0
Computer, communication and storage racks		3.0

b) Design with requirements on the ductility of the anchors.

The anchor or group of anchors is designed for the design actions including the seismic actions $A_{E,d}$ corresponding to the ultimate limit state (EN 1998-1). The tension steel capacity of the fastening shall be smaller than the tension capacity governed by concrete related failure modes. Sufficient elongation capacity of the anchors is required. The fastening shall not be accounted for energy dissipation in the global structural analysis or in the analysis of a non-structural element unless proper justification is provided by a non-linear time history (dynamic) analysis (according to EN 1998-1) and the hysteretic behaviour of the anchor is provided by an ETA. This approach is applicable only for the tension component of the load acting on the anchor.

Note: Option b) may not be suitable for the fastening of primary seismic members (EN 1998-1) due to the possible large non-recoverable displacements of the anchor that may be expected. It is recommended to use option b) for the fastening of secondary seismic members. Furthermore, unless shear loads acting on the fastening are resisted by additional means, additional anchors should be provided and designed in accordance with option a1) or a2).

- Only valid for anchor of seismic category C2,
- Anchor needs to comply with a list of requirements that to ensure ductility (e.g. stretch length of 8d),
- Recommended for secondary seismic members and non-structural attachments, may not be suitable for primary seismic members (considering possibly large non-recoverable displacements of the anchor),
- In order to ensure the steel failure, additional checks must be done (comparison between the concrete and steel resistance).

SEISMIC AND FIRE CONSIDERATIONS

2.6.3. Vertical effects

For the design of the anchors in connections between structural elements of primary and/or secondary seismic members the vertical component of the seismic action shall be taken into account according to EN 1998-1, Section 4.3.3.5.2 (2) to (4) if the vertical design ground acceleration a_{vg} is greater than 2.5 m/s^2.

The vertical effects of the seismic action F_{va} for non-structural elements may be neglected for the fastener when the vertical component of the design ground acceleration a_{vg} is less than 2.5 m/s^2 and the gravity loads are transferred through direct bearing of the fixture on the structure. The determination of the vertical seismic action effects of non-structural elements for use in a Country may be found in its National Annex to this EN. The recommended rule is the application of the formula:

$$F_{Va} = \frac{S_{Va} \cdot W_a \cdot \gamma_a}{q_a}$$

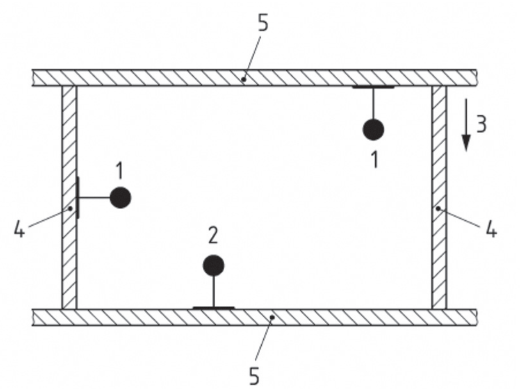


Figure 9: Vertical effects of the seismic action - Example

Key
1 include F_{Va}
2 neglect F_{Va} if $a_{Vg} \leq 2.5$ m / s^2
3 gravity force
4 wall
5 ceiling or floor

2.7. Resistances and required verifications

2.7.1. General provisions

- Limited to the anchor configurations of EN 1992-4
- Stand-off installations (grouted or not) are out of scope
- If the seismic contribution to the design load combination is ≤ 20% no explicit seismic design is needed. However, a seismic approved anchor is still required
- Cracked concrete must be considered unless proven otherwise
- The maximum value of each action effect (tension and shear component of forces for an anchor) shall be considered to act simultaneously if no other more accurate model is used for the estimation of the probable simultaneous value of each action effect
- An annular gap between an anchor and its fixture should be avoided in seismic design situations. For fastenings of non-structural elements in minor non-critical applications an annular gap (diameter d_f) of the clearance hole in the fixture not larger than the value given in EN 1992-4 is allowed. The effect of the annular gap on the behaviour of fastenings shall be taken into account
- Loosening of the nut or screw shall be prevented by appropriate measures

2.7.2. Required verifications

Table 6: Required verifications

	Failure mode	Single anchor	Anchor group	
			most loaded	anchor group
Tension	Steel failure	$N_{Sd,seis} \le N_{Rd,s,seis}$	$N^h_{Sd,seis} \le N^h_{Rd,s,seis}$	
	Pull-out failure	$N_{Sd,seis} \le N_{Rd,p,seis}$	$N^h_{Sd,seis} \le N^h_{Rd,p,seis}$	
	Combined pull-out and concrete failure[1)]	$N_{Sd,seis} \le N_{Rd,p,seis}$		$N^g_{Sd,seis} \le N^g_{Rd,p,seis}$
	Concrete cone failure	$N_{Sd,seis} \le N_{Rd,c,seis}$		$N^g_{Sd,seis} \le N^g_{Rd,c,seis}$
	Splitting [3)]	$N_{Sd,seis} \le N_{Rd,sp,seis}$		$N^g_{Sd,seis} \le N^g_{Rd,sp,seis}$
Shear	Steel failure, shear load without lever arm[2)]	$V_{Sd,seis} \le V_{Rd,s,seis}$	$V^h_{Sd,seis} \le V^h_{Rd,s,seis}$	
	Concrete pry-out failure	$V_{Sd,seis} \le V_{Rd,cp,seis}$		$V^g_{Sd,seis} \le V^g_{Rd,cp,seis}$
	Concrete edge failure	$V_{Sd,seis} \le V_{Rd,c,seis}$		$V^g_{Sd,seis} \le V^g_{Rd,c,seis}$

[1)] Verificaton for bonded anchors only.
[2)] Steel failure for shear loads with lever arm is not covered.
[3)] Verification is not required if cracked concrete is assumed and reinforcement resists the splitting forces.

2.7.3. Design Resistance

The seismic design resistance $R_{d,seis}$ ($N_{Rd,seis}$, $V_{Rd,seis}$) of a fastening is given by:

$$R_{d,seis} = \frac{R_{k,seis}}{\gamma_{M,seis}}$$

The characteristic seismic resistance $R_{k,seis}$ ($N_{Rk,seis}$, $V_{Rk,seis}$) of a fastening shall be calculated for each failure mode

$$R_{k,seis} = \alpha_{gap} \cdot \alpha_{seis} \cdot R^0_{k,seis}$$

where

a_{gap} = reduction factor to take into account inertia effects due to an annular gap between anchor and fixture in case of shear loading; given in the relevant ETA;

Note: The forces on the anchors are amplified in presence an annular gap under shear loading due to a hammer effect on the anchor. For reasons of simplicity this effect is considered only in the resistance of the fastening. In absence of information in the ETA the following values a_{gap} may be used. These values are based on a limited number of tests.

a_{gap} = 1.0 in case of no hole clearance between anchor and fixture;
= 0.5 in case of connections with hole clearance according to the following table

SEISMIC AND FIRE CONSIDERATIONS

External diameter d or d_{nom} [1]	[mm]	6	8	10	12	14	16	18	20	22	24	27	30
Diameter d_f of clearance hole in fixture	[mm]	7	9	12	14	16	18	20	22	24	26	30	33

[1] diameter *d* if bolt bears against fixture; diameter d_{nom} if sleeve bears against the fixture

a_{seis} = reduction factor to take into account the influence of large cracks and scatter of load displacement curves, see the following table

Table 7: Reduction factor a_{eq}

Loading	Failure mode	Single fastener[1]	Fastener group
Tension	Steel failure	1.00	1.00
	Concrete cone failure	0.85	0.75
	Pull-out failure	1.00	0.85
	Combined pull-out and concrete cone failure (bonded fastener)	1.00	0.85
	Concrete splitting failure	1.00	0.85
	Concrete blow-out failure	1.00	0.85
Shear	Steel failure	1.00	0.85
	Concrete pry-out failure	0.85	0.75
	Concrete edge failure	1.00	0.85

[1] This also applies where only one fastener in a group is subjected to tension load.

$R^0_{k,seis}$ = basic characteristic seismic resistance for a given failure mode determined as follows:

	Failure mode	ETA values (C1 or C2)	Calculated value as per EN 1992-4
Tension	Steel failure	$N^0_{Rk,s,seis}$ | $\gamma_{Ms,seis}$	
	Pull-out failure	$N^0_{Rk,p,seis}$ | $\gamma_{Mp,seis}$	
	Combined pull-out and concrete failure	$\tau_{Rk,seis}$ | $\gamma_{Mp,seis}$	$N^0_{Rk,p,seis}$
	Concrete cone failure	$\gamma_{Mc,seis}$	$N^0_{Rk,c,seis}$
	Splitting	$\gamma_{Msp,seis}$	$N^0_{Rk,sp,seis}$
Shear	Steel failure, shear load without lever arm	$V^0_{Rk,s,seis}$ | $\gamma_{Ms,seis}$	
	Concrete pry-out failure	$\gamma_{Mc,seis}$	$V^0_{Rk,cp,seis}$
	Concrete edge failure	$\gamma_{Mc,seis}$	$V^0_{Rk,c,seis}$

2.7.4. Displacements

The anchor displacement under tensile and shear load at damage limitation state (DLS) shall be limited to a value $\delta_{N,req(DLS)}$ and $\delta_{V,req(DLS)}$ to meet requirements regarding e.g. functionality and assumed support conditions. These values shall be selected based on the requirements of the specific application. When assuming a rigid support in the analysis the designer shall establish the limiting displacement compatible to the requirement for the structural behaviour.

Note: *In a number of cases, the acceptable displacement associated to a rigid support condition is considered to be in the range of 3 mm.*

If deformations (displacements or rotations) are relevant for the design of the connection (such as, for example, on secondary seismic members or façade elements) it shall be demonstrated that these deformations can be accommodated by the anchors.

If the anchor displacements $\delta_{N,Seis(DLS)}$ under tension loading and/or $\delta_{V,Seis(DLS)}$ under shear loading provided in the relevant ETA (for anchors qualified for seismic performance category C2) are higher than the corresponding required values $\delta_{N,req(DLS)}$ and/or $\delta_{V,req(DLS)}$, the design resistance may be reduced according to Equations (5.11) and (5.12) to meet the required displacement limits.

$$N_{Rd,seis,reduced} = N_{Rd,seis} \cdot \frac{\delta_{N,req(DLS)}}{\delta_{N,seis(DLS)}}$$

$$V_{Rd,seis,reduced} = V_{Rd,seis} \cdot \frac{\delta_{V,req(DLS)}}{\delta_{V,seis(DLS)}}$$

If fastenings and attached elements shall be operational after an earthquake the relevant displacements have to be taken into account.

Combined Tension and Shear

Table 8: Required verifications for post-installed fasteners without supplementary reinforcement subjected to a combined tension and shear load

	Failure mode	Verification
1	**Steel failure of fastener** [a]	$\left(\frac{N_{Ed}}{N_{Rd,seis}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd,seis}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	**Failure modes other than steel failure**	$\left(\frac{N_{Ed}}{N_{Rd,i,seis}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i,seis}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i,seis}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i,seis}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[a] This verification is not required in case of shear load with lever arm

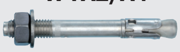
SEISMIC AND FIRE CONSIDERATIONS

Injection anchors

Anchor type	Size	Performance	
		C1	C2
WIT-VIZ S	M8		
	M10	✓	✓
	M12	✓	✓
	M16	✓	✓
	M20	✓	✓
	M24	✓	✓
WIT-VIZ A4	M8		
	M10	✓	✓
	M12	✓	✓
	M16	✓	✓
	M20	✓	✓
	M24	✓	✓
WIT-UH 300 M	M8	✓	
	M10	✓	
	M12	✓	✓
	M16	✓	✓
	M20	✓	✓
	M24	✓	✓
	M27	✓	
	M30	✓	
WIT-UH 300 R	Ø8	✓	
	Ø10	✓	
	Ø12	✓	
	Ø14	✓	
	Ø16	✓	
	Ø20	✓	
	Ø24	✓	
	Ø25	✓	
	Ø28	✓	
	Ø32	✓	

Anchor type	Size	Performance	
		C1	C2
WIT-PE 1000 M	M8	✓	
	M10	✓	
	M12	✓	✓
	M16	✓	✓
	M20	✓	✓
	M24	✓	✓
	M27	✓	
	M30	✓	
WIT-PE 1000 R	Ø8	✓	
	Ø10	✓	
	Ø12	✓	
	Ø14	✓	
	Ø16	✓	
	Ø20	✓	
	Ø24	✓	
	Ø25	✓	
	Ø28	✓	
	Ø32	✓	
WIT-VM 250 M	M8	✓	
	M10	✓	
	M12	✓	
	M16	✓	
	M20	✓	
	M24	✓	
	M27	✓	
	M30	✓	
WIT-VM 250 R	Ø8	✓	
	Ø10	✓	
	Ø12	✓	
	Ø14	✓	
	Ø16	✓	
	Ø20	✓	
	Ø25	✓	
	Ø28	✓	
	Ø32	✓	

Mechanical anchors

Anchor type	Size	Standard Effective anchorage depth (mm)	Performance	
			C1	C2
W-BS 	Ø6	55	✓	✓ 1)
	Ø8	65	✓	✓ 1)
	Ø10	85	✓	✓ 1)
	Ø12	100	✓	✓ 1)
	Ø14	115	✓	✓ 1)
W-FAZ/S 	M8	46	✓	✓
	M10	60	✓	✓
	M12	70	✓	✓
	M16	85	✓	✓
	M20	100	✓	✓
	M24	115		
	M27	125		
W-FAZ/A4 	M8	46	✓	✓
	M10	60	✓	✓
	M12	70	✓	✓
	M16	85	✓	✓
	M20	100	✓	✓
	M24	125		
W-HAZ/S 	10/M6	76	✓	✓
	12/M8	100	✓	✓
	15/M10	110	✓	✓
	18/M12	130	✓ 2)	✓ 2)
	24/M16	114	✓ 2)	✓ 2)
	24/M16L	150	✓ 2)	✓ 2)
	28/M20	185	✓ 2)	✓ 2)
	32/M24	210	✓ 2)	✓ 2)
W-HAZ/A4 	12/M8	100	✓	✓
	15/M10	110	✓	✓
	18/M12	130	✓	✓
	24/M16	150	✓ 2)	✓ 2)

1) Only for the galvanized version. C2 is not suitable for A4 and HCR

2) Not suitable for W-HAZ-SK

SEISMIC AND FIRE CONSIDERATIONS

2.8. Structural verifications under fire exposure and design values of the anchor resistances for the respective failure modes

In general, the duration of the fire resistance of anchorages depends mainly on the configuration of the structure itself (base materials, anchorage including the fixture). It is not possible to classify an anchor for its fire resistance. This evaluation concept includes the behaviour of the anchorage in concrete and the parts outside the concrete. The influence of the fixation is considered unfavourable.

The following information is for anchorages in normal weight concrete with a compressive strength of at least C 20/25 and at most C 50/60 used for normal structures under fire exposure. The determination of the duration of the fire resistance is according to the conditions given in EN 13501-2 using the "Standard ISO time-temperature Curve" (STC). This evaluation can be used as a basis for including a fire resistance class in European Technical Approvals (ETA) for metal anchors for use in cracked concrete. The base material (reinforced concrete), in which the anchor shall be anchored, shall have at least the same duration of fire resistance as the anchorage itself.

Local spalling is possible at fire attack. To avoid any influence of the spalling on the anchorage, the concrete member must be designed according to EN 1992-1-2. The members shall be made of concrete with quartzite additives and have to be protected from direct moisture; and the moisture content of the concrete has to be like in dry internal conditions respectively. The anchorage depth has to be increased for wet concrete by at least 30 mm compared to the given value in the approval.

2.8.1. Design concepts

When using the **Simplified design concept** for all load directions and failure modes the limit values must be observed (characteristic resistance in ultimate limit state under fire exposure $F_{Rk,fi(t)}$), which were developed by general test series and are on the safe side. Tests with fire exposure are not necessary when using the simplified design concept.

When using the **Experimental determination** for all load directions and failure modes the required investigations are given. The duration of fire resistance of the anchor can be determined from the results.

A combination of the design concepts is possible. For example: the duration of the fire resistance for individual failure modes (e.g. steel failure) can be determined by tests and for other failure modes (e.g. pull-out and concrete failure) the limit values can be determined using the simplified design method.

	Simplified Design Concept	**Experimental Determination**
Metal anchors	✔	✔
Bonded anchors	evaluation only for steel failure (special experimental determination)	special experimental determination

It can be assumed that for fastening of facade systems, the load bearing behaviour of the specific screwed in plastic anchor with a diameter 10 mm and a metal screw with a diameter 7 mm and a h_{ef} of 50 mm and a plastic sleeve made of polyamide has a sufficient resistance to fire at least 90 minutes (R90) if the applied load (no permanent tension load) is ≤ 0.8kN.

General provisions:

- Valid for anchors with an European Technical Approval (ETA), which can be used in cracked and non-cracked concrete
- The determination covers anchors with a fire attack from one side only. If the fire attack is from more than one side, the design method may be taken only, if the edge distance of the anchor is c ≥ 300 mm and ≥ 2 h_{ef}
- The determination is valid for unprotected anchors
- The characteristic spacing and edge distance for anchorages near the edge under fire exposure are taken as follows $s_{cr,N} = 2c_{cr,N} = 4h_{ef}$

- $\gamma_{M,fi}$ = 1.0 for steel failure and concrete related failure modes under shear loading. For concrete related failure modes under tension $\gamma_{M,fi}$ = 1.0 γ_{inst}
- $N_{Rk,p}$, $N^0_{Rk,c}$, $V^0_{Rk,c}$ characteristic resistances of a single anchor in cracked concrete C20/25 for concrete cone failure under normal temperature

2.8.2. Resistance

2.8.2.1. Fire resistance capacity in tension and shear

The following table provides a summary of the resistances to fire according to the various failure modes of fasteners. The overview shows values from the simplified design concept, which should be used if no values are provided in the corresponding European Technical Product Specification. The values of the simplified design concept are considered conservative. For more details on the resistance equations, please refer to annex D of the EN 1992-4.

Table 9: Fire resistance under the different failure modes

	Failure mode	Simplified Design Concept	Experimental Determination
Tension	Steel failure	$N_{Rk,s,fi} = A_s \cdot \sigma_{Rk,s,fi}$	given in ETA
	Pull-out failure	$N_{Rk,p,fi(90)} = 0.25 \cdot N_{Rk,p}$ $N_{Rk,p,fi(120)} = 0.2 \cdot N_{Rk,p}$	given in ETA
	Concrete cone failure	$N^0_{Rk,c,fi(90)} = \frac{h_{ef}}{200} \cdot N^0_{Rk,c} \leq N^0_{Rk,c}$ $N^0_{Rk,c,fi(120)} = 0.8 \cdot \frac{h_{ef}}{200} \cdot N^0_{Rk,c} \leq N^0_{Rk,c}$	$N^0_{Rk,c,fi(90)} = \frac{h_{ef}}{200} \cdot N^0_{Rk,c} \leq N^0_{Rk,c}$ $N^0_{Rk,c,fi(120)} = 0.8 \cdot \frac{h_{ef}}{200} \cdot N^0_{Rk,c} \leq N^0_{Rk,c}$
Shear	Steel failure, shear load without lever arm	$V_{Rk,s,fi} = A_s \cdot \sigma_{Rk,s,fi}$	given in ETA
	Steel failure, shear load with lever arm	$M^0_{Rk,s,fi} = 1.2 \cdot W_{el} \cdot \sigma_{Rk,s,fi}$	given in ETA
	Concrete pry-out failure	$V^0_{Rk,cp,fi(t)} = k \cdot N^0_{Rk,c,fi(t)}$	$V^0_{Rk,cp,fi(t)} = k \cdot N^0_{Rk,c,fi(t)}$
	Concrete edge failure	$V^0_{Rk,c,fi(90)} = 0.25 \cdot V^0_{Rk,c}$ $V^0_{Rk,c,fi(120)} = 0.2 \cdot V^0_{Rk,c}$	$V^0_{Rk,c,fi(90)} = 0.25 \cdot V^0_{Rk,c}$ $V^0_{Rk,c,fi(120)} = 0.2 \cdot V^0_{Rk,c}$

SEISMIC AND FIRE CONSIDERATIONS

SEISMIC AND FIRE

Table 10: Characteristic tension strength of an unprotected anchor made of C-steel according to EN 10025 in case of fire exposure

Fastener bolt / thread diameter	Embedment depth	Characteristic tension strength			
	h_{ef}	$\sigma_{Rk,s,fi(t)}$			
mm	mm	N/mm²			
		30 min (R15 to R30)	60 min (R45 and R60)	90 min (R90)	120 min (≤ R120)
⌀ 6 / M6	≥ 30	10	9	7	5
⌀ 8 / M8	≥ 30	10	9	7	5
⌀ 10 / M10	≥ 40	15	13	10	8
≥ ⌀ 12 / M12	≥ 50	20	15	13	10

Table 11: Characteristic tension strength of an unprotected anchor made of at least steel grade A4 according to the EN ISO 3506 series in case of fire exposure

Fastener bolt / thread diameter	Embedment depth	Characteristic tension strength			
	h_{ef}	$\sigma_{Rk,s,fi}$			
mm	mm	N/mm²			
		30 min (R15 to R30)	60 min (R45 and R60)	90 min (R90)	120 min (≤ R120)
⌀ 6 / M6	≥ 30	10	9	7	5
⌀ 8 / M8	≥ 30	20	16	12	10
⌀ 10 / M10	≥ 40	25	20	16	14
≥ ⌀ 12 / M12	≥ 50	30	25	20	16

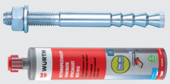
2.8.2.2. Required verifications for combined tension and shear loads

	Failure mode	Verification
1	**Steel failure of fastener** [a]	$$\left(\frac{N_{Ed}}{N_{Rd,fi}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd,fi}}\right)^2 \leq 1$$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	**Failure modes other than steel failure**	$$\left(\frac{N_{Ed}}{N_{Rd,i,fi}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i,fi}}\right)^{1.5} \leq 1$$ or $$\left(\frac{N_{Ed}}{N_{Rd,i,fi}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i,fi}}\right) \leq 1.2$$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[a] This verification is not required in case of shear load with lever arm

SEISMIC AND FIRE CONSIDERATIONS

Fire loads Bonded Anchors

Anchor type	Size	Effective anchorage depth (mm)	Max tensile loading (kN) for specified fire resistance time 1) 2)				Authority / No.
			R30	R60	R90	R120	
WIT-BS 	Ø10		4.40	3.30	2.30	1.70	Z-21.1-2075
	Ø12		7.30	5.80	4.20	3.40	
	Ø14		10.30	8.20	5.90	4.80	
WIT-VIZ S 	M8	50	1.04	0.47	-	-	MFPA Leipzig Nr. GS 3.2/ 18-075-1
	M10	60	2.50	1.45	0.39	-	
	M12	80	5.80	3.80	1.81	0.81	
	M16	125	7.62	5.81	4.01	3.11	
	M20	170	13.02	9.75	6.48	4.84	
	M24	170	13.02	9.75	6.48	4.84	
WIT-VIZ A4 	M8	50	1.04	0.47	-	-	MFPA Leipzig Nr. GS 3.2/ 18-075-1
	M10	60	2.50	1.45	0.39	-	
	M12	80	5.80	3.80	1.81	0.81	
	M16	125	7.62	5.81	4.01	3.11	
	M20	170	13.02	9.75	6.48	4.84	
	M24	170	13.02	9.75	6.48	4.84	
WIT-UH 300 M 3) 	M8	80	0.71	0.56	0.41	0.32	Ingenieur-büro Thiele 21807de 9.12.2018
	M10	90	1.42	1.11	0.79	0.61	
	M12	110	3.03	2.28	1.60	1.18	
	M16	125	5.65	4.24	2.98	2.20	
	M20	170	8.82	6.62	4.66	3.43	
	M24	210	12.71	9.53	6.71	4.94	
	M27	240	16.52	12.39	8.72	6.43	
	M30	270	20.20	15.15	10.66	7.85	
WIT-PE 1000 M 3) 	M8	80	1.10	0.88	0.33	0.00	Ingenieur-büro Thiele 22022e 14.05.2020
	M10	90	1.74	1.39	0.65	0.00	
	M12	110	3.03	2.28	1.60	0.88	
	M16	125	5.65	4.24	2.77	1.54	
	M20	170	8.82	6.62	4.66	3.43	
	M24	210	12.71	9.53	6.71	4.94	
	M27	240	16.52	12.39	8.72	6.43	
	M30	270	20.20	15.15	10.66	7.85	

Anchor type	Size	Effective anchorage depth (mm)	Max tensile loading (kN) for specified fire resistance time [1) 2)]				Authority / No.
			R30	R60	R90	R120	
WIT-VM 250 M [4)] 	M8	≥ 80	1.60	1.10	0.60	0.30	Technische Universität Kaiserslautern Project Number EBB 170019_6de
	M10	≥ 90	2.60	1.80	0.90	0.50	
	M12	≥ 110	3.40	2.60	1.80	0.50	
	M16	≥ 125	6.20	4.80	3.40	2.70	
	M20	≥ 170	9.80	7.50	5.30	4.20	
	M24	≥ 210	14.00	10.80	7.60	6.00	
	M27	≥ 250	18.30	14.10	9.90	7.90	
	M30	≥ 280	22.30	17.20	12.10	9.60	

1) All values are for reinforced concrete as base material of strength classes from C20/25 to C50/60
2) Data valid for steel failure. See approval for other failure modes
3) Values are for standard effective anchorage depths values in cracked concrete. Check the fire test report for the complete list of values
4) Values are for non-cracked concrete

SEISMIC AND FIRE CONSIDERATIONS

Fire loads Mechanical Anchors

Anchor type	Size	Effective anchorage depth (mm)	Max tensile loading (kN) for specified fire resistance time 1) 2)				Authority / No.
			R30	R60	R90	R120	
W-BS 	Ø6	31	0.90	0.80	0.60	0.40	ETA-16/0043
		44	0.90	0.80	0.60	0.40	
	Ø8	35	2.40	1.70	1.10	0.70	
		43	2.40	1.70	1.10	0.70	
		52	2.40	1.70	1.10	0.70	
	Ø10	43	4.40	3.30	2.30	1.70	
		60	4.40	3.30	2.30	1.70	
		68	4.40	3.30	2.30	1.70	
	Ø12	50	7.30	5.80	4.20	3.40	
		67	7.30	5.80	4.20	3.40	
		80	7.30	5.80	4.20	3.40	
	Ø14	58	10.30	8.20	5.90	4.80	
		79	10.30	8.20	5.90	4.80	
		92	10.30	8.20	5.90	4.80	
W-FAZ/S 	M8	46	1.50	1.10	0.80	0.70	ETA-99/0011
	M10	60	2.60	1.90	1.40	1.20	
	M12	70	4.10	3.00	2.40	2.20	
	M16	85	7.70	5.60	4.40	4.00	
	M20	100	9.40	8.20	6.90	6.30	
	M24	115	13.60	11.80	10.00	9.10	
	M27	125	17.60	15.30	13.00	11.80	
W-FAZ/A4 	M8	46	3.80	2.90	2.00	1.60	ETA-99/0011 of 2 October 2018
	M10	60	6.90	5.30	3.60	2.80	
	M12	70	12.70	9.40	6.10	4.50	
	M16	85	23.70	17.60	11.50	8.40	
	M20	100	33.50	25.00	16.40	12.10	
	M24	125	48.20	35.90	23.60	17.40	

Anchor type	Size	Effective anchorage depth (mm)	Max tensile loading (kN) for specified fire resistance time [1) 2)]				Authority / No.
			R30	R60	R90	R120	
W-HAZ/S 	10/M6		1.00	0.80	0.60	0.40	ETA-02-0031
	12/M8		1.90	1.50	1.00	0.80	
	15/M10		4.30	3.20	2.10	1.50	
	18/M12		6.30	4.60	3.00	2.00	
	24/M16		11.60	8.60	5.00	3.10	
	24/M16L		11.60	8.60	5.00	3.10	
	28/M20		18.30	13.50	7.70	4.90	
	32/M24		26.30	19.50	12.60	9.20	
W-HAZ/A4 	12/M8		6.10	4.40	2.60	1.80	ETA-02-0031
	15/M10		10.20	7.30	4.30	2.80	
	18/M12		15.70	11.10	6.40	4.10	
	24/M16		29.20	20.60	12.00	7.70	
W-FA/S 	M6/40		0.90	0.50	0.30	0.25	IBMB Braunschweig 7260/2018
	M8		1.40	0.80	0.50	0.40	
	M10		2.20	1.20	0.80	0.60	
	M12		3.20	1.80	1.20	0.90	
	M16		6.00	3.40	2.20	1.70	
	M20		10.00	5.25	3.60	2.75	
W-FA/A4 **W-FA/HCR** 	M6/40		0.90	0.50	0.30	0.25	IBMB Braunschweig 3067/2013
	M8		2.30	1.70	1.40	1.30	
	M10		3.60	2.60	2.20	2.00	
	M12		5.20	3.80	3.20	2.90	
	M16		9.70	7.00	6.00	5.40	
	M20		15.00	10.20	8.20	7.00	
W-ED/S 	M6		1.70	0.70	0.40	0.30	IBMB Braunschweig 3067/2013
	M8x30		1.70	0.70	0.40	0.30	
	M8x40		3.00	1.50	0.80	0.60	
	M10		4.70	2.40	1.30	1.00	
	M12		6.90	2.40	1.30	1.00	
	M16		12.50	5.60	3.50	2.50	
	M20		18.00	8.50	5.50	4.40	
W-ED/A4 	M6		1.70	0.70	0.40	0.30	IBMB Braunschweig 3067/2013
	M8x30		1.70	0.70	0.40	0.30	
	M8x40		3.00	1.50	0.80	0.60	
	M10		4.70	2.40	1.30	1.00	
	M12		6.90	2.40	1.30	1.00	
	M16		12.50	5.60	3.50	2.50	
	M20		18.00	8.50	5.50	4.40	

1) All values are for reinforced concrete as base material of strength classes from C20/25 to C50/60

2) Data valid for steel failure. See approval for other failure modes

3. Construction site tests

3.1. Test recommendations

These recommendations are valid for anchors with a European Technical Assessment (ETA). The job site tests are not considered to be a substitution of the Eurocode EN 1992-4 procedure for assessing the suitability of fixings in a particular base material. Tests in shear are not usually needed as shear performance is generally limited by the material strength of either the structure or the anchor. They may be needed when fixing to low strength masonry.

Tests for anchors on site may be required for two distinct purposes:

1.) To determine the suitability of a fixing and the Recommended Design Resistance of an anchor in the case where no manufacturer's data is available for the specific base material concerned, i.e. where the base material of the application is within the category of the ETA, but does not comply in terms of strength and/or dimensions.
2.) To validate the quality of installation of anchors used on the job, i.e. proof tests.

3.2. Pull-out tests for determining recommended design resistance

3.2.1. Number of tests

The characteristic resistance to be applied to an anchor should be determined by means of at least **15 pull-out tests** carried out on the construction work with a centric tension load acting on the anchor. Execution and evaluation of the tests as well as issue of the test report and determination of the characteristic resistance should be supervised by the person responsible for execution of works on site and be carried out by a competent person. Number and position of the anchors to be tested should be adapted to the relevant special conditions of the construction work in question and, for example, in the case of blind and larger areas be increased such that a reliable information about the characteristic resistance of the anchor embedded in the base material in question can be derived. The tests should take account of the unfavorable conditions of practical execution.

3.2.2. Installation of anchor

The anchor to be tested should be installed (e.g. preparation of drill hole, drilling tool to be used, drill bit, type of drilling hammer or rotation, thickness of fixture) and as far as spacing and edge distances are concerned be distributed in the same way as foreseen for the intended use.
Depending on the drilling tool, hard metal hammer-drill bits or hard metal percussion drill bits, respectively, according to ISO 5468 should be used. New drill bits should be used for one test series.
The cleaning process of the drill hole should follow the manufacturer's installation instruction using the corresponding tools.

3.2.3. Execution of test

The test rig used for the pull-out tests should allow a continuous slow increase of load recorded by a calibrated measuring equipment. The load should act perpendicular to the surface of the base material and be transmitted to the anchor via a hinge.
The reaction forces should be transmitted to the base material such that possible breakout of the concrete / masonry is not restricted. This condition is considered as fulfilled, if the support reaction forces are transmitted

a) Concrete: at a distance of at least 1.5 x h_{ef} from the anchors.
b) Masonry: either in adjacent masonry units or at a distance of at least 150 mm from the anchors.

The load should be progressively increased so that the load is achieved after not less than about 1 minute. Recording of load is carried out when the ultimate load is achieved.

3.2.4. Evaluation of results of pull-out tests

The characteristic resistance N_{Rk1} is obtained from the measured values of N1 as follows:

$$N_{Rk1} = \alpha \cdot N_1 \leq N_{Rk,ETA}$$

The characteristic resistance N_{Rk1} has to be equal or smaller than the characteristic resistance N_{Rk} which is given in the ETA for similar masonry (bricks or blocks).

N_1 = the mean value of the five smallest measured values at the ultimate load.

$N_{Rk,ETA}$ = characteristic resistance N_{Rk} given in the ETA for the same category of masonry.

a = 0.5 for plastic and bonded anchor acc. to TR 053.

a = 0.75 for mechanical and chemical anchor for use in concrete.

If in case of bonded anchors and mechanical anchors the number of pull-out tests is smaller than 15, the characteristic values are to be determined as a 5% fractile:

a) Mechanical and Bonded anchor for use in concrete:

$$N_{Rk1} = N_{Ru,m}(1 - k \cdot v) \cdot f_{b,N} \leq N_{Rk,ETA}^{C20/25}$$

$f_{b,N}$ is a factor for comparing the results with the same compressive concrete strength.

$$f_{b,N} = \sqrt{\frac{25}{f_{ck,cube}}} = \sqrt{\frac{20}{f_{ck,cyl}}}$$

b) Bonded anchor for use in masonry:

$$N_{Rk1} = N_{Ru,m}(1 - k \cdot v) \cdot \beta \leq N_{Rk,ETA}$$

$N_{Ru,m}$ = mean value of the ultimate load of the n tests.

v = coefficient of variation of the ultimate load.

β = is an influencing factor whose values are given in the approval document.

k = factor

Table 1: k factor for calculating 5% fractile

Number of tests n	5	6	7	8	9	10	11	12	13	14	15
k-factor for calclulating 5%-fractile	3.400	3.092	2.894	2.754	2.650	2.568	2.503	2.448	2.402	2.363	2.329

Note: coefficient of variation s unknown, one-sided confidence level p = 0.9

3.2.5. Determination of recommended design resistance

The Recommended Design Resistance: $N_{Rd} = \frac{N_{Rk1}}{\gamma_M}$

γ_M = material safety factor

The partial safety factors for the resistance of anchors with approval may be taken

a) Plastic and bonded anchors for use in masonry: $\gamma_M = 2.5$

b) Anchors for use in concrete: $\gamma_M = \gamma_{M,ETA}$ (1.25 x $\gamma_{M,ETA}$ in case concrete compressive strength is unknown)

In absence of national regulations the partial safety factors for the resistance of anchors without any approval may be taken

a) all base material $\gamma_M = 5$

3.3. Preliminary or proof tests for validating the quality of installation of anchors

3.3.1. Number of tests

The minimum number of fixings to be proof tested is 15. The minimum of 15 applies in any discrete area where different anchors may have been used, the base material is different, the condition of the base material has been affected by weather conditions e.g. on a different elevation or where anchors have been installed by different installation teams.

The tests are carried out on the construction work with a centric tension load acting on the anchor. Execution and evaluation of the tests as well as issue of the test report should be supervised by the person responsible for execution of works on site and be carried out by a competent person.

3.3.2. Installation of anchor

The anchor to be tested should be installed (e.g. preparation of drill hole, drilling tool to be used, drill bit, type of drilling hammer or rotation, thickness of fixture) and as far as spacing and edge distances are concerned be distributed in the same way as foreseen for the intended use. Depending on the drilling tool, hard metal hammer-drill bits or hard metal percussion drill bits, respectively, according to ISO 5468 should be used. New drill bits should be used for one test series.
The cleaning process of the drill hole should follow the manufacturer's installation instruction using the corresponding tools.

3.3.3. Execution of test

The test rig used for the pull-out tests should allow a continuous slow increase of load recorded by a calibrated measuring equipment. The load should act perpendicular to the surface of the base material and be transmitted to the anchor via a hinge.
The reaction forces should be transmitted to the base material such that possible breakout of the concrete / masonry is not restricted. This condition is considered as fulfilled, if the support reaction forces are transmitted

a) Concrete: at a distance of at least 1.5 x h_{ef} from the anchors.
b) Masonry: either in adjacent masonry units or at a distance of at least 150 mm from the anchors.

The load should be progressively increased so that the load is achieved after not less than about 1 minute. Recording of load is carried out when the ultimate load is achieved.

3.3.4. Calculation of proof load

a) Bonded anchors for use in masonry:

$N_p = 0.8 \cdot N_{Ed} \cdot \gamma_{Mp}$

with $\gamma_{Mp} = \gamma_M \cdot \frac{1}{\beta}$

N_p = load Np for the proof load tests
N_{Ed} = design value of action ($N_{Ek} \cdot \gamma_F$)
γ_M = partial safety factors for the resistance (= 2.5 for masonry units)
β = is an influencing factor whose values are given in the approval document

b) Anchors for use in concrete:

$N_p = 0.8 \cdot N_{Sd} \cdot \gamma_{M,p}$

$\gamma_{M,p}$ = material safety factor in case of pull-out failure

3.3.5. Acceptance criteria

Anchors can be said to have satisfied a proof test if the required load is held without movement or any damage or deformation occurring to either the fixing or the base material. Any anchor suffering movement or damage should be recorded as a failure. If, in any discreet area, 1 failure is encountered, the reason for failure should be investigated, the number of anchors tested in that area should be doubled to 5% and at least 6. If more than one fails, then 100% of the anchors should be tested, the reasons for failure determined and the specification reconsidered.

3.3.6. Determination of recommended design resistance

If the quality of installation is proven and the specification not reconsidered, the design resistances are calculated with the data given in the relevant approval.

In case of bonded anchors for use in masonry, where the base material of the application is within the category of the ETA but does not comply in terms of strength and/or dimensions, the Recommended Design Resistance is evaluated as follows:

The Recommended Design Resistance: $N_{Rd} = \frac{N_{Rk2}}{\gamma_M}$
with the characteristic resistance

a) Bonded anchors for use in masonry:

$N_{Rk2} = {}^{1}/_{0.8} \cdot N_p \cdot \beta \leq N_{Rk,ETA}$

$\gamma_M = 2.5.$

b) Anchors for use in concrete:

$N_{Rk2} = {}^{1}/_{0.8} \cdot N_p \leq N_{Rk,ETA}$

$\gamma_M = \gamma_{Mp}$ acc. to respective ETA
$\gamma_M = 1.25\ \gamma_{Mp}$ acc. to respective ETA.

4. Post-installed Reinforcement

4.1. General

The following chapter explains the design theory behind post-installed reinforcement bar (rebar) applications and is intended to provide the reader with a basic understanding on the design requirements related to the Eurocode EN 1992-1-1 and the European Assessment Document (EAD) 330087-00-0601.

Table 1 provides an overview of the specifications of our WIT-Rebar systems:

Table 1: Specification overview of WIT-Rebar systems

	WIT-PE 1000	WIT-UH 300	WIT-PE 510	WIT-VM 250
				
European Technical Assessment	ETA-19/0543	ETA-17/0036	ETA-20/1037	ETA-12/0166
Material	Two-component reactive resin mortar, pure epoxy	Urethane vinyl ester hybrid mortar	Two-component reactive resin mortar, pure epoxy	Two-component reaction resin mortar, vinyl ester
REBAR diameter	8 – 40 mm	8 – 32 mm	8 – 40 mm	8 – 32 mm
Drill hole cleaning with hollow drill-bit system	✔	✔	✔	X
Gelling- / working time at 20°C	30 min	3 min	30 min	6 min
Minimum curing time in dry concrete at 20°C	12 h	30 min	12 h	45 min
Minimum curing time in wet concrete at 20°C	24 h	60 min	24 h	90 min
Maximum embedment depth $l_{v,max}$	2000 mm	2000 mm	2000 mm	2000 mm
Temperature of base material in-service	-40°C – +80°C	-40°C – +80°C	-40°C – +80°C	-40°C – +80°C
Temperature of base material at installation	+5°C – +40°C	-5°C – +40°C	+5°C – +40°C	-10°C – +40°C
Fire resistance / Seismic / 100 years	✔ / ✔ / ✔	✔ / ✔ / ✔	✔ / X / X	✔ / X / X
Software / Eurocode	✔ / ✔	✔ / ✔	✔ / ✔	✔ / ✔

4.2. Anchor Theory vs. Rebar Theory

Table 2 shows a comparison of potential failure modes for rebar used as anchor and post-installed rebar connection.

Table 2: Comparison of potential failure modes

Rebar used as Anchor (EN 1992-4)		Post-installed Rebar Connection (EN 1992-1-1)	
Failure modes in Tension	**Failure modes in Shear**	**Failure modes in Tension**	**Failure modes in Shear**
Steel failure of fastener	Steel failure of fastener without lever arm	Steel failure of reinforcing bar	
	Steel failure of fastener with lever arm	Bond failure	
Pull-out failure of fastener	Concrete pry-out failure	Splitting failure	
Combined pull-out and concrete failure	Concrete edge failure		
Concrete cone failure			
Splitting failure			

4.2.1. Rebar used as Anchor

Situations where the concrete needs to take up tension loads from the anchorage or where reinforcing bars are designed to carry shear loads should be considered as "rebar used as anchors" and designed according to anchor design method such as given e.g. in the guidelines of EN 1992-4 or simplified in this Design Manual. Those guidelines verify all possible failure loads in tension and shear.

4.2.2. Post-installed Rebar Connection

The design of the rebar anchorage is performed according to structural concrete design codes, e.g. EN 1992-1-1. With a given test regime and the assessment criteria EAD 330087, it is proven that the load transfer for post-installed reinforcing bars is similar to cast in bars if the stiffness of the overall load transfer mechanism is similar to the cast-in system. The efficiency depends on the strength of the adhesive mortar against the concentrated load close to the ribs and on the capacity of load transfer at the interface of the drilled hole.

In many cases the bond values of post-installed bars are higher compared to cast in bars due to better performance of the adhesive mortar. But for small edge distance and/or narrow spacing, splitting or spalling forces become decisive due to the low tensile capacity of the concrete.

4.3. Post-installed rebar anchorage - The assessment criteria of EOTA-EAD 330087

The guideline specifies a number of tests in order to qualify products for post-installed rebar applications. These are the performance areas checked by the tests:

1. Bond strength in different strengths of concrete
2. Substandard hole cleaning in dry and wet concrete
3. Influence of temperature
4. Correct injection
5. Installation direction
6. Influence of sustained loads
7. Freeze-thaw conditions
8. High alkalinity and sulphurous atmosphere
9. Corrosion resistance
10. Resistance to fire

If an adhesive meets all assessment criteria, rebar connections carried out with this adhesive can be designed with the bond strength and minimum anchorage length according to EN 1992-1-1 as given in the tables below for different Würth injection mortars.

WIT FOR POST-INSTALLED REBAR

Adhesives (or in conjunction with a certain drilling procedure) which do not fully comply with all assessment criteria can still obtain an approval:

- If the bond strength obtained in tests does not fulfil the specified requirements, then bond strengths lower than those given by EN 1992-1-1 shall be applied. These values are given in the respective approval.
- If it cannot be shown that the bond strength of reinforcing bars post-installed with a selected product and cast-in reinforcing bars in cracked concrete (w = 0.3 mm) is similar, then the minimum anchorage length $l_{b,min}$ and the minimum overlap length $l_{0,min}$ shall be increased by a factor 1.5.

4.4. Rebar Applications

Products tested according to above guideline can be used for applications in non-carbonated concrete C12/15 to C50/60 (EN 206) only, which are also allowed with straight deformed cast-in bars according to (EN 1992), e.g. those in the following applications:

Note to the following figures: In the figures below, no transverse reinforcement is plotted, the transverse reinforcement as required by EN 1992 shall be present. The shear transfer between old and new concrete shall be designed according to EN 1992.

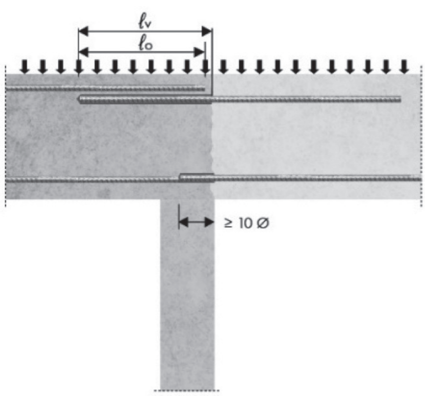


Figure 1: Overlap joint in slabs and beams

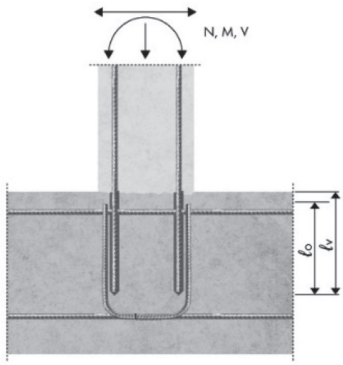


Figure 2: Overlap joint in a foundation of a column or wall where the rebars are stressed in tension

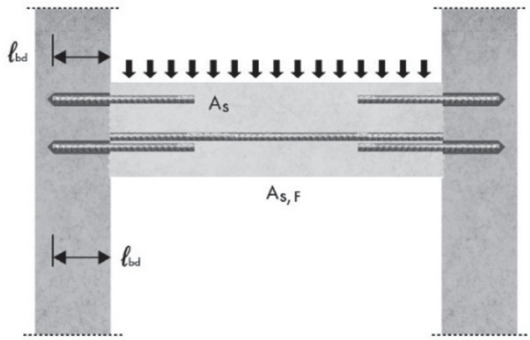


Figure 3: End anchoring of slabs or beams, designed as simply supported

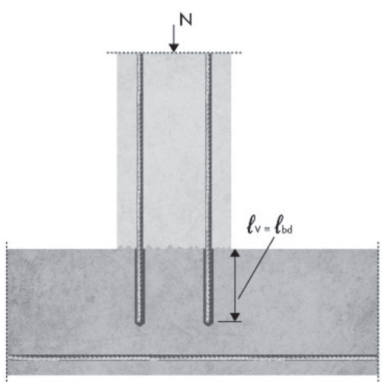


Figure 4: Rebar connection of components stressed primarily in compression. The rebars are stressed in compression

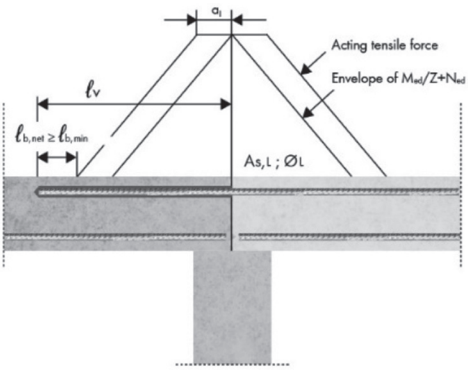


Figure 5: Anchoring of reinforcement to cover the line of acting tensile force

4.5. Design of Anchorage of longitudinal reinforcement with EN 1992-1-1

a) Reinforcing bars shall be so anchored that the bond forces are safely transmitted to the concrete avoiding longitudinal cracking or spalling. Transverse reinforcement shall be provided if necessary.

b) The ultimate bond strength shall be sufficient to prevent bond failure.

4.5.1. The design value of the ultimate bond stress

$$f_{bd} = 2.25 \cdot \eta_1 \cdot \eta_2 \cdot \frac{f_{ctk,0.05}}{1.5}$$

where:

- $f_{ck,\,0.05}$ ... is the 5% fractile characteristic tensile strength of concrete according to Table 3
- η_1 ... is a coefficient related to the quality of the bond condition and the position of the bar during concreting (details see EN 1992-1-1):
  - o η_1 = 1.0 when good conditions are obtained and
  - o η_1 = 0.7 for all other cases and for bars in structural elements built with slip-forms, unless it can be shown that good bond conditions exist
- η_2 ... is related to the bar diameter:
  - o η_2 = 1.0 for Ø ≤ 32 mm
  - o η_2 = (132 - Ø)/100 for Ø > 32 mm

Table 3: Strength characteristics for concrete

Compressive strength class		**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
f_{cm}	[N/mm²]	20	24	28	33	38	43	48	53	58
f_{ctm}	[N/mm²]	1.60	1.90	2.20	2.60	2.90	3.20	3.50	3.80	4.10
$f_{ctk,\,0.05}$	[N/mm²]	1.10	1.30	1.50	1.80	2.00	2.20	2.50	2.70	2.90
$f_{ctk,\,0.95}$	[N/mm²]	2.00	2.50	2.90	3.30	3.80	4.20	4.60	4.90	5.30
f_{bd} Ø ≤ 32	[N/mm²]	1.65	1.95	2.25	2.70	3.00	3.30	3.75	4.05	4.35
f_{bd} Ø ≤ 34	[N/mm²]	1.62	1.91	2.21	2.65	2.94	3.23	3.68	3.97	4.26
f_{bd} Ø ≤ 36	[N/mm²]	1.58	1.87	2.16	2.59	2.88	3.17	3.60	3.89	4.18
f_{bd} Ø ≤ 40	[N/mm²]	1.52	1.79	2.07	2.48	2.76	3.04	3.45	3.73	4.00

4.5.2. Development length

Development length is the shortest length needed for a reinforcing bar so that the yield strength can be induced in the bar.

$$N_{Rd,b} = N_{Rd,s}$$

$$f_{bd} \cdot l_{b,develop} \cdot \emptyset \cdot \pi = {}^{f_{yk}}/_{\gamma_s} \cdot \frac{\pi \cdot \emptyset^2}{4}$$

$$l_{b,develop} = \frac{\emptyset}{4} \cdot \frac{f_{yk}/\gamma_s}{f_{bd}}$$

Reinforced concrete members are often designed using strut and tie models. The forces are represented by trusses and the nodes of these trusses have to connect the forces in such a way that they are in balance: The sum of the concrete compression force, the support force and the steel tensile force equals zero. The node can maintain its function only when the bond between the reinforcing bar and the surrounding concrete is activated and in balance with the horizontal component of the concrete compression strength. The node has to physically provide a certain length over which the rebar can develop stress on its left side. This extension on the left side is called "development length" or "anchorage length". The length or the space on the left side depends on the method of anchorage: bend, hook or straight.

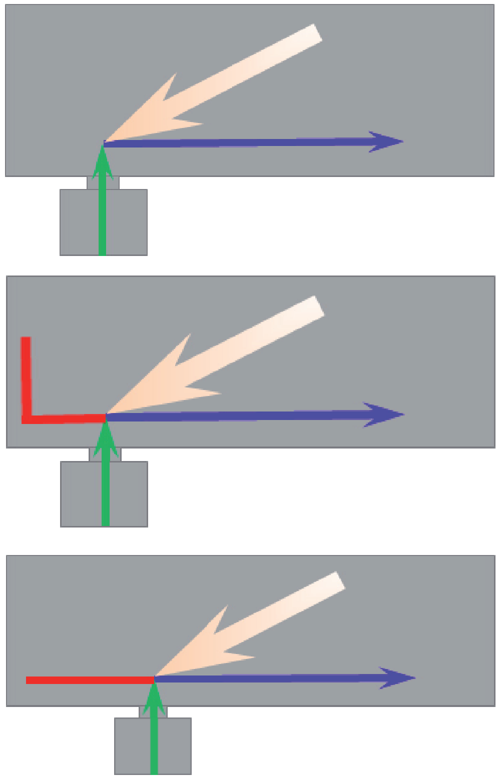


Figure 6: Node of trusses

Table 4: Design loads for good bond conditions

Bar size	Cross sectional area of reinforcement	Characteristic yield strength	Partial factor for reinforcing steel	Design resistance of reinforcement bar	Design Bond stress	Development length	Minimum anchorage length	Design load for good bond condition, C20/25																									
Ø	A_s	f_{yk}	γ_s	$N_{Rd,s}$	f_{bd}	l_{bd}	$l_{b,min}$	$N_{b,d}$																									
[mm]	[mm²]	[N/mm²]		[kN]	[N/mm²]	[mm]		[kN]																									
8	50.3	500	1.15	21.9	2.25	386	116	7	7	8	8	11	14	17	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	78.5	500	1.15	34.1	2.25	483	145	-	-	-	11	14	18	21	25	28	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12	113.1	500	1.15	49.2	2.25	580	174	-	-	-	-	17	21	25	30	34	42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	153.9	500	1.15	66.9	2.25	676	203	-	-	-	-	-	25	30	35	40	49	59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16	201.1	500	1.15	87.4	2.25	773	232	-	-	-	-	-	28	34	40	45	57	68	79	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	314.2	500	1.15	136.6	2.25	966	290	-	-	-	-	-	-	42	49	57	71	85	99	113	127	-	-	-	-	-	-	-	-	-	-	-	-
25	490.9	500	1.15	213.4	2.25	1208	362	-	-	-	-	-	-	-	-	71	88	106	124	141	159	177	194	212	-	-	-	-	-	-	-	-	-
28	615.8	500	1.15	267.7	2.25	1353	406	-	-	-	-	-	-	-	-	-	99	119	139	158	178	198	218	238	257	-	-	-	-	-	-	-	-
32	804.2	500	1.15	349.7	2.25	1546	464	-	-	-	-	-	-	-	-	-	113	136	158	181	204	226	249	271	294	317	339	-	-	-	-	-	-
34	907.9	500	1.15	394.7	2.21	1676	503	-	-	-	-	-	-	-	-	-	-	141	165	188	212	236	259	283	306	330	353	377	-	-	-	-	-
36	1017.9	500	1.15	442.6	2.16	1812	543	-	-	-	-	-	-	-	-	-	-	147	171	195	220	244	269	293	318	342	366	391	415	440	-	-	-
40	1256.6	500	1.15	546.4	2.07	2100	630	-	-	-	-	-	-	-		-	-	-	182	208	234	260	286	312	338	364	390	416	442	468	494	520	546
							Anchorage length [mm]	120	130	140	150	200	250	300	350	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100

4.5.3. Basic anchorage length

The calculation of the required anchorage length shall take into consideration the type of steel and bond properties of the bars. The basic required anchorage length $l_{b,rqd}$ for anchoring the force $A_s \sigma_{sd}$ in a bar assuming constant bond stress equal to f_{bd} follows from:

$$l_{b,rqd} = \frac{\emptyset}{4} \cdot \frac{\sigma_{Sd}}{f_{bd}}$$

4.5.4. Design anchorage length

According to EN 1992-1-1, the design anchorage length, l_{bd} is

$$l_{bd} = \alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \alpha_4 \cdot \alpha_5 \cdot l_{b,rqd} \geq l_{b,min}$$

The factors a_1 to a_5 subscripts take into account the form of the bars, concrete cover, confinement by transverse reinforcement, the influence of welded transverse bars along the design anchorage length and the effect of the pressure transverse to the plane of splitting along the design anchorage length.

In case of a post-installed rebar application, only straight bars are possible.

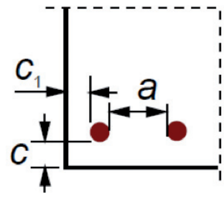


Fig. 1: Values for straight bars in beams and slabs (EN 1992-1-1) Note: c_d = min ($a/2$, c_1, c)

- a_1 = 1.0 for anchorage of straight bars
- a_2: $0.7 \leq 1 - 0.15\,(c_d - \emptyset)/\emptyset \leq 1.0$ for reinforcement bar in tension or a_2 = 1.0 for reinforcement bar in compression
- a_3 = 1.0 no transverse reinforcement
- a_4 = 1.0 no welded transverse reinforcement
- a_5: $0.7 \leq 1 - 0.04p \leq 1.0$ for confinement by transverse pressure p [MPa] at ultimate limit state along l_{bd}

➢ The product of ($a_2 a_3 a_5$) should be ≥ 0.7.

$l_{b,min}$ is the minimum anchorage length if no other limitation is applied:

- $l_{b,min} \geq \max\,(0.3 \cdot l_{b,rqd};\ 10\emptyset; 100\ \text{mm})$ for anchorages in tension
- $l_{b,min} \geq \max\,(0.6 \cdot l_{b,rqd};\ 10\emptyset; 100\ \text{mm})$ for anchorages in compression

The minimum anchorage length shall be multiplied by the amplification factor a_{lb} according Table 5 below:

Table 5: Amplification factor a_{lb} related to drilling method for concrete class C12/15 to C50/60

Injection mortar	Drilling method	Bar size	Amplification factor a_{lb}
WIT-PE 1000	All drilling methods	8 mm to 40 mm	1.0
WIT-UH 300	Hammer drilling (HD) Hollowing drill bit system (HDB) Compressed air drilling (CD)	8 mm to 32 mm	1.0
WIT-PE 510	Hammer drilling (HD) Hollowing drill bit system (HDB) Compressed air drilling (CD)	8 mm to 40 mm	1.0
WIT-VM 250	Diamond coring (DD)	8 mm to 40 mm	1.5
	Hammer drilling (HD) Hollowing drill bit system (HDB) Compressed air drilling (CD)	8 mm to 32 mm	1.0

4.5.5. Lap or splice length

According to EN 1992-1-1, the design lap length is

$$l_0 = \alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \alpha_5 \cdot \alpha_6 \cdot l_{b,rqd} \geq l_{0,min}$$

- α_1 = 1.0 for anchorage of straight bars
- α_2 = 1.0 for reinforcement bar in compression
- α_2: $0.7 \leq 1 - 0.15\ (c_d - \varnothing)/\varnothing \leq 1.0$ for reinforcement bar in tension
- α_3 = 1.0 no transverse reinforcement
- α_5: $0.7 \leq 1 - 0.04\rho \leq 1.0$ for confinement by transverse pressure ρ [MPa] along l_{bd}
- α_6: $1.0 \leq \alpha_6 \leq 1.5$ for influence of percentage of lapped bars relative to the total cross-section area according to the following table:

Table 6: Values of the coefficient

Percentage of lapped bars relative to the total cross-section area	< 25%	33%	50%	>50%
α_6	1.00	1.15	1.40	1.50

Note: Intermediate values may be determined by interpolation

➢ The product of $(\alpha_2\alpha_3\alpha_5)$ should be ≥ 0.7.

$l_{0,min}$ is the minimum lap length:

$$l_{0,min} \geq \max\,(0.3 \cdot \alpha_6 \cdot l_{b,rqd};\ 15\varnothing;\ 200\ \text{mm})$$

The minimum lap length shall be multiplied by the amplification factor α_{lb} according Table 5.

4.5.6. Concrete cover

Concrete cover is defined as the minimum distance between the outer surface of the concrete element and the surface of the embedded reinforcement. The nominal concrete cover is defined as a minimum cover plus a deviation allowance Δc_{dev}. The recommended value for Δc_{dev} = 10 mm.

$c_{nom} = c_{min} + \Delta c_{dev}$

The minimum concrete cover c_{min} is to ensure safe transmission of bond forces and protection against steel and fire is defined according to the following equation:

$c_{min} = \max\,(c_{min,b}; c_{min,dur}; 10\ \text{mm})$

where

- $c_{min,b}$ = minimum cover due to bond requirement
- $c_{min,dur}$ = minimum cover due to environmental conditions

a) $c_{min,b}$ is equivalent to the diameter of the reinforcing bar.

b) $c_{min,dur}$ can be obtained from Table 8:

Table 8: Values of minimum cover $c_{min,dur}$ requirements with regard to durability for reinforcement steel

		Exposure Class						
		X0	**XC1**	**XC2/XC3**	**XC4**	**XD1/XS1**	**XD2/XS2**	**XD3/XS3**
Structural Class	**S1**	10	10	10	15	20	25	30
	S2	10	10	15	20	25	30	35
	S3	10	10	20	25	30	35	40
	S4	10	15	25	30	35	40	45
	S5	15	20	30	35	40	45	50
	S6	20	25	35	40	45	50	55

POST-INSTALLED REBAR

WIT FOR POST-INSTALLED REBAR

According to the exposure class in a given situation, the table below from EN 1992-1-1 further provides the engineer with the indicative minimum concrete strength class for each exposure class:

Table 9: Indicative minimum strength class

Corrosion										
	Carbonation-induced corrosion				**Chloride-induced corrosion**			**Chloride-induced corrosion from sea-water**		
	XC1	XC2	XC3	XC4	XD1	XD2	XD3	XS1	XS2	XS3
Indicative minimum strength class	C20/25	C25/30	C30/37		C30/37		C35/45	C30/37	C35/45	
Damage to Concrete										
	No risk	**Freeze/Thaw Attack**			**Chemical Attack**					
	X0	XF1	XF2	XF3	XA1	XA2			XA3	
Indicative minimum strength class	C12/15	C30/37	C25/30	C30/37	C30/37				C35/45	

For our WIT-Rebar systems, the concrete cover shall be defined as

$$\min c = \max\,(c_{nom}; c_{min,inst})$$

The minimum cover of post-installed reinforcing bars $c_{min,inst}$ depends on the drilling method:

Table 10: Minimum cover related to drilling method

Drilling method	**Rebar diameter (∅)**	**Without drilling aid**	**With drilling aid**
Hammer drilling (HD) Hollow drill bit system (HDB)	< 25 mm	30 mm + 0.06 l_v ≥ 2∅	30 mm + 0.02 l_v ≥ 2 ∅
	≥ 25 mm	40 mm + 0.06 l_v ≥ 2∅	40 mm + 0.02 l_v ≥ 2 ∅
Diamond drilling (DD)	< 25 mm	Drill rig used as drilling aid	30 mm + 0.02 l_v ≥ 2 ∅
	≥ 25 mm		40 mm + 0.02 l_v ≥ 2 ∅
Compressed air drilling	< 25 mm	50 mm + 0.08 l_v	50 mm + 0.02 l_v
	≥ 25 mm	60 mm + 0.08 l_v	60 mm + 0.02 l_v

Comment: The minimum concrete cover acc. EN 1992-1-1:2004+AC:2010 must be observed

4.5.7. Spacing of bars and laps

The spacing of bars shall be such that the concrete can be placed and compacted satisfactorily for the development of adequate bond. The clear distance (horizontal and vertical) between individual parallel bars or horizontal layers of parallel bars should be not less than the max(∅; (d_g + 5 mm) or 20 mm) where d_g is the maximum size of aggregate (8.2; EN 1992-1-1:2011-01).

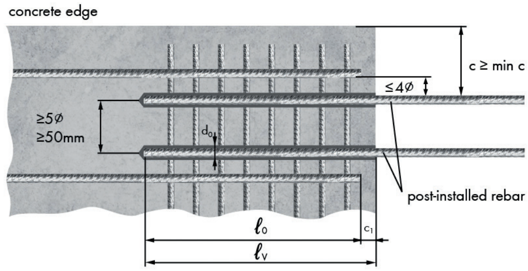


Figure 7: Adjacent laps

The spacing between post-installed reinforcing bars shall be greater max (5∅; 50 mm).

4.5.8. Embedment depth

Embedment depth for overlap joints
For calculation of the effective embedment depth of overlap joints the concrete cover at end-face of bonded-in rebar c_1 shall be considered:

$$l_v \geq l_0 + c_1$$

If the clear distance between the overlapping rebar is greater than 4 Ø the lap length shall be enlarged by the difference between the clear distance and 4 Ø.

4.5.9. Maximum embedment depth

Table 11: Maximum approved embedment depth for WIT-Rebar systems

Bar size, ∅ [mm]		**8**	**10**	**12**	**14**	**16**	**20**	**25**	**28**	**32**	**34**	**36**	**40**
Mortar	Drilling Method *	**Maximum permissible embedment depth, l_{max} [mm]**											
WIT-PE 1000	HD / CD / DD	800	1000	1200	1400	1600	2000	2000	2000	2000	2000	2000	2000
	HDB	800	1000	1000	1000	1000	1000	1000	1000	1000	-	-	-
WIT-UH 300	All methods	1000	1000	1200	1400	1600	2000	2000	2000	2000	-	-	-
WIT-PE 510	HD / CD / DD	800	1000	1200	1400	1600	2000	2000	2000	2000	2000	2000	2000
	HDB	800	1000	1000	1000	1000	1000	1000	1000	1000	-	-	-
WIT-VM 250	All methods	1000	1000	1200	1400	1600	2000	2000	1000	1000	-	-	-

* HD = Hammer drilling, CD = Compressed air drilling, HDB = Hollow drill bit system, DD = Diamond drilling

4.5.10. Transverse reinforcement

The requirements of transverse reinforcement in the area of the post-installed rebar connection shall comply with EN 1992-1-1, Section 8.7.4.

4.5.11. Connection joint

The transfer of shear forces between new concrete and existing structure shall be designed according to EN 1992-1-1, Section 6.2.5 "Shear at the interface between concrete cast at different times". The joints for concreting must be roughened to at least such an extent that aggregate protrude. In case of a carbonated surface of the existing concrete structure the carbonated layer shall be removed in the area of the post-installed rebar connection with a diameter of (Ø + 60 mm) prior to the installation of the new rebar. The depth of concrete to be removed shall correspond to at least the minimum concrete cover for the respective environmental conditions in accordance with EN 1992-1-1. The foregoing may be neglected if building components are new and not carbonated and if building components are in dry conditions.

4.5.12. Failure modes and anchorage length

In most cases the reinforcement bars are placed close to the surface of the concrete member to achieve good crack distribution and economical bending capacity. For splices at wide spacing, the bearing capacity of the concrete depends only on the thickness of the concrete cover. At narrow spacing the bearing capacity depends on the spacing and on the thickness of the cover. In the design codes the reduction of bearing capacity of the cover is taken into account by means of multiplying factors for the splice length. Splitting failure is decisive if the radial cracks propagate through the entire cover. Bond failure is caused by pull-out of the bar if the confinement (concrete cover, transverse reinforcement) is sufficient to prevent splitting of the concrete cover. EN 1992-1-1 controls the failure modes by limiting the α_2 value to $\alpha_2 \geq 0.7$. The spalling of the concrete cover or splitting between bars will be the controlling mode of failure. The value α_2 gives an explicit consideration for splitting and spalling as a function of concrete cover and bar spacing.

If α_2 is less than 0.7, corresponding to cover dimensions of $c_d/\phi > 3$ or spacing of $a/\phi > 6$, the cover or spacing is large enough so that splitting cannot occur anymore and pull-out will control.

4.6. Fire load case

4.6.1. General information

The load-bearing capacity in case of fire corresponds to the performance characteristic R according to DIN EN 13501-2. A classification of performance characteristics in case of fire according to DIN EN 13501-2 requires a time-dependent fire stress according to the unit temperature time curve (ETK), which is defined in DIN EN 13631. The National Annex to DIN EN 1991-1-2 also requires the application of standard time/temperature curve at any point of the structure for structural elements in building construction. If a sufficient load-bearing capacity under ETK load has been verified, this verification applies irrespective of the later use.

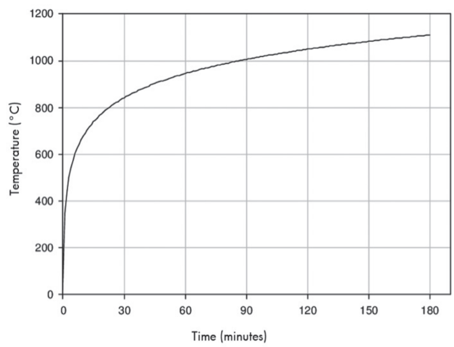


Figure 8: Standard time/temperature curve ISO 834

4.6.2. Application cases

To determine the load-bearing capacity of reinforcement connections in the event of fire, a basic distinction must be made between two applications. In application A, the thermally stressed surface shows the same direction as the reinforcement, which leads to a locally constant but time-varying temperature along the anchorage length l_{bd}.

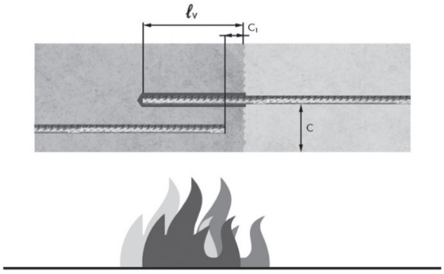


Figure 9: Fire load case - Application A

Alternatively for application B, the post-installed rebar is perpendicular to the thermally stressed surface, which results in a temporally and spatially variable temperature profile along the anchorage length l_{bd}.

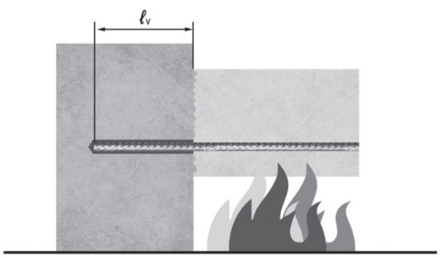


Figure 10: Fire load case - Application B

The distinction between application cases A and B is made exclusively according to the orientation of the flame-exposed surfaces in relation to the direction of the post-installed rebar and is not the same as the distinction between end anchoring and lap joint.

4.6.3. Load-bearing capacity

The load-bearing capacity of post-installed rebar connections in case of fire is significantly affected by the temperature-dependent bond stress $f_{bd,fi}$ (Θ) with

$$f_{bd,fi}(\theta) = k_{fi} \cdot f_{bd,fi}(\theta) \cdot f_{bd,PIR} \cdot \frac{\gamma_c}{\gamma_{M,fi}}$$

which is determined by experimental techniques. The reduction factor k_{fi} (Θ) under fire stress, the design value f_{bd} of the bond stress in cold case according to DIN EN 1992-1-1, which depends on the concrete strength class, and the reduction factor k_b with $f_{bd,PIR} = k_b \cdot f_{bd}$ are specified in the relative ETA. According to DIN EN 1992-1-1, Table 2.1N in accordance with the corresponding national annex for the permanent and temporary design situation, the following applies to the partial safety factor of concrete in cold conditions

$$\gamma_c = 1.5$$

In case of fire, the following applies according to DIN EN 1992-1-2, chapter 2.3 in accordance with the corresponding national appendix for the partial safety factor of concrete

$$\gamma_{M,fi} = 1.0$$

The design values f_{bd} of the composite stress in cold case are shown in Table 3. The values are applicable for all drilling methods, but they depend on the reinforcement bar diameter and are valid for good bond conditions according to DIN EN 1992-1-1, chapter 8.4.2. In case of other bond conditions, the specified values have to be multiplied by a factor of 0.7.

For WIT-PE 1000, the factor k_b can be found in ETA19/0543 in Table C2.

$$k_b = 1.0$$

and thus for all cases

$$f_{bd,PI} = f_{bd}$$

The temperature-dependent reduction factor $k_{b,fi(\Theta)}$ is (depending on the ETA) to be considered. The graph below shows reduction factors $k_{b,fi(\Theta)}$ for all WIT-Rebar systems

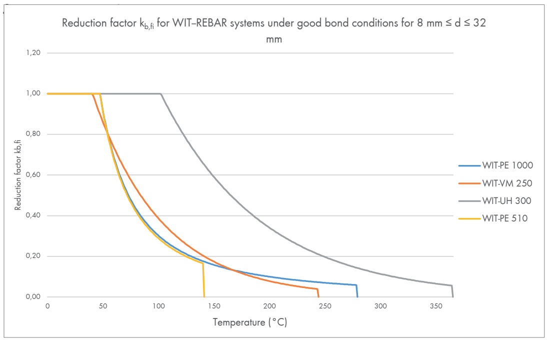


Figure 11: Reduction factor for WIT-Rebar systems (drilling methods HD/HBD/CD) for 8 mm ≤ d ≤ 32 mm

When designing post-installed rebar connections in case of fire, a distinction must be made between pull-out failure and steel failure, in addition to the distinction between application cases A and B.

4.6.4. Application case A

If the rebar connection in application A is in the same direction as the flamed surface, the function of the unit time-temperature curve results in a temperature along the rebar connection that varies over time but is locally constant. The time-dependent reinforcement temperature in case of fire is only dependent on the geometry of the existing component and the design in case of fire can be carried out using the time-dependent reinforcement temperature $\Theta(t)$ and the time-dependent bond stress $f_{bd,fi}$ ($\Theta(t)$).

4.6.4.1. Pull-out

If the stresses acting on a rebar connection are greater than the bond force that can be absorbed, failure occurs due to pull-out. The proof for the failure mode pull-out is performed in application A by determining the anchorage length $l_{b,rqd,fi}$ (t) required in case of fire. The value $l_{b,rqd,fi}$ (t) describes the basic value of the anchorage length in case of fire and is to be determined according to DIN EN 1992-1-1, equation (8.3) under consideration of the time- and temperature-dependent bond stress.

$$l_{b,rqd,fi}(t) = \frac{\emptyset}{4} \cdot \frac{\sigma_{sd,fi}}{f_{bd,fi}\,(\theta_{(t)})}$$

with

- $\emptyset$ = diameter of the reinforcement bar
- $\sigma_{sd,fi}$ = existing steel stress of the bar at the beginning of the anchorage length in the ultimate limit state under extraordinary design situation according to DIN EN 1990

The design value $l_{bd,fi}$ (t) of the anchorage length in case of fire is obtained analogously to the check under normal temperature according to DIN EN 19921-1, chapter 8.4.4.

4.6.4.2 Steel failure

The temperature-dependent load capacity of the rebar itself is limited by the load capacity of the steel cross-section. According to DIN EN 1992-1-2, Chapter 5.2(4), the reinforcement of statically determinate reinforced concrete structures may be verified in case of fire by means of a temperature criterion. The critical temperature is Θ_{crit} = 500°C. The proof for steel failure is therefore provided if the following applies to the most unfavorable (i.e. warmest) point of the rebar in the post-installed rebar connection.

$$\theta(t) \leq \theta_{crit} = 500°C$$

Alternatively, the verification of the reinforcing bar for steel failure in case of fire can be done by comparing the acting and the bond (tensile) force.

$$N_{fi.\theta(t),Rd} \geq N_{fi,Ed}$$

with $N_{fi,Ed}$: Stress on the bar at the beginning of the anchorage length in the ultimate limit state in case of an extraordinary design situation according to DIN EN 1990. The force that can be sustained in case of fire must be determined taking into account the temperature-dependent decrease of the yield strength according to DIN EN 1992-1-2, Table 3.2a.

$$f_{sy,\theta(t)} = k_{y\,\theta(t)} \cdot f_{yk}$$

You get the bond tensile force in case of fire as:

$$N_{fi,\theta(t),Rd} = k_{y\theta(t)} \cdot f_{yk} \cdot \frac{\pi\,.\theta^2}{4} \cdot \frac{1}{\gamma_{M,fi}}$$

In case of fire, the following applies in accordance with DIN EN 1992-1-2, Chapter 2.3 in accordance with the corresponding National Annex for the partial safety factor of reinforcing steel

$\gamma_{M.fi} = 1.0$

Table 12: Temperature for different fire durations vs. concrete cover

c [cm]	T [°C] with member thickness = 30 cm					
	Fire duration [min]					
	30	60	90	120	180	240
2	348	516	614	684	783	853
3	242	399	496	566	667	740
4	167	311	403	471	571	644
5	117	241	328	394	491	564
6	88	187	268	330	424	495
7	68	144	218	277	367	435
8	53	114	177	232	318	384
9	42	93	143	193	275	339
10	34	77	118	161	238	299
11	29	64	100	135	205	264
12	26	54	85	115	177	233
13	24	46	73	99	153	205
14	22	39	63	87	132	180
15	21	34	55	76	116	159
16	21	30	48	67	103	140
17	20	27	42	59	92	125
18	20	25	37	52	83	112
19	20	24	33	46	75	102
20	20	23	30	42	67	93
21	20	22	28	38	61	85
22	20	21	26	34	55	79
23	20	21	25	31	51	72
24	20	21	23	29	47	67
25	20	20	23	27	43	63

Table 13: Bond strength for different fire durations

$f_{bd,fi}$ [N/mm2] for member thickness = 30 cm										
Good bond conditions, C20/25										
8 mm ≤ d ≤ 32 mm										
	WIT-PE 1000						WIT-UH 300			
c [cm]	Fire duration [min]									
	30	60	90	120	180	240	30	60	90	120
2	-	-	-	-	-	-	0.23	-	-	-
3	0.25	-	-	-	-	-	0.74	-	-	-
4	0.46	-	-	-	-	-	1.69	0.35	-	-
5	0.80	0.25	-	-	-	-	2.91	0.74	0.29	-
6	1.26	0.38	0.22	-	-	-	3.45	1.36	0.56	0.28
7	1.93	0.58	0.30	0.20	-	-	3.45	2.17	0.96	0.50
8	2.89	0.84	0.42	0.27	-	-	3.45	3.03	1.52	0.83
9	3.45	1.16	0.58	0.36	0.21	-	3.45	3.45	2.19	1.26
10	3.45	1.57	0.80	0.48	0.26	-	3.45	3.45	2.89	1.80
11	3.45	2.11	1.04	0.64	0.33	0.22	3.45	3.45	3.45	2.40
12	3.45	2.80	1.34	0.84	0.42	0.27	3.45	3.45	3.45	3.00
13	3.45	3.45	1.71	1.05	0.53	0.33	3.45	3.45	3.45	3.45
14	3.45	3.45	2.17	1.30	0.66	0.40	3.45	3.45	3.45	3.45
15	3.45	3.45	2.73	1.61	0.82	0.50	3.45	3.45	3.45	3.45
16	3.45	3.45	3.40	1.98	0.99	0.61	3.45	3.45	3.45	3.45
17	3.45	3.45	3.45	2.43	1.18	0.73	3.45	3.45	3.45	3.45
18	3.45	3.45	3.45	2.95	1.40	0.87	3.45	3.45	3.45	3.45
19	3.45	3.45	3.45	3.45	1.66	1.01	3.45	3.45	3.45	3.45
20	3.45	3.45	3.45	3.45	1.95	1.17	3.45	3.45	3.45	3.45
21	3.45	3.45	3.45	3.45	2.29	1.34	3.45	3.45	3.45	3.45
22	3.45	3.45	3.45	3.45	2.66	1.53	3.45	3.45	3.45	3.45
23	3.45	3.45	3.45	3.45	3.07	1.74	3.45	3.45	3.45	3.45
24	3.45	3.45	3.45	3.45	3.45	1.96	3.45	3.45	3.45	3.45
25	3.45	3.45	3.45	3.45	3.45	2.19	3.45	3.45	3.45	3.45

4.6.5. Application case B

If the rebar connection in application B is perpendicular to the direction of the flamed surface, the temperature along the rebar connection changes over time and place - the temperature decreases with increasing distance from the flamed surface.

4.6.5.1. Pull out

A design in case of fire for the failure type pull-out in the form of the determination of a single time-dependent composite stress $f_{bd,fi}$ (Θ(t)) is not sufficient for application B because this stress is variable along the reinforcement connection. A procedure analogous to application A would therefore result in an additional required anchoring length $l_{b,rqd,fi}$ (t) at each point of the rebar.

On the safe side, it is of course conceivable and permissible to determine the required anchorage length $l_{b,rqd,fi}$ (t) analogous to application A, taking into account the most unfavorable (i.e. highest) temperature of the rebar in the existing component. However, the results obtained in this way can be considered as extremely conservative with increasing anchorage length.

A more economical approach, which makes use of the actual load-bearing capacity of the bonded joint, is to prove pull-out failure in application B by comparing the acting and the absorbing forces

$$N_{bd,fi,Rd\,(t)} \geq N_{fi,Ed}$$

The bond force $N_{bd,fi,Rd}$ (t) in the composite joint is obtained by integrating the temperature-dependent composite stress $f_{bd,fi}$ (Θ(t)) via the load-transmitting surface of the rebar

$$N_{bd,fi,Rd}(t) = \pi \cdot \emptyset \cdot \int_0^{l_v} f_{bd,fi}\left(\theta\,(t,x)\right)dx$$

with l_v : Development depth. The bond and acting forces are identical:

$$N_{bd,fi,Rd\,(t)} = N_{fi,Ed}$$

The development depth l_v for a defined time t corresponds to the required anchorage length $l_{b,rqd,fi}$ (t) according to the corresponding ETA and DIN EN 1992-1-1, Equation (8.3). Analogous to the application case A and the cold case, the design value $l_{bd,fi}$ (t) of the anchorage length in case of fire shall be determined according to DIN EN 1992-1-1, chapter 8.4.4.

4.6.5.2. Steel failure

In contrast to the failure due to pull-out, the check for steel failure must be performed at the most unfavorable check section, i.e. taking into account the maximum temperature occurring along the reinforcement bars at a given time t. The verification can be performed analogous to application A by means of the temperature criterion or by comparing the acting and the absorbing force.

Table 14: Tension load for different fire duration

$N_{bd,fi}$ [kN] d = 16 mm										
Good bond conditions, C20/25										
	WIT-PE 1000						WIT-UH 300			
l_v [cm]	Fire duration [min]									
	30	60	90	120	180	240	30	60	90	120
16	20.1	13.6	8.4	4.8	2.2	1.2	24.8	20.0	16.4	13.4
18	23.5	17.1	12.2	7.7	3.5	2.0	28.3	23.5	19.9	16.9
20	27.0	20.5	15.7	11.5	5.3	3.0	31.7	26.9	23.3	20.4
22	30.5	24.0	19.1	15.1	7.9	4.5	35.2	30.4	26.8	23.9
24	33.9	27.5	22.7	18.6	11.4	6.4	38.7	33.9	30.3	27.3
25	35.7	29.3	24.3	20.3	13.4	7.7	40.4	35.6	32.0	29.1
26	37.4	30.9	26.1	22.1	15.2	9.1	42.1	37.4	33.7	30.8
28	40.9	34.4	29.5	25.6	18.8	12.6	45.6	40.8	37.2	34.3
30	44.3	37.9	33.0	29.1	22.4	16.5	49.1	44.3	40.7	37.8
32	47.8	41.4	36.5	32.5	25.8	20.1	52.5	47.8	44.2	41.2
34	51.3	44.8	39.9	36.0	29.3	23.7	56.0	51.2	47.6	44.7
36	54.7	48.3	43.4	39.5	32.8	27.2	59.5	54.7	51.1	48.2
38	58.2	51.8	46.9	42.9	36.2	30.7	62.9	58.2	54.6	51.7
40	61.7	55.3	50.3	46.4	39.7	34.2	66.4	61.6	58.0	55.1
45	70.3	63.9	59.0	55.1	48.4	42.8	75.1	70.3	66.7	63.8
50	79.0	72.5	67.7	63.7	57.1	51.5	83.7	79.0	75.4	72.4
55	87.7	81.2	76.4	72.4	65.7	60.2	92.4	87.6	84.0	81.1
60	96.4	89.9	85.1	81.1	74.4	68.8	101.1	96.3	92.7	89.8
65	105.0	98.6	93.7	89.7	83.0	77.5	109.8	105.0	101.4	98.5
70	113.7	107.3	102.4	98.4	91.7	86.2	118.4	113.7	110.1	107.1
75	122.4	115.9	111.1	107.1	100.4	94.8	127.1	122.3	118.7	115.8
80	131.0	124.6	119.7	115.7	109.1	103.5	135.8	131.0	127.4	124.4
85	139.7	133.3	128.4	124.4	117.7	112.2	144.4	139.7	136.1	133.1
90	148.4	141.9	137.1	133.1	126.4	120.9	153.1	148.3	144.7	141.8
95	157.1	150.6	145.8	141.8	135.1	129.5	161.8	157.0	153.4	150.5
100	165.7	159.3	154.4	150.4	143.8	138.2	170.5	165.7	162.1	159.1
110	183.1	176.6	171.8	167.8	161.1	155.5	187.8	183.0	179.4	176.5
120	200.4	193.9	189.1	185.1	178.5	172.9	205.1	200.4	196.8	193.8
130	217.7	211.3	206.5	202.5	195.8	190.2	222.5	217.7	214.1	211.2
140	235.1	228.6	223.8	219.8	213.1	207.6	239.8	235.0	231.4	228.5
150	252.4	246.0	241.1	237.1	230.5	224.9	257.2	252.4	248.8	245.8
160	269.8	263.3	258.5	254.5	247.8	242.3	274.5	269.7	266.1	263.2

*For other diameters and concrete strengths, please contact Würth technical support

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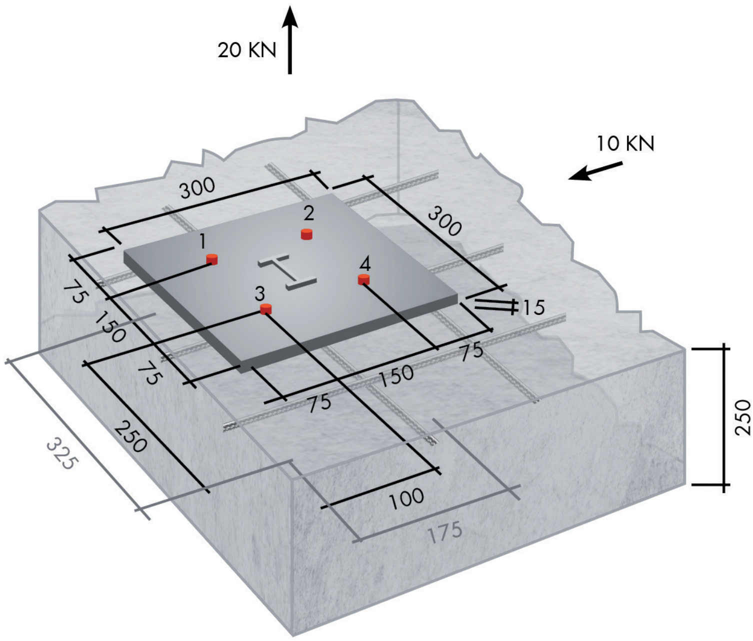
DESIGN EXAMPLES – BONDED ANCHORS



Actions			
Design value of tensile load	$N^{g}_{ed} =$	20	kN
Number of anchors in the group loaded with tension	n =	4	
Design value of tensile load acting on a single anchor	$N^{h}_{ed} = N^{g}_{ed}/n =$	5	kN
Percent of sustained load from total load	a_{sus}	70	%
Design value of shear load	$V^{g}_{Sd} =$	10	kN
Number of anchors in the group loaded with shear	n =	4	
Design value of shear load acting on a single anchor	$V^{h}_{ed} = V^{g}_{ed}/n =$	2.5	kN

Anchor data

Anchor type		WIT-UH 300 + W-VD-A/S M12
Steel grade		5.8
Anchor diameter	M	12
Anchorage depth	$h_{ef} =$	110

Base material

Characteristic compressive cube strength of concrete at 28 days	$f_{ck,cube} =$	25	N/mm²
Characteristic compressive cube strength of concrete at 28 days	$f_{ck,cyl} =$	20	N/mm²

Cracked concrete		**Non-cracked concrete**	✔

Structural verification

Tension		Shear	
$\beta_{N,s}$ =	$N^h_{Ed} / N_{Rd,s}$	$\beta_{V,s}$ =	$V^h_{Ed} / V_{Rd,s}$
$\beta_{N,s}$ =	18 %	$\beta_{V,s}$ =	12 %
$\beta_{N,p}$ =	$N^h_{Ed} / N_{Rd,p}$	$\beta_{V,cp}$ =	$V^h_{Ed} / V_{Rd,cp}$
$\beta_{N,p}$ =	30 %	$\beta_{V,cp}$ =	9 %
$\beta_{N,c}$ =	$N^h_{Ed} / N_{Rd,c}$	$\beta_{V,c}$ =	$V^h_{Ed} / V_{Rd,c}$
$\beta_{N,c}$ =	35 %	$\beta_{V,c}$ =	55 %
$\beta_{N,sp}$ =	$N^h_{Ed} / N_{Rd,sp}$		
$\beta_{N,sp}$ =	13 %		

I - Required verification of post-installed anchor in combined tension and shear load:

Assessment of steel failure only

	Utilization	Verification
Tension	18 %	$\beta_{N,max} \leq 1.00$
Shear	12 %	$\beta_{V,max} \leq 1.00$
Tension/shear combination	5 %	$\beta_{N,max}^{2.0} + \beta_{V,max}^{2.0} \leq 1.00$

II - Required verification of post-installed anchor in combined tension and shear load:

Assessment of failure modes other than steel

	Utilization	Verification
Tension	35 %	$\beta_{N,max} \leq 1.00$
Shear	55 %	$\beta_{V,max} \leq 1.00$
Tension/shear combination	62 %	$\beta_{N,max}^{1.5} + \beta_{V,max}^{1.5} \leq 1.00$

A. Required verification of post-installed anchor in tension

1. Steel failure

$N_{Rd,s}$	=	28.1	kN
$\beta_{N,s}$	=	0.18	

2. Combined pull-out and concrete failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$$

$N^0_{Rd,p}$	=	44.2	kN

a. Influence of concrete strength

$f_{b,N}$	=	1.0

b. Influence of embedment depth

f_{hef}	=	1.0

DESIGN EXAMPLES – BONDED ANCHORS

c. Influence of spacing									
$s_{cr,Np}$	=	330	mm						
s_x	=	150	mm	$s_x / s_{cr,p}$	=	0.45	$f_{sx,p}$	=	0.73
s_y	=	150	mm	$s_y / s_{cr,p}$	=	0.45	$f_{sy,p}$	=	0.73
d. Influence of edge distance									
$c_{cr,Np}$	=	165	mm						
c_x	=	100	mm	$c_x / c_{cr,p}$	=	0.61	$f_{cx,1,p}$	=	0.88
							$f_{cx,2,p}$	=	0.81
c_y	=	250	mm	$c_y / c_{cr,p}$	=	1.52	$f_{cy,p}$	=	1.00
e. Influence of sustained loading									
f_{sus}	=	1.0							
$N_{Rd,p}$	=	16.79	kN						
$\beta_{N,p}$	=	0.3							

3. Concrete cone failure

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

$N^0_{Rd,c}$	=	37.8	kN						
a. Influence of concrete strength									
$f_{b,N}$	=	1.0							
b. Influence of embedment depth									
f_{hef}	=	1.0							
c. Influence of spacing									
$s_{cr,N}$	=	330	mm						
s_x	=	150	mm	$s_x / s_{cr,N}$	=	0.45	f_{sx}	=	0.73
s_y	=	150	mm	$s_y / s_{cr,N}$	=	0.45	f_{sy}	=	0.73
d. Influence of edge distance									
$c_{cr,N}$	=	165	mm						
c_x	=	100	mm	$c_x / c_{cr,N}$	=	0.61	$f_{cx,1}$	=	0.88
							$f_{cx,2}$	=	0.81
c_y	=	250	mm	$c_y / c_{cr,N}$	=	1.52	f_{cy}	=	1.00
$N_{Rd,c}$	=	14.36	kN						
$\beta_{N,c}$	=	0.35							

4. Splitting failure

No verification is required if at least one of the following conditions is fulfilled.

a. The edge distance in all directions is $c \geq 1.0\ c_{cr,sp,}$ for single fasteners and $c \geq 1.2\ c_{cr,sp,}$ for groups of fasteners and the member depth is $h \geq h_{min}$ in both cases, with h_{min} corresponding to $c_{cr,sp}$.

b. The characteristic resistances for concrete cone failure and pull-out failure or combined pull-out and concrete failure (bonded fasteners) are calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to wk ≈ 0.3 mm.

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

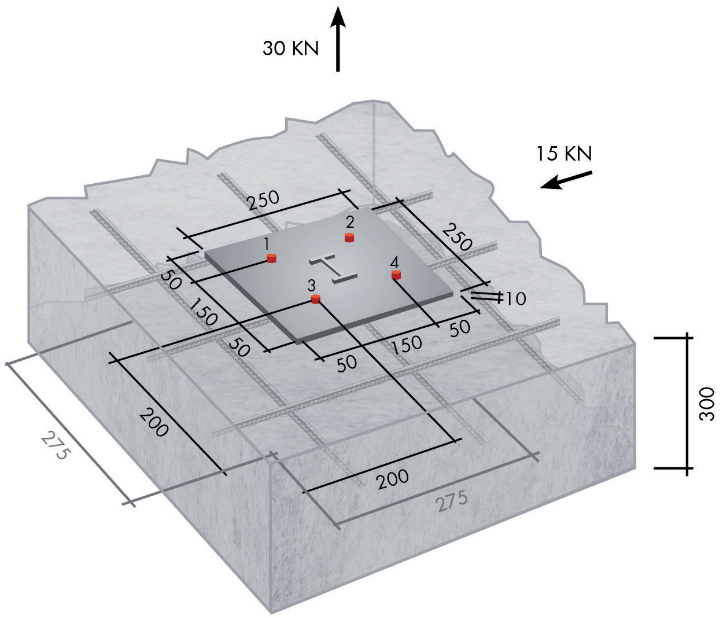
								Verification	
c_x	=	100	mm	$c_{cr,sp}$	=	264	mm	$c_x \geq c_{cr,sp}$	check required
				$1.2\ c_{cr,sp}$	=	316.8	mm	$c_x \geq 1.2\ c_{cr,sp}$	check required
c_y	=	250	mm	$c_{cr,sp}$	=	264	mm	$c_y \geq c_{cr,sp}$	check required
				$1.2\ c_{cr,sp}$	=	316.8	mm	$c_y \geq 1.2\ c_{cr,sp}$	check required
h	=	250	mm	h_{min}	=	140	mm	$h \geq h_{min}$	✔
$N^0_{Rd,sp}$	=	37.8	kN						
a. Influence of concrete strength									
$f_{b,N}$	=	1.00							
b. Influence of embedment depth									
f_{hef}	=	1.00							
c. Influence of Spacing									
$s_{cr,sp}$	=	220	mm						
s_x	=	150	mm	$s_x / s_{cr,sp}$	=	0.68		$f_{sx,sp}$ =	0.85
s_y	=	150	mm	$s_y / s_{cr,sp}$	=	0.68		$f_{sy,sp}$ =	0.85
d. Influence of edge distance									
$c_{cr,sp}$	=	110	mm						
c_x	=	100	mm	$c_x / c_{cr,sp}$	=	0.91		$f_{cx,1,sp}$ =	0.98
c_y	=	250	mm	$c_y / c_{cr,sp}$	=	2.27		$f_{cx,2,sp}$ =	1
								$f_{cy,sp}$ =	1
e. Influence of concrete member thickness									
h	=	250	mm	h_{min}	=	140		h/h_{min} =	1.79
f_h	=	1.48							
$N_{Rd,sp}$	=	39.6	kN						
$\beta_{N,sp}$	=	0.13							

DESIGN EXAMPLES

DESIGN EXAMPLES – BONDED ANCHORS

B. Required verification of post-installed anchor in shear												
1. Steel failure, shear load without lever arm												
$V_{Rd,s}$	=	20.2	kN									
$\beta_{V,s}$	=	0.12										
2. Concrete pry-out												
$V_{Rd,c}$	=	$k \cdot \min(N_{Rd,p;}\ N_{Rd,c})$										
$N_{Rd,c}$	=	14.36	kN									
k	=	2										
$V_{Rd,cp}$	=	28.72	kN									
$\beta_{V,cp}$	=	0.09										
3. Concrete edge breakout												
Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq \max\ (10\ h_{ef}\ ;\ 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.												
$V_{Rd,c}$	=	$V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V}\, f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$										
$V^0_{Rk,c}$	=	4.6	kN									
a. Influence of concrete strength												
$f_{b,N}$	=	1.00										
b. Influence of embedment depth												
$f_{hef,V}$	=	1.04										
c. Influence of spacing												
In groups loaded perpendicular to the edge, only two adjacent anchors closest and parallel to the edge carry the load. The same spacing should be used for the verification.												
s	=	150	mm	c_1	=	100	s/c_1	=	1.5	$f_{s,v}$	=	1.5
d. Influence of edge distance c_1												
c_1	=	100	mm	d	=	12	c_1/d	=	8.33	$f_{c1,v}$	=	1.26
e. Influence of edge distance c_2												
c_2	=	250	mm	c_1	=	100	c_2/c_1	=	2.50	$f_{c2,v}$	=	1
f. Influence on load direction												
a	=	0	°									
f_a	=	1										
g. Influence on member thickness												
h	=	250	mm	c_1	=	100	h/c_1	=	2.50			
f_h	=	1										
$V_{Rd,c}$	=	9.04	kN	for a single anchor								
$\beta_{V,c}$	=	0.55										

DESIGN TEMPLATE – MECHANICAL ANCHORS



Actions			
Design value of tensile load	N^{g}_{ed} =	30	kN
Number of anchors in the group loaded with tension	n =	4	
Design value of tensile load acting on a single anchor	$N^{h}_{ed} = N^{g}_{ed}/n$ =	7.5	kN
Design value of shear load	V^{g}_{ed} =	15	kN
Number of anchors in the group loaded with shear	n =	4	
Design value of shear load acting on a single anchor	$V^{h}_{ed} = V^{g}_{ed}/n$ =	3.75	kN
Anchor data			
Anchor type		W-FAZ/A4 M12	
Anchor diameter	M	12	
Anchorage depth	h_{ef} =	70	
Base material			
Compressive strength class of concrete			
Characteristic compressive cube strength of concrete at 28 days	$f_{ck,cube}$ =	37	N/mm²
Characteristic compressive cube strength of concrete at 28 days	$f_{ck,cyl}$ =	30	N/mm²
Cracked concrete ✔	**Non-cracked concrete**		

Structural verification			
Tension		**Shear**	
$\beta_{N,s}$ =	$N^h_{Ed} / N_{Rd,s}$	$\beta_{V,s}$ =	$V^h_{Ed} / V_{Rd,s}$
$\beta_{N,s}$ =	28 %	$\beta_{V,s}$ =	16 %
$\beta_{N,p}$ =	$N^h_{Ed} / N_{Rd,p}$	$\beta_{V,cp}$ =	$V^h_{Ed} / V_{Rd,cp}$
$\beta_{N,p}$ =	57 %	$\beta_{V,cp}$ =	13 %
$\beta_{N,c}$ =	$N^h_{Ed} / N_{Rd,c}$	$\beta_{V,cp}$ =	$V^h_{Ed} / V_{Rd,cp}$
$\beta_{N,c}$ =	62 %	$\beta_{V,cp}$ =	62 %
$\beta_{N,sp}$ =	$N^h_{Ed} / N_{Rd,sp}$		
$\beta_{N,sp}$ =	0 %		

I - Required verification of post-installed anchor in combined tension and shear load:

Assessment of steel failure only

	Utilization	Verification
Tension	28 %	$\beta_{N,max} \leq 1.00$
Shear	16 %	$\beta_{V,max} \leq 1.00$
Tension/shear combination	10 %	$\beta_{N,max}{}^{2.0} + \beta_{V,max}{}^{2.0} \leq 1.00$

II - Required verification of post-installed anchor in combined tension and shear load:

Assessment of failure modes other than steel

	Utilization	Verification
Tension	62 %	$\beta_{N,max} \leq 1.00$
Shear	62 %	$\beta_{V,max} \leq 1.00$
Tension/shear combination	98 %	$\beta_{N,max}{}^{1.5} + \beta_{V,max}{}^{1.5} \leq 1.00$

A. Required verification of post-installed anchor in tension

1. Steel failure

$\mathbf{N_{Rd,s}}$	=	**26.7**	**kN**
$\beta_{N,s}$	=	28	%

2. Pull-out

$N_{Rd,p}$	=	$N^0_{Rd,p} \cdot f_{b,N}$

a. Influence of concrete strength

$f_{b,N}$	=	1.22	
$N^0_{Rd,p}$	=	10.70	kN
$\mathbf{N_{Rd,p}}$	=	**13.05**	**kN**
$\beta_{N,p}$	=	57	%

DESIGN TEMPLATE – MECHANICAL ANCHORS

3. Concrete breakout

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

$N^0_{Rd,c}$	=	13.4								
a. Influence of concrete strength										
$f_{b,N}$	=	1.22								
b. Influence of spacing										
$s_{cr,N}$	=	210	mm							
s_x	=	150	mm	$s_x / s_{cr,N}$	=	0.71		f_{sx}	=	0.86
s_y	=	150	mm	$s_y / s_{cr,N}$	=	0.71		f_{sy}	=	0.86
d. Influence of edge distance										
$c_{cr,N}$	=	105	mm							
c_x	=	200	mm	$c_x / c_{cr,N}$	=	1.90		$f_{cx,1}$	=	1.00
								$f_{cx,2}$	=	1.00
c_y	=	200	mm	$c_y / c_{cr,N}$	=	1.90		f_{cy}	=	1.00
$N_{Rd,c}$	=	**12.09**	**kN**							
$\beta_{N,c}$	=	62	%							

4. Splitting failure

No verification is required if at least one of the following conditions is fulfilled.

a. The edge distance in all directions is $c \geq 1{,}0\ c_{cr,sp,}$ for single fasteners and $c \geq 1{,}2\ c_{cr,sp,}$ for groups of fasteners and the member depth is $h \geq h_{min}$ in both cases, with h_{min} corresponding to $c_{cr,sp}$.

(applies)

b. The characteristic resistances for concrete cone failure and pull-out failure (headed and post-installed mechanical fasteners) or combined pull-out and concrete failure (bonded fasteners) are calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to wk ≈ 0,3 mm.

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

								Verification	
c_x	=		mm	$c_{cr,sp}$	=		mm	$c_x \geq c_{cr,sp}$	Not required
					=		mm	$c_x \geq 1{,}2\ c_{cr,sp}$	Not required
c_y	=		mm	$c_{cr,sp}$	=		mm	$c_y \geq c_{cr,sp}$	Not required
					=		mm	$c_y \geq 1{,}2\ c_{cr,sp}$	Not required
h	=		mm	h_{min}	=		mm	$h \geq h_{min}$	
$N^0_{Rd,sp}$	=		kN						
a. Influence of concrete strength									
$f_{b,N}$	=								
b. Influence of embedment depth									
f_{hef}	=								

c. Influence of spacing									
$s_{cr,sp}$	=		mm						
s_x	=		mm	$s_x / s_{cr,sp}$	=		$f_{sx,sp}$	=	
s_y	=		mm	$s_y / s_{cr,sp}$	=		$f_{sy,sp}$	=	
d. Influence of edge distance									
$c_{cr,sp}$	=		mm						
c_x	=		mm	$c_x / c_{cr,sp}$	=		$f_{cx,1,sp}$	=	
							$f_{cx,2,sp}$	=	
c_y	=		mm	$c_y / c_{cr,sp}$	=		$f_{cy,sp}$	=	
e. Influence of concrete member thickness									
h	=		mm	h_{min}	=		mm	h/h_{min}	=
f_h	=								
$\mathbf{N_{Rd,sp}}$	**=**		kN						
$\beta_{N,sp}$	=								

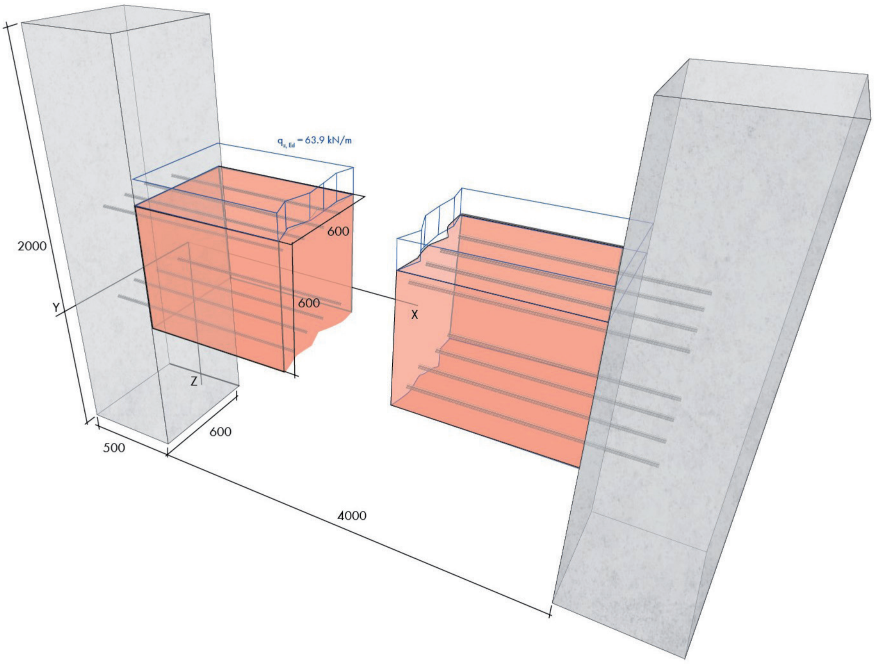
B. Required verification of post-installed anchor in shear			
1. Steel failure, shear load without lever arm			
$V^0_{Rd,s}$	=	24	kN
$\beta_{V,s}$	=	16	%
2. Concrete pry-out			
$V_{Rd,c}$	=	$k \cdot N_{Rd,c}$	
$N_{Rd,c}$	=	12.09	
k	=	2,4	
$\mathbf{V_{Rd,cp}}$	**=**	**29.02**	kN
$\beta_{V,cp}$	=	13	%
3. Concrete edge breakout			
Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq \max(10\ h_{ef}; 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.			
$V_{Rd,c}$	=	$V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_\alpha \cdot f_h$	
$V^0_{Rk,c}$	=	21.2	kN
a. Influence of concrete strength			
$f_{b,N}$	=	1.22	

DESIGN TEMPLATE – MECHANICAL ANCHORS

b. Influence of spacing											
In groups loaded perpendicular to the edge, only two adjacent anchors closest and parallel to the edge carry the load. The same spacing should be used for the verification.											
s	=	150	mm	c_1	=	200	s/c_1	=	0.75	$f_{s,v}$	=	1.25
c. Influence of edge distance											
c_2	=	200	mm	c_1	=	200	c_2/c_1	=	1	$f_{c2,v}$	=	0.75
d. Influence on load direction											
a	=	0	°								
f_a	=	1									
e. Influence on member thickness											
h	=	300	mm	c_1	=	200	h/c_1	=	1.50		
f_h	=	1									
$\mathbf{V_{Rd,c}}$	**=**	**24.25**	**kN**	for a single anchor							
$\beta_{V,c}$	=	62	%								

DESIGN EXAMPLES

DESIGN EXAMPLE - BEAM BETWEEN TWO COLUMNS



Base material of existing & new				
Characteristic compressive cube strength of concrete at 28 days	$f_{ck,cube}$ =	25	N/mm²
Characteristic compressive cube strength of concrete at 28 days	$f_{ck,cyl}$ =	30	N/mm²
Cracked concrete	✔	**Non-cracked concrete**		
Roughness of joint	=	rough		

Geometry			
Existing structure:			
Height	H =	2000	mm
Width	W =	600	mm
Depth	D =	500	mm
New structure:			
Height	H =	600	mm
Width	W =	600	mm
Span length	L =	4000	mm
Effective span length	L_{ef} =	4500	mm

Reinforcement			
Injection Anchor		WIT-UH 300	
Top reinforcement diameter	∅ =	16	mm
Bottom reinforcement diameter	∅ =	16	mm
Top reinforcement:			
Number of bars	n_{Top}	4	
Anchorage length	$l_{bd,1}$	193	mm
Drill hole depth	l_{v1}	250	mm
Drill diameter	d_0	20	mm
Bottom reinforcement:			
Number of bars	n_{Bot}	4	
Anchorage length	$l_{bd,2}$	196	mm
Drill hole depth	l_{v2}	250	mm
Drill diameter	d_0	20	mm

Actions
Beam self-weight = 25 * (0.6*0.6) * 1.35 = 12.15 kN/m
Slab self-weight = 25 * 0.25* 4 m * 1.35 = 33.75 kN/m
=> Dead load = 12.15 + 33.75 = 45.9 kN/m
Imposed load = 3 kN/m² (Category B - Office)
=> Live load = 3 * 4 m * 1.5 = 18 kN/m

A - Determination of the additional normal force due to shear loading			
F_{Ed}	=	$\max(\lvert V_{z,ed}\rvert \cdot a_l/z;\ 0.5 \cdot \lvert V_{z,ed}\rvert)$	EN 1992-1-1: 9.2.1.4 (9.3); NCI 9.3DE
$V_{z,ed}$	=	143.775 kN	
F_{Ed}	=	159.75 kN	

B - Verification of steel			
Bottom reinforcement (new)			
$\beta_{sb,2}$	=	$\sigma_{Ed} / \sigma_{Rd}$	degree of capacity utilisation
σ_{Ed}	=	N_{Ed}/A = 159.74 / 4 (π x 16^2/4) = 198.63 N/mm²	Design value of the actions
σ_R	=	f_{yk} / γ_{Ms} = 500 / 1.15 = 434.78 N/mm²	
$\beta_{sb,2}$	=	$\sigma_{Ed} / \sigma_{Rd}$ = 198.63 / 434.78 = **0.46**	degree of capacity utilisation

DESIGN EXAMPLE - BEAM BETWEEN TWO COLUMNS

C - Verification of concrete

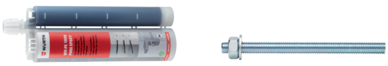
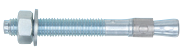
Bottom reinforcement (anchorage)

l_{bd}	=	$\max(\alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \alpha_5 \cdot l_{b,rqd}; l_{b,min})$		EN 1992-1-1: 8.4.4 (8.4)
$l_{b,rqd}$	=	$(d/4) \cdot (\sigma_{sd} / f_{bd})$ = (16/4) x (198.63 / 2.7) = 294 mm		EN 1992-1-1: 8.4.3 (8.3)
$l_{b,min}$	=	$\max(0.3 \cdot \alpha_1 \cdot \alpha_4 \cdot l_{b,rqd,min}; 2/3 \cdot 10 \cdot d; 2/3 \cdot 100\ mm) \cdot 1.0$		EN 1992-1-1: 8.4.4 (8.6)
$l_{b,rqd,min}$	=	$(d/4) \cdot (f_{yd} / f_{bd})$ = (16/4) x (500/1.15/2.7) = 644 mm		EN 1992-1-1: 8.4.3 (8.3)
$l_{b,min}$	=	max (0,3 x 1 x 1 x 644 ; 2/3 x 10 x 16; 2/3 x 100) = 193.2 mm		
l_{bd}	=	max (1 x 1 x 1x 1x 0.67 x 294 ; 193.2) = 196.9 mm		
l_v	=	250	mm	9.2.1.4 (3) extension to the calculated support position (effective span), which is in this case in the middle of the column (Commentary of the German National Annex)

Shear at the joint

β_{joint}	=	V_{Edi} / V_{Rdi}	degree of capacity utilisation
V_{Edi}	=	$\beta \cdot V_{Ed} / (z \cdot bi)$ = 1 x 143.775 / (600 x 600) = 0.399 N/mm²	EN 1992-1-1: 6.2.5 (6.24)
V_{Rdi}	=	$M_{in} (V_{Rdic}; V_{Rc,max})$	EN 1992-1-1: 6.2.5 (1)
V_{Rdic}	=	$c \cdot f_{ctd} + (\mu \cdot \sigma_D + \mu \cdot \sigma_z)$ = 0.4 x 1.0174 + (0.7 x 0 + 0.7 x 0) = 0.407 N/mm²	EN 1992-1-1: 6.2.5 (6.25)
$V_{Rc,max}$	=	$0.5 \cdot v \cdot f_{cd}$	EN 1992-1-1: 6.2.5 (6.25)
f_{cd}	=	$a_{cc} \cdot f_{ck} / \gamma_c$ = 0.85 x 20/1.5 = 14.17 N/mm²	EN 1992-1-1: 3.1.6 (3.15)
$V_{Rc,max}$	=	$0.5 \cdot v \cdot f_{cd}$ = 0.5 x 0.5 x 14.17 = 3.54 N/mm²	EN 1992-1-1: 6.2.5 (6.25)
β_{joint}	=	V_{Edi} / V_{rdi} = 0.399/0.407 = 0.98	Degree of capacity utilisation

ANCHOR SELECTION

Anchor/Screw	Base material		Load			
	Non-cracked	Cracked	Static	Seismic C1	Seismic C2	Fatigue
W-VIZ **Art. No. 0905 440..** 	✓	✓	✓	✓	✓	✓ 1)
WIT-BS **Art. No. 0905 450..** 	✓	✓	✓	–	–	–
WIT-UH 300 M **Art. No. 5918 500..** 	✓	✓	✓	✓	✓	–
WIT-UH 300 R **Art. No. 5918 500..** 	✓	✓	✓	✓	–	–
WIT-PE 1000 M **Art. No. 5918 605..** 	✓	✓	✓	✓	✓	–
WIT-PE 1000 R **Art. No. 5918 605..** 	✓	✓	✓	✓	–	–
WIT-PE 510 M **Art. No. 5918 615..** 	✓	✓	✓	–	–	–
WIT-PE 510 R **Art. No. 5918 615..** 	✓	✓	✓	–	–	–
WIT-VM 250 M **Art. No. 0903 450..** 	✓	✓	✓	✓	–	–
WIT-VM 250 R **Art. No. 0903 450..** 	✓	✓	✓	✓	–	–
WIT-PM 200 M **Art. No. 5918 24..** 	✓	–	✓	–	–	–
W-BS **Art. No. 5929..** 	✓ 2)	✓	✓	✓	✓	–
W-FAZ **Art. No. 5928..** 	✓	✓	✓	✓	✓	–
W-HAZ **Art. No. 0905 2..** 	✓	✓	✓	✓	✓	–
W-FA **Art. No. 5932..** 	✓	–	✓	–	–	–
W-ED **Art. No. 0904..** 	✓	–	✓	–	–	–

1) W-VIZ Dynamic version 2) for sizes Ø 6 -> Ø 14 3) Special consideration according to rebar theory

Fastening material					Fire resistance			Page number
Rebar	Steel, zinc electro plated	Steel, Hot-dipped	Stainless steel A4	High corrosion resistant steel HCR	R 120	ZTV-Ing 30/90		
						A4	HCR	
–	✓	✓	✓	✓	✓	–	✓	72
–	✓	–	✓	–	–	–	–	134
–	✓	✓	✓	✓	✓	–	–	160
✓	–	–	–	–	– [3)]	–	–	192
–	✓	✓	✓	✓	✓	–	–	222
✓	–	–	–	–	– [3)]	–	–	252
–	✓	✓	✓	✓	–	–	–	280
✓	–	–	–	–	– [3)]	–	–	304
–	✓	✓	✓	✓	✓	–	–	326
✓	–	–	–	–	– [3)]	–	–	352
–	✓	✓	✓	✓	–	–	–	376
–	✓	–	✓	✓	✓	–	–	400
–	✓	–	✓	✓	✓	–	✓	422
–	✓	–	✓	–	✓	–	–	454
–	✓	✓	✓	✓	–	–	✓	488
–	✓	–	✓	✓	✓	–	–	524

W-VIZ/S

W-VIZ-A/S

Galvanized (5 microns): M8 – M24

W-VIZ-A/F

Hot-dipped: M8 – M24

WIT-VIZ

WIT-VIZ EXPRESS

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

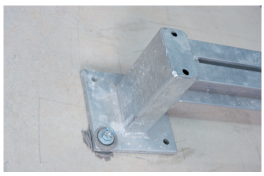
Suitable for:
Concrete C12/15, Natural stone with dense structure

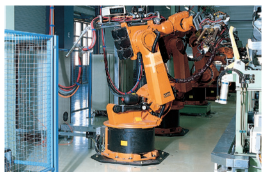
Type of installation		
Pre-positioned	In-place	Stand-off
✓	✓	✓

Installation condition		
Dry concrete	Wet concrete	Flooded drill hole
✓	✓	✓

Drilling method		
Hammer drill	Diamond drill	Hollow drill
✓	✓	✓

Applications





Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt, Berlin	ETAG 001-T5	ETA-04/0095, 11.05.2017
Fire resistance	MFPA Leipzig GmbH	TR 020	GS 3.2/18-075-1
LEED	eurofins		14.06.13
VOC Emissions Test report	eurofins	DEVL 1101903D, DEVL 1104875A	07.01.14

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness is according to anchor characteristics
- Anchor material is as specified in anchor material specification table
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²
- Bonding expansion system WIT-VIZ consists of an anchor rod WIT-VIZ-A/S and injection mortar WIT-VIZ or WIT-EXPRESS
- Temperature range I: -40°C to +80°C (max. long term/short term base material temperature +50°C/+80°C)
- Dry or wet conditions of drill hole, hammer and diamond core drilling
- Installation temperature range +5°C to +40°C

Mean ultimate resistance

Anchor type: WIT-VIZ, M8 - M12

Thread size				**M8**	**M8**	**M10**	**M10**	**M12**	**M12**	**M12**
Effective anchorage depth		h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	15.0	22.0	30.9	30.9	38.4	40.6	61.6
Shear	C20/25	$V_{Ru,m}$	[kN]	15.2	14.8	24.1	21.4	40.5	40.5	40.5
Cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	11.2	17.8	25.5	26.9	31.8	37.5	44.0
Shear	C20/25	$V_{Ru,m}$	[kN]	15.2	14.8	24.1	24.1	40.5	40.5	40.5

Anchor type: WIT-VIZ, M12 - M16

Thread size				**M12**	**M12**	**M12**	**M12**	**M16**	**M16**	**M16**
Effective anchorage depth		h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	61.6	65.9	65.9	65.9	62.2	80.9	100.9
Shear	C20/25	$V_{Ru,m}$	[kN]	40.5	40.5	40.5	40.5	75.4	75.4	75.4
Cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	47.1	61.3	61.3	61.3	44.7	68.3	99.2
Shear	C20/25	$V_{Ru,m}$	[kN]	40.5	40.5	40.5	40.5	75.4	75.4	75.4

Anchor type: WIT-VIZ, M16 - M24

Thread size				**M16**	**M16**	**M20**	**M20**	**M20**	**M24**	**M24**	**M24**
Effective anchorage depth		h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete											
Tension	C20/25	$N_{Ru,m}$	[kN]	100.9	115.9	107.9	196.0	196.0	201.0	237.6	237.6
Shear	C20/25	$V_{Ru,m}$	[kN]	75.4	75.4	82.3	117.6	117.6	169.0	169.0	169.0
Cracked concrete											
Tension	C20/25	$N_{Ru,m}$	[kN]	99.2	104.7	94.3	136.6	136.6	133.5	183.4	183.4
Shear	C20/25	$V_{Ru,m}$	[kN]	75.4	75.4	82.3	117.6	117.6	169.0	169.0	169.0

W-VIZ/S

Characterstic loads

Anchor type: WIT-VIZ, M8 - M12

Thread size				M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth		h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	9.0	17.4	22.9	25.0	32.0	28.8	35.2
	C50/60			14.2	18.0	25.0	25.0	35.0	45.6	54.0
Shear	≥ C20/25	V_{Rk}	[kN]	14.0	14.0	21.0	21.0	34.0	34.0	34.0
Cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	8.7	12.2	16.0	22.4	22.4	20.2	24.6
	C50/60			13.8	18.0	25.0	25.0	35.0	31.9	39.0
Shear	≥ C20/25	V_{Rk}	[kN]	14.0	14.0	21.0	21.0	34.0	34.0	34.0

Anchor type: WIT-VIZ, M12 - M16

Thread size				M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth		h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	40.0	49.2	50.0	50.0	42.0	52.9	68.8
	C50/60			54.0	57.0	57.0	57.0	66.4	83.7	108.7
Shear	≥ C20/25	V_{Rk}	[kN]	34.0	34.0	34.0	34.0	63.0	63.0	63.0
Cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	31.9	34.4	39.7	48.1	29.4	37.1	48.1
	C50/60			50.4	54.4	57.0	57.0	46.5	58.6	76.1
Shear	≥ C20/25	V_{Rk}	[kN]	34.0	34.0	34.0	34.0	58.8	63.0	63.0

Anchor type: WIT-VIZ, M16 - M24

Thread size				M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth		h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	75.0	90.0	60.7	109.0	128.8	109.0	139.1	166.0
	C50/60			111.0	97.0	95.9	172.4	188.0	172.4	220.0	222.0
Shear	≥ C20/25	V_{Rk}	[kN]	63.0	63.0	70.0	98.0	98.0	141.0	141.0	141.0
Cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	60.1	69.7	42.5	76.3	90.2	76.3	97.4	116.2
	C50/60			95.1	97.0	67.1	120.7	142.6	120.7	154.0	183.8
Shear	≥ C20/25	V_{Rk}	[kN]	63.0	63.0	70.0	98.0	98.0	141.0	141.0	141.0

Design loads

Anchor type: WIT-VIZ, M8 - M12

Thread size				**M8**	**M8**	**M10**	**M10**	**M12**	**M12**	**M12**
Effective anchorage depth		h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	6.0	11.6	15.2	16.7	21.3	19.2	23.5
	C50/60			9.5	12.0	16.7	16.7	23.3	30.4	36.0
Shear	≥ C20/25	V_{Rd}	[kN]	11.2	11.2	16.8	16.8	27.2	27.2	27.2
Cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	5.8	8.1	10.7	14.9	14.9	13.4	16.4
	C50/60			9.2	12.0	16.7	16.7	23.3	21.3	26.0
Shear	≥ C20/25	V_{Rd}	[kN]	11.2	11.2	16.8	16.8	27.2	26.9	27.2

Anchor type: WIT-VIZ, M12 - M16

Thread size				**M12**	**M12**	**M12**	**M12**	**M16**	**M16**	**M16**
Effective anchorage depth		h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	26.7	32.8	33.3	33.3	28.0	35.3	45.8
	C50/60			36.0	38.0	38.0	38.0	44.3	55.8	72.5
Shear	≥ C20/25	V_{Rd}	[kN]	27.2	27.2	27.2	27.2	50.4	50.4	50.4
Cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	21.3	23.0	26.5	32.1	19.6	24.7	32.1
	C50/60			33.6	36.3	38.0	38.0	31.0	39.1	50.7
Shear	≥ C20/25	V_{Rd}	[kN]	27.2	27.2	27.2	27.2	39.2	49.4	50.4

Anchor type: WIT-VIZ, M16 - M24

Thread size				**M16**	**M16**	**M20**	**M20**	**M20**	**M24**	**M24**	**M24**
Effective anchorage depth		h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	50.0	60.0	40.4	72.7	85.9	72.7	92.8	110.7
	C50/60			74.0	64.7	57.1	114.9	125.3	114.9	146.7	148.0
Shear	≥ C20/25	V_{Rd}	[kN]	50.4	50.4	50.0	78.4	78,4	112.8	112.8	112.8
Cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	40.1	46.5	28.3	50.9	60.1	50.9	64.9	77.5
	C50/60			63.4	64.7	44.8	80.5	95.1	80.5	102.7	122.5
Shear	≥ C20/25	V_{Rd}	[kN]	50.4	50.4	50.0	78.4	78.4	101.8	112.8	112.8

W-VIZ/S

Recommended/allowable loads [1)]

Anchor type: WIT-VIZ, M8 - M12

Thread size				M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth		h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete										
Tension	C20/25	N_{rec}	[kN]	4.3	8.3	10.9	11.9	15.2	13.7	16.8
	C50/60			6.8	8.6	11.9	11.9	16.7	21.7	25.7
Shear	≥ C20/25	V_{rec}	[kN]	8.0	8.0	12.0	12.0	19.4	19.4	19.4
Cracked concrete										
Tension	C20/25	N_{rec}	[kN]	4.1	5.8	7.6	10.7	10.7	9.6	11.7
	C50/60			6.6	8.6	11.9	11.9	16.7	15.2	18.6
Shear	≥ C20/25	V_{rec}	[kN]	8.0	8.0	12.0	12.0	19.4	19.2	19.4

1) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Anchor type: WIT-VIZ, M12 - M16

Thread size				M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth		h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete										
Tension	C20/25	N_{rec}	[kN]	19.0	23.4	23.8	23.8	20.0	25.2	32.7
	C50/60			25.7	27.1	27.1	27.1	31.6	39.9	51.8
Shear	≥ C20/25	V_{rec}	[kN]	19.4	19.4	19.4	19.4	36.0	36.0	36.0
Cracked concrete										
Tension	C20/25	N_{rec}	[kN]	15.2	16.4	18.9	22.9	14.0	17.6	22.9
	C50/60			24.0	25.9	27.1	27.1	22.1	27.9	36.2
Shear	≥ C20/25	V_{rec}	[kN]	19.4	19.4	19.4	19.4	28.0	35.3	36.0

11) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Anchor type: WIT-VIZ, M16 - M24

Thread size				M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth		h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete											
Tension	C20/25	N_{rec}	[kN]	35.7	42.9	28.9	51.9	61.4	51.9	66.3	79.1
	C50/60			52.9	46.2	40.8	82.1	89.5	82,1	104.8	105.7
Shear	≥ C20/25	V_{rec}	[kN]	36.0	36.0	35.7	56.0	56.0	80.6	80.6	80.6
Cracked concrete											
Tension	C20/25	N_{rec}	[kN]	28.6	33.2	20.2	36.3	42.9	36.3	46.4	55.3
	C50/60			45.3	46.2	32.0	57.5	67.9	57.5	73.3	87.5
Shear	≥ C20/25	V_{rec}	[kN]	36.0	36.0	35.7	56.0	56.0	72.7	80.6	80.6

1) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

WÜRTH

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization. we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole. hammer drilling
- Anchor material as specified in anchor material specification table

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Anchor type: WIT-VIZ, M8 - M12

Thread size			**M8**	**M8**	**M10**	**M10**	**M12**	**M12**	**M12**
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Design steel resistance	$N_{Rd,s}$	[kN]	10.0	12.0	16.7	16.7	23.3	32.7	36.0

Anchor type: WIT-VIZ, M12 - M16

Thread size			**M12**	**M12**	**M12**	**M12**	**M16**	**M16**	**M16**
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Design steel resistance	$N_{Rd,s}$	[kN]	36.0	38.0	38.0	38.0	58.7	63.3	74.0

Anchor type: WIT-VIZ, M16 - M24

Thread size			**M16**	**M16**	**M20**	**M20**	**M20**	**M24**	**M24**	**M24**
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Design steel resistance	$N_{Rd,s}$	[kN]	74.0	64.7	57.1	125.3	125.3	148.0	148.0	148.0

W-VIZ/S

2. Design pullout resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of pull-out failure of a single anchor

Anchor type: WIT-VIZ, M8 - M12

Thread size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete									
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	6.0	11.6	15.2	21.3	21.3	19.2	23.5
Cracked concrete									
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	5.8	8.1	10.7	14.9	14.9	13.4	16.4

Anchor type: WIT-VIZ, M12 - M16

Thread size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete									
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	26.7	32.8	33.3	33.3	28.0	35.3	45.8
Cracked concrete									
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	21.3	23.0	26.5	32.1	19.6	24.7	32.1

Anchor type: WIT-VIZ, M16 - M24

Thread size			M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete										
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	50.0	60.0	40.4	72.7	85.9	72.7	92.8	110.7
Cracked concrete										
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	40.1	46.5	28.3	50.9	60.1	50.9	64.9	77.5

a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

3. Design concrete cone resistance

The decisive design resistance in tension is the lowest value of the following failure modes:

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Anchor type: WIT-VIZ, M8 - M12

Thread size			**M8**	**M8**	**M10**	**M10**	**M12**	**M12**	**M12**
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete									
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	8.3	11.6	15.2	21.3	21.3	19.2	23.5
Cracked concrete									
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	5.8	8.1	10.7	14.9	14.9	13.4	16.4

Anchor type: WIT-VIZ, M12 - M16

Thread size			**M12**	**M12**	**M12**	**M12**	**M16**	**M16**	**M16**
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete									
Design concrete cone resistance	$N^0_{Rd.c}$	[kN]	30.4	32.8	37.8	45.8	28.0	35.3	45.8
Cracked concrete									
Design concrete cone resistance	$N^0_{Rd.c}$	[kN]	21.3	23.0	26.5	32.1	19.6	24.7	32.1

Anchor type: WIT-VIZ, M16 - M24

Thread size			**M16**	**M16**	**M20**	**M20**	**M20**	**M24**	**M24**	**M24**
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete										
Design concrete cone resistance	$N^0_{Rd.c}$	[kN]	57.3	66.4	40.4	72.7	85.9	72.7	92.8	110.7
Cracked concrete										
Design concrete cone resistance	$N^0_{Rd.c}$	[kN]	40.1	46.5	28.3	50.9	60.1	50.9	64.9	77.5

W-VIZ/S

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Anchor type: WIT-VIZ, M8 - M12

Thread size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Spacing	$s_{cr, N}$	[mm]	120.0	150.0	180.0	225.0	225.0	210.0	240.0
Edge distance	$c_{cr, N}$	[mm]	60.0	75.0	90.0	112.5	112.5	105.0	120.0

Anchor type: WIT-VIZ, M12 - M16

Thread size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Spacing	$s_{cr, N}$	[mm]	285.0	300.0	330.0	375.0	270.0	315.0	375.0
Edge distance	$c_{cr, N}$	[mm]	142.5	150.0	165.0	187.5	135.0	157.5	187.5

Anchor type: WIT-VIZ, M16 - M24

Thread size			M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Spacing	$s_{cr, N}$	[mm]	435.0	480.0	345.0	510.0	570.0	510.0	600.0	675.0
Edge distance	$c_{cr, N}$	[mm]	217.5	240.0	172.5	255.0	285.0	255.0	300.0	337.5

a. Influence of concrete strength

Table 6: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 8: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 9: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Anchor type: WIT-VIZ, M8 - M12

Thread size			**M8**	**M8**	**M10**	**M10**	**M12**	**M12**	**M12**
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete									
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	5.0	6.0	10.7	13.3	13.3	13.3	23.5

Anchor type: WIT-VIZ, M12 - M16

Thread size			**M12**	**M12**	**M12**	**M12**	**M16**	**M16**	**M16**
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete									
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	20.0	26.7	26.7	26.7	26.7	33.3	33.3

Anchor type: WIT-VIZ, M16 - M24

Thread size			**M16**	**M16**	**M20**	**M20**	**M20**	**M24**	**M24**	**M24**
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete										
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	40.0	53.3	40.4	72.7	76.7	72.7	92.8	93.3

Table 10: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Anchor type: WIT-VIZ, M8 - M12

Thread size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Characteristic spacing	$s_{cr, sp}$	[mm]	120.0	150.0	180.0	225.0	225.0	210.0	240.0
Characteristic edge distance	$c_{cr, sp}$	[mm]	60.0	75.0	90.0	112.5	112.5	105.0	120.0
Minimum member thickness	h_{min}	[mm]	100	100	120	150	150	140	160

Anchor type: WIT-VIZ, M12 - M16

Thread size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Characteristic spacing	$s_{cr, sp}$	[mm]	300.0	330.0	375.0	270.0	315.0	375.0	375.0
Characteristic edge distance	$c_{cr, sp}$	[mm]	150.0	165.0	187.5	135.0	157.5	187.5	187.5
Minimum member thickness	h_{min}	[mm]	190	200	220	250	180	200	250

Anchor type: WIT-VIZ, M16 - M24

Thread size			M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Characteristic spacing	$s_{cr, sp}$	[mm]	435.0	480.0	345.0	510.0	570.0	510.0	600.0	675.0
Characteristic edge distance	$c_{cr, sp}$	[mm]	217.5	240.0	172.5	255.0	285.0	255.0	300.0	337.5
Minimum member thickness	h_{min}	[mm]	290	320	230	340	380	340	400	450

a. Influence of concrete strength

Table 11: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

W-VIZ/S

b. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 12: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 13: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ / $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Anchor type: WIT-VIZ, M8 - M12

Thread size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Design steel resistance	$V_{Rd,s}$	[kN]	11.2	11.2	16.8	16.8	27.2	27.2	27.2

Anchor type: WIT-VIZ, M12 - M16

Thread size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Design steel resistance	$V_{Rd,s}$	[kN]	27.2	27.2	27.2	27.2	50.4	50.4	50.4

Anchor type: WIT-VIZ, M16 - M24

Thread size			M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Design steel resistance	$V_{Rd,s}$	[kN]	50.4	50.4	50.0	78.4	78.4	112.8	112.8	112.8

2. Concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot N_{Rd,c}$$

Table 16: factor k_8 for calculating design pry-out resistance

Anchor type: WIT-VIZ, M8 - M12

Thread size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Anchor type: WIT-VIZ, M12 - M16

Thread size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Anchor type: WIT-VIZ, M16 - M24

Thread size			M16	M16	M20	M20	M20	M24	M24	M24
Design concrete pry-out resistance	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

3. Concrete edge resistance

$$V_{Rd,c} = V^{0}_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_{a} \cdot f_{h}$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions c ≥ max (10 h_{ef} ; 60 d). For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 17: Design resistance $V^{0}_{Rd,c}$ in case of concrete edge failure

Anchor type: WIT-VIZ, M8 - M12

Thread size	M8		M8		M10		M10		M12		M12		M12	
h_{ef} [mm]	40		50		60		75		75		70		80	
Edge distance c_1	$V^{0}_{Rd,c}$													
[mm]	[kN]													
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
40	3.0	2.1	3.1	2.2	-	2.4	-	2.5	-	-	-	-	-	-
45	3.5	2.5	3.7	2.6	-	2.8	-	2.9	-	-	-	-	-	-
50	4.1	2.9	4.2	3.0	4.5	3.2	4.7	3.4	4.7	3.4	-	-	-	3.5
55	4.6	3.3	4.8	3.4	5.1	3.6	5.4	3.8	5.4	3.8	5.4	3.8	5.6	4.0
60	5.2	3.7	5.4	3.8	5.7	4.1	6.0	4.3	6.0	4.3	6.1	4.3	6.3	4.4
65	5.8	4.1	6.0	4.3	6.4	4.5	6.7	4.7	6.7	4.7	6.7	4.8	6.9	4.9
70	6.4	4.5	6.6	4.7	7.0	5.0	7.3	5.2	7.3	5.2	7.4	5.3	7.6	5.4
75	7.0	5.0	7.3	5.2	7.7	5.5	8.0	5.7	8.0	5.7	8.1	5.8	8.3	5.9
80	7.7	5.4	8.0	5.6	8.4	6.0	8.8	6.2	8.8	6.2	8.8	6.3	9.1	6.4
85	8.4	5.9	8.6	6.1	9.1	6.5	9.5	6.7	9.5	6.7	9.6	6.8	9.8	7.0
90	9.0	6.4	9.3	6.6	9.8	7.0	10.2	7.2	10.2	7.2	10.3	7.3	10.6	7.5
95	9.7	6.9	10.0	7.1	10.6	7.5	11.0	7.8	11.0	7.8	11.1	7.9	11.4	8.1
100	10.4	7.4	10.8	7.6	11.3	8.0	11.8	8.3	11.8	8.3	11.9	8.4	12.2	8.6
110	11.9	8.4	12.3	8.7	12.9	9.1	13.4	9.5	13.4	9.5	13.5	9.6	13.8	9.8
120	13.4	9.5	13.8	9.8	14.5	10.3	15.0	10.6	15.0	10.6	15.2	10.7	15.5	11.0
130	15.0	10.6	15.5	11.0	16.2	11.5	16.7	11.9	16.7	11.9	16.9	12.0	17.3	12.2
140	16.7	11.8	17.1	12.1	17.9	12.7	18.5	13.1	18.5	13.1	18.7	13.2	19.1	13.5
150	18.3	13.0	18.9	13.4	19.7	13.9	20.3	14.4	20.3	14.4	20.5	14.5	20.9	14.8
160	20.1	14.2	20.6	14.6	21.5	15.2	22.2	15.7	22.2	15.7	22.4	15.9	22.8	16.2
170	21.9	15.5	22.4	15.9	23.4	16.6	24.1	17.1	24.1	17.1	24.3	17.2	24.8	17.6
180	23.7	16.8	24.3	17.2	25.3	17.9	26.1	18.5	26.1	18.5	26.3	18.6	26.8	19.0
190	25.6	18.1	26.2	18.6	27.3	19.3	28.1	19.9	28.1	19.9	28.3	20.0	28.8	20.4
200	27.5	19.5	28.2	19.9	29.3	20.7	30.1	21.3	30.1	21.3	30.4	21.5	30.9	21.9
250	37.6	26.7	38.5	27.3	39.9	28.3	41.0	29.0	41.0	29.0	41.3	29.2	42.0	29.8
300	48.8	34.5	49.8	35.3	51.5	36.5	52.8	37.4	52.8	37.4	53.2	37.7	54.0	38.3
350	60.7	43.0	61.9	43.9	64.0	45.3	65.5	46.4	65.5	46.4	65.9	46.7	66.9	47.4
400	73.4	52.0	74.9	53.0	77.2	54.7	79.0	55.9	79.0	55.9	79.4	56.3	80.6	57.1
450	86.9	61.6	88.5	62.7	91.2	64.6	93.2	66.0	93.2	66.0	93.7	66.4	95.0	67.3
500	101.1	71.6	102.9	72.9	105.9	75.0	108.1	76.6	108.1	76.6	108.7	77.0	110.2	78.0
550	115.9	82.1	117.9	83.5	121.2	85.9	123.7	87.6	123.7	87.6	124.3	88.1	126.0	89.2
600	131.3	93.0	133.5	94.6	137.2	97.2	139.9	99.1	139.9	99.1	140.6	99.6	142.4	100.9
650	-	-	-	-	153.8	108.9	156.7	111.0	156.7	111.0	157.5	111.6	159.4	112.9
700	-	-	-	-	170.9	121.0	174.1	123.3	174.1	123.3	174.9	123.9	177.0	125.4
750	-	-	-	-	-	-	192.0	136.0	192.0	136.0	193.0	136.7	195.2	138.3
800	-	-	-	-	-	-	-	-	-	-	211.5	149.8	213.9	151.5

Anchor type: WIT-VIZ, M12 - M16

Thread size	M12		M12		M12		M12		M16		M16		M16	
h_{ef} [mm]	95		100		110		125		90		105		125	
Edge distance c_1	$V^0_{Rd,c}$													
[mm]	[kN]													
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
50	-	3.7	-	3.7	-	3.8	-	4.0	5.4	3.8	-	4.0	-	-
55	5.8	4.1	5.9	4.2	6.1	4.3	6.3	4.4	6.1	4.3	-	4.5	-	-
60	6.5	4.6	6.6	4.7	6.8	4.8	7.0	4.9	6.7	4.8	7.0	5.0	7.4	5.2
65	7.2	5.1	7.3	5.2	7.5	5.3	7.7	5.5	7.5	5.3	7.8	5.5	8.1	5.8
70	7.9	5.6	8.0	5.7	8.2	5.8	8.5	6.0	8.2	5.8	8.5	6.0	8.9	6.3
75	8.7	6.1	8.8	6.2	9.0	6.3	9.2	6.5	8.9	6.3	9.3	6.6	9.7	6.9
80	9.4	6.7	9.5	6.7	9.7	6.9	10.0	7.1	9.7	6.9	10.1	7.1	10.5	7.4
85	10.2	7.2	10.3	7.3	10.5	7.4	10.8	7.7	10.5	7.4	10.9	7.7	11.3	8.0
90	11.0	7.8	11.1	7.9	11.3	8.0	11.6	8.2	11.3	8.0	11.7	8.3	12.2	8.6
95	11.8	8.3	11.9	8.4	12.1	8.6	12.5	8.8	12.1	8.6	12.5	8.9	13.0	9.2
100	12.6	8.9	12.7	9.0	13.0	9.2	13.3	9.4	13.0	9.2	13.4	9.5	13.9	9.9
110	14.3	10.1	14.4	10.2	14.7	10.4	15.1	10.7	14.7	10.4	15.1	10.7	15.7	11.1
120	16.0	11.3	16.2	11.4	16.4	11.6	16.9	11.9	16.4	11.6	16.9	12.0	17.6	12.5
130	17.8	12.6	18.0	12.7	18.3	12.9	18.7	13.3	18.3	12.9	18.8	13.3	19.5	13.8
140	19.6	13.9	19.8	14.0	20.1	14.3	20.6	14.6	20.1	14.3	20.7	14.7	21.5	15.2
150	21.5	15.3	21.7	15.4	22.1	15.6	22.6	16.0	22.1	15.6	22.7	16.1	23.5	16.6
160	23.5	16.6	23.7	16.8	24.1	17.0	24.6	17.4	24.1	17.0	24.7	17.5	25.5	18.1
170	25.5	18.0	25.7	18.2	26.1	18.5	26.7	18.9	26.1	18.5	26.8	19.0	27.7	19.6
180	27.5	19.5	27.7	19.6	28.2	19.9	28.8	20.4	28.2	19.9	28.9	20.5	29.8	21.1
190	29.6	21.0	29.8	21.1	30.3	21.4	30.9	21.9	30.3	21.4	31.1	22.0	32.0	22.7
200	31.7	22.5	32.0	22.6	32.4	23.0	33.1	23.5	32.4	23.0	33.3	23.6	34.3	24.3
250	43.0	30.4	43.3	30.7	43.9	31.1	44.7	31.7	43.9	31.1	44.9	31.8	46.2	32.7
300	55.2	39.1	55.6	39.4	56.3	39.9	57.3	40.6	56.3	39.9	57.5	40.7	59.0	41.8
350	68.3	48.4	68.7	48.7	69.5	49.3	70.7	50.1	69.6	49.3	71.0	50.3	72.7	51.5
400	82.2	58.2	82.7	58.6	83.6	59.2	84.9	60.2	83.6	59.2	85.3	60.4	87.2	61.8
450	96.8	68.6	97.4	69.0	98.4	69.7	99.9	70.8	98.5	69.7	100.3	71.0	102.5	72.6
500	112.1	79.4	112.8	79.9	113.9	80.7	115.6	81.9	114.0	80.7	116.0	82.2	118.5	83.9
550	128.2	90.8	128.8	91.3	130.1	92.2	132.0	93.5	130.2	92.2	132.4	93.8	135.2	95.7
600	144.8	102.6	145.5	103.1	147.0	104.1	149.0	105.5	147.0	104.1	149.5	105.9	152.5	108.0
650	162.0	114.8	162.8	115.4	164.4	116.5	166.6	118.0	164.5	116.5	167.1	118.4	170.4	120.7
700	179.9	127.4	180.7	128.0	182.4	129.2	184.8	130.9	182.5	129.3	185.4	131.3	188.9	133.8
750	198.3	140.4	199.2	141.1	201.0	142.4	203.5	144.2	201.1	142.4	204.2	144.6	207.9	147.3
800	217.2	153.8	218.2	154.6	220.1	155.9	222.8	157.8	220.2	156.0	223.6	158.3	227.5	161.2
850	236.6	167.6	237.7	168.4	239.8	169.8	242.6	171.9	239.9	169.9	243.4	172.4	247.7	175.4
900	256.6	181.8	257.7	182.6	259.9	184.1	263.0	186.3	260.1	184.2	263.8	186.9	268.3	190.1
950	277.0	196.2	278.3	197.1	280.6	198.7	283.8	201.0	280.7	198.8	284.7	201.7	289.5	205.0
1000	-	-	299.3	212.0	301.7	213.7	305.1	216.1	301.9	213.8	306.1	216.8	311.1	220.4
1100	-	-	-	-	345.3	244.6	349.1	247.3	-	-	-	-	355.8	252.0
1200	-	-	-	-	-	-	394.9	279.7	-	-	-	-	402.2	284.9
1300	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1400	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1600	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1800	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1900	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2125	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2250	-	-	-	-	-	-	-	-	-	-	-	-	-	-

W-VIZ/S

Anchor type: WIT-VIZ, M16 - M24

Thread size	M16		M16		M20		M20		M20		M24		M24		M24	
h_{ef} [mm]	145		160		115		170		190		170		200		225	
Edge distance c_1	$V^0_{Rd,c}$															
[mm]	[kN]															
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
60	7.7	5.5	7.9	5.6	-	-	-	-	-	-	-	-	-	-	-	-
65	8.5	6.0	8.7	6.2	-	-	-	-	-	-	-	-	-	-	-	-
70	9.3	6.6	9.6	6.8	-	-	-	-	-	-	-	-	-	-	-	-
75	10.1	7.2	10.4	7.4	-	-	-	-	-	-	-	-	-	-	-	-
80	10.9	7.7	11.2	8.0	10.7	7.6	12.2	8.6	12.6	8.9	12.4	8.8	-	9.3	-	9.7
85	11.8	8.3	12.1	8.6	11.5	8.2	13.1	9.3	13.6	9.6	13.3	9.4	-	9.9	-	10.3
90	12.6	9.0	13.0	9.2	12.4	8.8	14.0	9.9	14.5	10.3	14.3	10.1	-	10.6	-	11.1
95	13.5	9.6	13.9	9.8	13.3	9.4	15.0	10.6	15.5	11.0	15.2	10.8	-	11.3	-	11.8
100	14.4	10.2	14.8	10.5	14.2	10.0	15.9	11.3	16.5	11.7	16.2	11.5	-	12.0	-	12.5
110	16.3	11.5	16.7	11.8	16.0	11.3	17.9	12.7	18.5	13.1	18.2	12.9	19.1	13.5	19.7	14.0
120	18.2	12.9	18.6	13.2	17.8	12.6	19.9	14.1	20.5	14.5	20.2	14.3	21.2	15.0	21.9	15.5
130	20.1	14.3	20.6	14.6	19.8	14.0	22.0	15.6	22.6	16.0	22.3	15.8	23.3	16.5	24.1	17.1
140	22.1	15.7	22.6	16.0	21.8	15.4	24.1	17.1	24.8	17.6	24.5	17.3	25.5	18.1	26.4	18.7
150	24.2	17.1	24.7	17.5	23.8	16.9	26.3	18.6	27.0	19.2	26.7	18.9	27.8	19.7	28.7	20.3
160	26.3	18.6	26.8	19.0	25.9	18.3	28.6	20.2	29.3	20.8	29.0	20.5	30.1	21.3	31.1	22.0
170	28.5	20.2	29.0	20.6	28.0	19.9	30.8	21.8	31.6	22.4	31.3	22.1	32.5	23.0	33.5	23.7
180	30.7	21.7	31.3	22.1	30.2	21.4	33.2	23.5	34.0	24.1	33.6	23.8	34.9	24.7	35.9	25.5
190	32.9	23.3	33.5	23.8	32.4	23.0	35.5	25.2	36.4	25.8	36.0	25.5	37.4	26.5	38.4	27.2
200	35.2	24.9	35.9	25.4	34.7	24.6	38.0	26.9	38.9	27.5	38.5	27.2	39.9	28.2	41.0	29.0
250	47.3	33.5	48.1	34.1	46.7	33.1	50.7	35.9	51.8	36.7	51.3	36.3	53.0	37.6	54.4	38.5
300	60.4	42.8	61.3	43.4	59.7	42.3	64.4	45.6	65.7	46.5	65.1	46.1	67.1	47.6	68.7	48.7
350	74.3	52.6	75.4	53.4	73.5	52.0	79.0	55.9	80.5	57.0	79.8	56.5	82.1	58.2	84.0	59.5
400	89.0	63.1	90.3	64.0	88.1	62.4	94.4	66.8	96.1	68.1	95.3	67.5	97.9	69.4	100.0	70.8
450	104.5	74.0	105.9	75.0	103.5	73.3	110.5	78.3	112.4	79.6	111.6	79.0	114.5	81.1	116.8	82.7
500	120.7	85.5	122.3	86.6	119.6	84.7	127.4	90.2	129.5	91.7	128.6	91.1	131.8	93.4	134.3	95.2
550	137.6	97.5	139.4	98.7	136.4	96.6	144.9	102.7	147.3	104.3	146.2	103.6	149.8	106.1	152.6	108.1
600	155.2	109.9	157.0	111.2	153.8	109.0	163.1	115.5	165.7	117.3	164.5	116.5	168.4	119.3	171.4	121.4
650	173.3	122.7	175.3	124.2	171.9	121.7	181.9	128.9	184.7	130.8	183.5	129.9	187.7	132.9	190.9	135.2
700	192.0	136.0	194.2	137.6	190.5	134.9	201.3	142.6	204.3	144.7	203.0	143.8	207.5	147.0	211.0	149.4
750	211.3	149.7	213.7	151.3	209.7	148.5	221.3	156.8	224.5	159.0	223.1	158.0	227.9	161.4	231.6	164.1
800	231.2	163.7	233.7	165.5	229.4	162.5	241.8	171.3	245.2	173.7	243.7	172.6	248.9	176.3	252.8	179.1
850	251.5	178.2	254.2	180.1	249.7	176.8	262.9	186.2	266.5	188.8	264.9	187.6	270.4	191.5	274.6	194.5
900	272.4	193.0	275.2	195.0	270.4	191.6	284.5	201.5	288.3	204.2	286.6	203.0	292.4	207.1	296.8	210.3
950	293.8	208.1	296.8	210.2	291.7	206.6	306.5	217.1	310.6	220.0	308.8	218.7	314.9	223.1	319.6	226.4
1000	315.7	223.6	318.8	225.8	313.5	222.0	329.1	233.1	333.3	236.1	331.5	234.8	337.9	239.4	342.9	242.9
1100	360.8	255.6	364.3	258.0	358.4	253.9	375.6	266.1	380.3	269.4	378.3	267.9	385.4	273.0	390.8	276.8
1200	407.7	288.8	411.5	291.5	405.1	287.0	424.0	300.3	429.1	303.9	426.9	302.4	434.6	307.8	440.5	312.0
1300	456.4	323.3	460.5	326.2	453.5	321.3	474.1	335.8	479.6	339.7	477.2	338.0	485.6	344.0	492.0	348.5
1400	506.6	358.9	511.1	362.1	-	-	525.8	372.4	531.8	376.7	529.2	374.9	538.3	381.3	545.2	386.2
1500	-	-	563.3	399.0	-	-	579.1	410.2	585.5	414.8	582.8	412.8	592.5	419.7	599.9	425.0
1600	-	-	617.1	437.1	-	-	634.0	449.1	640.9	453.9	638.0	451.9	648.3	459.2	656.2	464.8
1700	-	-	-	-	-	-	690.4	489.0	697.7	494.2	694.6	492.0	705.6	499.8	714.1	505.8
1800	-	-	-	-	-	-	-	-	755.9	535.4	-	-	764.4	541.4	773.3	547.8
1900	-	-	-	-	-	-	-	-	815.6	577.7	-	-	824.5	584.0	834.0	590.7
2000	-	-	-	-	-	-	-	-	-	-	-	-	886.1	627.6	896.0	634.7
2125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	975.5	691.0
2250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1056.9	748.7

a. Influence of concrete strength

Table 18: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 19: Influence of spacing on concrete edge resistance

s/c_1 [1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of edge distance

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1 [1]	1.00	1.10	1.20	1.30	1.40	1.50
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \leq c_2$

W-VIZ/S

d. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

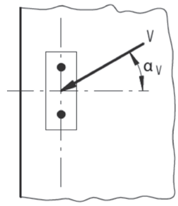


Table 21: Influence of load direction on concrete edge resistance

α[1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.

e. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1,2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1] This verification is not required in case of shear load with lever arm

Mechanical characteristics

Anchor type: WIT-VIZ, M8 - M24

Thread size			M8	M8	M10	M10	M12	M12	M12	M12	M12	M12	M12	M16	M16	M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80	95	100	110	125	90	105	125	145	115	170	190	170	200	225
Governing cross section																							
Stressed cross section	A_s	[mm²]	18.9	22.9	32.2	32.2	43.0	62.2	69.4	69.4	77.0	77.0	77.0	111.2	120.8	141.0	141.0	162.9	237.8	237.8	280.6	280.6	280.6
Section modulus	W	[mm³]	11.6	15.5	25.7	25.7	39.8	69.2	81.5	81.5	95.3	95.3	95.3	165.4	187.2	236.2	236.2	293.1	517.2	517.2	662.8	662.8	662.8
Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640	640	640	640	640	640	640	640	400	640	640	640	640	640
Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	560	800	800	800	800	800
Stressed cross section of threaded part																							
Stressed cross section	A_s	[mm²]	36.6	36.6	58.0	58.0	84.3	84.3	84.3	84.3	84.3	84.3	84.3	157.0	157.0	157.0	157.0	245.0	245.0	245.0	352.0	352.0	352.0
Section modulus	W	[mm³]	31.2	31.2	62.3	62.3	109.2	109.2	109.2	109.2	109.2	109.2	109.2	277.5	277.5	277.5	277.5	540.9	540.9	540.9	931.5	931.5	931.5
Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640	640	640	640	640	640	640	640	400	640	640	640	640	640
Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	560	800	800	800	800	800
Design bending moment	$M^0_{Rd,s}$	[Nm]	24	24	48	48	84	84	84	84	84	84	84	213	213	213	213	280	415	415	717	717	717

Material specifications

No.	Part	Steel, zinc plated		
		galvanized	hot-dip galvanized ≥ 40 µm	sherardized ≥ 40 µm
1	**Anchor rod**	Steel acc. to EN 10087:1998, galvanized and coated	Steel acc. to EN 10087:1998, hot-dip galvanized and coated	Steel acc. to EN 10087:1998, sherardized and coated
2a	**Washer**	Steel, zinc plated	Steel, zinc plated	Steel, zinc plated
2b	**Washer with bore**			
3	**Hexagon nut**	Property class 8 acc. to EN ISO 898-2:2012-08, galvanized	Property class 8 acc. to EN ISO 898-2:2012-08, hot-dip galvanized	Property class 8 acc. to EN ISO 898-2:2012-08, sherardized or hot-dip galvanized
4	**Mortar cartridge**	Vinyl Ester Resin, styrene free, mixing ratio 1:10		

W-VIZ/S

W-VIZ/S

Chemical resistance

Chemical Agent	Concentration	Resistant	Not Resistant
Acetic acid	>40		●
Acetic acid	10	●	
Acetone	5		●
Ammonia, aqueous solution	Conc.		●
Aniline			●
Calcium hydroxide			●
Carbon tetrachloride		●	
Diesel fuel		●	
Boric Acid, aqueous solution	all	●	
Glycol		●	
Formic acid	30	●	
Calcium hydroxide, suspended in water	all		●
Caustic soda solution	all		●
Citric acid	50	●	
Hydrochloric acid	all		●
Lactic acid	<80	●	
Sea water		●	
Formaldehyde, aqueous solution	20		●
Fuel Oil		●	
Glycol (Ethylene glycol)		●	
Isopropyl alcohol		●	
Linseed oil		●	
Magnesium chloride, aqueous solution	all	●	
Methanol			●
Nitric acid	30		●
Oleic acid		●	
Phenol, aqueous solution	all		●
Phosphoric acid	<80	●	
Potassium carbonate, aqueous solution	all		●
Potassium chlorite, aqueous solution	all	●	
Potassium nitrate, aqueous solution	all	●	
Sodium Chloride, aqueous solution	all	●	
Sodium phosphate, aqueous solution	all	●	
Sodium silicate	all		●
Sulfuric acid	<50	●	
Tartaric acid		●	
Toluene			●
Trichloroethylene			●
Ethanol	96		●

Results shown in the table are applicable to brief periods of chemical contact with full cured adhesive (e.g. temporary contact with adhesive during a spill).

Properties of adhesive

Temperature range	Base material temperature	Maximum long term base material temperature	Maximum short term base material temperature
Temperature range I	-40 °C to +80 °C	+50 °C	+80 °C
Temperature range II	-40 °C to +120 °C	+72 °C	+120 °C

Property		**Testing method**	**Results**
Stability			
UV-resistance (sunlight)			not resistant
Temperature resistance			120 °C
Water resistancy			resistant
Cleaning agents			1% tenside solution: no effects
Physical properties			
Flexural properties	Flexural strength	DIN EN 196-1	after 24 hours: 19.2 N/mm^2
Compressive properties	Compressive strength	DIN EN 196-1	after 24 hours: ≥ 96.1 N/mm^2
Dynamic modulus of elasticity		DIN EN 12504-4	after 24 hours: 13.79 GPa
Thermal conductivity	Modified transient plane source method		0.88 / 0.82 W/mK
Specific contact resistance		IEC 93	4.8 x 109 Ωcm
Density		DIN 53479	1.74 ± 0.1 g/cm^3
Workability features			
Watertightness / impermeability		DIN EN 12390-8	after 72 hours at 5bar: 0mm
Open time (10-20°C)			6 min
Curing time (10-20°C)			80 min
Shelf life			18 months

For information use only. Values are not to be considered as a specification and do not reflect the performance of the system. The given values are typical values and are subject to change without notice.

W-VIZ/S

Working and curing times WIT-VIZ

Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1)]
–5°C	90 min	6 h
–4°C to –1°C	45 min	6 h
0°C to 4°C	20 min	3 h
5°C to 9°C	12 min	2 h
10°C to 19°C	6 min	80 min
20°C to 29°C	4 min	45 min
30°C to 34°C	2 min	25 min
35°C to 39°C	80 s	20 min
40°C	80 s	15 min

[1)] for wet base material the curing time must be doubled

Working and curing times WIT-EXPRESS

Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1)]
-5°C	40 min	4 h
-4°C to -1°C	20 min	4 h
-0°C to 4°C	10 min	2 h
5°C to 9°C	6 min	1 h
10°C to 19°C	3 min	40 min
20°C to 29°C	1 min	20 min
+30°C	1 min	10 min
35°C to 39°C	80 s	20 min
40°C	80 s	15 min

[1)] for wet base material the curing time must be doubled

Installation parameters

Anchor type: WIT-VIZ, M8 - M12

Anchor size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	$h_{ef} \geq$	[mm]	40	50	60	75	75	70	80
Nominal drill hole diameter	d_0	[mm]	10	50	12	12	12	14	14
Drill-hole depth	$h_0 \geq$	[mm]	42	10	65	80	80	75	85
Diameter of cleaning brush	$D \geq$	[mm]	10,8	55	13	13	13	15	15
Diameter of cleaning brush	$T_{inst} \leq$	[Nm]	10	10,8	15	15	25	25	25
Diameter of clearance in hole in the fixture	Pre-positioned $d_f \leq$	[mm]	9	10	12	12	14	14	14
	Push-through $d_f \leq$	[mm]	-	9	14	14	14 [1)] / 16	16	16
Minimum thickness of member	h_{min}	[mm]	80	-	100	110 / 100 [2)]	110	110	110
Non-cracked Concrete									
Minimum spacing	s_{min}	[mm]	40	40	50	50	50	55	55
Minimum edge distance	c_{min}	[mm]	40	40	50	50	50	55	55
Cracked concrete									
Minimum spacing	s_{min}	[mm]	40	40	40	40	50	55	40
Minimum edge distance	c_{min}	[mm]	40	40	40	40	50	55	50

Anchor type: WIT-VIZ, M12 - M16

Anchor size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	$h_{ef} \geq$	[mm]	95	100	110	125	90	105	125
Nominal drill hole diameter	d_0	[mm]	14	14	14	14	18	18	18
Drill-hole depth	$h_0 \geq$	[mm]	100	105	115	130	98	113	133
Diameter of cleaning brush	$D \geq$	[mm]	15	15	15	15	19	19	19
Diameter of cleaning brush	$T_{inst} \leq$	[Nm]	25	30	30	30	50	50	50
Diameter of clearance in hole in the fixture	Pre-positioned $d_f \leq$	[mm]	14	14	14	14	18	18	18
	Push-through $d_f \leq$	[mm]	16	16	16	16	20	20	20
Minimum thickness of member	h_{min}	[mm]	130 / 125 [2)]	130	140	160	130	150	170 / 160 [2)]
Non-cracked Concrete									
Minimum spacing	s_{min}	[mm]	55	80 [3)]	81 [3)]	82 [3)]	50	60	60
Minimum edge distance	c_{min}	[mm]	55	55 [2)]	55 [2)]	55 [2)]	50	60	60
Cracked concrete									
Minimum spacing	s_{min}	[mm]	40	50	50	50	50	50	60
Minimum edge distance	c_{min}	[mm]	50	50	50	50	50	50	60

W-VIZ/S

Anchor type: WIT-VIZ, M16 - M24

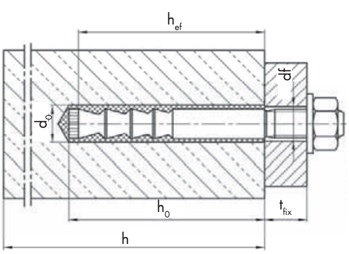
Anchor size			**M16**	**M16**	**M20**	**M20**	**M20**	**M20**	**M24**	**M24**
Effective anchorage depth	$h_{ef} \geq$	[mm]	145	160	115	170	190	170	200	225
Nominal drill hole diameter	d_0	[mm]	18	18	22	24	24	26	26	26
Drill-hole depth	$h_0 \geq$	[mm]	153	168	120	180	200	185	215	240
Diameter of cleaning brush	$D \geq$	[mm]	19	19	23	25	25	27	27	27
Diameter of cleaning brush	$T_{inst} \leq$	[Nm]	50	50	80	80	80	100	120	120
Diameter of clearance in hole in the fixture	Pre-positioned $d_f \leq$	[mm]	18	18	22	24 (22)	24 (22)	26	26	26
	Push-through $d_f \leq$	[mm]	20	20	24	26	26	28	28	28
Minimum thickness of member	h_{min}	[mm]	190 / 180 [2)]	205 / 200 [2)]	160	230 / 220 [2)]	250 / 240 [2)]	230 / 220 [2)]	270 / 260 [2)]	300 / 290 [2)]
Non-cracked Concrete										
Minimum spacing	s_{min}	[mm]	60	60	80	80	80	80	105	105
Minimum edge distance	c_{min}	[mm]	60	60	80	80	80	105	105	105
Cracked concrete										
Minimum spacing	s_{min}	[mm]	60	60	80	80	80	80	80	80
Minimum edge distance	c_{min}	[mm]	60	60	80	80	80	80	80	80

[1)] Check installation instructions

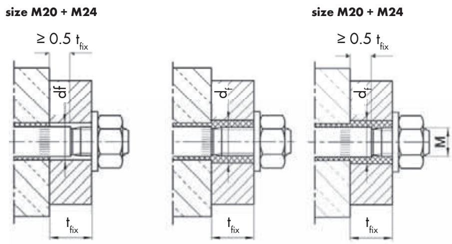
[2)] The remote face of the concrete member shall be inspected to ensure there has been no break-through by drilling. In case of break-through, the ground of the drill hole shall be closed with high strength mortar. The full bonded length hef shall be achieved and any potential loss of injection mortar shall be compensated

[3)] For an edge distance $c \geq 80$ mm a minimum spacing $s_{min} = 55$ mm is applicable

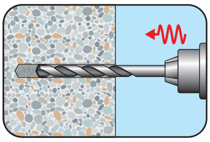
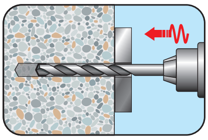
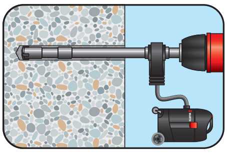
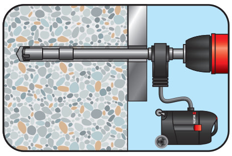
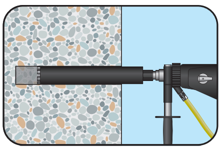
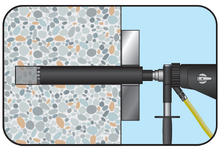
Pre-positioned installation

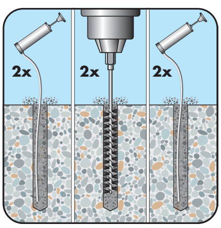
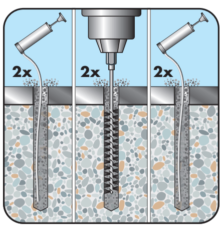


In-place installation



Installation instructions

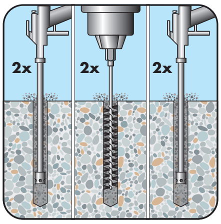
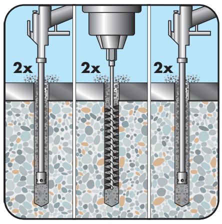
A) Bore hole drilling			
Prepositioned	Push-through	**1a.**	**Hammer (HD) or compressed air drilling (CD)**
			Drill a hole into the base material to the size and embedment depth required by the selected anchor rod. Proceed with Step B1.
Prepositioned	Push-through	**1b.**	**Hollow drill bit system (HDB)**
			Drill hole perpendicular to concrete surface by using a vacuum drill bit. The nominal underpressure of the vacuum cleaner must be at least 230 mbar / 23kPa. Make sure the **dust extraction is working properly** throughout the whole drilling process. Additional cleaning is not necessary. Proceed with Step C.
Prepositioned	Push-through	**1c.**	**Diamond drilling (DD)**
			Use diamond drill with diamond drill bit and depth gauge. Drill perpendicular to concrete surface. Re-move drill core at least up to the nominal hole depth and check drill hole depth. Proceed with Step B2.
Attention! Standing water in the bore hole must be removed before cleaning.			

B1) Bore hole cleaning			
MAC: Cleaning for rod threaded diameters shown below			
Prepositioned M8 – M16	Push-through M10 – M16	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean using a hand pump a minimum of <u>two</u> times.
 	 	**2b.**	Check diameter of cleaning brush. If the brush can be pushed into the drill hole without any resistance, it must be replaced. Check brush into the drill machine. Turn on the drill machine. Brush drill hole back and forth along the entire drill hole depth at least <u>two</u> times while rotated by drill machine.
		2c.	Finally blow the hole clean again with a hand pump a minimum of <u>two</u> times. For prepositioned installation, the extension tube with reduced diameter must be added to the blow-out pump for diameter M8.

W-VIZ/S

B1) Bore hole cleaning

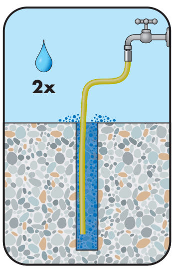
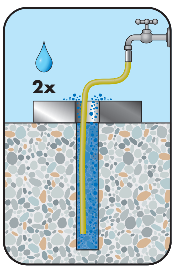
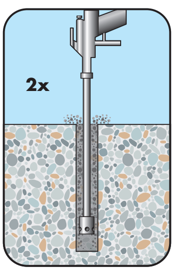
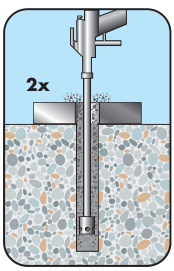
CAC: Cleaning for dry, wet and water-filled bore holes for threaded diameters shown below

Prepositioned M20 – M24	Push-through M20 – M24		
		**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust.
		2b.	Check diameter of cleaning brush. If the brush can be pushed into the drill hole without any resistance, it must be replaced. Check brush into the drill machine. Turn on the drill machine. Brush drill hole back and forth along the entire drill hole depth at least <u>two</u> times while rotated by drill machine.
		2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of <u>two</u> times until return air stream is free of noticeable dust.

After cleaning, the bore hole has to be protected against re-contamination in an appropriate way until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must no contaminate the bore hole again.

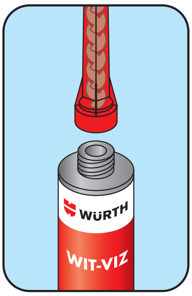
B2) Bore hole cleaning

SPCAC: Cleaning for dry, wet and water-filled bore holes for all diameters in non-cracked concrete

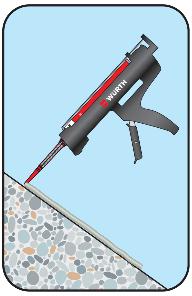
Prepositioned	Push-through		
		**2a.**	Flush drill hole with water, starting from the bottom, until clear water gets out of the drill hole.
Prepositioned	Push-through	**2b.**	Connect Air Blower to compressed air (min. 6 bar, oil-free). Open air valve and blow out drill hole along the entire depth with back and forth motion at least two times.
			

After cleaning, the bore hole has to be protected against re-contamination in an appropriate way until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must no contaminate the bore hole again.

C) Preparation of bar and cartridge



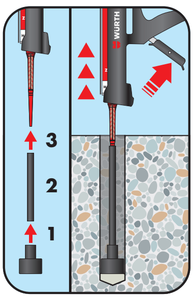
3a. Check expiration date on cartridge. Never use when expired. Remove cap from cartridge. Screw Mixer Nozzle on cartridge. When using a new cartridge, always use a new Mixer Nozzle. Never use cartridge without Mixer Nozzle and never use Mixer Nozzle without helix inside.



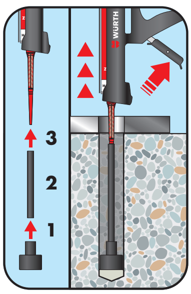
3b. Insert cartridge in Dispenser. Before injecting discard mortar (at least 2 full strokes or a line of 10 cm) until it shows a consistent grey colour. Never use this mortar.

D) Filling the bore hole

Prepositioned



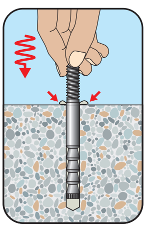
Push-through



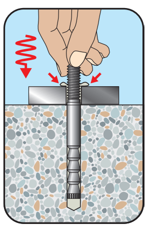
4. Prior to injection, check if Mixer Nozzle reaches the bottom of the drill hole. If it does not reach the bottom, plug Mixer Extension onto Mixer Nozzle in order to fill the drill hole properly. Fill hole with a sufficient quantity of injection mortar. Start from the bottom of the drill hole and work out to avoid trapping air pockets.

E) Setting the anchor

Prepositioned



Push-through



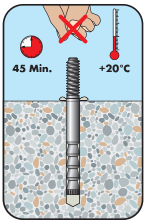
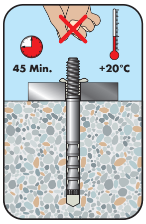
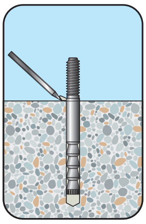
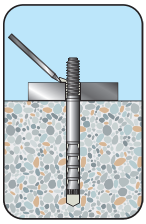
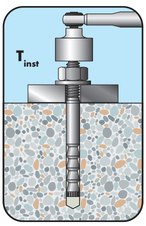
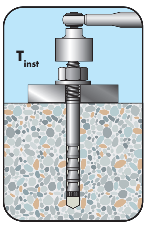
5a. Insert the anchor rod WIT-VIZ-A by hand, rotating slightly up to the full embedment depth as marked on the anchor rod.

In case of prepositioned installation, the anchor rod is properly set when excess mortar seeps from the hole.

In case of push-through installation, the annular gap in the clearance hole in the fixture has to be filled completely by excess mortar after the installation.

If the hole is not completely filled, pull out the anchor rod, let the mortar cure, drill out hole and repeat entire cleaning process.

W-VIZ/S

Prepositioned	Push-through		
		**5b.**	Follow minimum curing times. During curing time, the anchor rod must not be moved or loaded.
Prepositioned	Push-through	**5c.**	Remove excess mortar.
			
Prepositioned	Push-through	**5d.**	For both installation types, the fixture can be mounted after curing time. Apply installation torque Tinst by using a torque wrench. In case of push through installation, the annular gap between the anchor rod and attachment may be optionally filled with mortar. Therefore, replace regular washer by washer with bore and plug on reducing adapter on static mixer. The annular gap is completely filled when excess mortar seeps out.
			

Filling Quantity

Anchor type: WIT-VIZ, M8 - M24

Thread size			**M8**	**M10**	**M12**	**M16**	**M20**	**M20**	**M24**
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	22	24	26
Drill depth	h_0 / h_1	[mm]							
Filling volume per 10mm embedment depth		[ml]	1.05	1.20	1.20	1.50	2.29	2.30	2.30

Assumed waste of 15 % included.

W-VIZ/A4

W-VIZ-A/A4

Stainless steel - A4 (AISI 316): M8 - M24

W-VIZ-A/HCR

High corrosion resistant steel HCR: M8 - M24

WIT-VIZ

WIT-VIZ EXPRESS

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

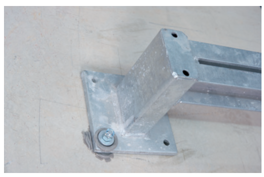
Suitable for:
Concrete C12/15, Natural stone with dense structure

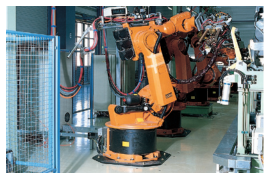
Type of installation		
Pre-positioned	In-place	Stand-off
✓	✓	✓

Installation condition		
Dry concrete	Wet concrete	Flooded drill hole
✓	✓	✓

Drilling method		
Hammer drill	Diamond drill	Hollow drill
✓	✓	✓

Applications





Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt, Berlin	ETAG 001-T5	ETA-04/0095, 11.05.2017
Fire resistance	MFPA Leipzig GmbH	TR 020	GS 3.2/18-075-1
LEED	eurofins		14.06.13
VOC Emissions Test report	eurofins	DEVL 1101903D, DEVL 1104875A	07.01.14

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness is according to anchor characteristics
- Anchor material is as specified in anchor material specification table
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²
- Bonding expansion system WIT-VIZ consists of an anchor rod WIT-VIZ-A/A4 or WIT-VIZ-A/HCR and injection mortar WIT-VIZ or WIT-EXPRESS
- Temperature range I: -40°C to +80°C (max. long term/short term base material temperature +50°C/+80°C)
- Dry or wet conditions of drill hole, hammer and diamond core drilling
- Installation temperature range +5°C to +40°C

Mean ultimate resistance

Anchor type: WIT-VIZ, M8 - M12

Thread size				M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth		h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	15.0	22.0	30.9	30.9	38.4	40.6	61.6
Shear	C20/25	$V_{Ru,m}$	[kN]	17.6	17.6	27.8	27.8	40.5	40.5	40.5
Cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	11.2	17.8	25.5	26.9	31.8	37.5	44.0
Shear	C20/25	$V_{Ru,m}$	[kN]	17.6	17.6	27.8	27.8	40.5	40.5	40.5

Anchor type: WIT-VIZ, M12 - M16

Thread size				M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth		h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	61.6	65.9	65.9	65.9	62.2	80.9	100.9
Shear	C20/25	$V_{Ru,m}$	[kN]	40.5	40.5	40.5	40.5	75.4	75.4	75.4
Cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	47.1	61.3	61.3	61.3	44.7	68.3	99.2
Shear	C20/25	$V_{Ru,m}$	[kN]	40.5	40.5	40.5	40.5	75.4	75.4	75.4

Anchor type: WIT-VIZ, M16 - M24

Thread size				M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth		h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete											
Tension	C20/25	$N_{Ru,m}$	[kN]	100.9	115.9	107.9	171.5	171.5	201.0	237.6	237.6
Shear	C20/25	$V_{Ru,m}$	[kN]	75.4	75.4	102.9	102.9	102.9	147.8	147.8	147.8
Cracked concrete											
Tension	C20/25	$N_{Ru,m}$	[kN]	99.2	104.7	94.3	136.6	136.6	133.5	183.4	183.4
Shear	C20/25	$V_{Ru,m}$	[kN]	75.4	75.4	102.9	102.9	102.9	147.8	147.8	147.8

W-VIZ/A4

Characterstic loads

Anchor type: WIT-VIZ, M8 - M12

Thread size				M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth		h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	9.0	17.4	22.9	25.0	32.0	28.8	35.2
	C50/60			14.2	18.0	25.0	25.0	35.0	45.6	54.0
Shear	≥ C20/25	V_{Rk}	[kN]	14.0	14.0	21.0	21.0	34.0	34.0	34.0
Cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	8.7	12.2	16.0	22.4	22.4	20.2	24.6
	C50/60			13.8	18.0	25.0	25.0	35.0	31.9	39.0
Shear	≥ C20/25	V_{Rk}	[kN]	14.0	14.0	21.0	21.0	34.0	34.0	34.0

Anchor type: WIT-VIZ, M12 - M16

Thread size				M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth		h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	40.0	49.2	50.0	50.0	42.0	52.9	68.8
	C50/60			54.0	57.0	57.0	57.0	66.4	83.7	108.7
Shear	≥ C20/25	V_{Rk}	[kN]	34.0	34.0	34.0	34.0	63.0	63.0	63.0
Cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	31.9	34.4	39.7	48.1	29.4	37.1	48.1
	C50/60			50.4	54.4	57.0	57.0	46.5	58.6	76.1
Shear	≥ C20/25	V_{Rk}	[kN]	34.0	34.0	34.0	34.0	58.8	63.0	63.0

Anchor type: WIT-VIZ, M16 - M24

Thread size				M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth		h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	75.0	90.0	60.7	109.0	128.8	109.0	139.1	166.0
	C50/60			111.0	97.0	95.9	172.4	188.0	172.4	220.0	222.0
Shear	≥ C20/25	V_{Rk}	[kN]	63.0	63.0	70.0	98.0	98.0	141.0	141.0	141.0
Cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	60.1	69.7	42.5	76.3	90.2	76.3	97.4	116.2
	C50/60			95.1	97.0	67.1	120.7	142.6	120.7	154.0	183.8
Shear	≥ C20/25	V_{Rk}	[kN]	63.0	63.0	70.0	98.0	98.0	141.0	141.0	141.0

Design loads

Anchor type: WIT-VIZ, M8 - M12

Thread size				M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth		h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	6.0	11.6	15.2	16.7	21.3	19.2	23.5
	C50/60			9.5	12.0	16.7	16.7	23.3	30.4	36.0
Shear	≥ C20/25	V_{Rd}	[kN]	11.2	11.2	16.8	16.8	27.2	27.2	27.2
Cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	5.8	8.1	10.7	14.9	14.9	13.4	16.4
	C50/60			9.2	12.0	16.7	16.7	23.3	21.3	26.0
Shear	≥ C20/25	V_{Rd}	[kN]	11.2	11.2	16.8	16.8	27.2	26.9	27.2

Anchor type: WIT-VIZ, M12 - M16

Thread size				M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth		h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	26.7	32.8	33.3	33.3	28.0	35.3	45.8
	C50/60			36.0	38.0	38.0	38.0	44.3	55.8	72.5
Shear	≥ C20/25	V_{Rd}	[kN]	27.2	27.2	27.2	27.2	50.4	50.4	50.4
Cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	21.3	23.0	26.5	32.1	19.6	24.7	32.1
	C50/60			33.6	36.3	38.0	38.0	31.0	39.1	50.7
Shear	≥ C20/25	V_{Rd}	[kN]	27.2	27.2	27.2	27.2	39.2	49.4	50.4

Anchor type: WIT-VIZ, M16 - M24

Thread size				M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth		h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	50.0	60.0	40.4	72.7	85.9	72.7	92.8	110.7
	C50/60			74.0	64.7	57.1	114.9	125.3	114.9	146.7	148.0
Shear	≥ C20/25	V_{Rd}	[kN]	50.4	50.4	50.0	78.4	78.4	112.8	112.8	112.8
Cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	40.1	46.5	28.3	50.9	60.1	50.9	64.9	77.5
	C50/60			63.4	64.7	44.8	80.5	95.1	80.5	102.7	122.5
Shear	≥ C20/25	V_{Rd}	[kN]	50.4	50.4	50.0	78.4	78.4	101.8	112.8	112.8

W-VIZ/A4

Recommended/allowable loads [1)]

Anchor type: WIT-VIZ, M8 - M12

Thread size				M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth		h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete										
Tension	C20/25	N_{rec}	[kN]	4.3	8.3	10.9	11.9	15.2	13.7	16.8
	C50/60			6.8	8.6	11.9	11.9	16.7	21.7	25.7
Shear	≥ C20/25	V_{rec}	[kN]	8.0	8.0	12.0	12.0	19.4	19.4	19.4
Cracked concrete										
Tension	C20/25	N_{rec}	[kN]	4.1	5.8	7.6	10.7	10.7	9.6	11.7
	C50/60			6.6	8.6	11.9	11.9	16.7	15.2	18.6
Shear	≥ C20/25	V_{rec}	[kN]	8.0	8.0	12.0	12.0	19.4	19.2	19.4

1) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Anchor type: WIT-VIZ, M12 - M16

Thread size				M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth		h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete										
Tension	C20/25	N_{rec}	[kN]	19.0	23.4	23.8	23.8	20.0	25.2	32.7
	C50/60			25.7	27.1	27.1	27.1	31.6	39.9	51.8
Shear	≥ C20/25	V_{rec}	[kN]	19.4	19.4	19.4	19.4	36.0	36.0	36.0
Cracked concrete										
Tension	C20/25	N_{rec}	[kN]	15.2	16.4	18.9	22.9	14.0	17.6	22.9
	C50/60			24.0	25.9	27.1	27.1	22.1	27.9	36.2
Shear	≥ C20/25	V_{rec}	[kN]	19.4	19.4	19.4	19.4	28.0	35.3	36.0

1) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Anchor type: WIT-VIZ, M16 - M24

Thread size				M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth		h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete											
Tension	C20/25	N_{rec}	[kN]	35.7	42.9	28.9	51.9	61.4	51.9	66.3	79.1
	C50/60			52.9	46.2	40.8	82.1	89.5	82.1	104.8	105.7
Shear	≥ C20/25	V_{rec}	[kN]	36.0	36.0	35.7	56.0	56.0	80.6	80.6	80.6
Cracked concrete											
Tension	C20/25	N_{rec}	[kN]	28.6	33.2	20.2	36.3	42.9	36.3	46.4	55.3
	C50/60			45.3	46.2	32.0	57.5	67.9	57.5	73.3	87.5
Shear	≥ C20/25	V_{rec}	[kN]	36.0	36.0	35.7	56.0	56.0	72.7	80.6	80.6

1) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole, hammer drilling
- Anchor material as specified in anchor material specification table

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Anchor type: WIT-VIZ, M8 - M12

Thread size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Design steel resistance	$N_{Rd,s}$	[kN]	10.0	12.0	16.7	16.7	23.3	32.7	36.0

Anchor type: WIT-VIZ, M12 - M16

Thread size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Design steel resistance	$N_{Rd,s}$	[kN]	36.0	38.0	38.0	38.0	58.7	63.3	74.0

Anchor type: WIT-VIZ, M16 - M24

Thread size			M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Design steel resistance	$N_{Rd,s}$	[kN]	74.0	64.7	57.1	125.3	125.3	148.0	148.0	148.0

2. Design pullout resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of pull-out failure of a single anchor

Anchor type: WIT-VIZ, M8 - M12

Thread size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete									
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	6.0	11.6	15.2	21.3	21.3	19.2	23.5
Cracked concrete									
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	5.8	8.1	10.7	14.9	14.9	13.4	16.4

Anchor type: WIT-VIZ, M12 - M16

Thread size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete									
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	26.7	32.8	33.3	33.3	28.0	35.3	45.8
Cracked concrete									
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	21.3	23.0	26.5	32.1	19.6	24.7	32.1

Anchor type: WIT-VIZ, M16 - M24

Thread size			M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete										
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	50.0	60.0	40.4	72.7	85.9	72.7	92.8	110.7
Cracked concrete										
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	40.1	46.5	28.3	50.9	60.1	50.9	64.9	77.5

a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Anchor type: WIT-VIZ, M8 - M12

Thread size			**M8**	**M8**	**M10**	**M10**	**M12**	**M12**	**M12**
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete									
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	8.3	11.6	15.2	21.3	21.3	19.2	23.5
Cracked concrete									
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	5.8	8.1	10.7	14.9	14.9	13.4	16.4

Anchor type: WIT-VIZ, M12 - M16

Thread size			**M12**	**M12**	**M12**	**M12**	**M16**	**M16**	**M16**
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete									
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	30.4	32.8	37.8	45.8	28.0	35.3	45.8
Cracked concrete									
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	21.3	23.0	26.5	32.1	19.6	24.7	32.1

Anchor type: WIT-VIZ, M16 - M24

Thread size			**M16**	**M16**	**M20**	**M20**	**M20**	**M24**	**M24**	**M24**
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete										
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	57.3	66.4	40.4	72.7	85.9	72.7	92.8	110.7
Cracked concrete										
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	40.1	46.5	28.3	50.9	60.1	50.9	64.9	77.5

W-VIZ/A4

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Anchor type: WIT-VIZ, M8 - M12

Thread size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Spacing	$s_{cr,N}$	[mm]	120.0	150.0	180.0	225.0	225.0	210.0	240.0
Edge distance	$c_{cr,N}$	[mm]	60.0	75.0	90.0	112.5	112.5	105.0	120.0

Anchor type: WIT-VIZ, M12 - M16

Thread size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Spacing	$s_{cr,N}$	[mm]	285.0	300.0	330.0	375.0	270.0	315.0	375.0
Edge distance	$c_{cr,N}$	[mm]	142.5	150.0	165.0	187.5	135.0	157.5	187.5

Anchor type: WIT-VIZ, M16 - M24

Thread size			M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Spacing	$s_{cr,N}$	[mm]	435.0	480.0	345.0	510.0	570.0	510.0	600.0	675.0
Edge distance	$c_{cr,N}$	[mm]	217.5	240.0	172.5	255.0	285.0	255.0	300.0	337.5

a. Influence of concrete strength

Table 6: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

1) Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 8: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 9: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Anchor type: WIT-VIZ, M8 - M12

Thread size			**M8**	**M8**	**M10**	**M10**	**M12**	**M12**	**M12**
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Non-cracked concrete									
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	5.0	6.0	10.7	13.3	13.3	13.3	23.5

Anchor type: WIT-VIZ, M12 - M16

Thread size			**M12**	**M12**	**M12**	**M12**	**M16**	**M16**	**M16**
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Non-cracked concrete									
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	20.0	26.7	26.7	26.7	26.7	33.3	33.3

Anchor type: WIT-VIZ, M16 - M24

Thread size			**M16**	**M16**	**M20**	**M20**	**M20**	**M24**	**M24**	**M24**
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Non-cracked concrete										
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	40.0	53.3	40.4	72.7	76.7	72.7	92.8	93.3

Table 10: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Anchor type: WIT-VIZ, M8 - M12

Thread size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Characteristic spacing	$s_{cr, sp}$	[mm]	120.0	150.0	180.0	225.0	225.0	210.0	240.0
Characteristic edge distance	$c_{cr, sp}$	[mm]	60.0	75.0	90.0	112.5	112.5	105.0	120.0
Minimum member thickness	h_{min}	[mm]	100	100	120	150	150	140	160

Anchor type: WIT-VIZ, M12 - M16

Thread size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Characteristic spacing	$s_{cr, sp}$	[mm]	285.0	300.0	330.0	375.0	270.0	315.0	375.0
Characteristic edge distance	$c_{cr, sp}$	[mm]	142.5	150.0	165.0	187.5	135.0	157.5	187.5
Minimum member thickness	h_{min}	[mm]	190	200	220	250	180	200	250

Anchor type: WIT-VIZ, M16 - M24

Thread size			M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Characteristic spacing	$s_{cr, sp}$	[mm]	435.0	480.0	345.0	510.0	570.0	510.0	600.0	675.0
Characteristic edge distance	$c_{cr, sp}$	[mm]	217.5	240.0	172.5	255.0	285.0	255.0	300.0	337.5
Minimum member thickness	h_{min}	[mm]	290	320	230	340	380	340	400	450

a. Influence of concrete strength

Table 11: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 12: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ 1)	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

1) Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 13: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ / $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1\ 5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure $V_{Rd,s}$
2. Concrete pry-out failure $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Anchor type: WIT-VIZ, M8 - M12

Thread size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Design steel resistance	$V_{Rd,s}$	[kN]	11.2	11.2	16.8	16.8	27.2	27.2	27.2

Anchor type: WIT-VIZ, M12 - M16

Thread size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Design steel resistance	$V_{Rd,s}$	[kN]	27.2	27.2	27.2	27.2	50.4	50.4	50.4

Anchor type: WIT-VIZ, M16 - M24

Thread size			M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Design steel resistance	$V_{Rd,s}$	[kN]	50.4	50.4	50.0	78.4	78.4	112.8	112.8	112.8

2. Concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot N_{Rd,c}$$

Table 16: factor k_8 for calculating design pry-out resistance

Anchor type: WIT-VIZ, M8 - M12

Thread size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Anchor type: WIT-VIZ, M12 - M16

Thread size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	h_{ef}	[mm]	95	100	110	125	90	105	125
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Anchor type: WIT-VIZ, M16 - M24

Thread size			M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth	h_{ef}	[mm]	145	160	115	170	190	170	200	225
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

W-VIZ/A4

3. Concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions c ≥ max (10 h_{ef} ; 60 d). For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 17: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Anchor type: WIT-VIZ, M8 - M12

Thread size	M8		M8		M10		M10		M12		M12		M12	
h_{ef} [mm]	40		50		60		75		75		70		80	
Edge distance c_1	$V^0_{Rd,c}$													
[mm]	[kN]													
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
40	3.0	2.1	3.1	2.2	-	2.4	-	2.5	-	-	-	-	-	-
45	3.5	2.5	3.7	2.6	-	2.8	-	2.9	-	-	-	-	-	-
50	4.1	2.9	4.2	3.0	4.5	3.2	4.7	3.4	4.7	3.4	-	-	-	3.5
55	4.6	3.3	4.8	3.4	5.1	3.6	5.4	3.8	5.4	3.8	5.4	3.8	5.6	4.0
60	5.2	3.7	5.4	3.8	5.7	4.1	6.0	4.3	6.0	4.3	6.1	4.3	6.3	4.4
65	5.8	4.1	6.0	4.3	6.4	4.5	6.7	4.7	6.7	4.7	6.7	4.8	6.9	4.9
70	6.4	4.5	6.6	4.7	7.0	5.0	7.3	5.2	7.3	5.2	7.4	5.3	7.6	5.4
75	7.0	5.0	7.3	5.2	7.7	5.5	8.0	5.7	8.0	5.7	8.1	5.8	8.3	5.9
80	7.7	5.4	8.0	5.6	8.4	6.0	8.8	6.2	8.8	6.2	8.8	6.3	9.1	6.4
85	8.4	5.9	8.6	6.1	9.1	6.5	9.5	6.7	9.5	6.7	9.6	6.8	9.8	7.0
90	9.0	6.4	9.3	6.6	9.8	7.0	10.2	7.2	10.2	7.2	10.3	7.3	10.6	7.5
95	9.7	6.9	10.0	7.1	10.6	7.5	11.0	7.8	11.0	7.8	11.1	7.9	11.4	8.1
100	10.4	7.4	10.8	7.6	11.3	8.0	11.8	8.3	11.8	8.3	11.9	8.4	12.2	8.6
110	11.9	8.4	12.3	8.7	12.9	9.1	13.4	9.5	13.4	9.5	13.5	9.6	13.8	9.8
120	13.4	9.5	13.8	9.8	14.5	10.3	15.0	10.6	15.0	10.6	15.2	10.7	15.5	11.0
130	15.0	10.6	15.5	11.0	16.2	11.5	16.7	11.9	16.7	11.9	16.9	12.0	17.3	12.2
140	16.7	11.8	17.1	12.1	17.9	12.7	18.5	13.1	18.5	13.1	18.7	13.2	19.1	13.5
150	18.3	13.0	18.9	13.4	19.7	13.9	20.3	14.4	20.3	14.4	20.5	14.5	20.9	14.8
160	20.1	14.2	20.6	14.6	21.5	15.2	22.2	15.7	22.2	15.7	22.4	15.9	22.8	16.2
170	21.9	15.5	22.4	15.9	23.4	16.6	24.1	17.1	24.1	17.1	24.3	17.2	24.8	17.6
180	23.7	16.8	24.3	17.2	25.3	17.9	26.1	18.5	26.1	18.5	26.3	18.6	26.8	19.0
190	25.6	18.1	26.2	18.6	27.3	19.3	28.1	19.9	28.1	19.9	28.3	20.0	28.8	20.4
200	27.5	19.5	28.2	19.9	29.3	20.7	30.1	21.3	30.1	21.3	30.4	21.5	30.9	21.9
250	37.6	26.7	38.5	27.3	39.9	28.3	41.0	29.0	41.0	29.0	41.3	29.2	42.0	29.8
300	48.8	34.5	49.8	35.3	51.5	36.5	52.8	37.4	52.8	37.4	53.2	37.7	54.0	38.3
350	60.7	43.0	61.9	43.9	64.0	45.3	65.5	46.4	65.5	46.4	65.9	46.7	66.9	47.4
400	73.4	52.0	74.9	53.0	77.2	54.7	79.0	55.9	79.0	55.9	79.4	56.3	80.6	57.1
450	86.9	61.6	88.5	62.7	91.2	64.6	93.2	66.0	93.2	66.0	93.7	66.4	95.0	67.3
500	101.1	71.6	102.9	72.9	105.9	75.0	108.1	76.6	108.1	76.6	108.7	77.0	110.2	78.0
550	115.9	82.1	117.9	83.5	121.2	85.9	123.7	87.6	123.7	87.6	124.3	88.1	126.0	89.2
600	131.3	93.0	133.5	94.6	137.2	97.2	139.9	99.1	139.9	99.1	140.6	99.6	142.4	100.9
650	-	-	-	-	153.8	108.9	156.7	111.0	156.7	111.0	157.5	111.6	159.4	112.9
700	-	-	-	-	170.9	121.0	174.1	123.3	174.1	123.3	174.9	123.9	177.0	125.4
750	-	-	-	-	-	-	192.0	136.0	192.0	136.0	193.0	136.7	195.2	138.3
800	-	-	-	-	-	-	-	-	-	-	211.5	149.8	213.9	151.5

Anchor type: WIT-VIZ, M12 - M16

Thread size	**M12**		**M12**		**M12**		**M12**		**M16**		**M16**		**M16**	
h_{ef} [mm]	95		100		110		125		90		105		125	
Edge distance c_1	$V^0_{Rd,c}$													
[mm]	[kN]													
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
50	-	3.7	-	3.7	-	3.8	-	4.0	5.4	3.8	-	4.0	-	-
55	5.8	4.1	5.9	4.2	6.1	4.3	6.3	4.4	6.1	4.3	-	4.5	-	-
60	6.5	4.6	6.6	4.7	6.8	4.8	7.0	4.9	6.7	4.8	7.0	5.0	7.4	5.2
65	7.2	5.1	7.3	5.2	7.5	5.3	7.7	5.5	7.5	5.3	7.8	5.5	8.1	5.8
70	7.9	5.6	8.0	5.7	8.2	5.8	8.5	6.0	8.2	5.8	8.5	6.0	8.9	6.3
75	8.7	6.1	8.8	6.2	9.0	6.3	9.2	6.5	8.9	6.3	9.3	6.6	9.7	6.9
80	9.4	6.7	9.5	6.7	9.7	6.9	10.0	7.1	9.7	6.9	10.1	7.1	10.5	7.4
85	10.2	7.2	10.3	7.3	10.5	7.4	10.8	7.7	10.5	7.4	10.9	7.7	11.3	8.0
90	11.0	7.8	11.1	7.9	11.3	8.0	11.6	8.2	11.3	8.0	11.7	8.3	12.2	8.6
95	11.8	8.3	11.9	8.4	12.1	8.6	12.5	8.8	12.1	8.6	12.5	8.9	13.0	9.2
100	12.6	8.9	12.7	9.0	13.0	9.2	13.3	9.4	13.0	9.2	13.4	9.5	13.9	9.9
110	14.3	10.1	14.4	10.2	14.7	10.4	15.1	10.7	14.7	10.4	15.1	10.7	15.7	11.1
120	16.0	11.3	16.2	11.4	16.4	11.6	16.9	11.9	16.4	11.6	16.9	12.0	17.6	12.5
130	17.8	12.6	18.0	12.7	18.3	12.9	18.7	13.3	18.3	12.9	18.8	13.3	19.5	13.8
140	19.6	13.9	19.8	14.0	20.1	14.3	20.6	14.6	20.1	14.3	20.7	14.7	21.5	15.2
150	21.5	15.3	21.7	15.4	22.1	15.6	22.6	16.0	22.1	15.6	22.7	16.1	23.5	16.6
160	23.5	16.6	23.7	16.8	24.1	17.0	24.6	17.4	24.1	17.0	24.7	17.5	25.5	18.1
170	25.5	18.0	25.7	18.2	26.1	18.5	26.7	18.9	26.1	18.5	26.8	19.0	27.7	19.6
180	27.5	19.5	27.7	19.6	28.2	19.9	28.8	20.4	28.2	19.9	28.9	20.5	29.8	21.1
190	29.6	21.0	29.8	21.1	30.3	21.4	30.9	21.9	30.3	21.4	31.1	22.0	32.0	22.7
200	31.7	22.5	32.0	22.6	32.4	23.0	33.1	23.5	32.4	23.0	33.3	23.6	34.3	24.3
250	43.0	30.4	43.3	30.7	43.9	31.1	44.7	31.7	43.9	31.1	44.9	31.8	46.2	32.7
300	55.2	39.1	55.6	39.4	56.3	39.9	57.3	40.6	56.3	39.9	57.5	40.7	59.0	41.8
350	68.3	48.4	68.7	48.7	69.5	49.3	70.7	50.1	69.6	49.3	71.0	50.3	72.7	51.5
400	82.2	58.2	82.7	58.6	83.6	59.2	84.9	60.2	83.6	59.2	85.3	60.4	87.2	61.8
450	96.8	68.6	97.4	69.0	98.4	69.7	99.9	70.8	98.5	69.7	100.3	71.0	102.5	72.6
500	112.1	79.4	112.8	79.9	113.9	80.7	115.6	81.9	114.0	80.7	116.0	82.2	118.5	83.9
550	128.2	90.8	128.8	91.3	130.1	92.2	132.0	93.5	130.2	92.2	132.4	93.8	135.2	95.7
600	144.8	102.6	145.5	103.1	147.0	104.1	149.0	105.5	147.0	104.1	149.5	105.9	152.5	108.0
650	162.0	114.8	162.8	115.4	164.4	116.5	166.6	118.0	164.5	116.5	167.1	118.4	170.4	120.7
700	179.9	127.4	180.7	128.0	182.4	129.2	184.8	130.9	182.5	129.3	185.4	131.3	188.9	133.8
750	198.3	140.4	199.2	141.1	201.0	142.4	203.5	144.2	201.1	142.4	204.2	144.6	207.9	147.3
800	217.2	153.8	218.2	154.6	220.1	155.9	222.8	157.8	220.2	156.0	223.6	158.3	227.5	161.2
850	236.6	167.6	237.7	168.4	239.8	169.8	242.6	171.9	239.9	169.9	243.4	172.4	247.7	175.4
900	256.6	181.8	257.7	182.6	259.9	184.1	263.0	186.3	260.1	184.2	263.8	186.9	268.3	190.1
950	277.0	196.2	278.3	197.1	280.6	198.7	283.8	201.0	280.7	198.8	284.7	201.7	289.5	205.0
1000	-	-	299.3	212.0	301.7	213.7	305.1	216.1	301.9	213.8	306.1	216.8	311.1	220.4
1100	-	-	-	-	345.3	244.6	349.1	247.3	-	-	-	-	355.8	252.0
1200	-	-	-	-	-	-	394.9	279.7	-	-	-	-	402.2	284.9
1300	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1400	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1600	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1800	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1900	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2125	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Anchor type: WIT-VIZ, M16 - M24

Thread size	M16		M16		M20		M20		M20	
h_{ef} [mm]	145		160		115		170		190	
Edge distance c_1	$V^0_{Rd,c}$									
[mm]	[kN]									
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
60	7.7	5.5	7.9	5.6	-	-	-	-	-	-
65	8.5	6.0	8.7	6.2	-	-	-	-	-	-
70	9.3	6.6	9.6	6.8	-	-	-	-	-	-
75	10.1	7.2	10.4	7.4	-	-	-	-	-	-
80	10.9	7.7	11.2	8.0	10.7	7.6	12.2	8.6	12.6	8.9
85	11.8	8.3	12.1	8.6	11.5	8.2	13.1	9.3	13.6	9.6
90	12.6	9.0	13.0	9.2	12.4	8.8	14.0	9.9	14.5	10.3
95	13.5	9.6	13.9	9.8	13.3	9.4	15.0	10.6	15.5	11.0
100	14.4	10.2	14.8	10.5	14.2	10.0	15.9	11.3	16.5	11.7
110	16.3	11.5	16.7	11.8	16.0	11.3	17.9	12.7	18.5	13.1
120	18.2	12.9	18.6	13.2	17.8	12.6	19.9	14.1	20.5	14.5
130	20.1	14.3	20.6	14.6	19.8	14.0	22.0	15.6	22.6	16.0
140	22.1	15.7	22.6	16.0	21.8	15.4	24.1	17.1	24.8	17.6
150	24.2	17.1	24.7	17.5	23.8	16.9	26.3	18.6	27.0	19.2
160	26.3	18.6	26.8	19.0	25.9	18.3	28.6	20.2	29.3	20.8
170	28.5	20.2	29.0	20.6	28.0	19.9	30.8	21.8	31.6	22.4
180	30.7	21.7	31.3	22.1	30.2	21.4	33.2	23.5	34.0	24.1
190	32.9	23.3	33.5	23.8	32.4	23.0	35.5	25.2	36.4	25.8
200	35.2	24.9	35.9	25.4	34.7	24.6	38.0	26.9	38.9	27.5
250	47.3	33.5	48.1	34.1	46.7	33.1	50.7	35.9	51.8	36.7
300	60.4	42.8	61.3	43.4	59.7	42.3	64.4	45.6	65.7	46.5
350	74.3	52.6	75.4	53.4	73.5	52.0	79.0	55.9	80.5	57.0
400	89.0	63.1	90.3	64.0	88.1	62.4	94.4	66.8	96.1	68.1
450	104.5	74.0	105.9	75.0	103.5	73.3	110.5	78.3	112.4	79.6
500	120.7	85.5	122.3	86.6	119.6	84.7	127.4	90.2	129.5	91.7
550	137.6	97.5	139.4	98.7	136.4	96.6	144.9	102.7	147.3	104.3
600	155.2	109.9	157.0	111.2	153.8	109.0	163.1	115.5	165.7	117.3
650	173.3	122.7	175.3	124.2	171.9	121.7	181.9	128.9	184.7	130.8
700	192.0	136.0	194.2	137.6	190.5	134.9	201.3	142.6	204.3	144.7
750	211.3	149.7	213.7	151.3	209.7	148.5	221.3	156.8	224.5	159.0
800	231.2	163.7	233.7	165.5	229.4	162.5	241.8	171.3	245.2	173.7
850	251.5	178.2	254.2	180.1	249.7	176.8	262.9	186.2	266.5	188.8
900	272.4	193.0	275.2	195.0	270.4	191.6	284.5	201.5	288.3	204.2
950	293.8	208.1	296.8	210.2	291.7	206.6	306.5	217.1	310.6	220.0
1000	315.7	223.6	318.8	225.8	313.5	222.0	329.1	233.1	333.3	236.1
1100	360.8	255.6	364.3	258.0	358.4	253.9	375.6	266.1	380.3	269.4
1200	407.7	288.8	411.5	291.5	405.1	287.0	424.0	300.3	429.1	303.9
1300	456.4	323.3	460.5	326.2	453.5	321.3	474.1	335.8	479.6	339.7
1400	506.6	358.9	511.1	362.1	-	-	525.8	372.4	531.8	376.7
1500	-	-	563.3	399.0	-	-	579.1	410.2	585.5	414.8
1600	-	-	617.1	437.1	-	-	634.0	449.1	640.9	453.9
1700	-	-	-	-	-	-	690.4	489.0	697.7	494.2
1800	-	-	-	-	-	-	-	-	755.9	535.4
1900	-	-	-	-	-	-	-	-	815.6	577.7

Anchor type: WIT-VIZ, M24

Thread size	M24		M24		M24	
h_{ef} [mm]	170		200		225	
Edge distance c_1	$V^0_{Rd,c}$					
[mm]	[kN]					
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
80	12.4	8.8	-	9.3	-	9.7
85	13.3	9.4	-	9.9	-	10.3
90	14.3	10.1	-	10.6	-	11.1
95	15.2	10.8	-	11.3	-	11.8
100	16.2	11.5	-	12.0	-	12.5
110	18.2	12.9	19.1	13.5	19.7	14.0
120	20.2	14.3	21.2	15.0	21.9	15.5
130	22.3	15.8	23.3	16.5	24.1	17.1
140	24.5	17.3	25.5	18.1	26.4	18.7
150	26.7	18.9	27.8	19.7	28.7	20.3
160	29.0	20.5	30.1	21.3	31.1	22.0
170	31.3	22.1	32.5	23.0	33.5	23.7
180	33.6	23.8	34.9	24.7	35.9	25.5
190	36.0	25.5	37.4	26.5	38.4	27.2
200	38.5	27.2	39.9	28.2	41.0	29.0
250	51.3	36.3	53.0	37.6	54.4	38.5
300	65.1	46.1	67.1	47.6	68.7	48.7
350	79.8	56.5	82.1	58.2	84.0	59.5
400	95.3	67.5	97.9	69.4	100.0	70.8
450	111.6	79.0	114.5	81.1	116.8	82.7
500	128.6	91.1	131.8	93.4	134.3	95.2
550	146.2	103.6	149.8	106.1	152.6	108.1
600	164.5	116.5	168.4	119.3	171.4	121.4
650	183.5	129.9	187.7	132.9	190.9	135.2
700	203.0	143.8	207.5	147.0	211.0	149.4
750	223.1	158.0	227.9	161.4	231.6	164.1
800	243.7	172.6	248.9	176.3	252.8	179.1
850	264.9	187.6	270.4	191.5	274.6	194.5
900	286.6	203.0	292.4	207.1	296.8	210.3
950	308.8	218.7	314.9	223.1	319.6	226.4
1000	331.5	234.8	337.9	239.4	342.9	242.9
1100	378.3	267.9	385.4	273.0	390.8	276.8
1200	426.9	302.4	434.6	307.8	440.5	312.0
1300	477.2	338.0	485.6	344.0	492.0	348.5
1400	529.2	374.9	538.3	381.3	545.2	386.2
1500	582.8	412.8	592.5	419.7	599.9	425.0
1600	638.0	451.9	648.3	459.2	656.2	464.8
1700	694.6	492.0	705.6	499.8	714.1	505.8
1800	-	-	764.4	541.4	773.3	547.8
1900	-	-	824.5	584.0	834.0	590.7
2000	-	-	886.1	627.6	896.0	634.7
2125	-	-	-	-	975.5	691.0
2250	-	-	-	-	1056.9	748.7

W-VIZ/A4

a. Influence of concrete strength

Table 18: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 19: Influence of spacing on concrete edge resistance

s/c_1[1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of edge distance

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\frac{c_2}{1\,5c_1}\right) \leq 1$$

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1[1]	1.00	1.10	1.20	1.30	1.40	1.50
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \leq c_2$

d. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{\cos^2\alpha_V + \left(\frac{\sin\alpha_V}{2}\right)^2}} \leq 2$$

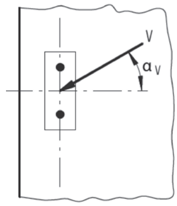


Table 21: Influence of load direction on concrete edge resistance

α[1)]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1)] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.

e. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1{,}2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

Mechanical characteristics

Anchor type: WIT-VIZ, M8 - M24

Thread size			M8	M8	M10	M10	M12	M12	M12	M12	M12	M12	M12	M16	M16	M16	M16	M20	M20	M20	M24	M24	M24
Effective anchorage depth	h_{ef}	[mm]	40	50	60	75	75	70	80	95	100	110	125	90	105	125	145	115	170	190	170	200	225
Governing cross section																							
Stressed cross section	A_s	[mm²]	18.9	22.9	32.2	32.2	43.0	62.2	69.4	69.4	77.0	77.0	77.0	111.2	120.8	141.0	141.0	162.9	237.8	237.8	280.6	280.6	280.6
Section modulus	W	[mm³]	11.6	15.5	25.7	25.7	39.8	69.2	81.5	81.5	95.3	95.3	95.3	165.4	187.2	236.2	236.2	293.1	517.2	517.2	662.8	662.8	662.8
Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640	640	640	640	640	640	640	640	560	560	560	560	560	560
Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	700	700	700	700	700	700
Stressed cross section of threaded part																							
Stressed cross section	A_s	[mm²]	36.6	36.6	58.0	58.0	84.3	84.3	84.3	84.3	84.3	84.3	84.3	157.0	157.0	157.0	157.0	245.0	245.0	245.0	352.0	352.0	352.0
Section modulus	W	[mm³]	31.2	31.2	62.3	62.3	109.2	109.2	109.2	109.2	109.2	109.2	109.2	277.5	277.5	277.5	277.5	540.9	540.9	540.9	931.5	931.5	931.5
Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640	640	640	640	640	640	640	640	560	560	560	560	560	560
Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800	800	800	800	800	800	800	800	700	700	700	700	700	700
Design bending moment	$M^0_{Rd,s}$	[Nm]	24	24	48	48	84	84	84	84	84	84	84	213	213	213	213	324	363	363	627	627	627

Material specifications

No.	Part	Stainless steel A4	High corrosion resistant steel (HCR)
1	**Anchor rod**	Stainless steel, 1.4401, 1.4404, 1.4571, 1.4362, EN 10088:2005, coated	High corrosion resistant steel 1.4529, 1.4565 acc. to EN 10088:2005, coated
2a	**Washer**	Stainless steel 1.4401, 1.4571, EN 10088:2005	High corrosion resistant steel 1.4529, 1.4565 acc. to EN 10088:2005, coated
2b	**Washer with bore**		
3	**Hexagon nut**	ISO 3506:2009 A4-70, 1.4401, 1.4571, EN 10088-2005	ISO 3506:2009, Property class 70, high corrosion resistant steel 1.4529 or 1.4565, EN 10088:2005
4	**Mortar cartridge**	Vinyl Ester Resin, styrene free, mixing ratio 1:10	

Chemical resistance

Chemical Agent	Concentration	Resistant	Not Resistant
Acetic acid	>40		●
Acetic acid	10	●	
Acetone	5		●
Ammonia, aqueous solution	conc.		●
Aniline			●
Calcium hydroxide			●
Carbon tetrachloride		●	
Diesel fuel		●	
Boric Acid, aqueous solution	all	●	
Glycol		●	
Formic acid	30	●	
Calcium hydroxide, suspended in water	all		●
Caustic soda solution	all		●
Citric acid	50	●	
Hydrochloric acid	all		●
Lactic acid	<80	●	
Sea water		●	
Formaldehyde, aqueous solution	20		●
Fuel Oil		●	
Glycol (Ethylene glycol)		●	
Isopropyl alcohol		●	
Linseed oil		●	
Magnesium chloride, aqueous solution	all	●	
Methanol			●
Nitric acid	30		●
Oleic acid		●	
Phenol, aqueous solution	all		●
Phosphoric acid	<80	●	
Potassium carbonate, aqueous solution	all		●
Potassium chlorite, aqueous solution	all	●	
Potassium nitrate, aqueous solution	all	●	
Sodium Chloride, aqueous solution	all	●	
Sodium phosphate, aqueous solution	all	●	
Sodium silicate	all		●
Sulfuric acid	<50	●	
Tartaric acid		●	
Toluene			●
Trichloroethylene			●
Ethanol	96		●

Results shown in the table are applicable to brief periods of chemical contact with full cured adhesive (e.g. temporary contact with adhesive during a spill).

W-VIZ/A4

Properties of adhesive

Temperature range	Base material temperature	Maximum long term base material temperature	Maximum short term base material temperature
Temperature range I	-40 °C to +80 °C	+50 °C	+80 °C
Temperature range II	-40 °C to +120 °C	+72 °C	+120 °C

Property		Testing method	Results
Stability			
UV-resistance (sunlight)			not resistant
Temperature resistance			120 °C
Water resistancy			resistant
Cleaning agents			1% tenside solution: no effects
Physical properties			
Flexural properties	Flexural strength	DIN EN 196-1	after 24 hours: 19.2 N/mm^2
Compressive properties	Compressive strength	DIN EN 196-1	after 24 hours: ≥ 96.1 N/mm^2
Dynamic modulus of elasticity		DIN EN 12504-4	after 24 hours: 13.79 GPa
Thermal conductivity	Modified transient plane source method		0.88 / 0.82 W/mK
Specific contact resistance		IEC 93	4.8 x 109 Ωcm
Density		DIN 53479	1.74 ± 0.1 g/cm^3
Workability features			
Watertightness / impermeability		DIN EN 12390-8	after 72 hours at 5bar: 0mm
Open time (10-20°C)			6 min
Curing time (10-20°C)			80 min
Shelf life			18 months

For information use only. Values are not to be considered as a specification and do not reflect the performance of the system. The given values are typical values and are subject to change without notice.

Working and curing times WIT-VIZ

Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1)]
–5°C	90 min	6 h
–4°C to –1°C	45 min	6 h
0°C to 4°C	20 min	3 h
5°C to 9°C	12 min	2 h
10°C to 19°C	6 min	80 min
20°C to 29°C	4 min	45 min
30°C to 34°C	2 min	25 min
35°C to 39°C	80 s	20 min
40°C	80 s	15 min

[1)] for wet base material the curing time must be doubled

Working and curing times WIT-EXPRESS

Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1)]
-5°C	40 min	4 h
-4°C to -1°C	20 min	4 h
-0°C to 4°C	10 min	2 h
5°C to 9°C	6 min	1 h
10°C to 19°C	3 min	40 min
20°C to 29°C	1 min	20 min
+30°C	1 min	10 min
35°C to 39°C	80 s	20 min
40°C	80 s	15 min

[1)] for wet base material the curing time must be doubled

W-VIZ/A4

W-VIZ/A4

Installation parameters

Anchor type: WIT-VIZ, M8 - M12

Anchor size			M8	M8	M10	M10	M12	M12	M12
Effective anchorage depth	$h_{ef} \geq$	[mm]	40	50	60	75	75	70	80
Nominal drill hole diameter	d_0	[mm]	10	10	12	12	12	14	14
Drill-hole depth	$h_0 \geq$	[mm]	42	55	65	80	80	75	85
Diameter of cleaning brush	$D \geq$	[mm]	10,8	10,8	13	13	13	15	15
Maximum torque moment	$T_{inst} \leq$	[Nm]	10	10	15	15	25	25	25
Diameter of clearance in hole in the fixture	Pre-positioned $d_f \leq$	[mm]	9	9	12	12	14	14	14
	Push-through $d_f \leq$	[mm]	-	-	14	14	14 [1)]/ 16	16	16
Minimum thickness of member	h_{min}	[mm]	80	80	100	110 / 100 [2)]	110	110	110
Non-cracked Concrete									
Minimum spacing	s_{min}	[mm]	40	40	50	50	50	55	55
Minimum edge distance	c_{min}	[mm]	40	40	50	50	50	55	55
Cracked concrete									
Minimum spacing	s_{min}	[mm]	40	40	40	40	50	55	40
Minimum edge distance	c_{min}	[mm]	40	40	40	40	50	55	50

Anchor type: WIT-VIZ, M12 - M16

Anchor size			M12	M12	M12	M12	M16	M16	M16
Effective anchorage depth	$h_{ef} \geq$	[mm]	95	100	110	125	90	105	125
Nominal drill hole diameter	d_0	[mm]	14	14	14	14	18	18	18
Drill-hole depth	$h_0 \geq$	[mm]	100	105	115	130	98	113	133
Diameter of cleaning brush	$D \geq$	[mm]	15	15	15	15	19	19	19
Maximum torque moment	$T_{inst} \leq$	[Nm]	25	30	30	30	50	50	50
Diameter of clearance in hole in the fixture	Pre-positioned $d_f \leq$	[mm]	14	14	14	14	18	18	18
	Push-through $d_f \leq$	[mm]	16	16	16	16	20	20	20
Minimum thickness of member	h_{min}	[mm]	130 / 125 [2)]	130	140	160	130	150	170 / 160 [2)]
Non-cracked Concrete									
Minimum spacing	s_{min}	[mm]	55	80 [3)]	81 [3)]	82 [3)]	50	60	60
Minimum edge distance	c_{min}	[mm]	55	55 [2)]	55 [2)]	55 [2)]	50	60	60
Cracked concrete									
Minimum spacing	s_{min}	[mm]	40	50	50	50	50	50	60
Minimum edge distance	c_{min}	[mm]	50	50	50	50	50	50	60

Anchor type: WIT-VIZ, M16 - M24

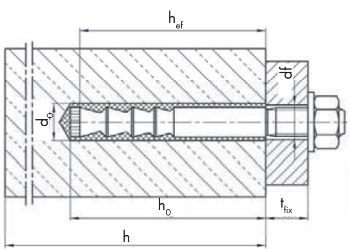
Anchor size			M16	M16	M20	M20	M20	M20	M24	M24
Effective anchorage depth	$h_{ef} \geq$	[mm]	145	160	115	170	190	170	200	225
Nominal drill hole diameter	d_0	[mm]	18	18	22	24	24	26	26	26
Drill-hole depth	$h_0 \geq$	[mm]	153	168	120	180	200	185	215	240
Diameter of cleaning brush	D ≥	[mm]	19	19	23	25	25	27	27	27
Maximum torque moment	$T_{inst} \leq$	[Nm]	50	50	80	80	80	100	120	120
Diameter of clearance in hole in the fixture	Pre-positioned $d_f \leq$	[mm]	18	18	22	24 (22)	24 (22)	26	26	26
	Push-through $d_f \leq$	[mm]	20	20	24	26	26	28	28	28
Minimum thickness of member	h_{min}	[mm]	190 / 180 [2)]	205 / 200 [2)]	160	230 / 220 [2)]	250 / 240 [2)]	230 / 220 [2)]	270 / 260 [2)]	300 / 290 [2)]
Non-cracked Concrete										
Minimum spacing	s_{min}	[mm]	60	60	80	80	80	80	105	105
Minimum edge distance	c_{min}	[mm]	60	60	80	80	80	105	105	105
Cracked concrete										
Minimum spacing	s_{min}	[mm]	60	60	80	80	80	80	80	80
Minimum edge distance	c_{min}	[mm]	60	60	80	80	80	80	80	80

1) Check installation instructions

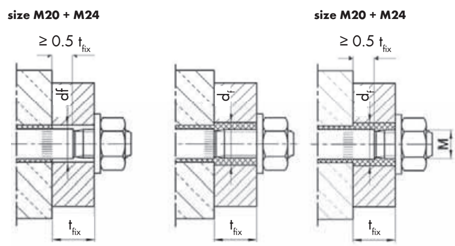
2) The remote face of the concrete member shall be inspected to ensure there has been no break-through by drilling. In case of break-through, the ground of the drill hole shall be closed with high strength mortar. The full bonded length hef shall be achieved and any potential loss of injection mortar shall be compensated

3) For an edge distance c ≥ 80 mm a minimum spacing s_{min} = 55 mm is applicable

Pre-positioned insatallation



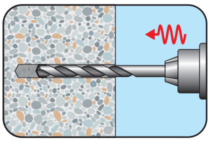
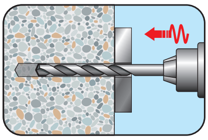
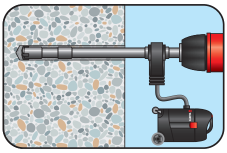
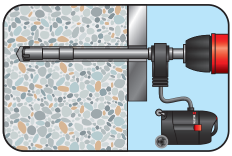
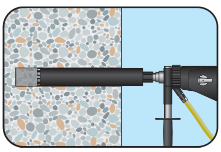
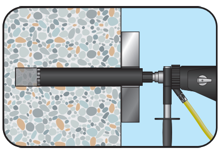
In-place installation

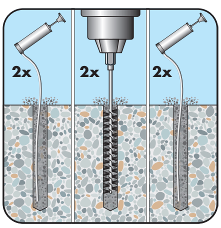
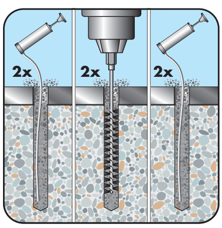


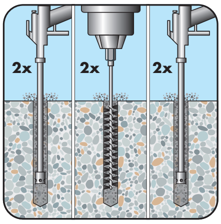
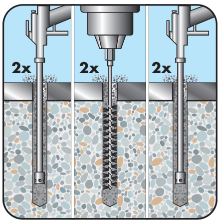
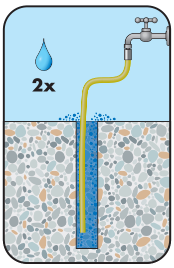
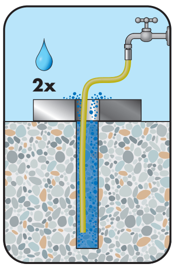
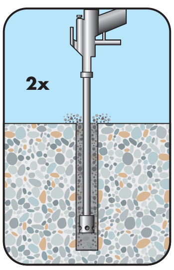
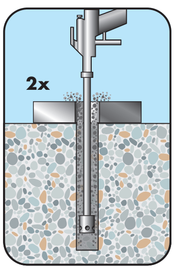
W-VIZ/A4

W-VIZ/A4

Installation instructions

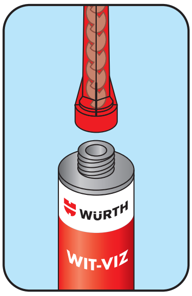
A) Bore hole drilling			
Prepositioned	Push-through	**1a.**	**Hammer (HD) or compressed air drilling (CD)**
			Drill a hole into the base material to the size and embedment depth required by the selected anchor rod. Proceed with Step B1.
Prepositioned	Push-through	**1b.**	**Hollow drill bit system (HDB)**
			Drill hole perpendicular to concrete surface by using a vacuum drill bit. The nominal underpressure of the vacuum cleaner must be at least 230 mbar / 23kPa. Make sure the **dust extraction is working properly** throughout the whole drilling process. Additional cleaning is not necessary. Proceed with Step C.
Prepositioned	Push-through	**1c.**	**Diamond drilling (DD)**
			Use diamond drill with diamond drill bit and depth gauge. Drill perpendicular to concrete surface. Remove drill core at least up to the nominal hole depth and check drill hole depth. Proceed with Step B2.
Attention! Standing water in the bore hole must be removed before cleaning.			

B1) Bore hole cleaning			
MAC: Cleaning for rod threaded diameters shown below			
Prepositioned M8 – M16	Push-through M10 – M16	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean using a hand pump a minimum of <u>two</u> times.
		**2b.**	Check diameter of cleaning brush. If the brush can be pushed into the drill hole without any resistance, it must be replaced. Check brush into the drill machine. Turn on the drill machine. Brush drill hole back and forth along the entire drill hole depth at least <u>two</u> times while rotated by drill machine.
		2c.	Finally blow the hole clean again with a hand pump a minimum of <u>two</u> times. For prepositioned installation, the extension tube with reduced diameter must be added to the blow-out pump for diameter M8.

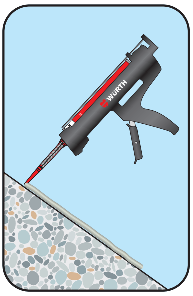
<table>
<tr><td colspan="4">CAC: Cleaning for dry, wet and water-filled bore holes for threaded diameters shown below</td></tr>
<tr><td>Prepositioned
M20 – M24</td><td>Push-through
M20 – M24</td><td>2a.</td><td>Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust.</td></tr>
<tr><td rowspan="2">
</td><td rowspan="2">
</td><td>2b.</td><td>Check diameter of cleaning brush. If the brush can be pushed into the drill hole without any resistance, it must be replaced. Check brush into the drill machine. Turn on the drill machine. Brush drill hole back and forth along the entire drill hole depth at least <u>two</u> times while rotated by drill machine.</td></tr>
<tr><td>2c.</td><td>Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of <u>two</u> times until return air stream is free of noticeable dust.</td></tr>
<tr><td colspan="4">After cleaning, the bore hole has to be protected against re-contamination in an appropriate way until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must no contaminate the bore hole again.</td></tr>
<tr><td colspan="4">B2) Bore hole cleaning</td></tr>
<tr><td colspan="4">SPCAC: Cleaning for dry, wet and water-filled bore holes for all diameters in non-cracked concrete</td></tr>
<tr><td>Prepositioned</td><td>Push-through</td><td rowspan="2">2a.</td><td rowspan="2">Flush drill hole with water, starting from the bottom, until clear water gets out of the drill hole.</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Prepositioned</td><td>Push-through</td><td rowspan="2">2b.</td><td rowspan="2">Connect Air Blower to compressed air (min. 6 bar, oil-free). Open air valve and blow out drill hole along the entire depth with back and forth motion at least two times.</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="4">After cleaning, the bore hole has to be protected against re-contamination in an appropriate way until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must no contaminate the bore hole again.</td></tr>
</table>

W-VIZ/A4

C) Preparation of bar and cartridge

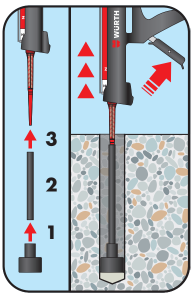
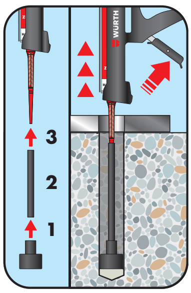


3a. Check expiration date on cartridge. Never use when expired. Remove cap from cartridge. Screw Mixer Nozzle on cartridge. When using a new cartridge, always use a new Mixer Nozzle. Never use cartridge without Mixer Nozzle and never use Mixer Nozzle without helix inside.



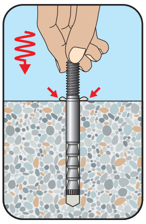
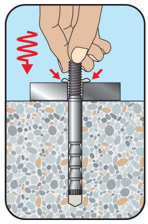
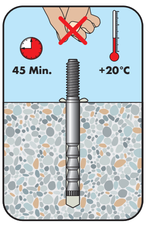
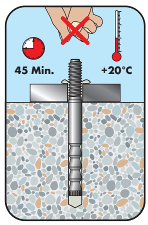
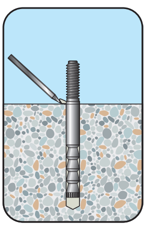
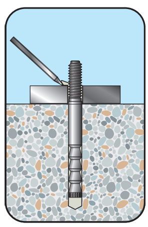
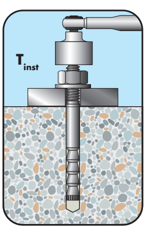
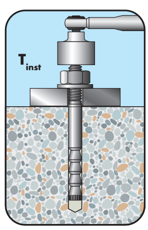
3b. Insert cartridge in Dispenser. Before injecting discard mortar (at least 2 full strokes or a line of 10 cm) until it shows a consistent grey colour. Never use this mortar.

D) Filling the bore hole

Prepositioned	Push-through
	

4. Prior to injection, check if Mixer Nozzle reaches the bottom of the drill hole. If it does not reach the bottom, plug Mixer Extension onto Mixer Nozzle in order to fill the drill hole properly. Fill hole with a sufficient quantity of injection mortar. Start from the bottom of the drill hole and work out to avoid trapping air pockets.

E) Setting the anchor

Prepositioned	Push-through	Step	Description
Prepositioned	Push-through	**5a.**	Insert the anchor rod WIT-VIZ-A by hand, rotating slightly up to the full embedment depth as marked on the anchor rod. In case of prepositioned installation, the anchor rod is properly set when excess mortar seeps from the hole. In case of push-through installation, the annular gap in the clearance hole in the fixture has to be filled completely by excess mortar after the installation. If the hole is not completely filled, pull out the anchor rod, let the mortar cure, drill out hole and repeat entire cleaning process.
			
Prepositioned	Push-through	**5b.**	Follow minimum curing times. During curing time, the anchor rod must not be moved or loaded.
			
Prepositioned	Push-through	**5c.**	Remove excess mortar.
			
Prepositioned	Push-through	**5d.**	For both installation types, the fixture can be mounted after curing time. Apply installation torque Tinst by using a torque wrench. In case of push through installation, the annular gap between the anchor rod and attachment may be optionally filled with mortar. Therefore, replace regular washer by washer with bore and plug on reducing adapter on static mixer. The annular gap is completely filled when excess mortar seeps out.
			

W-VIZ/A4

Filling Quantity

Anchor type: WIT-VIZ, M8 - M24

Thread size			**M8**	**M10**	**M12**	**M16**	**M20**	**M20**	**M24**
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	22	24	26
Drill depth	h_0 / h_1	[mm]							
Filling volume per 10mm embedment depth		[ml]	1.05	1.20	1.20	1.50	2.29	2.30	2.30

Assumed waste of 15 % included.

BONDED CONCRETE SCREW WIT-BS XL

150 ml

410 ml

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

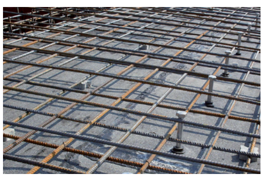
Cartridge sizes		Art. no.
150 ml	coaxial	**0905 450 301**
410 ml	coaxial	**0905 450 302**

Special insert
 
✓

Type of installation		
Pre-positioned	In-place	Stand-off
✓	✓	–

Drilling method		
Hammer drill	Diamond drill	Hollow drill
✓	✓	–

Applications



Approvals and certificates

Description	Authority/laboratory	No./date of issue
General building authority approval (German)	DIBt, Berlin	Pending

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness is according to installation parameters
- Anchor material is as specified in anchor material specification table
- Concrete C 20/25, f_{ck} = 20 N/mm^2
- Concrete C 50/60, f_{ck} = 60 N/mm^2
- Temperature range I: -40°C to +80°C (max. long term/short term base material temperature +50°C/+80°C)
- Dry or wet conditions of drill hole, hammer drilling
- Installation temperature range +5°C to +40°C

Characteristic loads

Screw size: Ø 10 – Ø 12

Screw Size				**Ø 10**	**Ø 10**	**Ø 10**	**Ø 10**	**Ø 12**	**Ø 12**	**Ø 12**	**Ø 12**
Effective anchorage depth		h_{ef}	[mm]	80	90	100	110	100	110	120	130
Non-cracked and cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	24.6	29.4	34.4	39.7	40.7	47.0	53.5	60.3
	C50/60			39.0	42.0	42.0	42.0	64.0	64.0	64.0	64.0
Shear	≥ C20/25	V_{Rk}	[kN]	34.0	34.0	34.0	34.0	42.0	42.0	42.0	42.0

Screw size: Ø 14/M16 – Ø 16/M18

Screw Size				**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**
Effective anchorage depth		h_{ef}	[mm]	100	110	125	140	100	125	140	160
Non-cracked and cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	40.7	47.0	56.9	67.4	40.7	56.9	67.4	82.4
	C50/60			64.3	74.2	89.9	90.0	64.3	89.9	106.6	110.0
Shear	≥ C20/25	V_{Rk}	[kN]	64.0	64.0	64.0	64.0	81.4	96.0	96.0	96.0

Screw size: Ø 22/M20 – Ø 22/M24

Screw Size				**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M24**	**Ø 22/ M24**	**Ø 22/ M24**	**Ø 22/ M24**
Effective anchorage depth		h_{ef}	[mm]	100	125	150	200	100	125	150	200
Non-cracked and cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	40.7	56.9	74.8	115.1	40.7	56.9	74.8	115.1
	C50/60			64.3	89.9	118.2	174.0	64.3	89.9	118.2	181.9
Shear	≥ C20/25	V_{Rk}	[kN]	81.4	107.0	107.0	107.0	81.4	107.0	107.0	107.0

BONDED CONCRETE SCREW WIT-BS XL

Design loads

Screw size: Ø 10 – Ø 12

Screw Size				Ø 10	Ø 10	Ø 10	Ø 10	Ø 12	Ø 12	Ø 12	Ø 12
Effective anchorage depth		h_{ef}	[mm]	80	90	100	110	100	110	120	130
Non-cracked and cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	16.4	19.6	23.0	26.5	27.1	31.3	35.7	40.2
	C50/60			26.0	30.0	30.0	30.0	42.9	45.7	45.7	45.7
Shear	≥ C20/25	V_{Rd}	[kN]	22.7	22.7	22.7	22.7	28.0	28.0	28.0	28.0

Screw size: Ø 14/M16 – Ø 16/M18

Screw Size				Ø 14/ M16	Ø 14/ M16	Ø 14/ M16	Ø 14/ M16	Ø 16/ M18	Ø 16/ M18	Ø 16/ M18	Ø 16/ M18
Effective anchorage depth		h_{ef}	[mm]	100	110	125	140	100	125	140	160
Non-cracked and cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	27.1	31.3	37.9	44.9	27.1	37.9	44.9	54.9
	C50/60			42.9	49.5	60.0	64.3	42.9	60.0	71.1	73.3
Shear	≥ C20/25	V_{Rd}	[kN]	42.7	42.7	42.7	42.7	54.3	64.0	64.0	64.0

Screw size: Ø 22/M20 – Ø 22/M24

Screw Size				Ø 22/ M20	Ø 22/ M20	Ø 22/ M20	Ø 22/ M20	Ø 22/ M24	Ø 22/ M24	Ø 22/ M24	Ø 22/ M24
Effective anchorage depth		h_{ef}	[mm]	100	125	150	200	100	125	150	200
Non-cracked and cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	27.1	37.9	49.8	76.7	27.1	37.9	49.8	76.7
	C50/60			42.9	60.0	78.8	116.0	42.9	60.0	78.8	121.2
Shear	≥ C20/25	V_{Rd}	[kN]	54.3	71.3	71.3	71.3	54.3	71.3	71.3	71.3

Recommended/allowable loads [1)]

Screw size: Ø 10 – Ø 12

Screw Size				Ø 10	Ø 10	Ø 10	Ø 10	Ø 12	Ø 12	Ø 12	Ø 12
Effective anchorage depth		h_{ef}	[mm]	80	90	100	110	100	110	120	130
Non-cracked and cracked concrete											
Tension	C20/25	N_{rec}	[kN]	11.7	14.0	16.4	18.9	19.4	22.4	25.5	28.7
	C50/60			18.6	21.4	21.4	21.4	30.6	32.7	32.7	32.7
Shear	≥ C20/25	V_{rec}	[kN]	16.2	16.2	16.2	16.2	20.0	20.0	20.0	20.0

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Screw size: Ø 14/M16 – Ø 16/M18

Screw Size				Ø 14/ M16	Ø 14/ M16	Ø 14/ M16	Ø 14/ M16	Ø 16/ M18	Ø 16/ M18	Ø 16/ M18	Ø 16/ M18
Effective anchorage depth		h_{ef}	[mm]	100	110	125	140	100	125	140	160
Non-cracked and cracked concrete											
Tension	C20/25	N_{rec}	[kN]	19.4	22.4	27.1	32.1	19.4	27.1	32.1	39.2
	C50/60			30.6	35.4	42.8	45.9	30.6	42.8	50.8	52.4
Shear	≥ C20/25	V_{rec}	[kN]	30.5	30.5	30.5	30.5	38.8	45.7	45.7	45.7

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Screw size: Ø 22/M20 – Ø 22/M24

Screw Size				Ø 22/ M20	Ø 22/ M20	Ø 22/ M20	Ø 22/ M20	Ø 22/ M24	Ø 22/ M24	Ø 22/ M24	Ø 22/ M24
Effective anchorage depth		h_{ef}	[mm]	100	125	150	200	100	125	150	200
Non-cracked and cracked concrete											
Tension	C20/25	N_{rec}	[kN]	19.4	27.1	35.6	54.8	19.4	27.1	35.6	54.8
	C50/60			30.6	42.8	56.3	82.9	30.6	42.8	56.3	86.6
Shear	≥ C20/25	V_{rec}	[kN]	38.8	51.0	51.0	51.0	38.8	51.0	51.0	51.0

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

BONDED CONCRETE SCREW WIT-BS XL

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole, hammer drilling
- Anchor material as specified in anchor material specification table

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Screw size: Ø 10 – Ø 12

Screw Size			**Ø 10**	**Ø 10**	**Ø 10**	**Ø 10**	**Ø 12**	**Ø 12**	**Ø 12**	**Ø 12**
Effective anchorage depth	h_{ef}	[mm]	80	90	100	110	100	110	120	130
Design steel resistance	$N_{Rd,s}$	[kN]	30.0	30.0	30.0	30.0	45.7	45.7	45.7	45.7

Screw size: Ø 14/M16 – Ø 16/M18

Screw Size			**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**
Effective anchorage depth	h_{ef}	[mm]	100	110	125	140	100	125	140	160
Design steel resistance	$N_{Rd,s}$	[kN]	64.3	64.3	64.3	64.3	73.3	73.3	73.3	73.3

Screw size: Ø 22/M20 – Ø 22/M24

Screw Size			**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M24**	**Ø 22/ M24**	**Ø 22/ M24**	**Ø 22/ M24**
Effective anchorage depth	h_{ef}	[mm]	100	125	150	200	100	125	150	200
Design steel resistance	$N_{Rd,s}$	[kN]	116.0	116.0	116.0	116.0	142.7	142.7	142.7	142.7

2. Design pullout resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of pull-out failure of a single anchor

Screw size: Ø 10 – Ø 12

Screw Size			**Ø 10**	**Ø 10**	**Ø 10**	**Ø 10**	**Ø 12**	**Ø 12**	**Ø 12**	**Ø 12**
Effective anchorage depth	h_{ef}	[mm]	80	90	100	110	100	110	120	130
Non-cracked and cracked concrete										
Combined pull-out / breakout resistance	$N^0_{Rd,p}$	[kN]	26.5	26.5	26.5	26.5	40.2	40.2	40.2	40.2

Screw size: Ø 14/M16 – Ø 16/M18

Screw Size			**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**
Effective anchorage depth	h_{ef}	[mm]	100	110	125	140	100	125	140	160
Non-cracked and cracked concrete										
Combined pull-out / breakout resistance	$N^0_{Rd,p}$	[kN]	44.9	44.9	44.9	44.9	54.9	54.9	54.9	54.9

Screw size: Ø 22/M20 – Ø 22/M24

Screw Size			**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M24**	**Ø 22/ M24**	**Ø 22/ M24**	**Ø 22/ M24**
Effective anchorage depth	h_{ef}	[mm]	100	125	150	200	100	125	150	200
Non-cracked and cracked concrete										
Combined pull-out / breakout resistance	$N^0_{Rd,p}$	[kN]	76.7	76.7	76.7	76.7	76.7	76.7	76.7	76.7

BONDED CONCRETE SCREW WIT-BS XL

a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Screw size: Ø 10 – Ø 12

Screw Size			Ø 10	Ø 10	Ø 10	Ø 10	Ø 12	Ø 12	Ø 12	Ø 12
Effective anchorage depth	h_{ef}	[mm]	80	90	100	110	100	110	120	130
Non-cracked and cracked concrete										
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	16.4	19.6	23.0	26.5	27.1	31.3	35.7	40.2

Screw size: Ø 14/M16 – Ø 16/M18

Screw Size			Ø 14/ M16	Ø 14/ M16	Ø 14/ M16	Ø 14/ M16	Ø 16/ M18	Ø 16/ M18	Ø 16/ M18	Ø 16/ M18
Effective anchorage depth	h_{ef}	[mm]	100	110	125	140	100	125	140	160
Non-cracked and cracked concrete										
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	27.1	31.3	37.9	44.9	27.1	37.9	44.9	54.9

Screw size: Ø 22/M20 – Ø 22/M24

Screw Size			Ø 22/ M20	Ø 22/ M20	Ø 22/ M20	Ø 22/ M20	Ø 22/ M24	Ø 22/ M24	Ø 22/ M24	Ø 22/ M24
Effective anchorage depth	h_{ef}	[mm]	100	125	150	200	100	125	150	200
Non-cracked and cracked concrete										
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	27.1	37.9	49.8	76.7	27.1	37.9	49.8	76.7

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Screw size: Ø 10 – Ø 12

Screw Size			Ø 10	Ø 10	Ø 10	Ø 10	Ø 12	Ø 12	Ø 12	Ø 12
Effective anchorage depth	h_{ef}	[mm]	80	90	100	110	100	110	120	130
Spacing	$s_{cr,N}$	[mm]	240	270	300	330	300	330	360	390
Edge distance	$c_{cr,N}$	[mm]	120	135	150	165	150	165	180	195

Screw size: Ø 14/M16 – Ø 16/M18

Screw Size			Ø 14/ M16	Ø 14/ M16	Ø 14/ M16	Ø 14/ M16	Ø 16/ M18	Ø 16/ M18	Ø 16/ M18	Ø 16/ M18
Effective anchorage depth	h_{ef}	[mm]	100	110	125	140	100	125	140	160
Spacing	$s_{cr,N}$	[mm]	300	330	375	420	300	375	420	480
Edge distance	$c_{cr,N}$	[mm]	150	165	188	210	150	188	210	240

Screw size: Ø 22/M20 – Ø 22/M24

Screw Size			Ø 22/ M20	Ø 22/ M20	Ø 22/ M20	Ø 22/ M20	Ø 22/ M24	Ø 22/ M24	Ø 22/ M24	Ø 22/ M24
Effective anchorage depth	h_{ef}	[mm]	100	125	150	200	100	125	150	200
Spacing	$s_{cr,N}$	[mm]	300	375	450	600	300	375	450	600
Edge distance	$c_{cr,N}$	[mm]	150	188	225	300	150	188	225	300

a. Influence of concrete strength

Table 6: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 8: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 9: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Screw size: Ø 10 – Ø 12

Screw Size			**Ø 10**	**Ø 10**	**Ø 10**	**Ø 10**	**Ø 12**	**Ø 12**	**Ø 12**	**Ø 12**
Effective anchorage depth	h_{ef}	[mm]	80	90	100	110	100	110	120	130
Non-cracked and cracked concrete										
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	16.4	19.6	23.0	26.5	27.1	31.3	35.7	40.2

Screw size: Ø 14/M16 – Ø 16/M18

Screw Size			**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**
Effective anchorage depth	h_{ef}	[mm]	100	110	125	140	100	125	140	160
Non-cracked and cracked concrete										
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	27.1	31.3	37.9	44.9	27.1	37.9	44.9	54.9

Screw size: Ø 22/M20 – Ø 22/M24

Screw Size			**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M24**	**Ø 22/ M24**	**Ø 22/ M24**	**Ø 22/ M24**
Effective anchorage depth	h_{ef}	[mm]	100	125	150	200	100	125	150	200
Non-cracked and cracked concrete										
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	27.1	37.9	49.8	76.7	27.1	37.9	49.8	76.7

Table 10: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Screw size: Ø 10 – Ø 12

Screw Size			**Ø 10**	**Ø 10**	**Ø 10**	**Ø 10**	**Ø 12**	**Ø 12**	**Ø 12**	**Ø 12**
Effective anchorage depth	h_{ef}	[mm]	80	90	100	110	100	110	120	130
Characteristic spacing	$s_{cr,sp}$	[mm]	320	360	400	440	400	440	480	520
Characteristic edge distance	$c_{cr,sp}$	[mm]	160	180	200	220	200	220	240	260
Minimum member thickness	h_{min}	[mm]	140	150	160	170	160	170	180	190

Screw size: Ø 14/M16 – Ø 16/M18

Screw Size			**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**
Effective anchorage depth	h_{ef}	[mm]	100	110	125	140	100	125	140	160
Characteristic spacing	$s_{cr,sp}$	[mm]	400	440	500	560	400	500	560	640
Characteristic edge distance	$c_{cr,sp}$	[mm]	200	220	250	280	200	250	280	320
Minimum member thickness	h_{min}	[mm]	170	180	195	210	170	195	210	230

Screw size: Ø 22/M20 – Ø 22/M24

Screw Size			**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M24**	**Ø 22/ M24**	**Ø 22/ M24**	**Ø 22/ M24**
Effective anchorage depth	h_{ef}	[mm]	100	125	150	200	100	125	150	200
Characteristic spacing	$s_{cr,sp}$	[mm]	400	500	600	800	400	500	600	800
Characteristic edge distance	$c_{cr,sp}$	[mm]	200	250	300	400	200	250	300	400
Minimum member thickness	h_{min}	[mm]	200	225	250	300	200	225	250	300

a. Influence of concrete strength

Table 11: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 12: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 13: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ / $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Steel resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Screw size: Ø 10 – Ø 12

Screw Size			**Ø 10**	**Ø 10**	**Ø 10**	**Ø 10**	**Ø 12**	**Ø 12**	**Ø 12**	**Ø 12**
Effective anchorage depth	h_{ef}	[mm]	80	90	100	110	100	110	120	130
Design steel resistance	$V_{Rd,s}$	[kN]	22.7	22.7	22.7	22.7	28.0	28.0	28.0	28.0

Screw size: Ø 14/M16 – Ø 16/M18

Screw Size			**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**
Effective anchorage depth	h_{ef}	[mm]	100	110	125	140	100	125	140	160
Design steel resistance	$V_{Rd,s}$	[kN]	42.7	42.7	42.7	42.7	64.0	64.0	64.0	64.0

Screw size: Ø 22/M20 – Ø 22/M24

Screw Size			**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M20**	**Ø 22/ M24**	**Ø 22/ M24**	**Ø 22/ M24**	**Ø 22/ M24**
Effective anchorage depth	h_{ef}	[mm]	100	125	150	200	100	125	150	200
Design steel resistance	$V_{Rd,s}$	[kN]	71.3	71.3	71.3	71.3	71.3	71.3	71.3	71.3

BONDED CONCRETE SCREW WIT-BS XL

2. Concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot N_{Rd,c}$$

Table 16: factor k_8 for calculating design pry-out resistance

Screw size: Ø 10 – Ø 12

Screw Size			**Ø 10**	**Ø 10**	**Ø 10**	**Ø 10**	**Ø 12**	**Ø 12**	**Ø 12**	**Ø 12**
Effective anchorage depth	h_{ef}	[mm]	80	90	100	110	100	110	120	130
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Screw size: Ø 14/M16 – Ø 16/M18

Screw Size			**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 14/ M16**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**	**Ø 16/ M18**
Effective anchorage depth	h_{ef}	[mm]	100	110	125	140	100	125	140	160
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Screw size: Ø 22/M20 – Ø 22/M24

Screw Size			**22/ M20**	**22/ M20**	**22/ M20**	**22/ M20**	**22/ M24**	**22/ M24**	**22/ M24**	**22/ M24**
Effective anchorage depth	h_{ef}	[mm]	100	125	150	200	100	125	150	200
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

3. Concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq \max(10\,h_{ef}\,;\,60\,d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 17: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Screw size: Ø 10 – Ø 16/M18

Screw Size	Ø 10	Ø 10	Ø 10	Ø 10	Ø 12	Ø 12	Ø 12	Ø 12	Ø 14/M16	Ø 14/M16	Ø 14/M16	Ø 14/M16	Ø 16/M18	Ø 16/M18
h_{ef} [mm]	80	90	100	110	100	110	120	130	100	110	125	140	100	125
	Cracked Concrete													
Edge distance c_1	$V^0_{Rd,c}$													
40	2.5	2.5	2.6	2.7	-	-	-	-	-	-	-	-	-	-
45	2.9	3.0	3.0	3.1	-	-	-	-	-	-	-	-	-	-
50	3.3	3.4	3.5	3.5	3.6	3.7	3.8	3.9	-	-	-	-	-	-
55	3.7	3.8	3.9	4.0	4.1	4.2	4.2	4.3	-	-	-	-	-	-
60	4.2	4.3	4.4	4.5	4.5	4.6	4.7	4.8	4.7	4.8	4.9	5.1	-	-
65	4.6	4.7	4.9	5.0	5.0	5.1	5.2	5.3	5.2	5.3	5.5	5.6	-	-
70	5.1	5.2	5.3	5.4	5.5	5.6	5.8	5.9	5.7	5.8	6.0	6.2	5.8	6.2
75	5.6	5.7	5.8	6.0	6.0	6.2	6.3	6.4	6.2	6.3	6.5	6.7	6.4	6.7
80	6.1	6.2	6.4	6.5	6.6	6.7	6.8	6.9	6.7	6.9	7.1	7.3	6.9	7.3
85	6.6	6.7	6.9	7.0	7.1	7.2	7.4	7.5	7.3	7.4	7.7	7.9	7.5	7.9
90	7.1	7.3	7.4	7.6	7.6	7.8	7.9	8.1	7.9	8.0	8.2	8.5	8.0	8.4
95	7.7	7.8	8.0	8.1	8.2	8.4	8.5	8.7	8.4	8.6	8.8	9.1	8.6	9.0
100	8.2	8.4	8.5	8.7	8.8	8.9	9.1	9.3	9.0	9.2	9.4	9.7	9.2	9.7
110	9.3	9.5	9.7	9.8	10.0	10.1	10.3	10.5	10.2	10.4	10.7	10.9	10.4	10.9
120	10.5	10.7	10.9	11.1	11.2	11.4	11.6	11.7	11.4	11.6	11.9	12.2	11.7	12.2
130	11.7	11.9	12.1	12.3	12.4	12.6	12.8	13.0	12.7	12.9	13.3	13.6	13.0	13.5
140	12.9	13.2	13.4	13.6	13.7	14.0	14.2	14.4	14.0	14.3	14.6	14.9	14.3	14.9
150	14.2	14.5	14.7	14.9	15.1	15.3	15.5	15.7	15.4	15.6	16.0	16.3	15.7	16.3
160	15.5	15.8	16.0	16.3	16.4	16.7	16.9	17.1	16.8	17.0	17.4	17.8	17.1	17.8
170	16.9	17.1	17.4	17.7	17.8	18.1	18.3	18.6	18.2	18.5	18.9	19.3	18.5	19.3
180	18.2	18.5	18.8	19.1	19.3	19.5	19.8	20.1	19.6	19.9	20.4	20.8	20.0	20.8
190	19.7	20.0	20.3	20.5	20.7	21.0	21.3	21.6	21.1	21.4	21.9	22.3	21.5	22.3
200	21.1	21.4	21.7	22.0	22.2	22.5	22.8	23.1	22.6	23.0	23.5	23.9	23.0	23.9
250	28.7	29.1	29.5	29.9	30.1	30.5	30.9	31.2	30.7	31.1	31.7	32.2	31.1	32.2
300	37.0	37.5	38.0	38.4	38.7	39.2	39.6	40.1	39.4	39.9	40.6	41.2	39.9	41.2
350	45.9	46.5	47.1	47.6	47.9	48.5	49.0	49.5	48.7	49.3	50.1	50.8	49.3	50.8
400	55.4	56.1	56.7	57.3	57.7	58.3	58.9	59.5	58.6	59.2	60.2	61.0	59.3	61.0
450	65.4	66.2	66.9	67.5	68.0	68.7	69.4	70.0	69.0	69.7	70.8	71.8	69.8	71.7
500	75.9	76.8	77.5	78.3	78.8	79.6	80.3	81.0	79.9	80.7	81.9	83.0	80.8	83.0
550	86.9	87.8	88.7	89.5	90.1	90.9	91.7	92.5	91.3	92.2	93.5	94.7	92.3	94.7
600	98.3	99.3	100.3	101.1	101.8	102.7	103.6	104.5	103.1	104.1	105.5	106.8	104.3	106.8
650	110.1	111.2	112.3	113.2	113.9	115.0	115.9	116.9	115.4	116.5	118.0	119.4	116.6	119.4
700	122.4	123.6	124.7	125.7	126.5	127.6	128.6	129.6	128.0	129.2	130.9	132.4	129.4	132.4
750	135.0	136.3	137.5	138.6	139.4	140.6	141.8	142.8	141.1	142.4	144.2	145.8	142.6	145.8
800	148.0	149.4	150.7	151.9	152.8	154.0	155.3	156.4	154.6	155.9	157.8	159.6	156.1	159.6
850	-	162.9	164.3	165.5	166.5	167.8	169.1	170.4	168.4	169.8	171.9	173.7	170.1	173.7
900	-	176.7	178.2	179.6	180.5	182.0	183.4	184.7	182.6	184.1	186.3	188.3	184.4	188.3
950	-	-	192.5	193.9	194.9	196.5	197.9	199.3	197.1	198.7	201.0	203.1	199.0	203.1
1000	-	-	207.1	208.6	209.7	211.3	212.9	214.3	212.0	213.7	216.1	218.3	214.0	218.3
1100	-	-	-	239.0	-	242.0	243.7	245.3	-	244.6	247.3	249.8	-	249.8
1200	-	-	-	-	-	-	275.8	277.5	-	-	279.7	282.4	-	282.4
1300	-	-	-	-	-	-	-	311.0	-	-	-	316.3	-	-
1400	-	-	-	-	-	-	-	-	-	-	-	351.4	-	-

BONDED CONCRETE SCREW WIT-BS XL

Screw size: Ø 16/M18 – Ø 22/M24

Screw Size	Ø 16/ M18	Ø 16/ M18	Ø 22/ M20	Ø 22/ M20	Ø 22/ M20	Ø 22/ M20	Ø 22/ M24	Ø 22/ M24	Ø 22/ M24	Ø 22/ M24
h_{ef} [mm]	140	160	100	125	150	200	100	125	150	200
	Cracked Concrete									
Edge distance c_1	$V^0_{Rd,c}$									
[mm]	[kN]									
70	6.3	6.6	-	-	-	-	-	-	-	-
75	6.9	7.2	-	-	-	-	-	-	-	-
80	7.5	7.8	7.3	7.7	8.2	8.9	7.3	7.7	8.2	8.9
85	8.1	8.4	7.9	8.4	8.8	9.6	7.9	8.4	8.8	9.6
90	8.7	9.0	8.5	9.0	9.4	10.2	8.5	9.0	9.4	10.2
95	9.3	9.6	9.1	9.6	10.1	10.9	9.1	9.6	10.1	10.9
100	9.9	10.2	9.7	10.2	10.7	11.6	9.7	10.2	10.7	11.6
110	11.2	11.5	11.0	11.5	12.1	13.0	11.0	11.5	12.1	13.0
120	12.5	12.9	12.3	12.9	13.5	14.5	12.3	12.9	13.5	14.5
130	13.9	14.3	13.6	14.3	14.9	16.0	13.6	14.3	14.9	16.0
140	15.3	15.7	15.0	15.7	16.3	17.5	15.0	15.7	16.3	17.5
150	16.7	17.1	16.4	17.2	17.8	19.1	16.4	17.2	17.8	19.1
160	18.2	18.6	17.9	18.7	19.4	20.7	17.9	18.7	19.4	20.7
170	19.7	20.2	19.3	20.2	21.0	22.3	19.3	20.2	21.0	22.3
180	21.2	21.7	20.9	21.7	22.6	24.0	20.9	21.7	22.6	24.0
190	22.8	23.3	22.4	23.3	24.2	25.7	22.4	23.3	24.2	25.7
200	24.4	25.0	24.0	25.0	25.9	27.5	24.0	25.0	25.9	27.5
250	32.8	33.5	32.3	33.5	34.6	36.6	32.3	33.5	34.6	36.6
300	41.9	42.8	41.4	42.8	44.1	46.4	41.4	42.8	44.1	46.4
350	51.6	52.6	51.0	52.7	54.2	56.9	51.0	52.7	54.2	56.9
400	61.9	63.1	61.2	63.2	64.9	67.9	61.2	63.2	64.9	67.9
450	72.8	74.1	72.0	74.1	76.1	79.4	72.0	74.1	76.1	79.4
500	84.1	85.5	83.3	85.6	87.8	91.5	83.3	85.6	87.8	91.5
550	95.9	97.5	95.0	97.6	100.0	104.1	95.0	97.6	100.0	104.1
600	108.2	109.9	107.2	110.1	112.6	117.1	107.2	110.1	112.6	117.1
650	120.9	122.8	119.8	122.9	125.7	130.5	119.8	122.9	125.7	130.5
700	134.0	136.0	132.9	136.2	139.2	144.4	132.9	136.2	139.2	144.4
750	147.5	149.7	146.3	149.9	153.1	158.6	146.3	149.9	153.1	158.6
800	161.4	163.7	160.1	164.0	167.4	173.3	160.1	164.0	167.4	173.3
850	175.7	178.2	174.3	178.4	182.0	188.3	174.3	178.4	182.0	188.3
900	190.4	193.0	188.9	193.2	197.1	203.7	188.9	193.2	197.1	203.7
950	205.4	208.1	203.8	208.4	212.5	219.5	203.8	208.4	212.5	219.5
1000	220.7	223.6	219.1	223.9	228.2	235.6	219.1	223.9	228.2	235.6
1100	252.4	255.5	250.6	255.9	260.6	268.8	250.6	255.9	260.6	268.8
1200	285.3	288.8	283.3	289.2	294.4	303.3	283.3	289.2	294.4	303.3
1300	319.4	323.2	317.3	323.7	329.3	339.0	317.3	323.7	329.3	339.0
1400	354.7	358.8	-	-	365.5	375.9	-	-	365.5	375.9
1500	-	395.6	-	-	402.7	413.9	-	-	402.7	413.9
1600	-	433.4	-	-	-	453.0	-	-	-	453.0
1700	-	-	-	-	-	493.2	-	-	-	493.2
1800	-	-	-	-	-	534.4	-	-	-	534.4
1900	-	-	-	-	-	576.6	-	-	-	576.6
2000	-	-	-	-	-	619.8	-	-	-	619.8

a. Influence of concrete strength

Table 18: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load.
The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 19: Influence of spacing on concrete edge resistance

s/c_1 [1)]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1)] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of edge distance

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\frac{c_2}{1.5c_1}\right) \leq 1$$

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1 [1)]	1.00	1.10	1.20	1.30	1.40	1.50
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1)] Distance to the second edge: $c_1 \leq c_2$

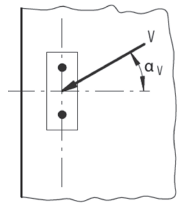
d. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 21: Influence of load direction on concrete edge resistance

α[1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.



e. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00	1.10	1.20	1.30	1.40	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

WIT-BS XL

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

BONDED CONCRETE SCREW WIT-BS XL

Mechanical characteristics

Screw size: Ø 10 – Ø 12

Screw size			Ø 10	Ø 10	Ø 10	Ø 10	Ø 12	Ø 12	Ø 12	Ø 12
Effective anchorage depth	h_{ef}	[mm]	80	90	100	110	100	110	120	130
Stressed cross section of threaded part										
Stressed cross section	A_s	[mm²]	65.0	65.0	65.0	65.0	96.8	96.8	96.8	96.8
Section modulus	W	[mm³]	74.0	74.0	74.0	74.0	134.3	134.3	134.3	134.3
Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640
Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	56.0	56.0	56.0	56.0	123.0	123.0	123.0	123.0
Partial factor tension direction	γ_{Ms}	[-]	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
Partial factor shear direction	γ_{Ms}	[-]	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Design bending moment	$M^0_{Rd,s}$	[Nm]	37.3	37.3	37.3	37.3	82.0	82.0	82.0	82.0

Screw size: Ø 14/M16 – Ø 16/M18

Screw size			Ø 14/ M16	Ø 14/ M16	Ø 14/ M16	Ø 14/ M16	Ø 16/ M18	Ø 16/ M18	Ø 16/ M18	Ø 16/ M18
Effective anchorage depth	h_{ef}	[mm]	100	110	125	140	100	125	140	160
Stressed cross section of threaded part										
Stressed cross section	A_s	[mm²]	134.8	134.8	134.8	134.8	172.0	172.0	172.0	172.0
Section modulus	W	[mm³]	220.7	220.7	220.7	220.7	318.3	318.3	318.3	318.3
Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640
Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	200.0	200.0	200.0	200.0	347.0	347.0	347.0	347.0
Partial factor tension direction	γ_{Ms}	[-]	1.40	1.40	1.40	1.40	1.50	1.50	1.50	1.50
Partial factor shear direction	γ_{Ms}	[-]	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Design bending moment	$M^0_{Rd,s}$	[Nm]	133.3	133.3	133.3	133.3	231.3	231.3	231.3	231.3

Screw size: Ø 22/M20 – Ø 22/M24

Screw size			Ø 22/ M20	Ø 22/ M20	Ø 22/ M20	Ø 22/ M20	Ø 22/ M24	Ø 22/ M24	Ø 22/ M24	Ø 22/ M24
Effective anchorage depth	h_{ef}	[mm]	100	125	150	200	100	125	150	200
Stressed cross section of threaded part										
Stressed cross section	A_s	[mm²]	330.1	330.1	330.1	330.1	330.1	330.1	330.1	330.1
Section modulus	W	[mm³]	845.8	845.8	845.8	845.8	845.8	845.8	845.8	845.8
Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640
Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	730.0	730.0	730.0	730.0	730.0	730.0	730.0	730.0
Partial factor tension direction	γ_{Ms}	[-]	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Partial factor shear direction	γ_{Ms}	[-]	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Design bending moment	$M^0_{Rd,s}$	[Nm]	486.7	486.7	486.7	486.7	486.7	486.7	486.7	486.7

Material specifications

Product name	Material
W-BS/S	- Steel EN 10263-4: 2018 galvanized acc. to EN ISO 4042:2018-11 - Zinc flake coating according to EN ISO 10683:2018-11 (≥ 5 µm)
W-BS/A4	1.4401; 1.4404; 1.4571; 1.4578
W-BS/HCR	1.4529

Working and curing times

Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1)]
–5°C to –1°C	60 min	360 min
0°C to 4°C	60 min	180 min
5°C to 9°C	60 min	120 min
10°C to 19°C	45 min	80 min
20°C to 29°C	15 min	45 min
30°C to 34°C	5 min	25 min
≥ 35°C	4 min	20 min

[1)] for wet base material the curing time must be doubled

BONDED CONCRETE SCREW WIT-BS XL

Installation parameters

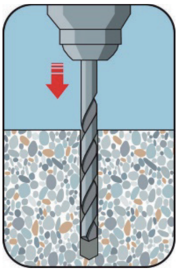
Screw type: W-BS XL, Ø 10 – Ø 22

Screw size			Ø 10	Ø 12	Ø 14	Ø 16	Ø 22
Effective anchorage depth	$h_{ef,min}$	[mm]	80	100	100	100	100
Nominal drill hole diameter	d_0	[mm]	10	12	14	16	22
Drill cuting diameter	$d_{cut} \leq$	[mm]	10.45	12.5	14.5	16.5	22.55
Drill-hole depth	$h_0 \geq$	[mm]	80	100	100	100	100
Diameter of steel brush	$d_b \geq$	[mm]	11	13	15	18	24
Diameter of clearance in hole	$d_f \leq$	[mm]	14	16	18	20	26
Maximum torque moment	$T_{inst} \leq$	[Nm]	40	60	80	100	200
Tangential impact wrench		[Nm]	Max. Nominal torque according to the manufacturer's information				
			400	650	650	650	1000
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 60		h_{ef} + 70		h_{ef} + 100
Minimum spacing	s_{min}	[mm]	40	50	60	70	80
Minimum edge distance	c_{min}	[mm]	40	50	60	70	80

WIT-BS XL

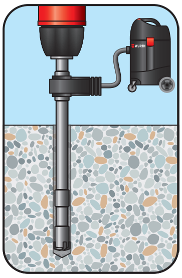
Installation instructions

A) Bore hole drilling



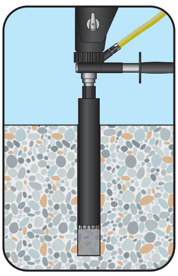
1a. Hammer (HD) or compressed air drilling (CD)

Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. Proceed with Step B1.



1b. Hollow drill bit system (HDB)

Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. This drilling system removes the dust and cleans the bore hole during drilling. Proceed with Step C.



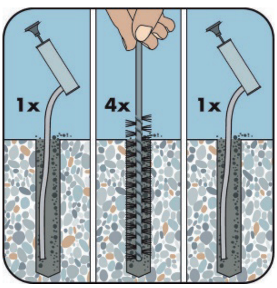
1c. Diamond drilling (DD)

Drill with diamond drill a hole into the base material to the size and embedment depth required by the selected anchor. Proceed with Step B2.
In case of aborted drill hole, the drill hole shall be filled with mortar.

Attention! Standing water in the bore hole must be removed before cleaning.

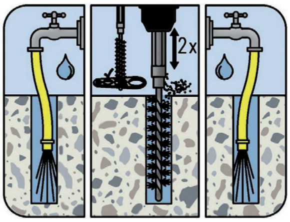
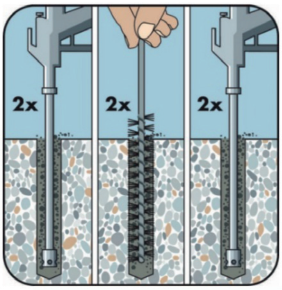
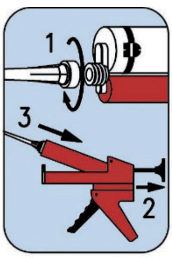
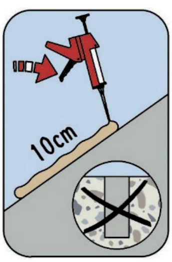
B1) Bore hole cleaning

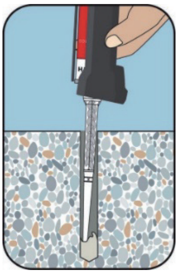
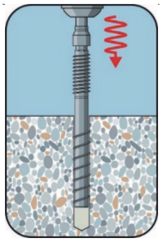
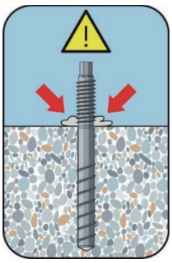
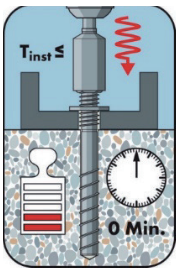
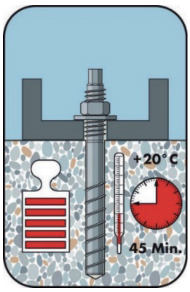
CAC: Cleaning for dry, wet and water-filled bore holes with all diameter in non-cracked and cracked concrete



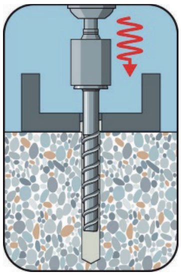
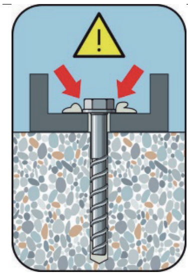
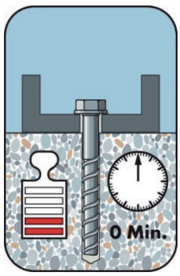
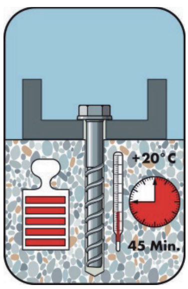
2a.	Starting from the bottom or back of the bore hole, blow the hole clean using a hand pump.
2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of <u>four</u> times. If the bore hole ground is not reached with the brush, a brush extension shall be used. Cleaning with a brush attached to a drilling machine or battery screwdriver is also possible.
2c.	Finally blow the hole clean again with a hand pump.

After cleaning, the bore hole has to be protected against re-contamination in an appropriate way until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must no contaminate the bore hole again.

B2) Bore hole cleaning		
SPCAC: Cleaning for dry, wet and water-filled bore holes for all diameters in non-cracked concrete		
	**2a.**	Rinsing with water until clear water comes out.
	2b.	Check the brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of <u>two</u> times in a twisting motion. If the bore hole ground is not reached with the brush, a brush extension must be used.
	2c.	Rinsing again with water until clear water comes out.
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of $_{two}$ times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of <u>two</u> times. If the bore hole ground is not reached with the brush, a brush extension shall be used. Cleaning with a brush attached to a drilling machine or battery screwdriver is also possible.
	2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.
After cleaning, the bore hole has to be protected against re-contamination in an appropriate way until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must no contaminate the bore hole again.		
C) Preparation of bar and cartridge		
	**3a.**	Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time as well as for every new cartridge, a new static-mixer shall be used.
	**3b.**	Prior to dispensing into the bore hole, squeeze out separately the mortar until it shows a consistent grey or red color (minimum of three full strokes) and discard non-uniformly mixed adhesive components.

D) Filling the bore hole		
	**4.**	Starting from the bottom or back of the cleaned bore hole, fill the hole up to approximately two-thirds with adhesive. Slowly withdraw the static mixing nozzle as the hole fills to avoid creating air pockets. If the bottom or back of the anchor hole is not reached, an approp-riate extension nozzle must be used. Observe the gel-/working times.
E) Setting the Screw (Pre-positioned) or F) for Push-through		
	**5a.**	Screw in the concrete screw using a tangential impact wrench. Note the nominal torque of the tangential impact wrench.
	**5b.**	After reaching the screw-in depth, the composite mortar must emerge on the concrete surface.
	**5c.**	The attachment can be installed immediately. The concrete screw can be loaded immediately with the design load.
	**5d.**	After the full curing time has been reached, the concrete screw may be loaded with the maximum design load. The curing time must be observed accordingly.

BONDED CONCRETE SCREW WIT-BS XL

F) Setting the Screw (Push-through installation)		
	**5a.**	Screw in the concrete screw using a tangential impact wrench. Note the nominal torque of the tangential impact wrench.
	**5b.**	After reaching the screw-in depth, the composite mortar must emerge on the concrete surface
	**5c.**	The attachment can be installed immediately. The concrete screw can be loaded immediately with the design load.
	**5d.**	After the full curing time has been reached, the concrete screw may be loaded with the maximum design load. The curing time must be observed accordingly.

Filling Quantity

Screw type: W-BS XL, Ø 10 – Ø 22

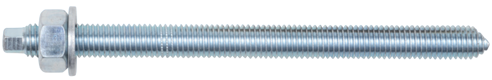
Screw size			**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 22**
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	22
Drill depth	h_0 / h_1	[mm]	= h_{ef}				
Filling volume per 10 mm embedment depth		[ml]	0.09	0.11	0.12	0.14	0.31

Assumed waste of 15 % included.

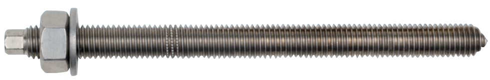
WIT-BS XL

WIT-UH 300 WITH THREADED ROD (METRIC)

280 ml 420 ml 825 ml



Galvanized (5 microns): M8 - M30



Stainless steel - A4 (AISI 316): M8 - M30

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Cartridge sizes		Art. no.
280 ml	peeler	**5918 504 280**
420 ml	coaxial	**5918 500 420**
825 ml	side-by-side	**5918 503 825**

Type of installation

Pre-positioned	In-place	Stand-off
✓	✓	✓

Installation condition

Dry concrete	Wet concrete	Flooded drill hole
✓	✓	✓

Drilling method

Hammer drill	Diamond drill	Hollow drill
✓	-	✓

Applications

Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt, Berlin	EAD 330499-01-0601	ETA-17/0127, 13.11.2020
ICC-ES Evaluation Report	ICC	AC 308	ESR-4466, 01.10.2019
Fire resistance	Ingenieurbüro Thiele	TR 020	210807, 09.02.2018
LEED	eurofins		16.03.17
VOC Emissions Test report	eurofins	DEVL 1101903D, DEVL 1104875A	16.03.17
NSF International	NSF International	NSF/ANSI Standard61	02.01.20

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness and embedment depth are according to anchor characteristics
- Anchor material, as specified in the tables, steel grade 5.8
- Concrete C 20/25, f_{ck} = 20 N/mm^2
- Concrete C 50/60, f_{ck} = 60 N/mm^2
- Temperature range I (min. base material temperature -40°C, max long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling

Characterstic resistance

Thread size				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	18.3	29.0	42.2	68.8	109.0	149.7	182.9	218.2
	C50/60			18.3	29.0	42.2	78.5	122.5	176.5	229.5	280.5
Shear	≥ C20/25	V_{Rk}	[kN]	8.8	13.9	20.2	37.7	58.8	84.7	110.2	134.6
Cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	14.1	21.2	33.2	48.1	76.3	104.8	128.0	152.8
	C50/60			15.5	23.3	36.5	62.2	99.9	121.9	156.8	195.9
Shear	≥ C20/25	V_{Rk}	[kN]	11.0	17.4	25.3	47.1	73.5	105.9	137.7	168.3

Design resistance

Thread size				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	12.2	19.3	28.1	45.8	72.7	99.8	121.9	145.5
	C50/60			12.2	19.3	28.1	52.3	81.7	117.7	153.0	187.0
Shear	≥ C20/25	V_{Rd}	[kN]	8.8	13.9	20.2	37.7	58.8	84.7	110.2	134.6
Cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	9.4	14.1	22.1	32.1	50.9	69.9	85.4	101.8
	C50/60			10.3	15.6	24.3	41.5	66.6	81.3	104.5	130.6
Shear	≥ C20/25	V_{Rd}	[kN]	8.8	13.9	20.2	37.7	58.8	84.7	110.2	134.6

WIT-UH 300 WITH THREADED ROD (METRIC)

Recommended/ allowable loads [1)]

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete											
Tension	C20/25	N_{rec}	[kN]	8.7	13.8	20.1	32.7	51.9	71.3	87.1	103.9
	C50/60			8.7	13.8	20.1	37.4	58.3	84.0	109.3	133.6
Shear	≥ C20/25	V_{rec}	[kN]	6.3	9.9	14.5	26.9	42.0	60.5	78.7	96.2
Cracked concrete											
Tension	C20/25	N_{rec}	[kN]	6.7	10.1	15.8	22.9	36.3	49.9	61.0	72.7
	C50/60			7.4	11.1	17.4	29.6	47.6	58.1	74.6	93.3
Shear	≥ C20/25	V_{rec}	[kN]	6.3	9.9	14.5	26.9	42.0	60.5	78.7	96.2

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Temperature range 1 (min. base material temperature -40°C, max. long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling (Installation factors might apply for other drilling methods)
- Anchor material according to specifications, steel grade 5.8 unless otherwise stated in the tables

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b;N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Design steel resistance	5.8	$N_{Rd,s}$	[kN]	12.2	19.3	28.1	52.3	81.7	117.7	153.0	187.0
	8.8	$N_{Rd,s}$		19.3	30.7	44.7	83.3	130.7	188.0	245.3	299.3
	A4	$N_{Rd,s}$		13.9	21.9	31.6	58.8	91.4	132.1	80.4	98.3

WIT-UH 300 WITH THREADED ROD (METRIC)

2. Design combined pull-out and concrete cone resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of combined pull-out and concrete cone failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	22.8	32.0	44.2	62.8	99.7	137.2	176.4	220.5
Cracked concrete										
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	9.4	14.1	22.1	37.7	60.5	73.9	95.0	118.8

- $s_{cr,p} = 7.3\, d\, (f_{sus} \cdot \tau_{Rk})^{0.5} \leq 3h_{ef}$
- $c_{cr,p} = s_{cr,p}/2$

Where τ_{Rk} is the value $\tau_{Rk,ucr}$ for non-cracked concrete C20/25

Table 3: Characteristic edge distance $c_{cr,p}$ and spacing $s_{cr,p}$ (f_{sus} = 1)

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Spacing	$s_{cr,p}$	[mm]	240	270	330	375	510	630	711	790
Edge distance	$c_{cr,p}$	[mm]	120	135	165	188	255	315	355	395

a. Influence of concrete strength

Table 4: Influence of concrete strength on combined pull-out and concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.02	1.04	1.07	1.08	1.09	1.10

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \frac{h_{ef}}{h_{ef,typ}}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „installation parameters".

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 5: Influence of spacing on combined pull-out and concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,p,}$ $f_{sy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,p,}$ $f_{sy,p}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,p,}$ $f_{sy,p}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,p,}$ $f_{sy,p}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,p} = 0.7 + 0.3\frac{c_x}{c_{cr,p}} \leq 1 \qquad f_{cx,2,p} = f_{cy,p} = \left(1 + \frac{c_{x(y)}}{c_{cr,p}}\right) \cdot \frac{1}{2} \leq 1$$

Table 6: Influence of edge distance on combined pull-out and concrete cone resistance

$c/c_{cr,P}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,p}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,p}$ / $f_{cy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-UH 300 WITH THREADED ROD (METRIC)

e. Influence of sustained loads

$$a_{sus} = \frac{N_{sus,d}}{N_{Ed}}$$

$N_{sus,d}$ = design value of sustained actions (permanent actions & permanent component of variable actions)
N_{Ed} = Value of total actions in tension loading at ultimate limit state

Table 7: Influence of sustained loads on combined pull-out and concrete cone resistance

a_{sus}	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
f_{sus}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases.

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 8: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	23.5	28.0	37.8	45.8	72.7	99.8	121.9	145.5
Cracked concrete										
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	16.4	19.6	26.5	32.1	50.9	69.9	85.4	101.8

Table 9: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Spacing	$s_{cr,N}$	[mm]	240	270	330	375	510	630	720	810
Edge distance	$c_{cr,N}$	[mm]	120	135	165	188	255	315	360	405

Above characteristic spacing and edge distances are given for the typical effective anchorage depths. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,N} = 3\ h_{ef} \text{ and } c_{cr,N} = 1.5\ h_{ef}$$

a. Influence of concrete strength

Table 10: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.24	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 11: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 12: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-UH 300 WITH THREADED ROD (METRIC)

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

Table 13: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Concrete cone resistance	$N^0_{Rd,sp}$	[kN]	22.8	28.0	37.8	45.8	72.7	99.8	121.9	145.5

Table 14: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Spacing	$s_{cr,sp}$	[mm]	360	420	528	600	816	1008	1152	1296
Edge distance	$c_{cr,sp}$	[mm]	180	210	264	300	408	504	576	648
Minimum member thickness	h_{min}	[mm]	110	120	140	161	214	266	300	340

Above characteristic spacing and edge distances are given for the typical effective anchorage depth. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,sp} = 2 \cdot c_{cr,sp} \quad \text{and} \quad c_{cr,sp} = \left\{ h_{ef} \leq 2\,h_{ef} \cdot \left(2.5 - \left(\frac{h_{min}}{h_{ef}}\right)\right) \leq 2.4\,h_{ef} \right\}$$

and h_{min} according to the table „anchor characteristics".

a. Influence of concrete strength

Table 15: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics“.

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 16: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 17: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ / $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

e. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 18: Influence of concrete member thickness on splitting resistance

h/h_{min}	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.3	2.4	2.7	2.8	2.9
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

WIT-UH 300 WITH THREADED ROD (METRIC)

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot min\ \{N_{Rd,p;}\ N_{Rd,c}\}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 19: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Design steel resistance	5.8	$V_{Rd,s}$	[kN]	8.8	13.9	20.2	37.7	58.8	84.7	110.2	134.6
	8.8			12.0	18.4	27.2	50.4	78.4	112.8	147.2	179.2
	A4			8.3	12.8	19.2	35.3	55.1	79.5	48.3	58.8

2. Design concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot min\ \{N_{Rd,p};N_{Rd,c}\}$$

Table 20: factor k_8 for calculating design pry-out resistance

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

3. Design concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq max\ (10\ h_{ef}\ ;\ 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 21: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.8	3.6	4.6	5.8	8.3	10.3	13.1	15.2
Cracked concrete										
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.0	2.5	3.2	4.1	5.9	7.3	9.3	10.7

a. Influence of concrete strength

Table 22: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

Table 23: Influence of embedment depth on concrete edge resistance

h_{ef}/d	4	5	6	7	8	9	10	11	≥ 12
$f_{hef,V}$	0.87	0.91	0.94	0.97	1.00	1.02	1.05	1.07	1.08

[1)] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 24: Influence of spacing on concrete edge resistance

s/c_1 [1)]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1)] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

d. Influence of edge distance c_1

Table 25: Influence of edge distance c_1 on concrete edge resistance

$c_{1/d}$	4	8	12	15	20	30	40	50	60	100	150	200
$f_{c1,V}$	0.47	1.19	2.05	2.76	4.05	6.95	10.22	13.76	17.54	34.66	59.52	87.35

WIT-UH 300 WITH THREADED ROD (METRIC)

e. Influence of edge distance c_2

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\frac{c_2}{1.5c_1}\right) \leq 1$$

Table 26: Influence of edge distance c_2 on concrete edge resistance

c_2/c_1 [1)]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1)] Distance to the second edge: $c_1 \leq c_2$

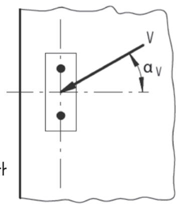
f. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 27: Influence of load direction on concrete edge resistance

α [1)]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1)] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with parallel to the edge only.



g. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 28: Influence of concrete member thickness on edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

WIT-UH 300 WITH THREADED ROD (METRIC)

Design bond strength

Service temperature for working life of 50 years

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +80°C	+50°C	+80°C
Temperature range III	- 40°C to +120°C	+72°C	+120°C
Temperature range IV	- 40°C to +160°C	+100°C	+160°C

Service temperature for working life of 100 years

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +80°C	+50°C	+80°C

Working life of 50 years

1- Non-cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Design bond resistance in non-cracked concrete C20/25 in case of manual air cleaning (MAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	9.4	9.4	8.9	8.3	No performance assessed			
Temperature range II				9.4	9.4	8.9	8.3				
Temperature range III				8.3	7.8	7.8	7.2				
Temperature range IV				6.7	6.1	6.1	5.6				
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	11.3	11.3	10.7	10.0	9.3	8.7	8.7	8.7
Temperature range II				11.3	11.3	10.7	10.0	9.3	8.7	8.7	8.7
Temperature range III				10.0	9.3	9.3	8.7	8.0	8.0	7.3	7.3
Temperature range IV				8.0	7.3	7.3	6.7	6.3	6.0	6.0	6.0
Design bond resistance in non-cracked concrete C20/25 in case of hollow drill bit system (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	9.4	9.4	8.9	8.3	7.8	7.2	7.2	7.2
Temperature range II				9.4	9.4	8.9	8.3	7.8	7.2	7.2	7.2
Temperature range III				8.3	7.8	7.8	7.2	6.7	6.7	6.1	6.1
Temperature range IV				6.7	6.1	6.1	5.6	5.3	5.0	5.0	5.0
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	8.1	8.1	7.6	7.1	6.7	6.2	6.2	6.2
Temperature range II				8.1	8.1	7.6	7.1	6.7	6.2	6.2	6.2
Temperature range III				7.1	6.7	6.7	6.2	5.7	5.7	5.2	5.2
Temperature range IV				5.7	5.2	5.2	4.8	4.5	4.3	4.3	4.3

WIT-UH 300 WITH THREADED ROD (METRIC)

2- Cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Design bond resistance in non-cracked concrete C20/25 in case of manual air cleaning (MAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	3.9	4.2	4.4	5.0	No performance assessed			
Temperature range II				3.9	4.2	4.4	5.0				
Temperature range III				3.3	3.6	3.9	4.2				
Temperature range IV				3.1	3.1	3.3	3.6				
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	4.7	5.0	5.3	6.0	5.7	4.7	4.7	4.7
Temperature range II				4.7	5.0	5.3	6.0	5.7	4.7	4.7	4.7
Temperature range III				4.0	4.3	4.7	5.0	4.7	4.0	4.0	4.0
Temperature range IV				3.7	3.7	4.0	4.3	4.0	3.7	3.7	3.7
Design bond resistance in non-cracked concrete C20/25 in case of hollow drill bit system (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	3.9	4.2	4.4	5.0	4.7	3.9	3.9	3.9
Temperature range II				3.9	4.2	4.4	5.0	4.7	3.9	3.9	3.9
Temperature range III				3.3	3.6	3.9	4.2	3.9	3.3	3.3	3.3
Temperature range IV				3.1	3.1	3.3	3.6	3.3	3.1	3.1	3.1
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	3.3	3.6	3.8	4.3	4.0	3.3	3.3	3.3
Temperature range II				3.3	3.6	3.8	4.3	4.0	3.3	3.3	3.3
Temperature range III				2.9	3.1	3.3	3.6	3.3	2.9	2.9	2.9
Temperature range IV				2.6	2.6	2.9	3.1	2.9	2.6	2.6	2.6

Working life of 100 years

1- Non-cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Design bond resistance in non-cracked concrete C20/25 in case of manual air cleaning (MAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr100}$	[N/mm^2]	9.4	9.4	8.9	8.3	No performance assessed			
Temperature range II				9.4	9.4	8.9	8.3				
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr100}$	[N/mm^2]	11.3	11.3	10.7	10.0	9.3	8.7	8.7	8.7
Temperature range II				11.3	11.3	10.7	10.0	9.3	8.7	8.7	8.7
Design bond resistance in non-cracked concrete C20/25 in case of hollow drill bit system (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr100}$	[N/mm^2]	9.4	9.4	8.9	8.3	7.8	7.2	7.2	7.2
Temperature range II				9.4	9.4	8.9	8.3	7.8	7.2	7.2	7.2
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr100}$	[N/mm^2]	8.1	8.1	7.6	7.1	6.7	6.2	6.2	6.2
Temperature range II				8.1	8.1	7.6	7.1	6.7	6.2	6.2	6.2

2- Cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Design bond resistance in non-cracked concrete C20/25 in case of manual air cleaning (MAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr100}$	[N/mm^2]	3.1	3.3	3.6	3.6	No performance assessed			
Temperature range II				3.1	3.3	3.6	3.6				
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr100}$	[N/mm^2]	3.7	4.0	4.3	4.3	4.3	4.3	4.3	4.3
Temperature range II				3.7	4.0	4.3	4.3	4.3	4.3	4.3	4.3
Design bond resistance in non-cracked concrete C20/25 in case of hollow drill bit system (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr100}$	[N/mm^2]	3.1	3.3	3.6	3.6	3.6	3.6	3.6	3.6
Temperature range II				3.1	3.3	3.6	3.6	3.6	3.6	3.6	3.6
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr100}$	[N/mm^2]	2.6	2.9	3.1	3.1	3.1	3.1	3.1	3.1
Temperature range II				2.6	2.9	3.1	3.1	3.1	3.1	3.1	3.1

WIT-UH 300 WITH THREADED ROD (METRIC)

Reduction factors

Working life of 50 years

1- Non-cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Reduction factor for non-cracked concrete C20/25 in case of manual air cleaning (MAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	No performance assessed			
Temperature range II				1.00	1.00	1.00	1.00				
Temperature range III				0.88	0.82	0.88	0.87				
Temperature range IV				0.71	0.65	0.69	0.67				
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.88	0.82	0.88	0.87	0.86	0.92	0.85	0.85
Temperature range IV				0.71	0.65	0.69	0.67	0.68	0.69	0.69	0.69
Reduction factor for non-cracked concrete C20/25 in case of hollow drill bit system (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.88	0.82	0.88	0.87	0.86	0.92	0.85	0.85
Temperature range IV				0.71	0.65	0.69	0.67	0.68	0.69	0.69	0.69
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.88	0.82	0.88	0.87	0.86	0.92	0.85	0.85
Temperature range IV				0.71	0.65	0.69	0.67	0.68	0.69	0.69	0.69

2- Cracked concrete

Thread size				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Reduction factor for non-cracked concrete C20/25 in case of manual air cleaning (MAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	No performance assessed			
Temperature range II				1.00	1.00	1.00	1.00				
Temperature range III				0.86	0.87	0.88	0.83				
Temperature range IV				0.79	0.73	0.75	0.72				
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.86	0.87	0.88	0.83	0.82	0.86	0.86	0.86
Temperature range IV				0.79	0.73	0.75	0.72	0.71	0.79	0.79	0.79
Reduction factor for non-cracked concrete C20/25 in case of hollow drill bit system (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.86	0.87	0.88	0.83	0.82	0.86	0.86	0.86
Temperature range IV				0.79	0.73	0.75	0.72	0.71	0.79	0.79	0.79
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.86	0.87	0.88	0.83	0.82	0.86	0.86	0.86
Temperature range IV				0.79	0.73	0.75	0.72	0.71	0.79	0.79	0.79

WIT-UH 300 WITH THREADED ROD (METRIC)

Working life of 100 years

1- Non-cracked concrete

Thread size				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Reduction factor for non-cracked concrete C20/25 in case of manual air cleaning (MAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr100}$	[N/mm²]	1.00	1.00	1.00	1.00	No performance assessed			
Temperature range II				1.00	1.00	1.00	1.00				
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Reduction factor for non-cracked concrete C20/25 in case of hollow drill bit system (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

2- Cracked concrete

Thread size				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Reduction factor for non-cracked concrete C20/25 in case of manual air cleaning (MAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr100}$	[N/mm²]	1.00	1.00	1.00	1.00	No performance assessed			
Temperature range II				1.00	1.00	1.00	1.00				
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Reduction factor for non-cracked concrete C20/25 in case of hollow drill bit system (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)											
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Mechanical characteristics

Steel grade	Thread size			M8	M10	M12	M16	M20	M24	M27	M30
	Stressed cross section	A_s	[mm²]	37	58	84	157	245	352	459	561
	Section modulus	W	[mm³]	31	62	109	277	541	935	1387	1874
4.6	Yield strength	f_y	[N/mm²]	240	240	240	240	240	240	240	240
	Tensile strength	f_u	[N/mm²]	400	400	400	400	400	400	400	400
	Design bending moment	$M^0_{Rd,s}$	[Nm]	9.0	18.0	31.1	79.6	155.7	268.9	398.8	538.9
4.8	Yield strength	f_y	[N/mm²]	320	320	320	320	320	320	320	320
	Tensile strength	f_u	[N/mm²]	400	400	400	400	400	400	400	400
	Design bending moment	$M^0_{Rd,s}$	[Nm]	12.0	24.0	41.6	106.4	208.0	359.2	532.8	720.0
5.6	Yield strength	f_y	[N/mm²]	300	300	300	300	300	300	300	300
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	11.4	22.2	38.9	99.4	194.0	335.3	498.8	672.5
5.8	Yield strength	f_y	[N/mm²]	400	400	400	400	400	400	400	400
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	15.2	29.6	52	132.8	259.2	448	666.4	898.4
8.8	Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640
	Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800
	Design bending moment	$M^0_{Rd,s}$	[Nm]	24.0	48.0	84.0	212.8	415.2	716.8	1066.4	1437.6
A4-50	Yield strength	f_y	[N/mm²]	210	210	210	210	210	210	210	210
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	8.0	15.5	27.7	70.2	136.6	235.7	349.6	472.7
A4-70	Yield strength	f_y	[N/mm²]	450	450	450	450	450	450	-	-
	Tensile strength	f_u	[N/mm²]	700	700	700	700	700	700	-	-
	Design bending moment	$M^0_{Rd,s}$	[Nm]	16.7	33.3	59.0	148.7	291.0	502.6	-	-

WIT-UH 300 WITH THREADED ROD (METRIC)

Material specifications

Part	Designation	Material				
Steel, zinc plated (Steel acc. to EN 10087:1998 or EN 10263:2001)						
- zinc plated	≥ 5 µm	acc. to EN ISO 4042:1999				
- hot-dip galvanized	≥ 40 µm	acc. to EN ISO 1461:2009 and EN ISO 10684:2004+AC:2009				
- sherardized	≥ 45 µm	acc. to EN ISO 17668:2016				
1	Anchor rod	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 898-1:2013	4.6	f_{uk} = 400 N/mm²	f_{yk} = 240 N/mm²	A5 > 8%
			4.8	f_{uk} = 400 N/mm²	f_{yk} = 320 N/mm²	A5 > 8%
			5.6	f_{uk} = 500 N/mm²	f_{yk} = 300 N/mm²	A5 > 8%
			5.8	f_{uk} = 500 N/mm²	f_{yk} = 400 N/mm²	A5 > 8%
			8.8	f_{uk} = 800 N/mm²	f_{yk} = 640 N/mm²	A5 > 12% [3)]
2	Hexagon nut	acc. to EN ISO 898-2:2012	4	for anchor rod class 4.6 or 4.8		
			5	for anchor rod class 5.6 or 5.8		
			8	for anchor rod class 8.8		
3a	Washer	Steel, zinc plated, hot-dip galvanized or sherardized (e.g.: EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000, or EN ISO 7094:2000)				
3b	Filling Washer	Steel, zinc plated, hot-dip galvanized or sherardized				
4	Internal threaded anchor rod	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 898-1:2013	5.8	f_{uk} = 500 N/mm²	f_{yk} = 400 N/mm²	A5 > 8%
			8.8	f_{uk} = 800 N/mm²	f_{yk} = 640 N/mm²	A5 > 8%

<table>
<tr><th>Part</th><th>Designation</th><th colspan="5">Material</th></tr>
<tr><td colspan="7">Stainless steel A2 (Material 1.4301 / 1.4303 / 1.4307 / 1.4567 or 1.4541, acc. to EN 1088-1:2014)
Stainless steel A4 (Material 1.4401 / 1.4404 / 1.4571 / 1.4362 or 1.4578, acc. to EN 10088-1:2014)
High corrosion resistance steel (Material 1.4529 or 1.4565, acc. to EN 10088-1:2014)</td></tr>
<tr><td rowspan="4">1</td><td rowspan="4">Anchor rod [1) 4)]</td><td colspan="2">Property class</td><td>Characteristic tensile strength</td><td>Characteristic yield strength</td><td>Elongation at fracture</td></tr>
<tr><td rowspan="3">acc. to EN ISO 3506-1:2009</td><td>50</td><td>$f_{uk} = 400\ N/mm^2$</td><td>$f_{yk} = 240\ N/mm^2$</td><td>A5 > 12% [3)]</td></tr>
<tr><td>70</td><td>$f_{uk} = 400\ N/mm^2$</td><td>$f_{yk} = 320\ N/mm^2$</td><td>A5 > 12% [3)]</td></tr>
<tr><td>80</td><td>$f_{uk} = 500\ N/mm^2$</td><td>$f_{yk} = 300\ N/mm^2$</td><td>A5 > 12% [3)]</td></tr>
<tr><td rowspan="3">2</td><td rowspan="3">Hexagon nut [1) 4)]</td><td rowspan="3">acc. to EN ISO 3506-1:2009</td><td>50</td><td colspan="3">for anchor rod class 50</td></tr>
<tr><td>70</td><td colspan="3">for anchor rod class 70</td></tr>
<tr><td>80</td><td colspan="3">for anchor rod class 80</td></tr>
<tr><td>3a</td><td>Washer</td><td colspan="5">Stainless steel A2 (Material 1.4301 / 1.4303 / 1.4307 / 1.4567 or 1.4541, acc. to EN 1088-1:2014)
Stainless steel A4 (Material 1.4401 / 1.4404 / 1.4571 / 1.4362 or 1.4578, acc. to EN 10088-1:2014)
HCR: Material 1.4529 or 1.4565, acc. to EN 10088-1:2014
(e.g.: EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000, or EN ISO 7094:2000)</td></tr>
<tr><td>3b</td><td>Filling Washer</td><td colspan="5">Stainless steel A4, High corrosion resistance steel</td></tr>
<tr><td rowspan="3">4</td><td rowspan="3">Internal threaded anchor rod [1) 2)]</td><td colspan="2">Property class</td><td>Characteristic tensile strength</td><td>Characteristic yield strength</td><td>Elongation at fracture</td></tr>
<tr><td rowspan="2">acc. to EN ISO 3506-1:2009</td><td>50</td><td>$f_{uk} = 500\ N/mm^2$</td><td>$f_{yk} = 210\ N/mm^2$</td><td>A5 > 8%</td></tr>
<tr><td>70</td><td>$f_{uk} = 700\ N/mm^2$</td><td>$f_{yk} = 450\ N/mm^2$</td><td>A5 > 8%</td></tr>
</table>

1) Property class 70 for anchor rods up to M24 and Internal threaded anchor rods up to IG-M16

2) for IG-M20 only property class 50

3) A_5 > 8% fracture elongation if no requirement for performance category C2 exists

4) Property class 80 only for stainless steel A4

WIT-UH 300 WITH THREADED ROD (METRIC)

Chemical resistance

Chemical Agent	Concentration	Resistant	Not Resistant
Air		●	
Acetic acid	10	●	
Ammonia, aqueous solution	5	●	
Chlorinated lime	10	●	
Citric acid	10	●	
Demineralized Water	100	●	
Diesel Fuel	100	●	
Ethanol	100		●
Ethyl Acetate	100		●
Fuel Oil	100	●	
Gasoline	100	●	
Hydraulic fluid	100	●	
Isopropyi alcohol	100		●
Lactic acid	10	●	
Linseed oil	100	●	
Lubricating oil	100	●	
Methanol	100		●
Phosphoric acid	10	●	
Potassium Hydroxide pH 13.2	100	●	
Salt (Calcium Chloride)	100	●	
Sea water	100	●	
Sodium Carbonate	10	●	
Sulfuric acid	10	●	

Properties of adhesive

Property		Testing method	Result/Mean Value
Stability			
UV-resistance (sunlight)			Resistant
Temperature stability			≤ 160°C
Physical properties			
Flexural properties	Flexural strength	DIN EN 196-1	after 24 hours: 22.2 N/mm²
Compressive properties	Compressive strength		after 24 hours:126 N/mm²
Tensile properties	Tensile strength	DIN EN ISO 527-2	14.9 N/mm²
	Coefficient of elasticity		8300 N/mm²
	Mean strain at fracture		2.6%
Shrinkage		DIN 52450	< 1.8 ‰
Shore-hardness A		DIN EN ISO 868	97.6
Density		Weighing	1.78 kg/dm³
Thermal conductivity		DIN EN 993-15	1.06 W/mK
Specific heat capacity			1.09 J/Kg K
Electrical resistance		DIN IEC 93	$7.2 \cdot 10^{13}$ Ω
Workability features			
Working time (20°C)			3 min
Curing time (20°C)			30 mins
Shelf-life			18 months

For information use only. Values are not to be considered as a specification and do not reflect the performance of the system. The given values are typical values and are subject to change without notice.

Working and curing times

Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1)]
–5°C to –1°C	50 min	5 h
0°C to 4°C	25 min	3.5 h
5°C to 9°C	15 min	2 h
10°C to 14°C	10 min	60 min
15°C to 19°C	6 min	40 min
20°C to 29°C	3 min	30 min
30°C to 40°C	2 min	30 min

[1)] for wet base material the curing time must be doubled

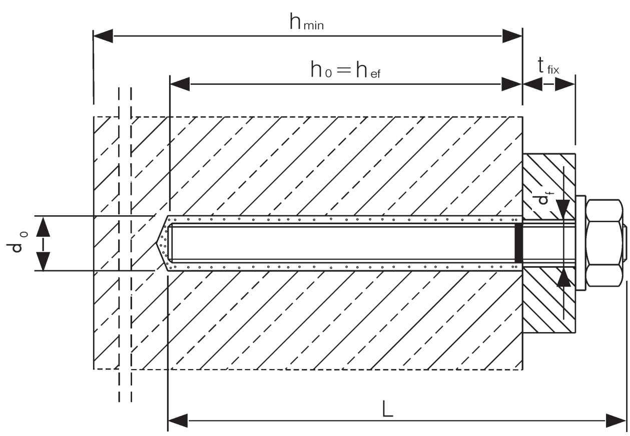
WIT-UH 300 WITH THREADED ROD (METRIC)

Installation parameters

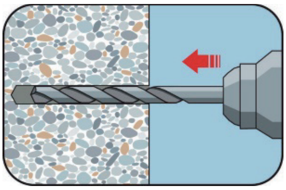
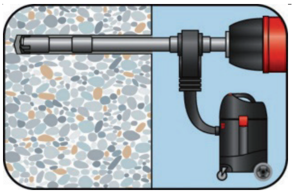
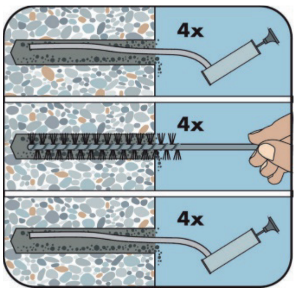
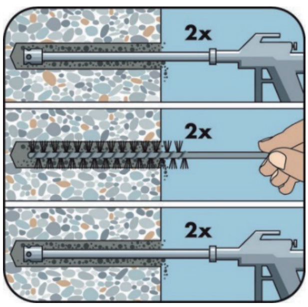
Anchor size			M8	M10	M12	M16	M20	M24	M27	M30
Diameter of element	$d = d_{nom}$	[mm]	8	10	12	16	20	24	27	30
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	22	28	30	35
Effective anchorage depth	$h_{ef,min}$	[mm]	60	60	70	80	90	96	108	120
	$h_{ef,max}$	[mm]	160	200	240	320	400	480	540	600
Diameter of clearance in hole in the fixture [1]	Prepositioned installation $d_{f\leq}$	[mm]	9	12	14	18	22	26	30	33
	Push through installation d_f	[mm]	12	14	16	20	24	30	33	40
Maximum torque moment	max $T_{inst} \leq$	[Nm]	10	20	40 [2]	60	100	170	250	300
Minimum thickness of member	h_{min}		h_{ef} + 30 mm ≥ 100 mm			$h_{ef} + 2d_0$				
Minimum spacing	s_{min}	[mm]	40	50	60	75	95	115	125	140
Minimum edge distance	c_{min}	[mm]	35	40	45	50	60	65	75	80

[1] For application under seismic loading the diameter of clearance hole in the fixture shall be at maximum d1 + 1 mm or alternatively the annular gap between fixture and anchor rod shall be filled force-fit with mortar

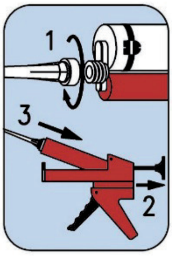
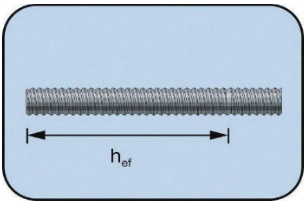
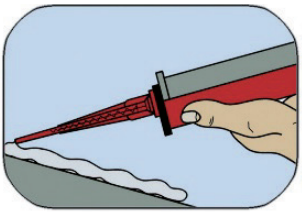
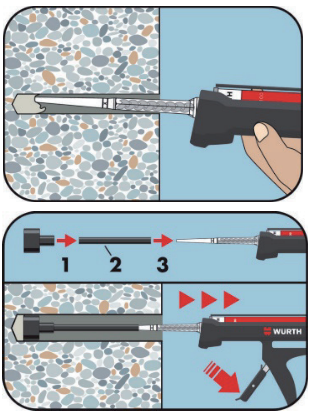
[2] Maximum Toruqe moment for M12 with steel Grade 4.6 is 35 Nm

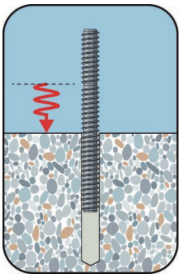
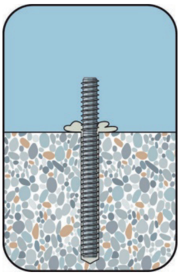
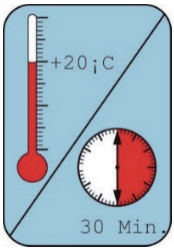
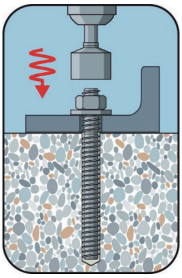


Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer (HD) or compressed air drilling (CD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. Proceed with Step B. In case of aborted drill hole, the drill hole shall be filled with mortar.
	**1b.**	**Hollow drill bit system (HDB)** Drill a hole into the base material to the size and embedment depth required by the selected anchor. This drilling system removes the dust and cleans the bore hole during drilling (all conditions). Proceed with Step C. In case of aborted drill hole, the drill hole shall be filled with mortar.
B) Bore hole cleaning		
MAC: Cleaning for bore hole diameter $d_0 \leq 20$ mm and bore hole depth $h_0 \leq 10\ d_{nom}$ (non-cracked concrete only!)		
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean using a hand pump a minimum of four times.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of four times in a twisting motion. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with a hand pump a minimum of four times.
CAC: Cleaning for dry, wet and water-filled bore holes with all diameters non-cracked and cracked concrete		
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of four times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of four times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of four times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.
After cleaning, the bore hole has to be protected against rec-contamination in an appropriate way, until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must not contaminate the bore hole again.		

WIT-UH 300 WITH THREADED ROD (METRIC)

C) Preparation of anchor rod and cartridge		
	**3a.**	Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time as well as for every new cartridge, a new static-mixer shall be used.
	**3b.**	Prior to inserting the anchor rod into the filled bore hole, the position of the embedment depth shall be marked on the anchor rod.
	**3c.**	Prior to dispensing into the bore hole, squeeze out separately the mortar until it shows a consistent grey or red color (minimum of three full strokes) and discard non-uniformly mixed adhesive components.
D) Filling the bore hole		
	**4.**	Starting from the bottom or back of the cleaned bore hole, fill the hole up to approximately two-thirds with adhesive. Slowly withdraw the static mixing nozzle as the hole fills to avoid creating air pockets. If the bottom or back of the anchor hole is not reached, an appropriate extension nozzle must be used. Observe the gel-/ working times. Piston plugs and mixer nozzle extensions hall be used for the following applications: • Horizontal assembly (horizontal direction) and ground erection (vertical downwards direction): Drill bit-Ø $d_0 \geq 18$ mm and embedment depth $h_{ef} > 250$ mm • Overhead assembly (vertical upwards direction): Drill bit-Ø $d_0 \geq 18$ mm

E) Setting the anchor rod		
	**5a.**	Push the threaded rod into the bore hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached. The bar should be free of dirt, grease, oil or other foreign material.
	**5b.**	After inserting the anchor, the annular gap between the anchor rod and concrete, in case of a push through ins-tallation, additionally also the fixture, must be completely filled with mortar. If excess mortar is not visible at the top of the hole, the requirement is not fulfilled and the application has to be renewed. For overhead application, the anchor rod shall be fixed (e.g. wedges).
	**5c.**	Allow the adhesive to cure to the specified time prior to applying any load or torque. Do not move or load the anchor until it is fully cured.
	**5d.**	After fully curing, the add-on part can be installed with up to the max. torque by using a calibrated torque wrench. In case of prepositioned installation, the annular gap between anchor and fixture can be optionally filled with mortar. Therefore, substitute the washer by the filling washer and connect the mixer reduction nozzle to the tip of the mixer. The annular gap is filled with mortar when mortar oozes out of the washer.

WIT-UH 300 WITH THREADED ROD (METRIC)

Filling Quantity

Anchor type: M8 - M30

Anchor size			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	22	28	30	35
Drill depth	h_0 / h_1	[mm]	= h_{ef}							
Filling volume per 10mm embedment depth		[ml]	0.53	0.70	0.89	1.27	1.78	3.35	3.22	5.10

Assumed waste of 15 % included.

WIT-UH 300 WITH REBAR

280 ml 420 ml 825 ml

Ø8 - Ø32

Rebar not supplied by Würth

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Cartridge sizes		Art. no.
280 ml	peeler	**5918 504 280**
420 ml	coaxial	**5918 500 420**
825 ml	side-by-side	**5918 503 825**

Installation condition		
Dry concrete	Wet concrete	Flooded drill hole
✓	✓	✓

Drilling method		
Hammer drill	Diamond drill	Hollow drill
✓	–	✓

Applications




Approvals and certificates

Description	Authority / laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt, Berlin	EAD 330087-00-0601	ETA-17/0036, 14.05.2019
European Technical Assessment	DIBt, Berlin	EAD 330499-01-0601	ETA-17/0127, 13.11.2020
ICC-ES Evaluation Report	ICC	AC 308	ESR-4466, 01.10.2019
Fire resistance	Ingenieurbüro Thiele	TR 020	210807, 09.02.2018
LEED	eurofins		16.03.17
VOC Emissions Test report	eurofins	DEVL 1101903D, DEVL 1104875A	16.03.17
NSF International	NSF International	NSF/ANSI Standard61	02.01.20

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness and embedment depth are according to anchor characteristics
- Rebar material is according to specifications, steel grade B500B
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²
- Temperature range I (min. base material temperature -40°C, max long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling

Characterstic resistance

Rebar size				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete												
Tension	C20/25	N_{Rk}	[kN]	27.5	39.6	56.8	68.8	68.8	109.0	149.7	218.2	255.6
	C50/60			27.5	43.5	62.2	84.7	89.8	152.7	235.9	338.8	404.2
Shear	≥ C20/25	V_{Rk}	[kN]	13.8	21.7	31.1	42.4	55.3	86.4	135.0	169.4	221.1
Cracked concrete												
Tension	C20/25	N_{Rk}	[kN]	11.1	15.6	24.9	35.7	40.8	69.4	104.8	152.8	178.9
	C50/60			12.2	17.1	27.4	39.3	44.9	76.4	127.0	182.9	232.2
Shear	≥ C20/25	V_{Rk}	[kN]	13.8	21.7	31.1	42.4	55.3	86.4	135.0	169.4	221.1

Design resistance

Rebar size				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete												
Tension	C20/25	N_{Rd}	[kN]	18.8	26.4	37.8	45.8	45.8	72.7	99.8	145.5	170.4
	C50/60			19.6	29.0	42.6	56.4	59.9	101.8	157.2	226.4	269.4
Shear	≥ C20/25	V_{Rd}	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	90.0	112.9	147.4
Cracked concrete												
Tension	C20/25	N_{Rd}	[kN]	7.4	10.4	16.6	23.8	27.2	46.3	69.9	101.8	119.3
	C50/60			8.1	11.4	18.2	26.2	29.9	50.9	84.7	121.9	154.8
Shear	≥ C20/25	V_{Rd}	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	90.0	112.9	147.4

WIT-UH 300 WITH REBAR

Recommended / allowable loads [1)]

Rebar size				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete												
Tension	C20/25	N_{rec}	[kN]	13.4	18.8	27.0	32.7	32.7	51.9	71.3	103.9	121.7
	C50/60			14.0	20.7	30.4	40.3	42.8	72.7	112.3	161.7	192.5
Shear	≥ C20/25	V_{rec}	[kN]	6.5	10.3	14.8	20.2	26.3	41.1	64.3	80.7	105.3
Cracked concrete												
Tension	C20/25	N_{rec}	[kN]	5.3	7.4	11.8	17.0	19.4	33.1	49.9	72.7	85.2
	C50/60			5.8	8.1	13.0	18.7	21.4	36.4	60.5	87.1	110.6
Shear	≥ C20/25	V_{rec}	[kN]	6.5	10.3	14.8	20.2	26.3	41.1	64.3	80.7	105.3

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Temperature range 1 (min. base material temperature -40°C, max. long term/short term base material temperature: +24°C/40°C)
- Dry or wet conditions of drill hole, hammer drilling (Installation factors might apply for other drilling methods)
- Rebar material according to specifications, steel grade B500B

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b;N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Design steel resistance	$N_{Rd,s}$	[kN]	19.6	31.0	44.4	60.5	79.0	123.4	192.9	242.0	315.9

WIT-UH 300 WITH REBAR

2. Design combined pull-out and concrete cone resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of combined pull-out and concrete cone failure of a single anchor

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete											
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	18.8	26.4	38.7	51.3	54.5	92.6	142.9	205.8	261.4
Cracked concrete											
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	7.4	10.4	16.6	23.8	27.2	46.3	77.0	110.8	140.7

- $s_{cr,p} = 7.3\, d\, (f_{sus} \cdot \tau_{Rk})^{0.5} \leq 3h_{ef}$
- $c_{cr,p} = s_{cr,p}/2$

Where τ_{Rk} is the value $\tau_{Rk,ucr}$ for non-cracked concrete C20/25

Table 3: Characteristic edge distance $c_{cr,p}$ and spacing $s_{cr,p}$ (f_{sus} = 1)

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Spacing	$s_{cr,p}$	[mm]	219	270	328	375	375	510	630	737	842
Edge distance	$c_{cr,p}$	[mm]	109	135	164	188	188	255	315	368	421

a. Influence of concrete strength

Table 4: Influence of concrete strength on combined pull-out and concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.02	1.04	1.07	1.08	1.09	1.10

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \frac{h_{ef}}{h_{ef,\,typ}}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „installation parameters".

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 5: Influence of spacing on combined pull-out and concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,p,}$ $f_{sy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,p,}$ $f_{sy,p}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,p,}$ $f_{sy,p}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,p,}$ $f_{sy,p}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,p} = 0.7 + 0.3\frac{c_x}{c_{cr,p}} \leq 1 \qquad f_{cx,2,p} = f_{cy,p} = \left(1 + \frac{c_{x(y)}}{c_{cr,p}}\right) \cdot \frac{1}{2} \leq 1$$

Table 6: Influence of edge distance on combined pull-out and concrete cone resistance

$c/c_{cr,P}$	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,55	0,60	0,65	0,70	0,75	0,70	0,75	0,90	0,95	≥ 1
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-UH 300 WITH REBAR

e. Influence of sustained loads

$$a_{sus} = \frac{N_{sus,d}}{N_{Ed}}$$

$N_{sus,d}$ = design value of sustained actions (permanent actions & permanent component of variable actions)
N_{Ed} = Value of total actions in tension loading at ultimate limit state

Table 7: Influence of sustained loads on combined pull-out and concrete cone resistance

a_{sus}	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
f_{sus}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases.

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 8: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete											
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	23.5	28.0	37.8	45.8	45.8	72.7	99.8	145.5	170.4
Cracked concrete											
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	16.4	19.6	26.5	32.1	32.1	50.9	69.9	101.8	119.3

Table 9: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Spacing	$s_{cr,N}$	[mm]	240	270	330	375	375	510	630	810	900
Edge distance	$c_{cr,N}$	[mm]	120	135	165	188	188	255	315	405	450

Above characteristic spacing and edge distances are given for the typical effective anchorage depths. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$s_{cr,N} = 3\ h_{ef}$ and $c_{cr,N} = 1.5\ h_{ef}$

a. Influence of concrete strength

Table 10: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + (n_{x(y)} - 1)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 11: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 12: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

Table 13: Design resistance $N_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete											
Concrete cone resistance	$N^0_{Rd,sp}$	[kN]	18.8	26.4	37.8	45.8	45.8	72.7	99.8	145.5	170.4

Table 14: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Characteristic spacing	$s_{cr,sp}$	[mm]	360	420	528	600	590	816	1004	1296	1440
Characteristic edge distance	$c_{cr,sp}$	[mm]	180	210	264	300	295	408	502	648	720
Minimum member thickness	h_{min}	[mm]	110	120	140	161	165	220	274	340	380

Above characteristic spacing and edge distances are given for the typical effective anchorage depth. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,sp} = 2 \cdot c_{cr,sp} \quad \text{and} \quad c_{cr,sp} = \left\{ h_{ef} \leq 2\, h_{ef} \cdot \left(2.5 - \left(\frac{h_{min}}{h_{ef}}\right)\right) \leq 2.4\, h_{ef} \right\}$$

and h_{min} according to the table „anchor characteristics".

a. Influence of concrete strength

Table 15: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics“.

c. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 16: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 17: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ / $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

e. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 18: Influence of concrete member thickness on splitting resistance

h/h_{min}	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.3	2.4	2.7	2.8	2.9
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

WIT-UH 300 WITH REBAR

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot min\ \{N_{Rd,p;}\ N_{Rd,c}\}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 19: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Design steel resistance	$V_{Rd,s}$	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	90.0	112.9	147.4

2. Design concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot min\ \{N_{Rd,p};N_{Rd,c}\}$$

Table 20: factor k_8 for calculating design pry-out resistance

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

3. Design concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions c ≥ max (10 h_{ef} ; 60 d). For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 21: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage length	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete											
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.8	3.6	4.6	5.6	7.2	10.0	11.3	13.9	17.2
Cracked concrete											
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.0	2.5	3.2	4.0	5.1	7.1	8.0	9.8	12.2

a. Influence of concrete strength

Table 22: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

Table 23: Influence of embedment depth on concrete edge resistance

h_{ef}/d	4	5	6	7	8	9	10	11	≥ 12
$f_{hef,V}$	0.87	0.91	0.94	0.97	1.00	1.02	1.05	1.07	1.08

c. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 24: Influence of spacing on concrete edge resistance

s/c_1[1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

d. Influence of edge distance c_1

Table 25: Influence of edge distance c_1 on concrete edge resistance

c_1/d	4	8	12	15	20	30	40	50	60	100	150	200
$f_{c1,V}$	0.47	1.19	2.05	2.76	4.05	6.95	10.22	13.76	17.54	34.66	59.52	87.35

WIT-UH 300 WITH REBAR

e. Influence of edge distance c_2

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\frac{c_2}{1.5c_1}\right) \leq 1$$

Table 26: Influence of edge distance c_2 on concrete edge resistance

$c_{2/c1}$ [1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \leq c_2$

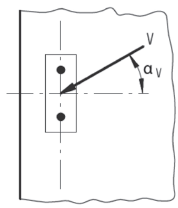
f. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 27: Influence of load direction on concrete edge resistance

α [1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.



g. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 28: Influence of concrete member thickness on edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

WIT-UH 300 WITH REBAR

Design bond strength

Service temperature for working life of 50 years

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +80°C	+50°C	+80°C
Temperature range III	- 40°C to +120°C	+72°C	+120°C
Temperature range IV	- 40°C to +160°C	+100°C	+160°C

Service temperature for working life of 100 years

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +80°C	+50°C	+80°C

Working life of 50 years

1- Non-cracked concrete

Rebar size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Design bond resistance in non-cracked concrete C20/25 in case of manual air cleaning (MAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	7.8	7.8	7.8	7.8	7.2	No performance assessed	No performance assessed	No performance assessed	No performance assessed	No performance assessed
Temperature range II				7.8	7.8	7.8	7.8	7.2					
Temperature range III				7.2	6.7	6.7	6.7	6.7					
Temperature range IV				5.3	5.3	5.3	5.0	5.0					
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	9.3	9.3	9.3	9.3	8.7	8.7	8.7	8.7	8.7	8.7
Temperature range II				9.3	9.3	9.3	9.3	8.7	8.7	8.7	8.7	8.7	8.7
Temperature range III				8.7	8.0	8.0	8.0	8.0	7.3	7.3	7.3	7.3	7.3
Temperature range IV				6.3	6.3	6.3	6.0	6.0	6.0	6.0	6.0	5.7	5.7
Design bond resistance in non-cracked concrete C20/25 in case of hollow drill bit system (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	7.8	7.8	7.8	7.8	7.2	7.2	7.2	7.2	7.2	7.2
Temperature range II				7.8	7.8	7.8	7.8	7.2	7.2	7.2	7.2	7.2	7.2
Temperature range III				7.2	6.7	6.7	6.7	6.7	6.1	6.1	6.1	6.1	6.1
Temperature range IV				5.3	5.3	5.3	5.0	5.0	5.0	5.0	5.0	4.7	4.7
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	6.7	6.7	6.7	6.7	6.2	6.2	6.2	6.2	6.2	6.2
Temperature range II				6.7	6.7	6.7	6.7	6.2	6.2	6.2	6.2	6.2	6.2
Temperature range III				6.2	5.7	5.7	5.7	5.7	5.2	5.2	5.2	5.2	5.2
Temperature range IV				4.5	4.5	4.5	4.3	4.3	4.3	4.3	4.3	4.0	4.0

WIT-UH 300 WITH REBAR

2- Cracked concrete

Rebar size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Design bond resistance in cracked concrete C20/25 in case of manual air cleaning (MAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	3.1	3.1	3.3	3.6	3.6	No performance assessed				
Temperature range II				3.1	3.1	3.3	3.6	3.6					
Temperature range III				2.5	2.8	2.8	3.1	3.1					
Temperature range IV				2.2	2.5	2.5	2.8	2.8					
Design bond resistance in cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	3.7	3.7	4.0	4.3	4.3	4.3	4.3	4.7	4.7	4.7
Temperature range II				3.7	3.7	4.0	4.3	4.3	4.3	4.3	4.7	4.7	4.7
Temperature range III				3.0	3.3	3.3	3.7	3.7	3.7	3.7	4.0	4.0	4.0
Temperature range IV				2.7	3.0	3.0	3.3	3.3	3.3	3.3	3.3	3.3	3.3
Design bond resistance in cracked concrete C20/25 in case of hollow drill bit system (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	3.1	3.1	3.3	3.6	3.6	3.6	3.6	3.9	3.9	3.9
Temperature range II				3.1	3.1	3.3	3.6	3.6	3.6	3.6	3.9	3.9	3.9
Temperature range III				2.5	2.8	2.8	3.1	3.1	3.1	3.1	3.3	3.3	3.3
Temperature range IV				2.2	2.5	2.5	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Design bond resistance in cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Flooded bore hole	$\tau_{Rd,cr}$	[N/mm²]	2.6	2.6	2.9	3.1	3.1	3.1	3.1	3.3	3.3	3.3
Temperature range II				2.6	2.6	2.9	3.1	3.1	3.1	3.1	3.3	3.3	3.3
Temperature range III				2.1	2.4	2.4	2.6	2.6	2.6	2.6	2.9	2.9	2.9
Temperature range IV				1.9	2.1	2.1	2.4	2.4	2.4	2.4	2.4	2.4	2.4

Working life of 100 years

1- Non-cracked concrete

Rebar size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Design bond resistance in non-cracked concrete C20/25 in case of manual air cleaning (MAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr,100}$	$[N/mm^2]$	7.8	7.8	7.8	7.8	7.2	No performance assessed				
Temperature range II				7.8	7.8	7.8	7.8	7.2					
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet oncrete	$\tau_{Rd,ucr,100}$	$[N/mm^2]$	9.3	9.3	9.3	9.3	8.7	8.7	8.7	8.7	8.7	8.7
Temperature range II				9.3	9.3	9.3	9.3	8.7	8.7	8.7	8.7	8.7	8.7
Design bond resistance in non-cracked concrete C20/25 in case of hollow drill bit system (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr,100}$	$[N/mm^2]$	7.8	7.8	7.8	7.8	7.2	7.2	7.2	7.2	7.2	7.2
Temperature range II				7.8	7.8	7.8	7.8	7.2	7.2	7.2	7.2	7.2	7.2
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr,100}$	$[N/mm^2]$	6.7	6.7	6.7	6.7	6.2	6.2	6.2	6.2	6.2	6.2
Temperature range II				6.7	6.7	6.7	6.7	6.2	6.2	6.2	6.2	6.2	6.2

2- Cracked concrete

Rebar size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Design bond resistance in cracked concrete C20/25 in case of manual air cleaning (MAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr,100}$	$[N/mm^2]$	2.5	2.5	2.5	2.5	2.5	No performance assessed				
Temperature range II				2.5	2.5	2.5	2.5	2.5					
Design bond resistance in racked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr,100}$	$[N/mm^2]$	3.0	3.0	3.0	3.0	3.0	2.7	2.7	2.7	2.7	2.7
Temperature range II				3.0	3.0	3.0	3.0	3.0	2.7	2.7	2.7	2.7	2.7
Design bond resistance in cracked concrete C20/25 in case of hollow drill bit system (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr,100}$	$[N/mm^2]$	2.5	2.5	2.5	2.5	2.5	2.2	2.2	2.2	2.2	2.2
Temperature range II				2.5	2.5	2.5	2.5	2.5	2.2	2.2	2.2	2.2	2.2
Design bond resistance in cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Flooded bore hole	$\tau_{Rd,cr,100}$	$[N/mm^2]$	2.1	2.1	2.1	2.1	2.1	1.9	1.9	1.9	1.9	1.9
Temperature range II				2.1	2.1	2.1	2.1	2.1	1.9	1.9	1.9	1.9	1.9

WIT-UH 300 WITH REBAR

Reduction factors

Working life of 50 years

1- Non-cracked concrete

Rebar size				**Ø8**	**Ø10**	**Ø12**	**Ø14**	**Ø16**	**Ø20**	**Ø24**	**Ø25**	**Ø28**	**Ø32**
Reduction factor for non-cracked concrete C20/25 in case of manual air cleaning (MAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	No performance assessed				
Temperature range II				1.00	1.00	1.00	1.00	1.00					
Temperature range III				0.93	0.86	0.86	0.86	0.92					
Temperature range IV				0.68	0.68	0.68	0.64	0.69					
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.93	0.86	0.86	0.86	0.92	0.85	0.85	0.85	0.85	0.85
Temperature range IV				0.68	0.68	0.68	0.64	0.69	0.69	0.69	0.69	0.65	0.65
Reduction factor for non-cracked concrete C20/25 in case of hollow drill bit system (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.93	0.86	0.86	0.86	0.92	0.85	0.85	0.85	0.85	0.85
Temperature range IV				0.68	0.68	0.68	0.64	0.69	0.69	0.69	0.69	0.65	0.65
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.93	0.86	0.86	0.86	0.92	0.85	0.85	0.85	0.85	0.85
Temperature range IV				0.68	0.68	0.68	0.64	0.69	0.69	0.69	0.69	0.65	0.65

2- Cracked concrete

Rebar size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factor for cracked concrete C20/25 in case of manual air cleaning (MAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	No performance assessed				
Temperature range II				1.00	1.00	1.00	1.00	1.00					
Temperature range III				0.82	0.91	0.83	0.85	0.85					
Temperature range IV				0.73	0.82	0.75	0.77	0.77					
Reduction factor for cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.82	0.91	0.83	0.85	0.85	0.85	0.85	0.86	0.86	0.86
Temperature range IV				0.73	0.82	0.75	0.77	0.77	0.77	0.77	0.71	0.71	0.71
Reduction factor for cracked concrete C20/25 in case of hollow drill bit system (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.82	0.91	0.83	0.85	0.85	0.85	0.85	0.86	0.86	0.86
Temperature range IV				0.73	0.82	0.75	0.77	0.77	0.77	0.77	0.71	0.71	0.71
Reduction factor for cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Flooded bore hole	$\tau_{Rd,cr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.82	0.91	0.83	0.85	0.85	0.85	0.85	0.86	0.86	0.86
Temperature range IV				0.73	0.82	0.75	0.77	0.77	0.77	0.77	0.71	0.71	0.71

WIT-UH 300 WITH REBAR

Working life of 100 years

1- Non-cracked concrete

Rebar size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factor for non-cracked concrete C20/25 in case of manual air cleaning (MAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr,100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	No performance assessed				
Temperature range II				1.00	1.00	1.00	1.00	1.00					
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet oncrete	$\tau_{Rd,ucr,100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Reduction factor for non-cracked concrete C20/25 in case of hollow drill bit system (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr,100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr,100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

2- Cracked concrete

Rebar size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factor for cracked concrete C20/25 in case of manual air cleaning (MAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr,100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	No performance assessed				
Temperature range II				1.00	1.00	1.00	1.00	1.00					
Reduction factor for racked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr,100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Reduction factor for cracked concrete C20/25 in case of hollow drill bit system (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr,100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Reduction factor for cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Flooded bore hole	$\tau_{Rd,cr,100}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Mechanical characteristics

Steel grade	Rebar size			Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
	Stressed cross section	A_s	[mm²]	50	79	113	154	201	314	452	491	616	804
	Section modulus	W	[mm³]	50	98	170	269	402	785	1357	1534	2155	3217
460A	Yield strength	f_y	[N/mm²]	460	460	460	460	460	460	460	460	460	460
	Tensile strength	f_u	[N/mm²]	483	483	483	483	483	483	483	483	483	483
	Design bending moment	$M^0_{Rd,s}$	[Nm]	19	38	66	104	155	303	524	593	833	1243
460B	Yield strength	fy	[N/mm²]	460	460	460	460	460	460	460	460	460	460
	Tensile strength	fu	[N/mm²]	497	497	497	497	497	497	497	497	497	497
	Design bending moment	$M^0_{Rd,s}$	[Nm]	20	39	68	107	160	312	540	610	857	1279
B500B	Yield strength	f_y	[N/mm²]	500	500	500	500	500	500	500	500	500	500
	Tensile strength	f_u	[N/mm²]	550	550	550	550	550	550	550	550	550	550
	Design bending moment	$M^0_{Rd,s}$	[Nm]	22	43	75	118	177	345	597	675	948	1415

Material specifications

Product form		**Bars and de-coiled rods**		
Class		**A**	**B**	**C**
Characteristic yield strength f_{yk} or $f_{0,2k}$ (MPa)		400 to 600		
Minimum value of $k = (f_t/f_y)_k$		≥ 1.05	≥ 1.08	≥ 1.15 < 1.35
Characteristic strain at maximum force, ε_{uk} (%)		≥ 2.5	≥ 5.0	≥ 7.5
Bendability		Bend/Rebend test		
Maximum deviation from nominal mass (individual bar or wire) (%)	Nominal bar size (mm) ≤ 8 > 8	+/- 6.0 +/- 4.5		

WIT-UH 300 R

WIT-UH 300 WITH REBAR

Chemical resistance

Chemical agent	Concentration	Resistant	Not Resistant
Air		●	
Acetic acid	10	●	
Ammonia, aqueous solution	5	●	
Chlorinated lime	10	●	
Citric acid	10	●	
Demineralized Water	100	●	
Diesel Fuel	100	●	
Ethanol	100		●
Ethyl Acetate	100		●
Fuel Oil	100	●	
Gasoline	100	●	
Hydraulic fluid	100	●	
Isopropyi alcohol	100		●
Lactic acid	10	●	
Linseed oil	100	●	
Lubricating oil	100	●	
Methanol	100		●
Phosphoric acid	10	●	
Potassium Hydroxide pH 13.2	100	●	
Salt (Calcium Chloride)	100	●	
Sea water	100	●	
Sodium Carbonate	10	●	
Sulfuric acid	10	●	

Properties of adhesive

Property		Testing method	Result / Mean value
Stability			
UV-resistance (sunlight)			Resistant
Temperature stability			≤ 160°C
Physical properties			
Flexural properties	Flexural strength	DIN EN 196-1	after 24 hours: 22,2 N/mm^2
Compressive properties	Compressive strength		after 24 hours:126 N/mm^2
Tensile properties	Tensile strength	DIN EN ISO 527-2	14,9 N/mm^2
	Coefficient of elasticity		8300 N/mm^2
	Mean strain at fracture		2,6 %
Shrinkage		DIN 52450	< 1,8 ‰
Shore-hardness A		DIN EN ISO 868	97,6
Density		Weighing	1,78 kg/dm^3
Thermal conductivity		DIN EN 993-15	1,06 W/mK
Specific heat capacity			1,09 J/Kg K
Electrical resistance		DIN IEC 93	$7{,}2 . 10^{13}$ Ω
Workability features			
Working time (20°C)			3 min
Curing time (20°C)			30 mins
Shelf-life			18 months

For information use only. Values are not to be considered as a specification and do not reflect the performance of the system. The given values are typical values and are subject to change without notice.

Working and curing times

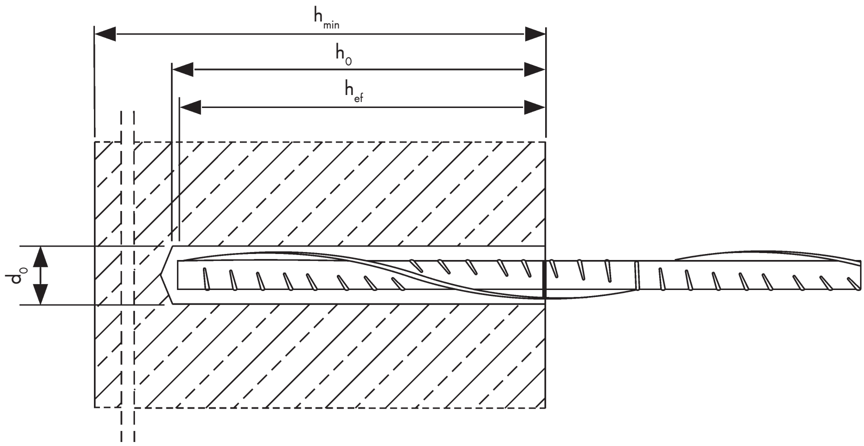
Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1)]
–5°C to –1°C	50 min	5 h
0°C to 4°C	25 min	3.5 h
5°C to 9°C	15 min	2 h
10°C to 14°C	10 min	60 min
15°C to 19°C	6 min	40 min
20°C to 29°C	3 min	30 min
30°C to 40°C	2 min	30 min

[1)] for wet base material the curing time must be doubled

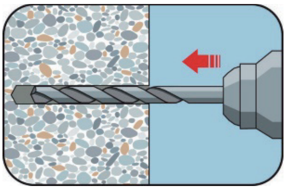
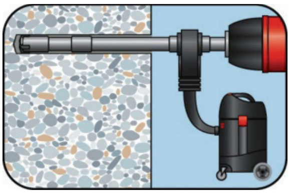
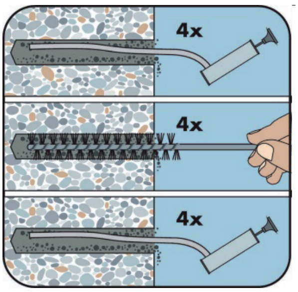
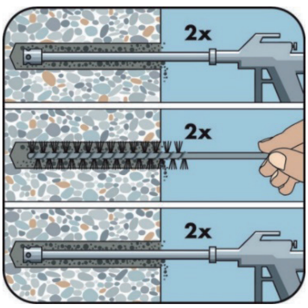
WIT-UH 300 WITH REBAR

Installation parameters

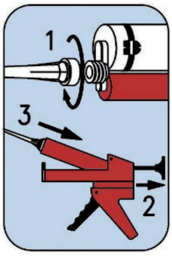
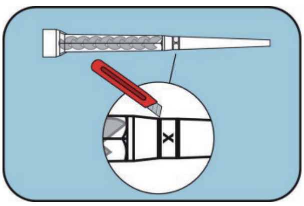
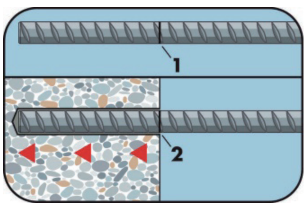
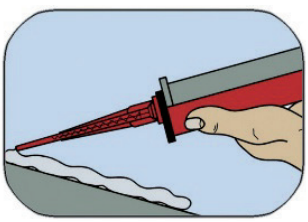
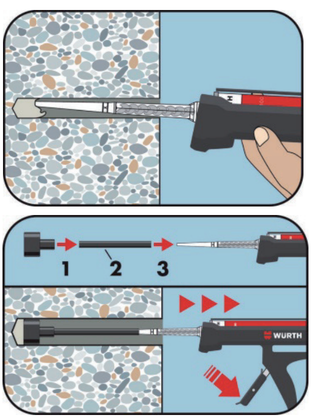
Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Diameter of element	$d = d_{nom}$	[mm]	8	10	12	14	16	20	24	25	28	32
Nominal drill hole diameter	d_0	[mm]	12	14	16	18	20	25	32	32	35	40
Effective anchorage depth	$h_{ef,min}$	[mm]	60	60	70	75	80	90	96	100	112	128
	$h_{ef,max}$	[mm]	160	200	240	280	320	400	480	500	560	640
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 mm		$h_{ef} + 2d_0$							
Minimum spacing	s_{min}	[mm]	40	50	60	70	75	95	120	120	130	150
Minimum edge distance	c_{min}	[mm]	35	40	45	50	50	60	70	70	75	85

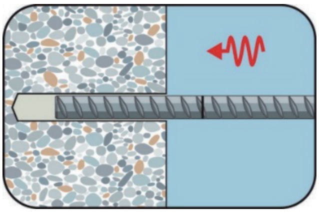
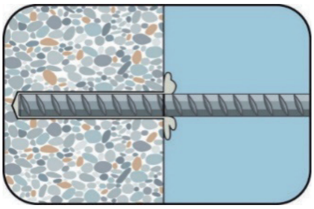
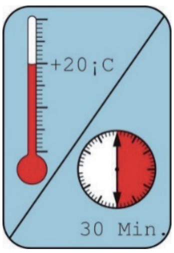


Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer (HD) or compressed air drilling (CD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. Proceed with Step B.
	**1b.**	**Hollow drill bit system (HDB)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. This drilling system removes the dust and cleans the bore hole during drilling. Proceed with Step C.
B) Bore hole cleaning		
MAC: Cleaning for bore hole diameter $d_0 \leq 20$ mm and bore hole depth $h_0 \leq 10$ ds (non-cracked concrete only!)		
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean using a hand pump a minimum of four times.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of four times in a twisting motion. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with a hand pump a minimum of four times.
CAC: Cleaning for all bore hole diameter and bore hole depth with drilling method HD and CD (non-cracked & cracked concrete)		
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of two times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.

WIT-UH 300 WITH REBAR

C) Preparation of bar and cartridge		
	**3.**	Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time as well as for every new cartridge, a new static-mixer shall be used.
	**3a.**	In case of using the mixer extension VL 16/1,8, the tip of the mixer nozzle has to be cut off at position "X".
	**3b.**	Prior to inserting the reinforcing bar into the filled bore hole, the position of the embedment depth shall be marked (e.g. with tape) on the reinforcing bar. After that, insert the bar in the empty hole to verify hole and depth lv. The anchor should be free of dirt, grease, oil and other foreign material.
	**3c.**	Prior to dispensing into the bore hole, squeeze out separately the mortar until it shows a consistent grey or red color (minimum of three full strokes) and discard non-uniformly mixed adhesive components.
D) Filling the bore hole		
	**4.**	Starting from the bottom or back of the cleaned bore hole, fill the hole with adhesive until the level mark at the mixer extension is visible at the top of the hole. For embedment larger than 190 mm, an extension nozzle shall be used. Slowly withdraw the static mixing nozzle. Using a piston plug during injection of the mortar helps to avoid creating air pockets. For overhead and horizontal installation and bore holes deeper than 240 mm, a piston plug and the appropriate mixer extension must be used. Observe the gel-/ working times.

E) Setting the rebar		
	**5a.**	Push the reinforcing bar into the bore hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached. The bar should be free of dirt, grease, oil or other foreign material.
	**5b.**	Be sure that the bar is inserted in the bore hole until the embedment mark is at the concrete surface and that excess mortar is visible at the top of the hole. If these requirements are not maintained, the application has to be renewed. For horizontal and overhead installation, fix embedded part (e.g. with wedges).
	**5c.**	Observe gelling time t_{gel}. Attend that the gelling time can vary according to the base material temperature. Do not move or load the bar until full curing time tcure has elapsed. Allow the adhesive to cure to the specified time prior to applying any load. Do no move or load the bar until it is fully cured. After full curing time t_{cure} has elapsed, the add-on part can be installed.

WIT-UH 300 WITH REBAR

Filling Quantity

Anchor size: Ø 8 - Ø 32

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Nominal drill hole diameter	d_0	[mm]	12	14	16	18	20	25	32	32	35	40
Drill depth	h_0 / h_1	[mm]					= h_{ef}					
Filling volume per 10mm embedment depth		[ml]	0.81	1.01	1.21	1.43	1.66	2.59	4.85	4.47	5.07	6.62

Assumed waste of 15 % included.

WIT-UH 300 R

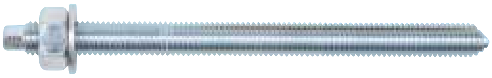
WIT-PE 1000 WITH THREADED ROD (METRIC)

440 ml   585 ml   1400 ml

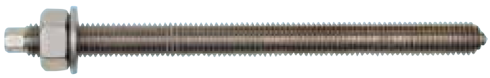
Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Cartridge sizes		Art. no.
440 ml	side-by-side	**5918 605 440**
585 ml	side-by-side	**5918 605 585**
1400 ml	side-by-side	**5918 605 140**



Galvanized (5 microns): M8 - M30



Stainless steel - A4 (AISI 316): M8 - M30

Type of installation		
Pre-positioned	In-place	Stand-off
✓	✓	✓

Installation condition		
Dry concrete	Wet concrete	Flooded drill hole
✓	✓	✓

Drilling method		
Hammer drill	Diamond drill	Hollow drill
✓	✓	✓

Applications




Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt. Berlin	EAD 330499-01-0601	ETA-19/0542. 06.11.2020
ICC-ES Evaluation Report	ICC	AC 308	requested
Fire resistance	Ingenieurbüro Thiele	TR 020	22022. 14.05.2020
LEED	eurofins		19.09.19
VOC Emissions Test report	eurofins	DEVL 1101903D. DEVL 1104875A	19.09.19
NSF International	NSF International	NSF/ANSI Standard61	02.01.20

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness and embedment depth are according to anchor characteristics
- Anchor material according is to specifications. steel grade 5.8 unless otherwise stated
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²
- Temperature range I (min. base material temperature -40°C, max long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling

Characterstic resistance

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	18.3	29.0	42.2	68.8	109.0	149.7	182.9	218.2
	C50/60			18.3	29.0	42.2	78.5	122.5	176.5	229.5	280.5
Shear	≥ C20/25	V_{Rk}	[kN]	11.0	17.4	25.3	47.1	73.5	105.9	137.7	168.3
Cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	14.1	19.8	35.2	48.1	76.3	104.8	128.0	152.8
	C50/60			15.5	21.8	38.8	58.7	99.9	148.0	190.3	237.9
Shear	≥ C20/25	V_{Rk}	[kN]	11.0	17.4	25.3	47.1	73.5	105.9	137.7	168.3

Design resistance

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	12.2	19.3	28.1	45.8	72.7	99.8	121.9	145.5
	C50/60			12.2	19.3	28.1	52.3	81.7	117.7	153.0	187.0
Shear	≥ C20/25	V_{Rd}	[kN]	8.8	13.9	20.2	37.7	58.8	84.7	110.2	134.6
Cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	9.4	13.2	23.5	32.1	50.9	69.9	85.4	101.8
	C50/60			10.3	14.5	25.8	39.2	66.6	98.7	126.9	158.6
Shear	≥ C20/25	V_{Rd}	[kN]	8.8	13.9	20.2	37.7	58.8	84.7	110.2	134.6

WIT-PE 1000 WITH THREADED ROD (METRIC)

Recommended/allowable loads [1)]

Thread size				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete											
Tension	C20/25	N_{rec}	[kN]	8.7	13.8	20.1	32.7	51.9	71.3	87.1	103.9
	C50/60			8.7	13.8	20.1	37.4	58.3	84.0	109.3	133.6
Shear	≥ C20/25	V_{rec}	[kN]	6.3	9.9	14.5	26.9	42.0	60.5	78.7	96.2
Cracked concrete											
Tension	C20/25	N_{rec}	[kN]	6.7	9.4	16.8	22.9	36.3	49.9	61.0	72.7
	C50/60			7.4	10.4	18.5	28.0	47.6	70.5	90.6	113.3
Shear	≥ C20/25	V_{rec}	[kN]	6.3	9.9	14.5	26.9	42.0	60.5	78.7	96.2

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Temperature range 1 (min. base material temperature -40°C, max. long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling (Installation factors might apply for other drilling methods)
- Anchor material according to specifications, steel grade 5.8 unless otherwise stated in the tables

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b;N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Design steel resistance	5.8	$N_{Rd,s}$	[kN]	12.2	19.3	28.1	52.3	81.7	117.7	153.0	187.0
	8.8	$N_{Rd,s}$	[kN]	19.3	30.7	44.7	83.3	130.7	188.0	245.3	299.3
	A4	$N_{Rd,s}$	[kN]	13.9	21.9	31.6	58.8	91.4	132.1	80.4	98.3

WIT-PE 1000 WITH THREADED ROD (METRIC)

2. Design combined pull-out and concrete cone resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of combined pull-out and concrete cone failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	26.8	37.7	52.5	79.6	128.2	179.4	217.1	271.4
Cracked concrete										
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	9.4	13.2	23.5	35.6	60.5	89.7	115.4	144.2

- $s_{cr,p} = 7.3\, d\, (f_{sus} \cdot \tau_{Rk})^{0.5} \leq 3h_{ef}$
- $c_{cr,p} = s_{cr,p}/2$

Where τ_{Rk} is the value $\tau_{Rk,ucr}$ for non-cracked concrete C20/25

Table 3: Characteristic edge distance $c_{cr,p}$ and spacing $s_{cr,p}$ (f_{sus} = 1)

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Spacing	$s_{cr,p}$	[mm]	240	270	330	375	510	630	720	810
Edge distance	$c_{cr,p}$	[mm]	120	135	165	188	255	315	360	405

a. Influence of concrete strength

Table 4: Influence of concrete strength on combined pull-out and concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.02	1.04	1.07	1.08	1.09	1.10

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \frac{h_{ef}}{h_{ef,typ}}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „installation parameters".

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 5: Influence of spacing on combined pull-out and concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,p}$, $f_{sy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,p}$, $f_{sy,p}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,p}$, $f_{sy,p}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,p}$, $f_{sy,p}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,p} = 0.7 + 0.3\,\frac{c_x}{c_{cr,p}} \leq 1 \qquad f_{cx,2,p} = f_{cy,p} = \left(1 + \frac{c_{x(y)}}{c_{cr,p}}\right) \cdot \frac{1}{2} \leq 1$$

Table 6: Influence of edge distance on combined pull-out and concrete cone resistance

$c/c_{cr,P}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,p}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,p}$ / $f_{cy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-PE 1000 WITH THREADED ROD (METRIC)

e. Influence of sustained loads

$$a_{sus} = \frac{N_{sus,d}}{N_{Ed}}$$

$N_{sus,d}$ = design value of sustained actions (permanent actions & permanent component of variable actions)

N_{Ed} = Value of total actions in tension loading at ultimate limit state

Table 7: Influence of sustained loads on combined pull-out and concrete cone resistance

a_{sus}	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
f_{sus}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.80

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases.

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 8: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	23.5	28.0	37.8	45.8	72.7	99.8	121.9	145.5
Cracked concrete										
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	16.4	19.6	26.5	32.1	50.9	69.9	85.4	101.8

Table 9: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Spacing	$s_{cr,N}$	[mm]	240	270	330	375	510	630	720	810
Edge distance	$c_{cr,N}$	[mm]	120	135	165	188	255	315	360	405

Above characteristic spacing and edge distances are given for the typical effective anchorage depths. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$s_{cr,N} = 3\ h_{ef}$ and $c_{cr,N} = 1.5\ h_{ef}$

a. Influence of concrete strength

Table 10: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,\,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 11: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\,\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 12: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-PE 1000 WITH THREADED ROD (METRIC)

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

Table 13: Design resistance $N_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Concrete splitting resistance	$N^0_{Rd,sp}$	[kN]	23.5	28.0	37.8	45.8	72.7	99.8	121.9	145.5

Table 14: Characteristic edge distance $c_{cr.sp}$ and spacing $s_{cr.sp}$

Thread size			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Spacing	$s_{cr,sp}$	[mm]	360	420	528	600	816	1008	1152	1296
Edge distance	$c_{cr,sp}$	[mm]	180	210	264	300	408	504	576	648
Minimum member thickness	h_{min}	[mm]	110	120	140	161	218	266	304	340

Above characteristic spacing and edge distances are given for the typical effective anchorage depth. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$s_{cr,sp} = 2 \cdot c_{cr,sp}$ and $c_{cr,sp} = \left\{ h_{ef} \le 2\, h_{ef} \cdot \left(2.5 - \left(\frac{h_{min}}{h_{ef}}\right)\right) \le 2.4\, h_{ef} \right\}$

and h_{min} according to the table „anchor characteristics".

a. Influence of concrete strength

Table 15: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

1) strength at 28 days of 150 mm diameter by 300 mm cylinders

2) strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx,\,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 16: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\,\frac{c_x}{c_{cr,sp}} \leq 1 \qquad\qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 17: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

e. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 18: Influence of concrete member thickness on splitting resistance

h/h_{min}	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.3	2.4	2.7	2.8	2.9
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

WIT-PE 1000 WITH THREADED ROD (METRIC)

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot min\ \{N_{Rd,p;}\ N_{Rd,c}\}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 19: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Design steel resistance	5.8	$V_{Rd,s}$	[kN]	8.8	13.9	20.2	37.7	58.8	84.7	110.2	134.6
	8.8		[kN]	12.0	18.4	27.2	50.4	78.4	112.8	147.2	179.2
	A4		[kN]	8.3	12.8	19.2	35.3	55.1	79.5	48.3	58.8

2. Design concrete pry-out resistance

$$V_{Rd.c} = k_8 \cdot min\ \{N_{Rd.p};N_{Rd.c}\}$$

Table 20: factor k_8 for calculating design pry-out resistance

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

3. Design concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions c ≥ max (10 h_{ef} ; 60 d). For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 21: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.8	3.6	4.6	5.8	8.3	10.3	13.1	15.2
Cracked concrete										
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.0	2.5	3.2	4.1	5.9	7.3	9.3	10.7

a. Influence of concrete strength

Table 22: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

Table 23: Influence of embedment depth on concrete edge resistance

h_{ef}/d	4	5	6	7	8	9	10	11	≥ 12
$f_{hef,V}$	0.87	0.91	0.94	0.97	1.00	1.02	1.05	1.07	1.08

[1] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 24: Influence of spacing on concrete edge resistance

s/c_1[1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s. when there are different spacing in the row closest to the edge.

d. Influence of edge distance c_1

Table 25: Influence of edge distance c_1 on concrete edge resistance

$c_{1/d}$	4	8	12	15	20	30	40	50	60	100	150	200
$f_{c1,V}$	0.47	1.19	2.05	2.76	4.05	6.95	10.22	13.76	17.54	34.66	59.52	87.35

e. Influence of edge distance c_2

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\frac{c_2}{1.5c_1}\right) \leq 1$$

Table 26: Influence of edge distance c_2 on concrete edge resistance

c_2/c_1 [1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \leq c_2$

f. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

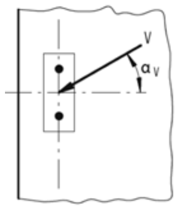


Table 27: Influence of load direction on concrete edge resistance

α [1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.

g. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 28: Influence of concrete member thickness on edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

WIT-PE 1000 WITH THREADED ROD (METRIC)

Design bond strength

Service Temperature for working life of 50 years

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +72°C	+50°C	+72°C

Service temperature for working life of 100 years

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +80°C	+50°C	+80°C
Temperature range III	- 40°C to +120°C	+72°C	+120°C
Temperature range IV	- 40°C to +160°C	+100°C	+160°C

Working life of 50 years

1- Non-cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes (HD) and compressed air drilled holes (CD)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	13.3	13.3	12.7	12.7	12.0	11.3	10.7	10.7
Temperature range II				10.0	10.0	10.0	9.3	8.7	8.7	8.0	8.0
Temperature range I	Flooded bore hole			11.1	11.1	10.6	10.6	10.0	9.4	8.9	8.9
Temperature range II				8.3	8.3	8.3	7.8	7.2	7.2	6.7	6.7
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes with hollow drill bit (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	11.3	10.7	10.7	10.7	10.0	9.3	9.3	8.7
Temperature range II				9.3	9.3	9.3	8.7	8.7	8.0	8.0	7.3
Temperature range I	Flooded bore hole			8.9	8.9	8.9	8.3	8.3	7.8	7.8	7.2
Temperature range II				7.8	7.8	7.8	7.2	7.2	6.7	6.7	6.1
Design bond resistance in non-cracked concrete C20/25 in diamond drilled holes (DD)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	10.0	9.3	9.3	8.7	8.0	8.0	7.3	7.3
Temperature range II				8.0	8.0	7.3	6.7	6.3	6.3	6.0	6.0
Temperature range I	Flooded bore hole			8.3	7.8	7.8	6.2	5.7	5.7	5.2	5.2
Temperature range II				6.7	6.7	6.1	4.8	4.5	4.5	4.3	4.3

2- Cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Design bond resistance in cracked concrete C20/25 in hammer drilled holes (HD) compressed air drilled holes (CD) and with hollow drill bit (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	4.7	4.7	5.7	5.7	5.7	5.7	5.7	5.7
Temperature range II				4.0	4.0	4.7	4.7	4.7	4.7	4.7	4.7
Temperature range I	Flooded bore hole			3.9	3.9	4.7	4.7	4.7	4.7	4.7	4.7
Temperature range II				3.3	3.3	3.9	3.9	3.9	3.9	3.9	3.9

WIT-PE 1000 WITH THREADED ROD (METRIC)

Working life of 100 years

1- Non-cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes (HD) and compressed air drilled holes (CD)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	13.3	13.3	12.7	12.7	12.0	11.3	10.7	10.7
Temperature range II				10.0	10.0	10.0	9.3	8.7	8.7	8.0	8.0
Temperature range I	Flooded bore hole			11.1	11.1	10.6	10.6	10.0	9.4	8.9	8.9
Temperature range II				8.3	8.3	8.3	7.8	7.2	7.2	6.7	6.7
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes with hollow drill bit (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	11.3	10.7	10.7	10.7	10.0	9.3	9.3	8.7
Temperature range II				9.3	9.3	9.3	8.7	8.7	8.0	8.0	7.3
Temperature range I	Flooded bore hole			8.9	8.9	8.9	8.3	8.3	7.8	7.8	7.2
Temperature range II				7.8	7.8	7.8	7.2	7.2	6.7	6.7	6.1
Design bond resistance in non-cracked concrete C20/25 in diamond drilled holes (DD)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	10.0	9.3	9.3	8.7	8.0	8.0	7.3	7.3
Temperature range II				7.3	7.3	6.7	6.7	6.3	6.0	5.7	5.7
Temperature range I	Flooded bore hole			8.3	7.8	7.8	6.2	5.7	5.7	5.2	5.2
Temperature range II				6.1	6.1	5.6	4.8	4.5	4.3	4.0	4.0

2- Cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Design bond resistance in cracked concrete C20/25 in hammer drilled holes (HD) compressed air drilled holes (CD) and with hollow drill bit (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	4.3	4.3	5.0	5.0	5.0	5.0	5.0	5.0
Temperature range II				3.7	3.7	4.3	4.3	4.3	4.3	4.3	4.3
Temperature range I	Flooded bore hole			3.6	3.6	4.2	4.2	4.2	4.2	4.2	4.2
Temperature range II				3.1	3.1	3.6	3.6	3.6	3.6	3.6	3.6

Reduction factors

1- Non-cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes (HD) and compressed air drilled holes (CD)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.75	0.75	0.79	0.74	0.72	0.76	0.75	0.75
Temperature range I	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.75	0.75	0.79	0.74	0.72	0.76	0.75	0.75
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes with hollow drill bit (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.82	0.88	0.88	0.81	0.87	0.86	0.86	0.85
Temperature range I	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.88	0.88	0.88	0.87	0.87	0.86	0.86	0.85
Reduction factor for non-cracked concrete C20/25 in diamond drilled holes (DD)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.80	0.86	0.79	0.77	0.79	0.79	0.82	0.82
Temperature range I	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.80	0.86	0.79	0.77	0.79	0.79	0.82	0.82

2- Cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Reduction factor for cracked concrete C20/25 in hammer drilled holes (HD) compressed air drilled holes (CD) and with hollow drill bit (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.86	0.86	0.82	0.82	0.82	0.82	0.82	0.82
Temperature range I	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.86	0.86	0.82	0.82	0.82	0.82	0.82	0.82

WIT-PE 1000 WITH THREADED ROD (METRIC)

Working life of 100 years

1- Non-cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes (HD) and compressed air drilled holes (CD)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.75	0.75	0.79	0.74	0.72	0.76	0.75	0.75
Temperature range I	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.75	0.75	0.79	0.74	0.72	0.76	0.75	0.75
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes with hollow drill bit (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.82	0.88	0.88	0.81	0.87	0.86	0.86	0.85
Temperature range I	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.88	0.88	0.88	0.87	0.87	0.86	0.86	0.85
Reduction factor for non-cracked concrete C20/25 in diamond drilled holes (DD)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.73	0.79	0.71	0.77	0.79	0.75	0.77	0.77
Temperature range I	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.73	0.79	0.71	0.77	0.79	0.75	0.77	0.77

2- Cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Reduction factor for cracked concrete C20/25 in hammer drilled holes (HD) compressed air drilled holes (CD) and with hollow drill bit (HDB)											
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.85	0.85	0.87	0.87	0.87	0.87	0.87	0.87
Temperature range I	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.85	0.85	0.87	0.87	0.87	0.87	0.87	0.87

Mechanical characteristics

Steel grade	Thread size			M8	M10	M12	M16	M20	M24	M27	M30
	Stressed cross section	A_s	[mm²]	37	58	84	157	245	352	459	561
	Section modulus	W	[mm³]	31	62	109	277	541	935	1387	1874
4.6	Yield strength	f_y	[N/mm²]	240	240	240	240	240	240	240	240
	Tensile strength	f_u	[N/mm²]	400	400	400	400	400	400	400	400
	Design bending moment	$M^0_{Rd,s}$	[Nm]	9.0	18.0	31.1	79.6	155.7	268.9	398.8	538.9
4.8	Yield strength	f_y	[N/mm²]	320	320	320	320	320	320	320	320
	Tensile strength	f_u	[N/mm²]	400	400	400	400	400	400	400	400
	Design bending moment	$M^0_{Rd,s}$	[Nm]	12.0	24.0	41.6	106.4	208.0	359.2	532.8	720.0
5.6	Yield strength	f_y	[N/mm²]	300	300	300	300	300	300	300	300
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	11.4	22.2	38.9	99.4	194.0	335.3	498.8	672.5
5.8	Yield strength	f_y	[N/mm²]	400	400	400	400	400	400	400	400
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	15.2	29.6	52	132.8	259.2	448	666.4	898.4
8.8	Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640
	Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800
	Design bending moment	$M^0_{Rd,s}$	[Nm]	24.0	48.0	84.0	212.8	415.2	716.8	1066.4	1437.6
A4-50	Yield strength	f_y	[N/mm²]	210	210	210	210	210	210	210	210
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	8.0	15.5	27.7	70.2	136.6	235.7	349.6	472.7
A4-70	Yield strength	f_y	[N/mm²]	450	450	450	450	450	450	-	-
	Tensile strength	f_u	[N/mm²]	700	700	700	700	700	700	-	-
	Design bending moment	$M^0_{Rd,s}$	[Nm]	16.7	33.3	59.0	148.7	291.0	502.6	-	-

WIT-PE 1000 WITH THREADED ROD (METRIC)

Material specifications

Part	Designation	Material				
Steel, zinc plated (Steel acc. to EN 10087:1998 or EN 10263:2001) - zinc plated ≥ 5 µm acc. to EN ISO 4042:1999 - hot-dip galvanized ≥ 40 µm acc. to EN ISO 1461:2009 and EN ISO 10684:2004+AC:2009 - sherardized ≥ 45 µm acc. to EN ISO 17668:2016						
1	Anchor rod	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 898-1:2013	4.6	f_{uk} = 400 N/mm²	f_{yk} = 240 N/mm²	A5 > 8%
			4.8	f_{uk} = 400 N/mm²	f_{yk} = 320 N/mm²	A5 > 8%
			5.6	f_{uk} = 500 N/mm²	f_{yk} = 300 N/mm²	A5 > 8%
			5.8	f_{uk} = 500 N/mm²	f_{yk} = 400 N/mm²	A5 > 8%
			8.8	f_{uk} = 800 N/mm²	f_{yk} = 640 N/mm²	A5 > 12% [3)]
2	Hexagon nut	acc. to EN ISO 898-2:2012	4	for anchor rod class 4.6 or 4.8		
			5	for anchor rod class 5.6 or 5.8		
			8	for anchor rod class 8.8		
3a	Washer	Steel, zinc plated, hot-dip galvanized or sherardized (e.g.: EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000, or EN ISO 7094:2000)				
3b	Filling washer	Steel, zinc plated, hot-dip galvanized or sherardized				
4	Internal threaded anchor rod	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 898-1:2013	5.8	f_{uk} = 500 N/mm²	f_{yk} = 400 N/mm²	A5 > 8%
			8.8	f_{uk} = 800 N/mm²	f_{yk} = 640 N/mm²	A5 > 8%

Part	Designation	Material				
Stainless steel A2 (Material 1.4301 / 1.4303 / 1.4307 / 1.4567 or 1.4541, acc. to EN 1088-1:2014) **Stainless steel A4** (Material 1.4401 / 1.4404 / 1.4571 / 1.4362 or 1.4578, acc. to EN 10088-1:2014) **High corrosion resistance steel** (Material 1.4529 or 1.4565, acc. to EN 10088-1:2014)						
1	Anchor rod [1) 4)]	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 3506-1:2009	50	f_{uk} = 400 N/mm²	f_{yk} = 240 N/mm²	A5 > 12% [3)]
			70	f_{uk} = 400 N/mm²	f_{yk} = 320 N/mm²	A5 > 12% [3)]
			80	f_{uk} = 500 N/mm²	f_{yk} = 300 N/mm²	A5 > 12% [3)]
2	Hexagon nut [1) 4)]	acc. to EN ISO 3506-1:2009	50	for anchor rod class 50		
			70	for anchor rod class 70		
			80	for anchor rod class 80		
3a	Washer	Stainless steel A2 (Material 1.4301 / 1.4303 / 1.4307 / 1.4567 or 1.4541, acc. to EN 1088-1:2014) Stainless steel A4 (Material 1.4401 / 1.4404 / 1.4571 / 1.4362 or 1.4578, acc. to EN 10088-1:2014) HCR: Material 1.4529 or 1.4565, acc. to EN 10088-1:2014 (e.g.: EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000, or EN ISO 7094:2000)				
3b	Filling washer	Stainless steel A4. High corrosion resistance steel				
4	Internal threaded anchor rod [1) 2)]	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 3506-1:2009	50	f_{uk} = 500 N/mm²	f_{yk} = 210 N/mm²	A5 > 8%
			70	f_{uk} = 700 N/mm²	f_{yk} = 450 N/mm²	A5 > 8%

1) Property class 70 for anchor rods up to M24 and Internal threaded anchor rods up to IG-M16

2) for IG-M20 only property class 50

3) A_5 > 8% fracture elongation if no requirement for performance category C2 exists

4) Property class 80 only for stainless steel A4

WIT-PE 1000 WITH THREADED ROD (METRIC)

Chemical resistance

Chemical agent	Concentration	Resistant	Not Resistant
Acetic acid (Vinegar)	40		●
Acetone	10		●
Ammonia, aqueous solution	5	●	
Aniline	100		●
Beer	100	●	
Benzine (kp 100-140°F)	100	●	
Benzene	100		●
Boric Acid, aqueous solution		●	
Calcium carbonate, suspended in water	All	●	
Calcium chloride, suspended in water		●	
Calcium hydroxide, suspended in water		●	
Carbon tetrachloride	100	●	
Caustic soda (Sodium hydroxide)	40	●	
Citric acid	All	●	
Chlorine	All	●	
Diesel oil	100	●	
Ethyl alcohol, aqueous solution	50		●
Formaldehyde, aqueous solution	30	●	
Formic acid (Methanoic acid)	100		●
Formic acid (Methanoic acid)	10	●	
Freon		●	
Fuel Oil		●	
Gasoline (premium grade)	100	●	
Glycol (Ethylene glycol)		●	
Hydrogen peroxide	30		●
Hydrochloric acid (Muriatic Acid)	Conc.		●
Isopropyl alcohol	100		●
Lactic acid	All		●
Laitance		●	
Linseed oil	100	●	
Lubricating oil	100	●	
Magnesium chloride, aqueous solution	All	●	
Methanol	100		●
Motor oil (SAE 20 W-50)	100	●	
Nitric acid	10		●
Oleic acid	100	●	
Perchloroethylene	100	●	
Petroleum	100	●	
Phenol, aqueous solution (Carbonic acid)	8		●
Phosphoric acid	85	●	
Phosphoric acid	10	●	
Potash lye (potassium hydroxide, 10% and 40% solutions)		●	
Potassium carbonate, aqueous solution	All	●	
Potassium chlorite, aqueous solution	All	●	
Potassium nitrate, aqueous solution	All	●	

WÜRTH

Chemical Agent	Concentration	Resistant	Not Resistant
Sodium carbonate, aqueous solution	All	●	
Sodium chloride, aqueous solution	All	●	
Sodium phosphate, aqueous solution	All	●	
Sodium silicate	All	●	
Sulfuric acid	30		●
Tartaric acid	All	●	
Tetrachloroethylene	100	●	
Toluene			●
Turpentine	100	●	
Trichloroethylene	100		●

Properties of adhesive

Property		Testing method	Result/Mean value
Stability			
UV-resistance (sunlight)			resistant
Temperature resistance			72°C
Water resistance			resistant
Physical properties			
Flexural properties	Flexural strength	DIN EN 196-1	after 24 hours: 22.2 N/mm^2
Compressive properties	Compressive strength		after 24 hours:126 N/mm^2
Tensile properties	Tensile strength	DIN EN ISO 527-2	< 1.8 ‰
	Coefficient of elasticity		97.6
	Mean strain at fracture		1.78 kg/dm^3
Shrinkage		DIN 52450	≤ 1.4 ‰
Shore-hardness A		DIN EN ISO 868	99.4
Shore-hardness D			86.1
Density		Weighing	≤ 1.50 kg/dm^3
Thermal conductivity		DIN EN 993-15	0.50 W/mK
Specific heat capacity			1.350 J/Kg K
Electrical resistance		DIN IEC 93	$8.0 . 10^{12}\ \Omega$
Workability features			
Water tightness / Impermeability		DIN EN 12390-8	0 mm
Working time (20°C)			30 min
Curing time (20°C)			12 hr
Shelf-life			24 months

For information use only. Values are not to be considered as a specification and do not reflect the performance of the system. The given values are typical values and are subject to change without notice.

WIT-PE 1000 WITH THREADED ROD (METRIC)

Working and curing times

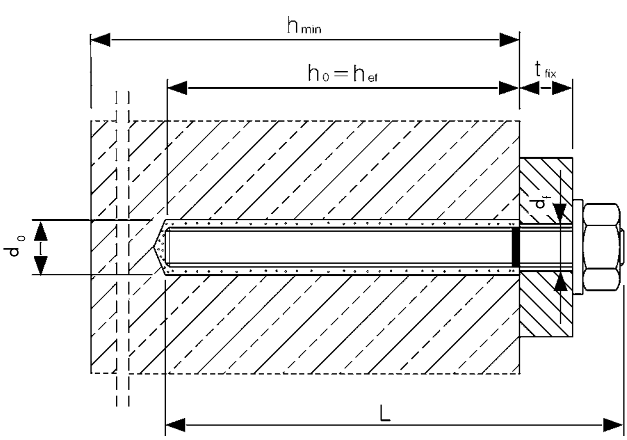
Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1]
0 °C to 4 °C	90 min	144 h
5 °C to 9 °C	80 min	48 h
10 °C to 14 °C	60 min	28 h
15 °C to 19 °C	40 min	18 h
20 °C to 24 °C	30 min	12 h
25 °C to 34 °C	12 min	9 h
35 °C to 39 °C	8 min	6 h
+40 °C	8 min	4 h

[1] for wet base material the curing time must be doubled

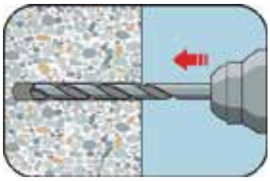
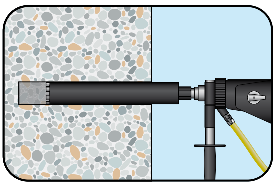
Installation parameters

Anchor size			M8	M10	M12	M16	M20	M24	M27	M30
Diameter of element	$d = d_{nom}$	[mm]	8	10	12	16	20	24	27	30
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	22	28	30	35
Effective anchorage depth	$h_{ef,min}$	[mm]	60	60	70	80	90	96	108	120
	$h_{ef,max}$	[mm]	160	200	240	320	400	480	540	600
Diameter of clearance in hole in the fixture	Prepositioned installation $d_f \leq$	[mm]	9	12	14	18	22	26	30	33
	Push through installation df	[mm]	12	14	16	20	24	30	33	40
Maximum torque moment	max $T_{inst} \leq$	[Nm]	10	20	40 [1]	60	100	170	250	300
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 mm			$h_{ef} + 2d_0$				
Minimum spacing	s_{min}	[mm]	40	50	60	75	95	115	125	140
Minimum edge distance	c_{min}	[mm]	35	40	45	50	60	65	75	80

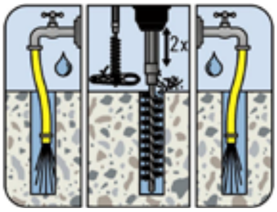
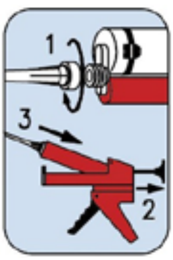
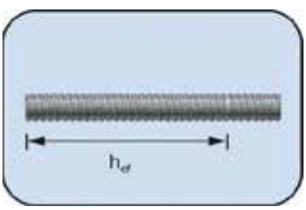
[1] *Maximum Toruqe moment for M12 with steel Grade 4.6 is 35 Nm*

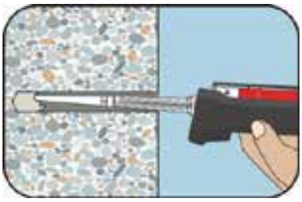
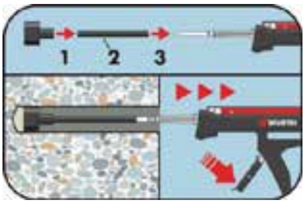
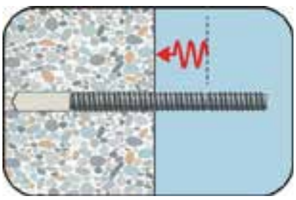
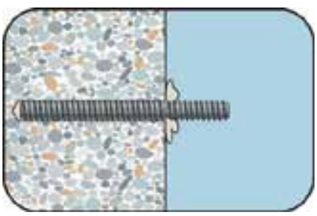
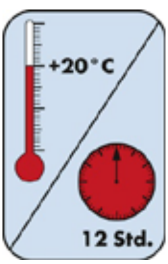


Installation instructions

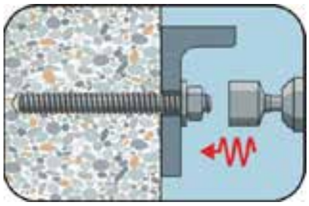
A) Bore hole drilling		
	**1a.**	**Hammer (HD) or compressed air drilling (CD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. Proceed with Step B1.
	**1b.**	**Hollow drill bit system (HDB)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. This drilling system removes the dust and cleans the bore hole during drilling. Proceed with Step C.
	**2c.**	**Diamond drilling (DD)** Drill with diamond drill a hole into the base material to the size and embedment depth required by the selected anchor. Proceed with Step B2. In case of aborted drill hole, the drill hole shall be filled with mortar.
Attention! Standing water in the bore hole must be removed before cleaning.		
B1) Bore hole cleaning		
CAC: Cleaning for dry, wet and water-filled bore holes with all diameter in non-cracked and cracked concrete		
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of <u>two</u> times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.
After cleaning, the bore hole has to be protected against re-contamination in an appropriate way until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must no contaminate the bore hole again.		

WIT-PE 1000 WITH THREADED ROD (METRIC)

B2) Bore hole cleaning		
SPCAC: Cleaning for dry, wet and water-filled bore holes for all diameters in non-cracked concrete		
	**2a.**	Rinsing with water until clear water comes out.
	2b.	Check the brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of <u>two</u> times in a twisting motion. If the bore hole ground is not reached with the brush, a brush extension must be used.
	2c.	Rinsing again with water until clear water comes out.
	**2d.**	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.
	2e.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of <u>two</u> times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2f.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.
After cleaning, the bore hole has to be protected against re-contamination in an appropriate way until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must no contaminate the bore hole again.		
C) Preparation of bar and cartridge		
	**3a.**	Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time as well as for every new cartridge, a new static-mixer shall be used.
	**3b.**	Prior to inserting the anchor rod into the filled bore hole, the position of the embedment depth shall be marked on the anchor rod. After that, insert the rod in the empty hole to verify hole and depth lv. The anchor should be free of dirt, grease, oil and other foreign material.

	**3c.**	Prior to dispensing into the bore hole, squeeze out separately the mortar until it shows a consistent grey or red color (minimum of three full strokes) and discard non-uniformly mixed adhesive components.
D) Filling the bore hole		
 	**4.**	Starting from the bottom or back of the cleaned bore hole, fill the hole up to approximately two-thirds with adhesive. Slowly withdraw the static mixing nozzle as the hole fills to avoid creating air pockets. If the bottom or back of the anchor hole is not reached, an appropriate extension nozzle must be used. Observe the gel-/ working times. Piston plugs and mixer nozzle extensions shall be used for the following applications: • Horizontal assembly (horizontal direction) and ground erection (vertical downwards direction): Drill bit-Ø d_0 ≥ 18 mm and embedment depth hef > 250 mm • Overhead assembly (vertical upwards direction): Drill bit-Ø d_0 ≥ 18 mm
E) Setting the rebar		
	**5a.**	Push the anchor rod into the bore hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached. The rod should be free of dirt, grease, oil or other foreign material.
	**5b.**	After inserting the anchor, the annular gap between the anchor rod and concrete, in case of a push through installation, in addition to the fixture, must be completely filled with mortar. Be sure that the anchor rod is inserted in the bore hole until the embedment mark is at the concrete surface and that excess mortar is visible at the top of the hole. If these requirements are not maintained, the application has to be renewed. For overhead installation, fix embedded part (e.g. with wedges).
	**5c.**	Allow the adhesive to cure to the specified time prior to applying any load or torque. Do not move or load the anchor until it is fully cured.

WIT-PE 1000 WITH THREADED ROD (METRIC)

	**5d.**	After full curing, the add-on part can be installed with up to the max. torque by using a calibrated torque wrench. In case of prepositioned installation, the annular gap between the anchor and fixture can be optionally filled with mortar. Therefore, substitute the washer by the filling washer and connect the mixer reduction nozzle to the tip of the mixer. The annular gap is filled with mortar when mortar oozes out of the washer.

Filling quantity

Anchor type: M8 - M30

Anchor size			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	22	28	30	35
Drill depth	h_0 / h_1	[mm]	$= h_{ef}$							
Filling volume per 10mm embedment depth		[ml]	0.53	0.70	0.89	1.27	1.78	3.35	3.22	5.10

Assumed waste of 15 % included.

WIT-PE 1000 WITH REBAR

440 ml | 585 ml | 1400 ml

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Cartridge sizes		Art. no.
440 ml	side-by-side	**5918 605 440**
585 ml	side-by-side	**5918 605 585**
1400 ml	side-by-side	**5918 605 140**

Ø8 - Ø32

Rebar not supplied by Würth

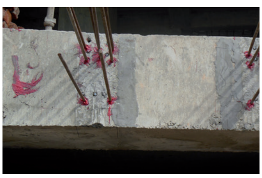
Installation condition		
Dry concrete	Wet concrete	Flooded drill hole
✓	✓	✓

Drilling method		
Hammer drill	Diamond drill	Hollow drill
✓	✓	✓

WIT-PE 1000 R

Applications






Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt. Berlin	EAD 330499-01-0601	ETA-19/0542, 06.11.2020
European Technical Assessment	DIBt. Berlin	EAD 330087-00-0601	ETA-19/0543, 17.04.2020
ICC-ES Evaluation Report	ICC	AC 308	ELC-4757, 05.2021
Fire resistance	Ingenieurbüro Thiele	TR 020	22022. 14.05.2020
LEED	eurofins		19.09.19
VOC Emissions Test report	eurofins	DEVL 1101903D. DEVL 1104875A	19.09.19
NSF International	NSF International	NSF/ANSI Standard61	02.01.20

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness and embedment depth are according to anchor characteristics
- Rebar material is according to specifications, steel grade B500B
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²
- Temperature range I (min. base material temperature -40°C, max long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling

Characteristic resistance

Rebar size				**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete													
Tension	C20/25	N_{Rk}	[kN]	27.5	42.0	56.8	68.8	68.8	109.0	149.7	149.7	218.2	255.6
	C50/60			27.5	43.5	62.2	84.7	108.7	172.4	236.7	236.7	338.8	404.2
Shear	≥ C20/25	V_{Rk}	[kN]	13.8	21.7	31.1	42.4	55.3	86.4	124.3	135.0	169.4	221.1
Cracked concrete													
Tension	C20/25	N_{Rk}	[kN]	14.1	19.8	35.2	46.7	48.1	76.3	104.8	104.8	152.8	178.9
	C50/60			15.5	21.8	38.8	51.4	58.7	99.9	148.0	154.2	222.1	282.2
Shear	≥ C20/25	V_{Rk}	[kN]	13.8	21.7	31.1	42.4	55.3	86.4	124.3	135.0	169.4	221.1

Design resistance

Rebar size				**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete													
Tension	C20/25	N_{Rd}	[kN]	19.6	28.0	37.8	45.8	45.8	72.7	99.8	99.8	145.5	170.4
	C50/60			19.6	31.0	44.4	60.5	72.5	114.9	157.8	157.8	230.1	269.4
Shear	≥ C20/25	V_{Rd}	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	82.9	90.0	112.9	147.4
Cracked concrete													
Tension	C20/25	N_{Rd}	[kN]	9.4	13.2	23.5	31.2	32.1	50.9	69.9	69.9	101.8	119.3
	C50/60			10.3	14.5	25.8	34.3	39.2	66.6	98.7	102.8	148.0	188.0
Shear	≥ C20/25	V_{Rd}	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	82.9	90.0	112.9	147.4

WIT-PE 1000 WITH REBAR

Recommended/allowable loads [1)]

Rebar size				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete													
Tension	C20/25	N_{rec}	[kN]	14.0	20.0	27.0	32.7	32.7	51.9	71.3	71.3	103.9	121.7
	C50/60			14.0	22.2	31.7	43.2	51.8	82.1	112.7	112.7	164.3	192.5
Shear	≥ C20/25	V_{rec}	[kN]	6.5	10.3	14.8	20.2	26.3	41.1	59.2	64.3	80.7	105.3
Cracked concrete													
Tension	C20/25	N_{rec}	[kN]	6.7	9.4	16.8	22.3	22.9	36.3	49.9	49.9	72.7	85.2
	C50/60			7,4	10.4	18.5	24.5	28.0	47.6	70.5	73.4	105.7	134.3
Shear	≥ C20/25	V_{rec}	[kN]	6.5	10.3	14.8	20.2	26.3	41.1	59.2	64.3	80.7	105.3

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Temperature range 1 (min. base material temperature -40°C, max. long term/short term base material temperature: +24°C/40°C)
- Dry or wet conditions of drill hole, hammer drilling (Installation factors might apply for other drilling methods)
- Rebar material according to specifications, steel grade B500B

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b;N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_{h}$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Design steel resistance	$N_{Rd,s}$	[kN]	19.6	31.0	44.4	60.5	79.0	123.4	177.6	192.9	242.0	315.9

WIT-PE 1000 WITH REBAR

2. Design combined pull-out and concrete cone resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of combined pull-out and concrete cone failure of a single anchor

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete												
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	21.4	30.2	44.2	58.6	67.0	113.9	158.3	164.9	237.5	301.6
Cracked concrete												
Combined pull-out concrete cone resistance	$N^0_{Rd,p}$	[kN]	9.4	13.2	23.5	31.2	35.6	60.5	89.7	93.5	134.6	170.9

- $s_{cr,p} = 7.3\,d\,(f_{sus} \cdot \tau_{Rk})^{0.5} \leq 3h_{ef}$
- $c_{cr,p} = s_{cr,p}/2$

Where τ_{Rk} is the value $\tau_{Rk,ucr}$ for non-cracked concrete C20/25

Table 3: Characteristic edge distance $c_{cr,p}$ and spacing $s_{cr,p}$ (f_{sus} = 1)

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Spacing	$s_{cr,p}$	[mm]	234	270	330	375	375	510	630	630	792	900
Edge distance	$c_{cr,p}$	[mm]	117	135	165	188	188	255	315	315	396	450

a. Influence of concrete strength

Table 4: Influence of concrete strength on combined pull-out and concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.02	1.04	1.07	1.08	1.09	1.10

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \frac{h_{ef}}{h_{ef,typ}}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „installation parameters".

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 5: Influence of spacing on combined pull-out and concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,p,}$ $f_{sy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,p,}$ $f_{sy,p}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,p,}$ $f_{sy,p}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,p,}$ $f_{sy,p}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,p} = 0.7 + 0.3\frac{c_x}{c_{cr,p}} \leq 1 \qquad f_{cx,2,p} = f_{cy,p} = \left(1 + \frac{c_{x(y)}}{c_{cr,p}}\right) \cdot \frac{1}{2} \leq 1$$

Table 6: Influence of edge distance on combined pull-out and concrete cone resistance

$c/c_{cr,P}$	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,55	0,60	0,65	0,70	0,75	0,70	0,75	0,90	0,95	≥ 1
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-PE 1000 WITH REBAR

e. Influence of sustained loads

$$a_{sus} = \frac{N_{sus,d}}{N_{Ed}}$$

$N_{sus,d}$ = design value of sustained actions (permanent actions & permanent component of variable actions)
N_{Ed} = Value of total actions in tension loading at ultimate limit state

Table 7: Influence of sustained loads on combined pull-out and concrete cone resistance

a_{sus}	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
f_{sus}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.80

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases.

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 8: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete												
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	23.5	28.0	37.8	45.8	45.8	72.7	99.8	99.8	145.5	170.4
Cracked concrete												
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	16.4	19.6	26.5	32.1	32.1	50.9	69.9	69.9	101.8	119.3

Table 9: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Spacing	$s_{cr,N}$	[mm]	240	270	330	375	375	510	630	630	810	900
Edge distance	$c_{cr,N}$	[mm]	120	135	165	188	188	255	315	315	405	450

Above characteristic spacing and edge distances are given for the typical effective anchorage depths. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,N} = 3\ h_{ef} \text{ and } c_{cr,N} = 1.5\ h_{ef}$$

a. Influence of concrete strength

Table 10: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 11: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 12: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-PE 1000 WITH REBAR

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

Table 13: Design resistance $N_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete												
Splitting resistance	$N^0_{Rd,sp}$	[kN]	21.4	28.0	37.8	45.8	45.8	72.7	99.8	99.8	145.5	170.4

Table 14: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Characteristic spacing	$s_{cr,sp}$	[mm]	360	420	528	600	590	816	1004	1004	1296	1440
Characteristic edge distance	$c_{cr,sp}$	[mm]	180	210	264	300	295	408	502	502	648	720
Minimum member thickness	h_{min}	[mm]	110	120	142	161	165	218	274	274	340	380

Above characteristic spacing and edge distances are given for the typical effective anchorage depth. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,sp} = 2 \cdot c_{cr,sp} \quad \text{and} \quad c_{cr,sp} = \left\{ h_{ef} \le 2\, h_{ef} \cdot \left(2.5 - \left(\frac{h_{min}}{h_{ef}}\right)\right) \le 2.4\, h_{ef} \right\}$$

and h_{min} according to the table „anchor characteristics".

a. Influence of concrete strength

Table 15: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + (n_{x(y)} - 1)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 16: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 17: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

e. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 18: Influence of concrete member thickness on splitting resistance

h/h_{min}	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.3	2.4	2.7	2.8	2.9
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

WIT-PE 1000 WITH REBAR

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot min\ \{N_{Rd,p;}\ N_{Rd,c}\}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 19: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Design steel resistance	$V_{Rd,s}$	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	82.9	90.0	112.9	147.4

2. Design concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot min\ \{N_{Rd,p};N_{Rd,c}\}$$

Table 20: factor k_8 for calculating design pry-out resistance

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

3. Design concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq max\ (10\ h_{ef}\ ;\ 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 21: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete												
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.8	3.6	4.6	5.6	5.8	8.3	12.2	12.2	14.3	17.2
Cracked concrete												
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.0	2.5	3.2	4.0	4.1	5.9	8.6	8.6	10.2	12.2

a. Influence of concrete strength

Table 22: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

Table 23: Influence of embedment depth on concrete edge resistance

h_{ef}/d	4	5	6	7	8	9	10	11	≥ 12
$f_{hef,V}$	0.87	0.91	0.94	0.97	1.00	1.02	1.05	1.07	1.08

c. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 24: Influence of spacing on concrete edge resistance

s/c_1[1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

WIT-PE 1000 R

WIT-PE 1000 WITH REBAR

d. Influence of edge distance c_1

Table 25: Influence of edge distance c_1 on concrete edge resistance

c_1/d	4	8	12	15	20	30	40	50	60	100	150	200
$f_{c1,V}$	0.47	1.19	2.05	2.76	4.05	6.95	10.22	13.76	17.54	34.66	59.52	87.35

e. Influence of edge distance c_2

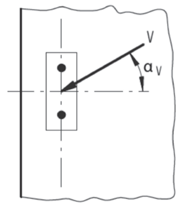
$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\frac{c_2}{1.5c_1}\right) \leq 1$$

Table 26: Influence of edge distance c_2 on concrete edge resistance

$c_{2/c1}$ [1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \leq c_2$

f. Influence of load direction



$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 27: Influence of load direction on concrete edge resistance

α[1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.

g. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 28: Influence of concrete member thickness on edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1] This verification is not required in case of shear load with lever arm

WIT-PE 1000 WITH REBAR

Design bond strength

Service temperature for working life of 50 years

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +72°C	+50°C	+72°C

Working life of 50 years

1- Non-cracked concrete

Thread size				**Ø8**	**Ø10**	**Ø12**	**Ø14**	**Ø16**	**Ø20**	**Ø24**	**Ø25**	**Ø28**	**Ø32**
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes (HD) and compressed air drilled holes (CD)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	10.7	10.7	10.7	10.7	10.7	10.7	10.0	10.0	10.0	10.0
Temperature range II	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.3	7.3
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	8.9	8.9	8.9	8.9	8.9	8.9	8.3	8.3	8.3	8.3
Temperature range II	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.1	6.1
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	9.3	9.3	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
Temperature range II	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	8.0	8.0	8.0	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Temperature range II	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	9.3	8.7	8.7	8.7	8.0	8.0	7.3	7.3	7.3	7.3
Temperature range II	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	7.3	7.3	6.7	6.7	6.7	6.3	6.3	6.3	6.0	6.0
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	7.8	7.2	7.2	7.2	5.7	5.7	5.2	5.2	5.2	5.2
Temperature range II	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	6.1	6.1	5.6	5.6	4.8	4.5	4.5	4.5	4.3	4.3

2- Cracked concrete

Thread size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Design bond resistance in cracked concrete C20/25 in hammer drilled holes (HD) compressed air drilled holes (CD) and with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	4.7	4.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
Temperature range II				4.0	4.0	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Temperature range I	Flooded bore hole			3.9	3.9	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Temperature range II				3.3	3.3	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9

Working life of 100 years

1- Non-cracked concrete

Thread size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes (HD) and compressed air drilled holes (CD)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	10.7	10.7	10.7	10.7	10.7	10.7	10.0	10.0	10.0	10.0
Temperature range II				8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.3	7.3
Temperature range I	Flooded bore hole			8.9	8.9	8.9	8.9	8.9	8.9	8.3	8.3	8.3	8.3
Temperature range II				6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.7	6.1	6.1
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	9.3	9.3	8.7	8.7	8.7	8.7	8.7	8.7	8.7	8.7
Temperature range II				8.0	8.0	8.0	7.3	7.3	7.3	7.3	7.3	7.3	7.3
Temperature range I	Flooded bore hole			7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
Temperature range II				6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1	6.1
Design bond resistance in non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	9.3	8.7	8.7	8.7	8.0	8.0	7.3	7.3	7.3	7.3
Temperature range II				7.3	7.3	6.7	6.7	6.7	6.3	6.3	6.3	6.0	6.0
Temperature range I	Flooded bore hole			7.8	7.2	7.2	7.2	5.7	5.7	5.2	5.2	5.2	5.2
Temperature range II				6.1	6.1	5.6	5.6	4.8	4.5	4.5	4.5	4.3	4.3

WIT-PE 1000 WITH REBAR

2- Cracked concrete

Thread size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Design bond resistance in cracked concrete C20/25 in hammer drilled holes (HD) compressed air drilled holes (CD) and with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	4.3	4.3	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Temperature range II	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	3.7	3.7	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Temperature range III	Flooded bore hole	$\tau_{Rd,cr}$	[N/mm²]	3.6	3.6	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2
Temperature range III	Flooded bore hole	$\tau_{Rd,cr}$	[N/mm²]	3.1	3.1	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6

Reduction factors

Working life of 50 years

1- Non-cracked concrete

Thread size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes (HD) and compressed air drilled holes (CD)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	0.75	0.75	0.75	0.75	0.75	0.75	0.80	0.80	0.73	0.73
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	0.75	0.75	0.75	0.75	0.75	0.75	0.80	0.80	0.73	0.73
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	0.86	0.86	0.92	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]	0.79	0.85	0.77	0.77	0.83	0.79	0.86	0.86	0.82	0.82
Temperature range I	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	0.79	0.85	0.77	0.77	0.83	0.79	0.86	0.86	0.82	0.82

2- Cracked concrete

Thread size					Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factor for cracked concrete C20/25 in hammer drilled holes (HD) compressed air drilled holes (CD) and with hollow drill bit (HDB)														
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II					0.86	0.86	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82
Temperature range I	Flooded bore hole				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II					0.86	0.86	0.82	0.82	0.82	0.82	0.82	0.82	0.82	0.82

Working life of 100 years

1- Non-cracked concrete

Thread size					Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes (HD) and compressed air drilled holes (CD)														
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II					0.75	0.75	0.75	0.75	0.75	0.75	0.80	0.80	0.73	0.73
Temperature range I	Flooded bore hole				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II					0.75	0.75	0.75	0.75	0.75	0.75	0.80	0.80	0.73	0.73
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes with hollow drill bit (HDB)														
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II					0.86	0.86	0.92	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Temperature range I	Flooded bore hole				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II					0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Reduction factor for non-cracked concrete C20/25 in case of compressed air cleaning (CAC)														
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm²]		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II					0.79	0.85	0.77	0.77	0.83	0.79	0.86	0.86	0.82	0.82
Temperature range I	Flooded bore hole				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II					0.79	0.85	0.77	0.77	0.83	0.79	0.86	0.86	0.82	0.82

WIT-PE 1000 WITH REBAR

2- Cracked concrete

Thread size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factor for cracked concrete C20/25 in hammer drilled holes (HD) compressed air drilled holes (CD) and with hollow drill bit (HDB)													
Temperature range I	Dry and wet concrete	$\tau_{Rd,cr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.85	0.85	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Temperature range III	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range III				0.85	0.85	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87

Mechanical characteristics

Steel grade	Rebar size			Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
	Stressed cross section	A_s	[mm²]	50	79	113	154	201	314	452	491	616	804
	Section modulus	W	[mm³]	50	98	170	269	402	785	1357	1534	2155	3217
460A	Yield strength	f_y	[N/mm²]	460	460	460	460	460	460	460	460	460	460
	Tensile strength	f_u	[N/mm²]	483	483	483	483	483	483	483	483	483	483
	Design bending moment	$M^0_{Rd,s}$	[Nm]	19	38	66	104	155	303	524	593	833	1243
460B	Yield strength	fy	[N/mm²]	460	460	460	460	460	460	460	460	460	460
	Tensile strength	fu	[N/mm²]	497	497	497	497	497	497	497	497	497	497
	Design bending moment	$M^0_{Rd,s}$	[Nm]	20	39	68	107	160	312	540	610	857	1279
B500B	Yield strength	f_y	[N/mm²]	500	500	500	500	500	500	500	500	500	500
	Tensile strength	f_u	[N/mm²]	550	550	550	550	550	550	550	550	550	550
	Design bending moment	$M^0_{Rd,s}$	[Nm]	22	43	75	118	177	345	597	675	948	1415

Material specifications

Product form		Bars and de-coiled rods		
Class		**A**	**B**	**V**
Characteristic yield strength f_{yk} or $f_{0,2k}$ (MPa)		400 to 600		
Minimum value of $k = (f_t/f_y)_k$		≥ 1,05	≥ 1,08	≥ 1,15 < 1,35
Characteristic strain at maximum force, ε_{uk} (%)		≥ 2,5	≥ 5,0	≥ 7,5
Bendability		Bend/Rebend test		
Maximum deviation from nominal mass (individual bar or wire) (%)	Nominal bar size (mm) ≤ 8 > 8	 +/- 6,0 +/- 4,5		

WIT-PE 1000 R

WIT-PE 1000 WITH REBAR

Chemical resistance

Chemical agent	Concentration	Resistant	Not Resistant
Acetic acid (Vinegar)	40		●
Acetone	10		●
Ammonia, aqueous solution	5	●	
Aniline	100		●
Beer	100	●	
Benzine (kp 100-140°F)	100	●	
Benzene	100		●
Boric Acid, aqueous solution		●	
Calcium carbonate, suspended in water	All	●	
Calcium chloride, suspended in water		●	
Calcium hydroxide, suspended in water		●	
Carbon tetrachloride	100	●	
Caustic soda (Sodium hydroxide)	40	●	
Citric acid	All	●	
Chlorine	All	●	
Diesel oil	100	●	
Ethyl alcohol, aqueous solution	50		●
Formaldehyde, aqueous solution	30	●	
Formic acid (Methanoic acid)	100		●
Formic acid (Methanoic acid)	10	●	
Freon		●	
Fuel Oil		●	
Gasoline (premium grade)	100	●	
Glycol (Ethylene glycol)		●	
Hydrogen peroxide	30		●
Hydrochloric acid (Muriatic Acid)	Conc.		●
Isopropyl alcohol	100		●
Lactic acid	All		●
Laitance		●	
Linseed oil	100	●	
Lubricating oil	100	●	
Magnesium chloride, aqueous solution	All	●	
Methanol	100		●
Motor oil (SAE 20 W-50)	100	●	
Nitric acid	10		●
Oleic acid	100	●	
Perchloroethylene	100	●	
Petroleum	100	●	
Phenol, aqueous solution (Carbonic acid)	8		●
Phosphoric acid	85	●	
Phosphoric acid	10	●	
Potash lye (potassium hydroxide, 10% and 40% solutions)		●	
Potassium carbonate, aqueous solution	All	●	
Potassium chlorite, aqueous solution	All	●	
Potassium nitrate, aqueous solution	All	●	
Sodium carbonate, aqueous solution	All	●	
Sodium chloride, aqueous solution	All	●	
Sodium phosphate, aqueous solution	All	●	
Sodium silicate	All	●	
Sulfuric acid	30		●
Tartaric acid	All	●	
Tetrachloroethylene	100	●	
Toluene			●
Turpentine	100	●	
Trichloroethylene	100		●

Properties of adhesive

Property		Testing method	Result / Mean value
Stability			
UV-resistance (sunlight)			resistant
Temperature resistance			72 °C
Water resistance			resistant
Physical properties			
Flexural properties	Flexural strength	DIN EN 196-1	after 24 hours: 66,0 N/mm²
Compressive properties	Compressive strength		after 24 hours:122 N/mm²
Tensile properties	Tensile strength	DIN EN ISO 527-2	44,2 N/mm²
	Coefficient of elasticity		6,300 N/mm²
	Mean strain at fracture		1,0 %
Shrinkage		DIN 52450	≤ 1,4 ‰
Shore-hardness A		DIN EN ISO 868	99,4
Shore-hardness D			86,1
Density		Weighing	≤ 1,50 kg/dm³
Thermal conductivity		DIN EN 993-15	0,50 W/mK
Specific heat capacity			1,350 J/Kg K
Electrical resistance		DIN IEC 93	8,0 . 10_{12} Ω
Workability features			
Water tightness / impermeability		DIN EN 12390-8	0 mm
Working time (20 °C)			3 min
Curing time (20 °C)			30 mins
Shelf-life			18 months

For information use only. Values are not to be considered as a specification and do not reflect the performance of the system. The given values are typical values and are subject to change without notice.

Working and curing times

Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1)]
0 °C to 4 °C	90 min	144 h
5 °C to 9 °C	80 min	48 h
10 °C to 14 °C	60 min	28 h
15 °C to 19 °C	40 min	18 h
20 °C to 24 °C	30 min	12 h
25 °C to 34 °C	12 min	9 h
35 °C to 39 °C	8 min	6 h
+40 °C	8 min	4 h

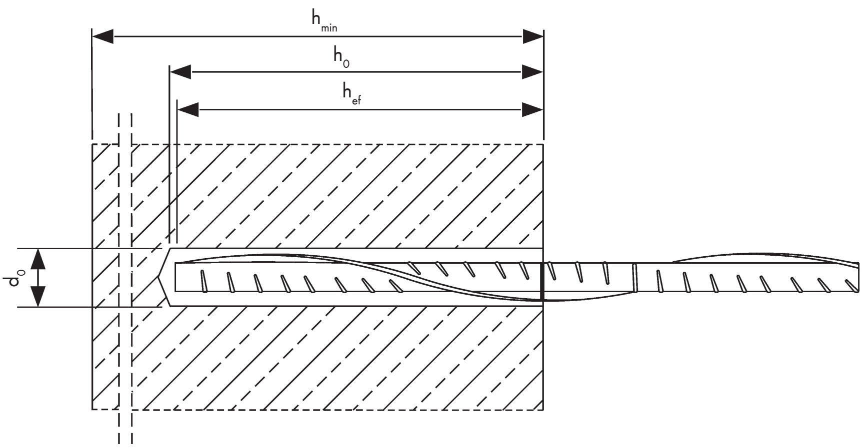
[1)] for wet base material the curing time must be doubled

WIT-PE 1000 WITH REBAR

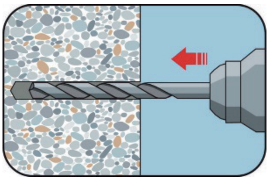
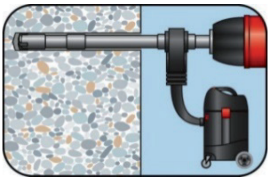
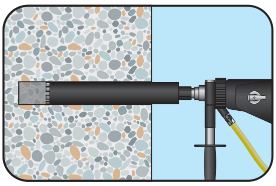
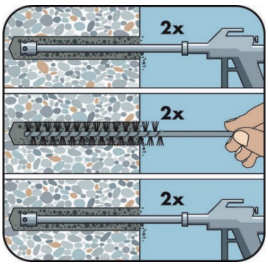
Installation parameters

<table>
<tr><td>Rebar size</td><td></td><td></td><td colspan="2">Ø 8[1)]</td><td colspan="2">Ø 10[1)]</td><td colspan="2">Ø 12[1)]</td><td colspan="2">Ø 14</td><td colspan="2">Ø 16</td><td colspan="2">Ø 20</td><td colspan="2">Ø 24[1)]</td><td colspan="2">Ø 25[1)]</td><td colspan="2">Ø 28</td><td colspan="2">Ø 32</td></tr>
<tr><td>Diameter of element</td><td>$d = d_{nom}$</td><td>[mm]</td><td colspan="2">8</td><td colspan="2">10</td><td colspan="2">12</td><td colspan="2">14</td><td colspan="2">16</td><td colspan="2">20</td><td colspan="2">24</td><td colspan="2">25</td><td colspan="2">28</td><td colspan="2">32</td></tr>
<tr><td>Nominal drill hole diameter</td><td>d_0</td><td>[mm]</td><td>10</td><td>12</td><td>12</td><td>14</td><td>14</td><td>16</td><td colspan="2">18</td><td colspan="2">20</td><td colspan="2">25</td><td>30</td><td>32</td><td>30</td><td>32</td><td colspan="2">35</td><td colspan="2">40</td></tr>
<tr><td rowspan="2">Effective anchorage depth</td><td>$h_{ef,min}$</td><td>[mm]</td><td colspan="2">60</td><td colspan="2">60</td><td colspan="2">70</td><td colspan="2">75</td><td colspan="2">80</td><td colspan="2">90</td><td colspan="2">96</td><td colspan="2">100</td><td colspan="2">112</td><td colspan="2">128</td></tr>
<tr><td>$h_{ef,max}$</td><td>[mm]</td><td colspan="2">160</td><td colspan="2">200</td><td colspan="2">240</td><td colspan="2">280</td><td colspan="2">320</td><td colspan="2">400</td><td colspan="2">480</td><td colspan="2">500</td><td colspan="2">560</td><td colspan="2">640</td></tr>
<tr><td>Minimum thickness of member</td><td>h_{min}</td><td>[mm]</td><td colspan="5">h_{ef} + 30 mm ≥ 100 mm</td><td colspan="15">$h_{ef} + 2d_0$</td></tr>
<tr><td>Minimum spacing</td><td>s_{min}</td><td>[mm]</td><td colspan="2">40</td><td colspan="2">50</td><td colspan="2">60</td><td colspan="2">70</td><td colspan="2">75</td><td colspan="2">85</td><td colspan="2">120</td><td colspan="2">120</td><td colspan="2">130</td><td colspan="2">150</td></tr>
<tr><td>Minimum edge distance</td><td>c_{min}</td><td>[mm]</td><td colspan="2">35</td><td colspan="2">40</td><td colspan="2">45</td><td colspan="2">50</td><td colspan="2">50</td><td colspan="2">60</td><td colspan="2">70</td><td colspan="2">70</td><td colspan="2">75</td><td colspan="2">85</td></tr>
</table>

[1)] both nominal drill hole diameter can be used

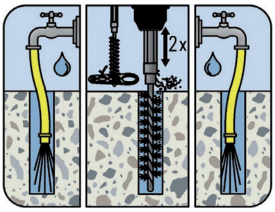


Installation instructions

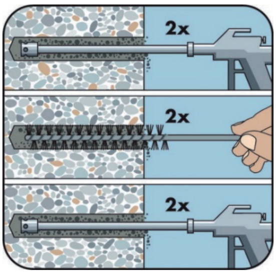
A) Bore hole drilling		
	**1a.**	**Hammer (HD) or compressed air drilling (CD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. Proceed with Step B1.
	**1b.**	**Hollow drill bit system (HDB)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. This drilling system removes the dust and cleans the bore hole during drilling. Proceed with Step C.
	**1c.**	**Diamond drilling (DD)** Drill with diamond drill a hole into the base material to the size and embedment depth required by the selected anchor. Proceed with Step B2.
B1) Bore hole cleaning		
CAC: Cleaning for all bore hole diameter and bore hole depth with drilling method HD and CD		
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of two times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.

WIT-PE 1000 WITH REBAR

B2) Bore hole cleaning

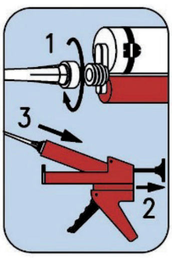
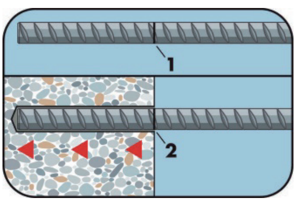
	**2a.**	Rinsing with water until clear water comes out.
	2b.	Check the brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of two times in a twisting motion. If the bore hole ground is not reached with the brush, a brush extension must be used.
	2c.	Rinsing again with water until clear water comes out.

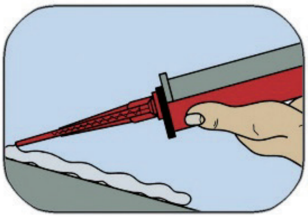
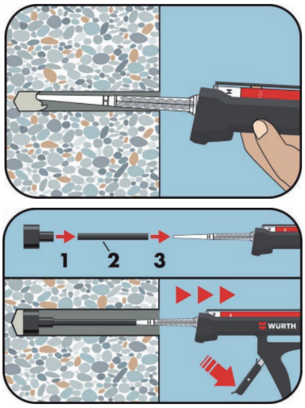
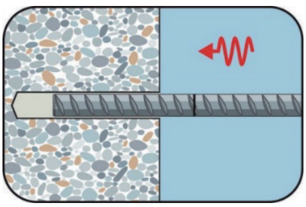
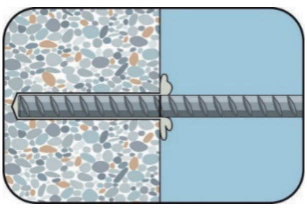
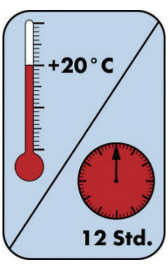
Attention! Standing water in the bore hole must be removed before proceeding to cleaning.

	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,mi}$n a minimum of two times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.

After cleaning, the bore hole has to be protected against re-contamination in an appropriate way until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must no contaminate the bore hole again.

C) Preparation of bar and cartridge

	**3a.**	Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time as well as for every new cartridge, a new static-mixer shall be used.
	**3b.**	Prior to inserting the reinforcing bar into the filled bore hole, the position of the embedment depth shall be marked (e.g. with tape) on the reinforcing bar. After that, insert the bar in the empty hole to verify hole and depth lv. The anchor should be free of dirt, grease, oil and other foreign material.

	**3c.**	Prior to dispensing into the bore hole, squeeze out separately the mortar until it shows a consistent grey or red color (minimum of three full strokes) and discard non-uniformly mixed adhesive components.
D) Filling the bore hole		
	**4.**	Starting from the bottom or back of the cleaned bore hole, fill the hole with adhesive until the level mark at the mixer extension is visible at the top of the hole. For embedment larger than 190 mm, an extension nozzle shall be used. Slowly withdraw the static mixing nozzle. Using a piston plug during injection of the mortar helps to avoid creating air pockets. For overhead and horizontal installation and bore holes deeper than 240 mm, a piston plug and the appropriate mixer extension must be used. Observe the gel-/working times.
E) Setting the rebar		
	**5a.**	Push the reinforcing bar into the bore hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached. The bar should be free of dirt, grease, oil or other foreign material.
	**5b.**	Be sure that the bar is inserted in the bore hole until the embedment mark is at the concrete surface and that excess mortar is visible at the top of the hole. If these requirements are not maintained, the application has to be renewed. For horizontal and overhead installation, fix embedded part (e.g. with wedges).
	**5c.**	Observe gelling time t_{gel}. Attend that the gelling time can vary according to the base material temperature. Do not move or load the bar until full curing time t_{cure} has elapsed.

WIT-PE 1000 WITH REBAR

Filling Quantity

Anchor type: M8 - M30

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Nominal drill hole diameter	d_0	[mm]	12	14	16	18	20	25	32	32	35	40
Drill depth	h_0 / h_1	[mm]	= l_v									
Filling volume per 10mm embedment depth		[ml]	0.81	1.01	1.21	1.43	1.66	2.59	4.85	4.47	5.07	6.62

Assumed waste of 15 % included.

WIT-PE 510 WITH THREADED ROD (METRIC)

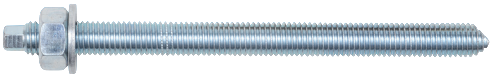
440 ml

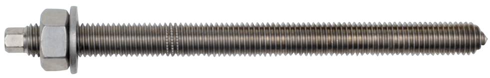
585 ml

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Cartridge sizes		Art. no.
440 ml	side-by-side	**5918 615 440**
585 ml	side-by-side	**5918 615 585**


Galvanized (5 microns): M8 - M30


Stainless steel - A4 (AISI 316): M8 - M30

Type of installation		
Pre-positioned	In-place	Stand-off
✓	✓	✓

Installation condition		
Dry concrete	Wet concrete	Flooded drill hole
✓	✓	✓

Drilling method		
Hammer drill	Diamond drill	Hollow drill
✓	-	✓

Applications




Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt. Berlin	EAD 330499-01-0601	ETA-20/1038. 02.02.2021

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness and embedment depth are according to anchor characteristics
- Anchor material according is to specifications. steel grade 5.8 unless otherwise stated
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²
- Temperature range I (min. base material temperature -40°C, max long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling

Characterstic resistance

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	18.0	29.0	42.0	68.8	109.0	149.7	182.9	218.2
	C50/60			18.0	29.0	42.0	78.0	122.0	176.0	230.0	280.0
Shear	≥ C20/25	V_{Rk}	[kN]	11.0	17.0	25.0	47.0	74.0	106.0	138.0	168.0
Cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	14.1	19.8	29.0	44.0	74.8	95.0	122.1	152.7
	C50/60			15.5	21.8	31.9	48.4	82.2	104.5	134.4	167.9
Shear	≥ C20/25	V_{Rk}	[kN]	11.0	17.0	25.0	47.0	74.0	106.0	138.0	168.0

Design resistance

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	12.0	19.3	27.0	32.7	51.9	71.3	87.1	103.9
	C50/60			12.0	19.3	28.0	46.1	78.3	107.8	137.7	164.3
Shear	≥ C20/25	V_{Rd}	[kN]	8.8	13.6	20.0	37.6	59.2	84.8	110.4	134.4
Cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	6.7	9.4	13.8	20.9	35.6	45.2	58.2	72.7
	C50/60			7.4	10.4	15.2	23.0	39.2	49.8	64.0	80.0
Shear	≥ C20/25	V_{Rd}	[kN]	8.8	13.6	20.0	37.6	59.2	84.8	110.4	134.4

WIT-PE 510 WITH THREADED ROD (METRIC)

Recommended/allowable loads [1)]

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete											
Tension	C20/25	N_{rec}	[kN]	8.6	13.8	19.3	23.4	37.1	50.9	62.2	74.2
	C50/60			8.6	13.8	20.0	32.9	56.0	77.0	98.4	117.4
Shear	≥ C20/25	V_{rec}	[kN]	6.3	9.7	14.3	26.9	42.3	60.6	78.9	96.0
Cracked concrete											
Tension	C20/25	N_{rec}	[kN]	4.8	6.7	9.9	15.0	25.4	32.3	41.5	51.9
	C50/60			5.3	7.4	10.9	16.5	28.0	35.5	45.7	57.1
Shear	≥ C20/25	V_{rec}	[kN]	6.3	9.7	14.3	26.9	42.3	60.6	78.9	96.0

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Temperature range 1 (min. base material temperature -40°C, max. long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling (Installation factors might apply for other drilling methods)
- Anchor material according to specifications, steel grade 5.8 unless otherwise stated in the tables

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b;N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Design steel resistance	5.8	$N_{Rd,s}$	[kN]	12.0	19.3	28.0	52.0	81.3	117.3	153.3	186.7
	8.8	$N_{Rd,s}$	[kN]	19.3	30.7	44.7	83.3	130.7	188.0	245.3	299.3
	A4	$N_{Rd,s}$	[kN]	13.9	21.9	31.6	58.8	91.4	132.1	80.4	98.3

WIT-PE 510 WITH THREADED ROD (METRIC)

2. Design combined pull-out and concrete cone resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of combined pull-out and concrete cone failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	14.4	20.2	29.6	41.9	71.2	98.0	126.0	157.5
Cracked concrete										
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	6.7	9.4	13.8	20.9	35.6	45.2	58.2	72.7

- $s_{cr,p} = 7.3\, d\, (f_{sus} \cdot \tau_{Rk})^{0.5} \leq 3h_{ef}$
- $c_{cr,p} = s_{cr,p}/2$

Where τ_{Rk} is the value $\tau_{Rk,ucr}$ for non-cracked concrete C20/25

Table 3: Characteristic edge distance $c_{cr,p}$ and spacing $s_{cr,p}$ (f_{sus} = 1)

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Spacing	$s_{cr,p}$	[mm]	226	270	330	375	510	630	711	790
Edge distance	$c_{cr,p}$	[mm]	113	135	165	188	255	315	355	395

a. Influence of concrete strength

Table 4: Influence of concrete strength on combined pull-out and concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.02	1.04	1.07	1.08	1.09	1.10

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \frac{h_{ef}}{h_{ef,typ}}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „installation parameters".

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 5: Influence of spacing on combined pull-out and concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,p}$, $f_{sy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,p}$, $f_{sy,p}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,p}$, $f_{sy,p}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,p}$, $f_{sy,p}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,p} = 0.7 + 0.3\frac{c_x}{c_{cr,p}} \leq 1 \qquad f_{cx,2,p} = f_{cy,p} = \left(1 + \frac{c_{x(y)}}{c_{cr,p}}\right) \cdot \frac{1}{2} \leq 1$$

Table 6: Influence of edge distance on combined pull-out and concrete cone resistance

$c/c_{cr,P}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,p}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,p}$, $f_{cy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-PE 510 WITH THREADED ROD (METRIC)

e. Influence of sustained loads

$$a_{sus} = \frac{N_{sus,d}}{N_{Ed}}$$

$N_{sus,d}$ = design value of sustained actions (permanent actions & permanent component of variable actions)

N_{Ed} = Value of total actions in tension loading at ultimate limit state

Table 7: Influence of sustained loads on combined pull-out and concrete cone resistance

a_{sus}	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
f_{sus}	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.80	0.70	0.60

3. Design Concrete Cone Resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases.

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 8: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	16.8	20.0	27.0	32.7	51.9	71.3	87.1	103.9
Cracked concrete										
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	11.7	14.0	18.9	22.9	36.3	49.9	61.0	72.7

Table 9: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Spacing	$s_{cr,N}$	[mm]	240	270	330	375	510	630	720	810
Edge distance	$c_{cr,N}$	[mm]	120	135	165	188	255	315	360	405

Above characteristic spacing and edge distances are given for the typical effective anchorage depths. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$s_{cr,N} = 3\ h_{ef}$ and $c_{cr,N} = 1.5\ h_{ef}$

a. Influence of concrete strength

Table 10: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,\,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 11: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 12: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-PE 510 WITH THREADED ROD (METRIC)

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

Table 13: Design resistance $N_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Concrete splitting resistance	$N^0_{Rd,c}$	[kN]	14.4	20.0	27.0	32.7	51.9	71.3	87.1	103.9

Table 14: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Thread size			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Spacing	$s_{cr,sp}$	[mm]	360	420	528	600	816	1008	1152	1296
Edge distance	$c_{cr,sp}$	[mm]	180	210	264	300	408	504	576	648
Minimum member thickness	h_{min}	[mm]	110	120	140	161	218	266	304	340

Above characteristic spacing and edge distances are given for the typical effective anchorage depth. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,sp} = 2 \cdot c_{cr,sp} \quad \text{and} \quad c_{cr,sp} = \left\{ h_{ef} \leq 2\, h_{ef} \cdot \left(2.5 - \left(\frac{h_{min}}{h_{ef}}\right)\right) \leq 2.4\, h_{ef} \right\}$$

and h_{min} according to the table „anchor characteristics".

a. Influence of concrete strength

Table 15: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx,\,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 16: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 17: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

e. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 18: Influence of concrete member thickness on splitting resistance

h/h_{min}	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.3	2.4	2.7	2.8	2.9
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

WIT-PE 510 WITH THREADED ROD (METRIC)

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot min\ \{N_{Rd,p;} N_{Rd,c}\}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 19: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Design steel resistance	5.8	$V_{Rd,s}$	[kN]	8.8	13.6	20.0	37.6	59.2	84.8	110.4	134.4
	8.8		[kN]	12.0	18.4	27.2	50.4	78.4	112.8	147.2	179.2
	A4		[kN]	8.3	12.8	19.2	35.3	55.1	79.5	48.3	58.8

2. Design concrete pry-out resistance

$$V_{Rd.c} = k_8 \cdot min\ \{N_{Rd.p};N_{Rd.c}\}$$

Table 20: factor k_8 for calculating design pry-out resistance

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

3. Design concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq max\ (10\ h_{ef}\ ;\ 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 21: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.8	3.6	4.6	5.8	8.3	10.3	13.1	15.2
Cracked concrete										
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.0	2.5	3.2	4.1	5.9	7.3	9.3	10.7

a. Influence of concrete strength

Table 22: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

Table 23: Influence of embedment depth on concrete edge resistance

h_{ef}/d	4	5	6	7	8	9	10	11	≥ 12
$f_{hef,V}$	0.87	0.91	0.94	0.97	1.00	1.02	1.05	1.07	1.08

[1] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 24: Influence of spacing on concrete edge resistance

s/c_1[1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s. when there are different spacing in the row closest to the edge.

d. Influence of edge distance c_1

Table 25: Influence of edge distance c_1 on concrete edge resistance

$c_{1/d}$	4	8	12	15	20	30	40	50	60	100	150	200
$f_{c1,V}$	0.47	1.19	2.05	2.76	4.05	6.95	10.22	13.76	17.54	34.66	59.52	87.35

WIT-PE 510 WITH THREADED ROD (METRIC)

e. Influence of edge distance c_2

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\frac{c_2}{1.5c_1}\right) \leq 1$$

Table 26: Influence of edge distance c_2 on concrete edge resistance

c_2/c_1 [1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \leq c_2$

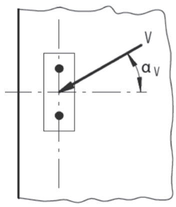
f. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 27: Influence of load direction on concrete edge resistance

α [1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.



g. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 28: Influence of concrete member thickness on edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

WIT-PE 510 M

WIT-PE 510 WITH THREADED ROD (METRIC)

Design bond strength

Service temperature for working life of 50 years

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +60°C	+35°C	+60°C
Temperature range III	- 40°C to +70°C	+43°C	+70°C

Working life of 50 years

1- Non-cracked concrete

Thread size				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes (HD), with hollow drill bit (HDB), and compressed air drilled holes (CD)											
Temperature range I	Dry, wet concrete and flooded bore holee	$\tau_{Rd,ucr}$	[N/mm²]	7.14	7.14	7.14	6.67	6.67	6.19	6.19	6.19
Temperature range II				4.76	4.76	4.76	4.52	4.52	4.29	4.29	4.29
Temperature range III				3.33	3.33	3.33	3.10	3.10	2.86	2.86	2.86

2- Cracked concrete

Thread size				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Design bond resistance in cracked concrete C20/25 in hammer drilled holes (HD), with hollow drill bit (HDB), and compressed air drilled holes (CD)											
Temperature range I	Dry, wet concrete and flooded bore holee	$\tau_{Rd,ucr}$	[N/mm²]	3.33	3.33	3.33	3.33	3.33	2.86	2.86	2.86
Temperature range II				2.38	2.38	2.38	2.38	2.38	2.14	2.14	2.14
Temperature range III				1.67	1.67	1.67	1.67	1.67	1.43	1.43	1.43

Reduction factors

Working life of 50 years

1- Non-cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Reduction factor for non-cracked concrete C20/25 in hammer drilled holes (HD), with hollow drill bit (HDB), and compressed air drilled holes (CD)											
Temperature range I	Dry, wet concrete and flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.67	0.67	0.67	0.68	0.68	0.69	0.69	0.69
Temperature range III				0.47	0.47	0.47	0.46	0.46	0.46	0.46	0.46

2- Cracked concrete

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Reduction factor for in cracked concrete C20/25 in hammer drilled holes (HD), with hollow drill bit (HDB), and compressed air drilled holes (CD)											
Temperature range I	Dry, wet concrete and flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.71	0.71	0.71	0.71	0.71	0.75	0.75	0.75
Temperature range III				0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50

WIT-PE 510 WITH THREADED ROD (METRIC)

Mechanical characteristics

Steel grade	Thread size			M8	M10	M12	M16	M20	M24	M27	M30
	Stressed cross section	A_s	[mm²]	37	58	84	157	245	352	459	561
	Section modulus	W	[mm³]	31	62	109	277	541	935	1387	1874
4.6	Yield strength	f_y	[N/mm²]	240	240	240	240	240	240	240	240
	Tensile strength	f_u	[N/mm²]	400	400	400	400	400	400	400	400
	Design bending moment	$M^0_{Rd,s}$	[Nm]	9.0	18.0	31.1	79.6	155.7	268.9	398.8	538.9
4.8	Yield strength	f_y	[N/mm²]	320	320	320	320	320	320	320	320
	Tensile strength	f_u	[N/mm²]	400	400	400	400	400	400	400	400
	Design bending moment	$M^0_{Rd,s}$	[Nm]	12.0	24.0	41.6	106.4	208.0	359.2	532.8	720.0
5.6	Yield strength	f_y	[N/mm²]	300	300	300	300	300	300	300	300
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	11.4	22.2	38.9	99.4	194.0	335.3	498.8	672.5
5.8	Yield strength	f_y	[N/mm²]	400	400	400	400	400	400	400	400
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	15.2	29.6	52	132.8	259.2	448	666.4	898.4
8.8	Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640
	Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800
	Design bending moment	$M^0_{Rd,s}$	[Nm]	24.0	48.0	84.0	212.8	415.2	716.8	1066.4	1437.6
A4-50	Yield strength	f_y	[N/mm²]	210	210	210	210	210	210	210	210
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	8.0	15.5	27.7	70.2	136.6	235.7	349.6	472.7
A4-70	Yield strength	f_y	[N/mm²]	450	450	450	450	450	450	-	-
	Tensile strength	f_u	[N/mm²]	700	700	700	700	700	700	-	-
	Design bending moment	$M^0_{Rd,s}$	[Nm]	16.7	33.3	59.0	148.7	291.0	502.6	-	-

Material specifications

Part	Designation	Material				
Steel, zinc plated (Steel acc. to EN 10087:1998 or EN 10263:2001)						
- zinc plated	≥ 5 µm	acc. to EN ISO 4042:1999				
- hot-dip galvanized	≥ 40 µm	acc. to EN ISO 1461:2009 and EN ISO 10684:2004+AC:2009				
- sherardized	≥ 45 µm	acc. to EN ISO 17668:2016				
1	Anchor rod	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 898-1:2013	4.6	f_{uk} = 400 N/mm²	f_{yk} = 240 N/mm²	A5 > 8%
			4.8	f_{uk} = 400 N/mm²	f_{yk} = 320 N/mm²	A5 > 8%
			5.6	f_{uk} = 500 N/mm²	f_{yk} = 300 N/mm²	A5 > 8%
			5.8	f_{uk} = 500 N/mm²	f_{yk} = 400 N/mm²	A5 > 8%
			8.8	f_{uk} = 800 N/mm²	f_{yk} = 640 N/mm²	A5 > 12% [3)]
2	Hexagon nut	acc. to EN ISO 898-2:2012	4	for anchor rod class 4.6 or 4.8		
			5	for anchor rod class 5.6 or 5.8		
			8	for anchor rod class 8.8		
3a	Washer	Steel, zinc plated, hot-dip galvanized or sherardized (e.g.: EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000, or EN ISO 7094:2000)				
3b	Filling washer	Steel, zinc plated, hot-dip galvanized or sherardized				
4	Internal threaded anchor rod	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 898-1:2013	5.8	f_{uk} = 500 N/mm²	f_{yk} = 400 N/mm²	A5 > 8%
			8.8	f_{uk} = 800 N/mm²	f_{yk} = 640 N/mm²	A5 > 8%

WIT-PE 510 WITH THREADED ROD (METRIC)

Part	Designation	Material				
Stainless steel A2 (Material 1.4301 / 1.4303 / 1.4307 / 1.4567 or 1.4541, acc. to EN 1088-1:2014) **Stainless steel A4** (Material 1.4401 / 1.4404 / 1.4571 / 1.4362 or 1.4578, acc. to EN 10088-1:2014) **High corrosion resistance steel** (Material 1.4529 or 1.4565, acc. to EN 10088-1:2014)						
1	Anchor rod [1) 4)]	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 3506-1:2009	50	f_{uk} = 400 N/mm²	f_{yk} = 240 N/mm²	A5 > 12% [3)]
			70	f_{uk} = 400 N/mm²	f_{yk} = 320 N/mm²	A5 > 12% [3)]
			80	f_{uk} = 500 N/mm²	f_{yk} = 300 N/mm²	A5 > 12% [3)]
2	Hexagon nut [1) 4)]	acc. to EN ISO 3506-1:2009	50	for anchor rod class 50		
			70	for anchor rod class 70		
			80	for anchor rod class 80		
3a	Washer	Stainless steel A2 (Material 1.4301 / 1.4303 / 1.4307 / 1.4567 or 1.4541, acc. to EN 1088-1:2014) Stainless steel A4 (Material 1.4401 / 1.4404 / 1.4571 / 1.4362 or 1.4578, acc. to EN 10088-1:2014) HCR: Material 1.4529 or 1.4565, acc. to EN 10088-1:2014 (e.g.: EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000, or EN ISO 7094:2000)				
3b	Filling washer	Stainless steel A4. High corrosion resistance steel				
4	Internal threaded anchor rod [1) 2)]	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 3506-1:2009	50	f_{uk} = 500 N/mm²	f_{yk} = 210 N/mm²	A5 > 8%
			70	f_{uk} = 700 N/mm²	f_{yk} = 450 N/mm²	A5 > 8%

1) Property class 70 for anchor rods up to M24 and Internal threaded anchor rods up to IG-M16

2) for IG-M20 only property class 50

3) A_5 > 8% fracture elongation if no requirement for performance category C2 exists

4) Property class 80 only for stainless steel A4

Working and curing times

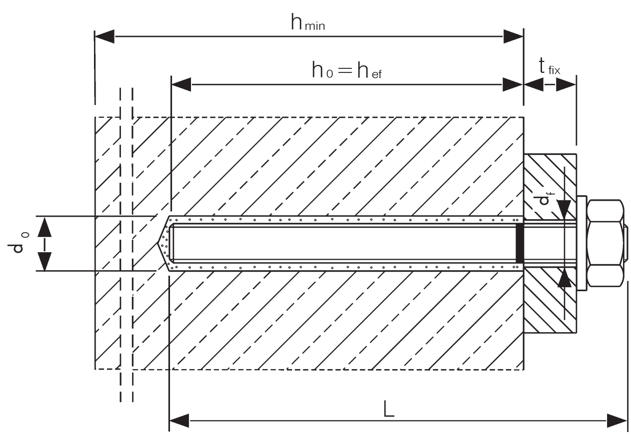
Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1)]
5 °C to 9 °C	80 min	60 h
10 °C to 14 °C	60 min	48 h
15 °C to 19 °C	40 min	24 h
20 °C to 24 °C	30 min	12 h
25 °C to 34 °C	12 min	10 h
35 °C to 39 °C	8 min	7 h
+40 °C	8 min	4 h

[1)] for wet base material the curing time must be doubled

Installation parameters

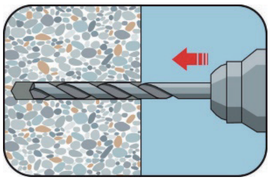
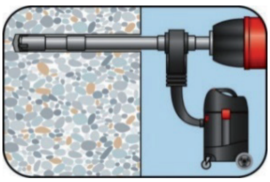
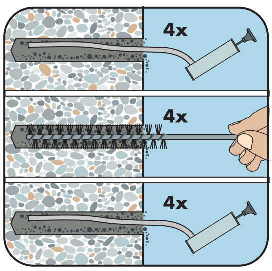
Anchor size			M8	M10	M12	M16	M20	M24	M27	M30
Diameter of element	$d = d_{nom}$	[mm]	8	10	12	16	20	24	27	30
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	22	28	30	35
Effective anchorage depth	$h_{ef,min}$	[mm]	60	60	70	80	90	96	108	120
	$h_{ef,max}$	[mm]	160	200	240	320	400	480	540	600
Diameter of clearance in hole in the fixture	Prepositioned installation $d_f \leq$	[mm]	9	12	14	18	22	26	30	33
	Push through installation df	[mm]	12	14	16	20	24	30	33	40
Maximum torque moment	max $T_{inst} \leq$	[Nm]	10	20	40 [1)]	60	100	170	250	300
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 mm			$h_{ef} + 2d_0$				
Minimum spacing	s_{min}	[mm]	40	50	60	75	95	115	125	140
Minimum edge distance	c_{min}	[mm]	35	40	45	50	60	65	75	80

[1)] Maximum torque moment for M12 with steel Grade 4.6 is 35 Nm



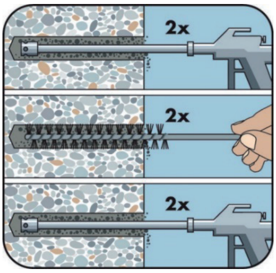
WIT-PE 510 WITH THREADED ROD (METRIC)

Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer (HD) or compressed air drilling (CD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. Proceed with Step B1. In case of aborted drill hole, the drill hole shall be filled with mortar.
	**1b.**	**Hollow drill bit system (HDB)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. This drilling system removes the dust and cleans the bore hole during drilling (all conditions). Proceed with Step C. In case of aborted drill hole, the drill hole shall be filled with mortar.
Attention! Standing water in the bore hole must be removed before cleaning.		
B1) Bore hole cleaning		
MAC: Cleaning for dry and wet bore holes with diameter d0 ≤ 20 mm and bore hole depth h ≤ 10 dnom (non-cracked concrete only!)		
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean with a hand pump a minimum of <u>four</u> times until return air stream is free of noticeable dust.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of <u>four</u> times in a twisting motion. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with a hand pump a minimum of <u>four</u> times until return air stream is free of noticeable dust.
After cleaning, the bore hole has to be protected against re-contamination in an appropriate way until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must no contaminate the bore hole again.		

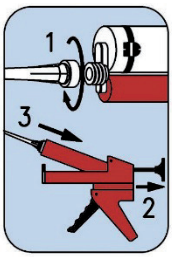
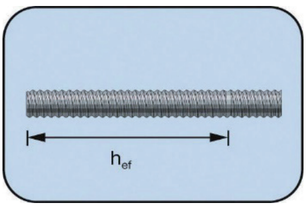
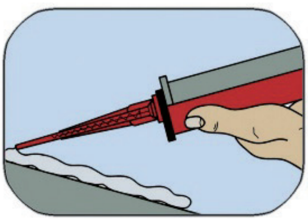
B2) Bore hole cleaning

CAC: Cleaning for dry, wet and water-filled bore holes for all diameters in non-cracked and cracked concrete

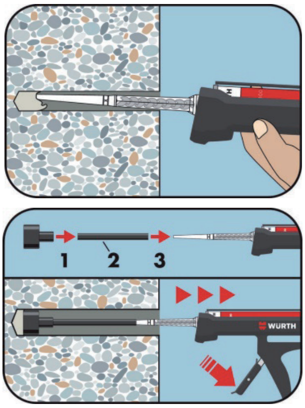
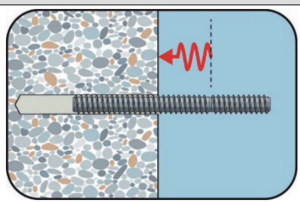
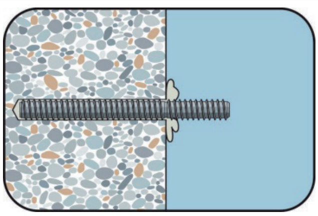
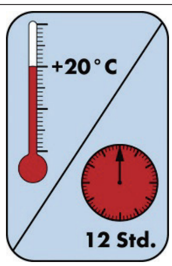
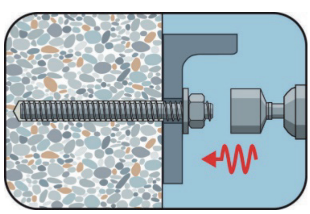
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of two times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.

After cleaning, the bore hole has to be protected against re-contamination in an appropriate way until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must no contaminate the bore hole again.

C) Preparation of bar and cartridge

	**3a.**	Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time as well as for every new cartridge, a new static-mixer shall be used.
	**3b.**	Prior to inserting the anchor rod into the filled bore hole, the position of the embedment depth shall be marked on the anchor rod. After that, insert the rod in the empty hole to verify hole and depth lv. The anchor should be free of dirt, grease, oil and other foreign material.
	**3c.**	Prior to dispensing into the bore hole, squeeze out separately the mortar until it shows a consistent grey or red color (minimum of three full strokes) and discard non-uniformly mixed adhesive components.

WIT-PE 510 WITH THREADED ROD (METRIC)

D) Filling the bore hole		
	**4.**	Starting from the bottom or back of the cleaned bore hole, fill the hole up to approximately two-thirds with adhesive. Slowly withdraw the static mixing nozzle as the hole fills to avoid creating air pockets. If the bottom or back of the anchor hole is not reached, an appropriate extension nozzle must be used. Observe the gel-/working times. Piston plugs and mixer nozzle extensions shall be used for the following applications: • Horizontal assembly (horizontal direction) and ground erection (vertical downwards direction): Drill bit-Ø $d_0 \geq 18$ mm and embedment depth hef > 250 mm • Overhead assembly (vertical upwards direction): Drill bit-Ø $d_0 \geq 18$ mm
E) Setting the rebar		
	**5a.**	Push the anchor rod into the bore hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached. The rod should be free of dirt, grease, oil or other foreign material.
	**5b.**	After inserting the anchor, the annular gap between the anchor rod and concrete, in case of a push through installation, in addition to the fixture, must be completely filled with mortar. Be sure that the anchor rod is inserted in the bore hole until the embedment mark is at the concrete surface and that excess mortar is visible at the top of the hole. If these requirements are not maintained, the application has to be renewed. For overhead installation, fix embedded part (e.g. with wedges).
	**5c.**	Allow the adhesive to cure to the specified time prior to applying any load or torque. Do not move or load the anchor until it is fully cured.
	**5d.**	After full curing, the add-on part can be installed with up to the max. torque by using a calibrated torque wrench. In case of prepositioned installation, the annular gap between the anchor and fixture can be optionally filled with mortar. Therefore, substitute the washer by the filling washer and connect the mixer reduction nozzle to the tip of the mixer. The annular gap is filled with mortar when mortar oozes out of the washer.

Filling quantity

Anchor type: M8 - M30

Anchor size			M8	M10	M12	M16	M20	M24	M27	M30
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	22	28	30	35
Drill depth	h_0 / h_1	[mm]	$= h_{ef}$							
Filling volume per 10mm embedment depth		[ml]	0.53	0.70	0.89	1.27	1.78	3.35	3.22	5.10

Assumed waste of 15 % included.

WIT-PE 510 WITH REBAR

440 ml 585 ml

Ø8 - Ø32

Rebar not supplied by Würth

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Cartridge sizes		Art. no.
440 ml	side-by-side	**5918 615 440**
585 ml	side-by-side	**5918 615 585**

Installation condition		
Dry concrete	Wet concrete	Flooded drill hole
✓	✓	✓

Drilling method		
Hammer drill	Diamond drill	Hollow drill
✓	✓	✓

Applications




Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt, Berlin	EAD 330499-01-0601	ETA-20/1038, 02.04.2021
European Technical Assessment	DIBt, Berlin	EAD 330087-00-0601	ETA-20/1037, 04.03.2021

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness and embedment depth are according to anchor characteristics
- Rebar material is according to specifications, steel grade B500B
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²
- Temperature range I (min. base material temperature -40°C, max long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling

Characteristic resistance

Rebar size				**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete													
Tension	C20/25	N_{Rk}	[kN]	27.5	39.6	56.8	66.0	68.8	109.0	149.7	149.7	218.2	255.6
	C50/60			27.5	43.5	62.2	72.6	82.9	141.0	209.0	199.6	287.4	364.9
Shear	≥ C20/25	V_{Rk}	[kN]	13.8	21.7	31.1	42.4	55.3	86.4	124.3	135.0	169.4	221.1
Cracked concrete													
Tension	C20/25	N_{Rk}	[kN]	12.1	19.8	29.0	35.7	40.8	64.1	95.0	99.0	130.6	165.9
	C50/60			13.3	21.8	31.9	39.3	44.9	70.5	104.5	108.9	143.7	182.5
Shear	≥ C20/25	V_{Rk}	[kN]	13.8	21.7	31.1	42.4	55.3	86.4	124.3	135.0	169.4	221.1

Design resistance

Rebar size				**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete													
Tension	C20/25	N_{Rd}	[kN]	13.4	18.8	27.0	31.4	32.7	51.9	71.3	71.3	103.9	121.7
	C50/60			14.7	20.7	30.4	34.6	39.5	67.1	99.5	95.0	136.8	173.8
Shear	≥ C20/25	V_{Rd}	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	82.9	90.0	112.9	147.4
Cracked concrete													
Tension	C20/25	N_{Rd}	[kN]	5.7	9.4	13.8	17.0	19.4	30.5	45.2	47.1	62.2	79.0
	C50/60			6.3	10.4	15.2	18.7	21.4	33.6	49.8	51.8	68.4	86.9
Shear	≥ C20/25	V_{Rd}	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	82.9	90.0	112.9	147.4

WIT-PE 510 WITH REBAR

Recommended/allowable loads [1)]

Rebar size				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete													
Tension	C20/25	N_{rec}	[kN]	9.6	13.5	19.3	22.4	23.4	37.1	50.9	50.9	74.2	86.9
	C50/60			10.5	14.8	21.7	24.7	28.2	48.0	71.1	67.9	97.7	124.1
Shear	≥ C20/25	V_{rec}	[kN]	6.5	10.3	14.8	20.2	26.3	41.1	59.2	64.3	80.7	105.3
Cracked concrete													
Tension	C20/25	N_{rec}	[kN]	4.1	6.7	9.9	12.2	13.9	21.8	32.3	33.7	44.4	56.4
	C50/60			4.5	7.4	10.9	13.4	15.3	24.0	35.5	37.0	48.9	62.1
Shear	≥ C20/25	V_{rec}	[kN]	6.5	10.3	14.8	20.2	26.3	41.1	59.2	64.3	80.7	105.3

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Temperature range 1 (min. base material temperature -40°C, max. long term/short term base material temperature: +24°C/40°C)
- Dry or wet conditions of drill hole, hammer drilling (Installation factors might apply for other drilling methods)
- Rebar material according to specifications, steel grade B500B

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b;N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 24	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Design steel resistance	$N_{Rd,s}$	[kN]	19.6	31.0	44.4	60.5	79.0	123.4	177.6	192.9	242.0	315.9

WIT-PE 510 WITH REBAR

2. Design combined pull-out and concrete cone resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of combined pull-out and concrete cone failure of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete												
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	13.4	18.8	27.6	31.4	35.9	61.0	90.5	86.4	124.4	158.0
Cracked concrete												
Combined pull-out concrete cone resistance	$N^0_{Rd,p}$	[kN]	5.7	9.4	13.8	17.0	19.4	30.5	45.2	47.1	62.2	79.0

- $s_{cr,p} = 7.3\, d\, (f_{sus} \cdot \tau_{Rk})^{0.5} \leq 3h_{ef}$
- $c_{cr,p} = s_{cr,p}/2$

Where τ_{Rk} is the value $\tau_{Rk,ucr}$ for non-cracked concrete C20/25

Table 3: Characteristic edge distance $c_{cr,p}$ and spacing $s_{cr,p}$ (f_{sus} = 1)

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Spacing	$s_{cr,p}$	[mm]	219	270	328	354	375	506	607	605	678	775
Edge distance	$c_{cr,p}$	[mm]	109	135	164	177	188	253	303	303	339	387

a. Influence of concrete strength

Table 4: Influence of concrete strength on combined pull-out and concrete cone resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.02	1.04	1.07	1.08	1.09	1.10

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \frac{h_{ef}}{h_{ef,typ}}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „installation parameters".

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 5: Influence of spacing on combined pull-out and concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,p}$, $f_{sy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,p}$, $f_{sy,p}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,p}$, $f_{sy,p}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,p}$, $f_{sy,p}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,p} = 0.7 + 0.3\frac{c_x}{c_{cr,p}} \leq 1 \qquad f_{cx,2,p} = f_{cy,p} = \left(1 + \frac{c_{x(y)}}{c_{cr,p}}\right) \cdot \frac{1}{2} \leq 1$$

Table 6: Influence of edge distance on combined pull-out and concrete cone resistance

$c/c_{cr,P}$	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,55	0,60	0,65	0,70	0,75	0,70	0,75	0,90	0,95	≥ 1
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-PE 510 WITH REBAR

e. Influence of sustained loads

$$a_{sus} = \frac{N_{sus,d}}{N_{Ed}}$$

$N_{sus,d}$ = design value of sustained actions (permanent actions & permanent component of variable actions)
N_{Ed} = Value of total actions in tension loading at ultimate limit state

Table 7: Influence of sustained loads on combined pull-out and concrete cone resistance

a_{sus}	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
f_{sus}	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.80	0.70	0.60

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases.

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 8: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete												
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	16.8	20.0	27.0	32.7	32.7	51.9	71.3	71.3	103.9	121.7
Cracked concrete												
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	11.7	14.0	18.9	22.9	22.9	36.3	49.9	49.9	72.7	85.2

Table 9: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Spacing	$s_{cr,N}$	[mm]	240	270	330	375	375	510	630	630	810	900
Edge distance	$c_{cr,N}$	[mm]	120	135	165	188	188	255	315	315	405	450

Above characteristic spacing and edge distances are given for the typical effective anchorage depths. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$s_{cr,N} = 3\ h_{ef}$ and $c_{cr,N} = 1.5\ h_{ef}$

a. Influence of concrete strength

Table 10: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 11: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 12: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-PE 510 WITH REBAR

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

Table 13: Design resistance $N_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete												
Splitting resistance	$N^0_{Rd,c}$	[kN]	13.4	18.8	27.0	31.4	32.7	51.9	71.3	71.3	103.9	121.7

Table 14: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Characteristic spacing	$s_{cr,sp}$	[mm]	360	420	528	600	590	816	1004	1004	1296	1440
Characteristic edge distance	$c_{cr,sp}$	[mm]	180	210	264	300	295	408	502	502	648	720
Minimum member thickness	h_{min}	[mm]	110	120	142	161	165	218	274	274	340	380

Above characteristic spacing and edge distances are given for the typical effective anchorage depth. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,sp} = 2 \cdot c_{cr,sp} \quad \text{and} \quad c_{cr,sp} = \left\{ h_{ef} \le 2\, h_{ef} \cdot \left(2.5 - \left(\frac{h_{min}}{h_{ef}}\right)\right) \le 2.4\, h_{ef} \right\}$$

and h_{min} according to the table „anchor characteristics".

a. Influence of concrete strength

Table 15: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx,\,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 16: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 17: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1,\,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,\,sp}$ / $f_{cy,\,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

e. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 18: Influence of concrete member thickness on splitting resistance

h/h_{min}	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.3	2.4	2.7	2.8	2.9
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

WIT-PE 510 WITH REBAR

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot min\ \{N_{Rd,p;}\ N_{Rd,c}\}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 19: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Design steel resistance	$V_{Rd,s}$	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	82.9	90.0	112.9	147.4

2. Design concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot min\ \{N_{Rd,p};N_{Rd,c}\}$$

Table 20: factor k_8 for calculating design pry-out resistance

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

3. Design concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq max\ (10\ h_{ef}\ ;\ 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 21: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	210	270	300
Non-cracked concrete												
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.8	3.6	4.6	5.6	5.8	8.3	12.2	12.2	14.3	17.2
Cracked concrete												
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.0	2.5	3.2	4.0	4.1	5.9	8.6	8.6	10.2	12.2

a. Influence of concrete strength

Table 22: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders[1)]	f_{ck}	[N/mm^2]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2)]	$f_{ck,cube}$	[N/mm^2]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

Table 23: Influence of embedment depth on concrete edge resistance

h_{ef}/d	4	5	6	7	8	9	10	11	≥ 12
$f_{hef,V}$	0.87	0.91	0.94	0.97	1.00	1.02	1.05	1.07	1.08

c. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 24: Influence of spacing on concrete edge resistance

s/c_1[1)]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1)] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

WIT-PE 510 WITH REBAR

d. Influence of edge distance c_1

Table 25: Influence of edge distance c_1 on concrete edge resistance

c_1/d	4	8	12	15	20	30	40	50	60	100	150	200
$f_{c1,V}$	0.47	1.19	2.05	2.76	4.05	6.95	10.22	13.76	17.54	34.66	59.52	87.35

e. Influence of edge distance c_2

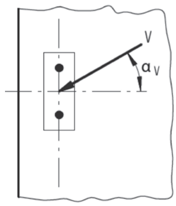
$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\frac{c_2}{1.5c_1}\right) \leq 1$$

Table 26: Influence of edge distance c_2 on concrete edge resistance

$c_{2/c1}$ [1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \leq c_2$

f. Influence of load direction



$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 27: Influence of load direction on concrete edge resistance

α [1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.

g. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 28: Influence of concrete member thickness on edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

WIT-PE 510 WITH REBAR

Design bond strength

Service temperature for working life of 50 years

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +60°C	+35°C	+60°C
Temperature range III	- 40°C to +70°C	+43°C	+70°C

Working life of 50 years

1- Non-cracked concrete

Thread size				**Ø8**	**Ø10**	**Ø12**	**Ø14**	**Ø16**	**Ø20**	**Ø24**	**Ø25**	**Ø28**	**Ø32**
Design bond resistance in non-cracked concrete C20/25 in hammer drilled holes (HD), with hollow drill bit (HDB), and compressed air drilled holes (CD)													
Temperature range I	Dry, wet concrete and flooded bore holee	$\tau_{Rd,ucr}$	[N/mm²]	6.7	6.7	6.7	5.7	5.7	5.7	5.7	5.2	5.2	5.2
Temperature range II				4.5	4.5	4.5	4.0	4.0	4.0	3.6	3.6	3.6	3.6
Temperature range III				2.9	2.9	2.9	2.9	2.9	2.6	2.6	2.6	2.4	2.4

2- Cracked concrete

Thread size				**Ø8**	**Ø10**	**Ø12**	**Ø14**	**Ø16**	**Ø20**	**Ø24**	**Ø25**	**Ø28**	**Ø32**
Design bond resistance in cracked concrete C20/25 in hammer drilled holes (HD), with hollow drill bit (HDB), and compressed air drilled holes (CD)													
Temperature range I	Dry, wet concrete and flooded bore holee	$\tau_{Rd,ucr}$	[N/mm²]	2.9	3.3	3.3	3.1	3.1	2.9	2.9	2.9	2.6	2.6
Temperature range II				1.9	2.1	2.1	2.1	1.9	1.9	1.9	1.9	1.7	1.7
Temperature range III				1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2

Reduction factors

Working life of 50 years

1- Non-cracked concrete

Rebar size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factors in non-cracked concrete C20/25 in hammer drilled holes (HD), with hollow drill bit (HDB), and compressed air drilled holes (CD)													
Temperature range I	Dry, wet concrete and flooded bore hole	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.68	0.68	0.68	0.71	0.71	0.71	0.63	0.68	0.68	0.68
Temperature range III				0.43	0.43	0.43	0.50	0.50	0.46	0.46	0.50	0.45	0.45

2- Cracked concrete

Rebar size				Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
Reduction factors in cracked concrete C20/25 in hammer drilled holes (HD), with hollow drill bit (HDB), and compressed air drilled holes (CD)													
Temperature range I	Dry, wet concrete and flooded bore hole	$\tau_{Rd,cr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II				0.67	0.64	0.64	0.69	0.62	0.67	0.67	0.67	0.64	0.64
Temperature range III				0.42	0.36	0.36	0.38	0.38	0.42	0.42	0.42	0.45	0.45

WIT-PE 510 WITH REBAR

Mechanical characteristics

Steel grade	Rebar size			Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
	Stressed cross section	A_s	[mm²]	50	79	113	154	201	314	452	491	616	804
	Section modulus	W	[mm³]	50	98	170	269	402	785	1357	1534	2155	3217
460A	Yield strength	f_y	[N/mm²]	460	460	460	460	460	460	460	460	460	460
	Tensile strength	f_u	[N/mm²]	483	483	483	483	483	483	483	483	483	483
	Design bending moment	$M^0_{Rd,s}$	[Nm]	19	38	66	104	155	303	524	593	833	1243
460B	Yield strength	fy	[N/mm²]	460	460	460	460	460	460	460	460	460	460
	Tensile strength	fu	[N/mm²]	497	497	497	497	497	497	497	497	497	497
	Design bending moment	$M^0_{Rd,s}$	[Nm]	20	39	68	107	160	312	540	610	857	1279
B500B	Yield strength	f_y	[N/mm²]	500	500	500	500	500	500	500	500	500	500
	Tensile strength	f_u	[N/mm²]	550	550	550	550	550	550	550	550	550	550
	Design bending moment	$M^0_{Rd,s}$	[Nm]	22	43	75	118	177	345	597	675	948	1415

Material specifications

Product form		**Bars and de-coiled rods**		
Class		**A**	**B**	**V**
Characteristic yield strength f_{yk} or $f_{0,2k}$ (MPa)		400 to 600		
Minimum value of $k = (f_t/f_y)_k$		≥ 1,05	≥ 1,08	≥ 1,15 < 1,35
Characteristic strain at maximum force, ε_{uk} (%)		≥ 2,5	≥ 5,0	≥ 7,5
Bendability		Bend/Rebend test		
Maximum deviation from nominal mass (individual bar or wire) (%)	Nominal bar size (mm) ≤ 8 > 8	+/- 6,0 +/- 4,5		

WIT-PE 510 R

Working and curing times

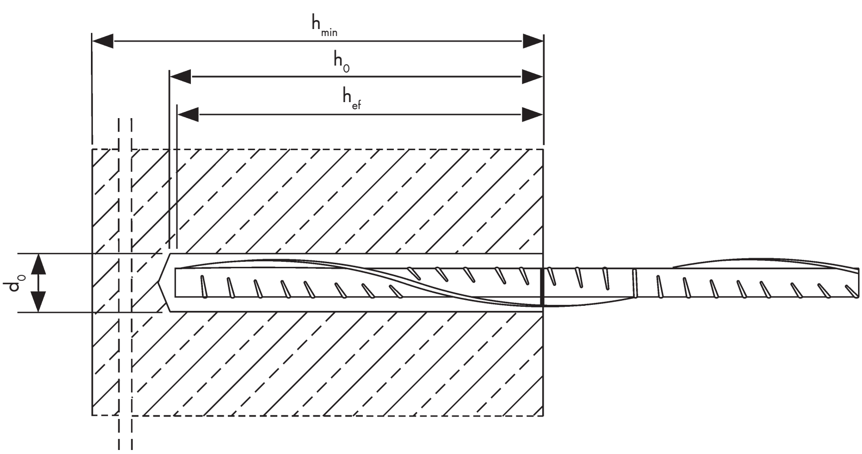
Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1]
5°C to 9°C	80 min	60 h
10°C to 14°C	60 min	48 h
15°C to 19°C	40 min	24 h
20°C to 24°C	30 min	12 h
25°C to 34°C	12 min	10 h
35°C to 39°C	8 min	7 h
+40°C	8 min	4 h

[1] for wet base material the curing time must be doubled

Installation parameters

Rebar size			Ø 8[1]	Ø 10[1]	Ø 12[1]	Ø 14	Ø 16	Ø 20	Ø 24[1]	Ø 25[1]	Ø 28	Ø 32
Diameter of element	$d = d_{nom}$	[mm]	8	10	12	14	16	20	24	25	28	32
Nominal drill hole diameter	d_0	[mm]	10 / 12	12 / 14	14 / 16	18	20	25	30 / 32	30 / 32	35	40
Effective anchorage depth	$h_{ef,min}$	[mm]	60	60	70	75	80	90	96	100	112	128
	$h_{ef,max}$	[mm]	160	200	240	280	320	400	480	500	560	640
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 mm			$h_{ef} + 2d_0$						
Minimum spacing	s_{min}	[mm]	40	50	60	70	75	85	120	120	130	150
Minimum edge distance	c_{min}	[mm]	35	40	45	50	50	60	70	70	75	85

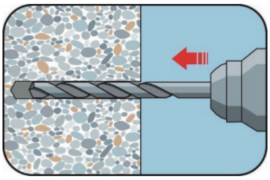
[1] both nominal drill hole diameter can be used



WIT-PE 510 WITH REBAR

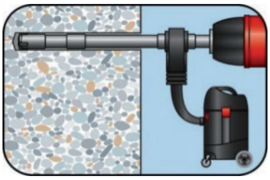
Installation instructions

A) Bore hole drilling



1a. Hammer (HD) or compressed air drilling (CD)

Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. Proceed with Step B1.

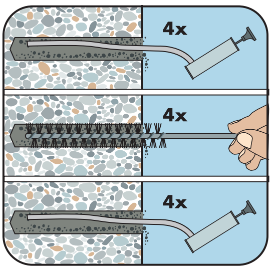


1b. Hollow drill bit system (HDB)

Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. This drilling system removes the dust and cleans the bore hole during drilling. Proceed with Step C.

B) Bore hole cleaning

MAC: Cleaning for dry and wet bore holes with diameter d0 ≤ 20 mm and bore hole depth h ≤ 10 d_{nom} (non-cracked concrete only!)

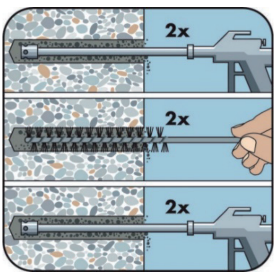


2a. Starting from the bottom or back of the bore hole, blow the hole clean with a hand pump a minimum of four times until return air stream is free of noticeable dust.

2b. Check brush diameter. Brush the hole with an appropriate sized wire brush > db,min a minimum of four times in a twisting motion. If the bore hole ground is not reached with the brush, a brush extension shall be used.

2c. Finally blow the hole clean again with a hand pump a minimum of four times until return air stream is free of noticeable dust.

CAC: Cleaning for dry, wet and water-filled bore holes for all diameters in non-cracked and cracked concrete

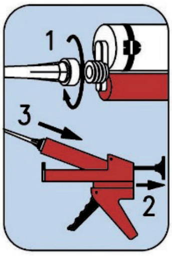


2a. Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.

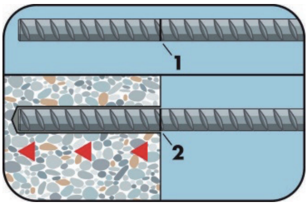
2b. Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of two times. If the bore hole ground is not reached with the brush, a brush extension shall be used.

2c. Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of two times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.

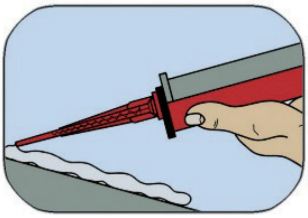
C) Preparation of bar and cartridge



3a. Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time as well as for every new cartridge, a new static-mixer shall be used.

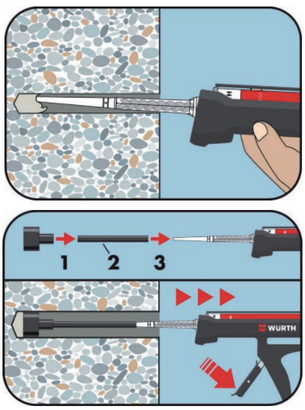


3b. Prior to inserting the reinforcing bar into the filled bore hole, the position of the embedment depth shall be marked (e.g. with tape) on the reinforcing bar. After that, insert the bar in the empty hole to verify hole and depth lv. The anchor should be free of dirt, grease, oil and other foreign material.



3c. Prior to dispensing into the bore hole, squeeze out separately the mortar until it shows a consistent grey or red color (minimum of three full strokes) and discard non-uniformly mixed adhesive components.

D) Filling the bore hole

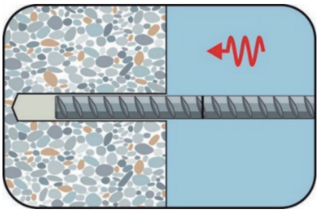
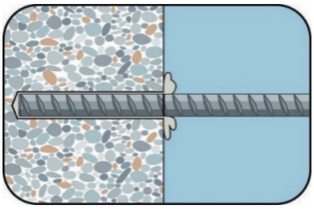
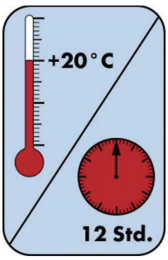


4. Starting from the bottom or back of the cleaned bore hole, fill the hole up to approximately two-thirds with adhesive. Slowly withdraw the static mixing nozzle as the hole fills to avoid creating air pockets. If the bottom or back of the anchor hole is not reached, an appropriate extension nozzle must be used. Observe the gel-/working times.

Piston plugs and mixer nozzle extensions shall be used for the following applications:

- Horizontal assembly (horizontal direction) and ground erection (vertical downwards direction):
  Drill bit-Ø $d_0 \geq 18$ mm and embedment depth hef > 250 mm
- Overhead assembly (vertical upwards direction):
  Drill bit-Ø $d_0 \geq 18$ mm

WIT-PE 510 WITH REBAR

E) Setting the rebar		
	**5a.**	Push the reinforcing bar into the bore hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached. The bar should be free of dirt, grease, oil or other foreign material.
	**5b.**	Be sure that the bar is inserted in the bore hole until the embedment mark is at the concrete surface and that excess mortar is visible at the top of the hole. If these requirements are not maintained, the application has to be renewed. For horizontal and overhead installation, fix embedded part (e.g. with wedges).
	**5c.**	Observe gelling time t_{gel}. Attend that the gelling time can vary according to the base material temperature. Do not move or load the bar until full curing time t_{cure} has elapsed.

Filling quantity

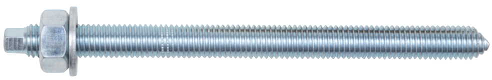
Anchor type: M8 - M30

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Nominal drill hole diameter	d_0	[mm]	12	14	16	18	20	25	32	32	35	40
Drill depth	h_0 / h_1	[mm]	= l_v									
Filling volume per 10mm embedment depth		[ml]	0.81	1.01	1.21	1.43	1.66	2.59	4.85	4.47	5.07	6.62

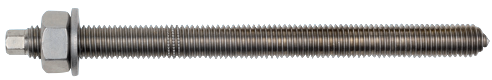
Assumed waste of 15 % included.

WIT-VM 250 WITH THREADED ROD (METRIC)

300 ml 330 ml 420 ml 825 ml



Galvanized (5 microns): M8 - M30



Stainless steel - A4 (AISI 316): M8 - M30

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, natural stone with dense structure

Cartridge sizes		**Art. no.**
300 ml	foil-in-tube	**0903 450 201**
420 ml	coaxial	**0903 450 205**
825 ml	side-by-side	**0903 450 206**
WIT-Nordic = WIT-VM 250 for up to −20°C*:		
330 ml	coaxial	**0903 450 102**

* For more information, please visit our Würth Online Shop

Type of installation		
Pre-positioned	In-place	Stand-off
✓	-	✓

Installation condition		
Dry concrete	Wet concrete	Flooded drill hole
✓	✓	✓

Drilling method		
Hammer drill	Diamond drill	Hollow drill
✓	-	✓

Applications

Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt, Berlin	ETAG 001-T5	ETA-12/0164, 12.11.2015
ICC-ES Evaluation Report	ICC	AC 308	ESR-4457, 01.09.2019
Fire resistance (concrete)	TU Kaiserslautern	TR 020	EBB 170019_6, 12.02.2018
LEED	eurofins		30.10.12
VOC Emissions Test report	eurofins	DEVL 1101903D, DEVL 1104875A	13.03.13
NSF International	NSF International	NSF/ANSI Standard61	02.01.20

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness and embedment depth are according to anchor characteristics
- Anchor material according is to specifications,
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²
- Temperature range I (min. base material temperature -40°C, max long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling

Characterstic resistance

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	18.3	29.0	42.2	68.8	109.0	149.7	182.9	218.2
	C50/60			18.3	29.0	42.2	78.5	122.5	176.5	223.9	251.9
Shear	≥ C20/25	V_{Rk}		11.0	17.4	25.3	47.1	73.5	105.9	137.7	168.3
Cracked concrete											
Tension	C20/25	N_{Rk}	[kN]	8.0	14.1	22.8	34.6	58.7	87.1	128.0	152.8
	C50/60			8.8	15.6	25.1	38.0	64.6	95.8	145.6	181.9
Shear	≥ C20/25	V_{Rk}		11.0	17.4	25.3	47.1	73.5	105.9	137.7	168.3

Design resistance

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	12.2	18.8	27.6	38.2	60.6	83.2	101.6	121.2
	C50/60			12.2	19.3	28.1	46.1	78.3	106.4	124.4	140.0
Shear	≥ C20/25	V_{Rd}		8.8	13.9	20.2	37.7	58.8	84.7	110.2	134.6
Cracked concrete											
Tension	C20/25	N_{Rd}	[kN]	5.4	7.9	12.7	19.2	32.6	48.4	71.1	84.9
	C50/60			5.9	8.6	13.9	21.1	35.9	53.2	80.9	101.1
Shear	≥ C20/25	V_{Rd}		8.8	13.9	20.2	37.7	58.8	84.7	110.2	134.6

WIT-VM 250 WITH THREADED ROD (METRIC)

Recommended/allowable loads [1)]

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete											
Tension	C20/25	N_{rec}	[kN]	8.7	13.5	19.7	27.3	43.3	59.4	72.6	86.6
	C50/60			8.7	13.8	20.1	32.9	56.0	76.0	88.9	100.0
Shear	≥ C20/25	V_{rec}		6.3	9.9	14.5	26.9	42.0	60.5	78.7	96.2
Cracked concrete											
Tension	C20/25	N_{rec}	[kN]	3,8	5,6	9,1	13,7	23,3	34,6	50,8	60,6
	C50/60			4,2	6,2	10,0	15,1	25,6	38,0	57,8	72,2
Shear	≥ C20/25	V_{rec}		6,3	9,9	14,5	26,9	42,0	60,5	78,7	96,2

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

WIT-VM 250 M

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Temperature range 1 (min. base material temperature -40°C, max. long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling (Installation factors might apply for other drilling methods)
- Anchor material according to specifications, steel grade 5.8 unless otherwise stated in the tables

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b;N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Design steel resistance	5.8	$N_{Rd,s}$	[kN]	12.2	19.3	28.1	52.3	81.7	117.7	153.0	187.0
	8.8	$N_{Rd,s}$	[kN]	19.3	30.7	44.7	83.3	130.7	188.0	245.3	299.3
	A4	$N_{Rd,s}$	[kN]	13.9	21.9	31.6	58.8	91.4	132.1	80.4	98.3

WIT-VM 250 M

WIT-VM 250 WITH THREADED ROD (METRIC)

2. Design combined pull-out and concrete cone resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of combined pull-out and concrete cone failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	13.4	18.8	27.6	41.9	71.2	96.8	113.1	127.2
Cracked concrete										
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	5.4	7.9	12.7	19.2	32.6	48.4	73.5	91.9

- $s_{cr,p} = 7.3\,d\,(f_{sus} \cdot \tau_{Rk})^{0.5} \leq 3h_{ef}$
- $c_{cr,p} = s_{cr,p}/2$

Where τ_{Rk} is the value $\tau_{Rk,ucr}$ for non-cracked concrete C20/25

Table 3: Characteristic edge distance $c_{cr,p}$ and spacing $s_{cr,p}$ (f_{sus} = 1)

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Spacing	$s_{cr,Np}$	[mm]	185	253	303	375	506	581	623	657
Edge distance	$c_{cr,Np}$	[mm]	92	126	152	188	253	291	312	329

a. Influence of concrete strength

Table 4: Influence of concrete strength on combined pull-out and concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.02	1.04	1.07	1.08	1.09	1.10

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \frac{h_{ef}}{h_{ef,\,typ}}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „installation parameters".

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 5: Influence of spacing on combined pull-out and concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	$f_{sx,p}$, $f_{sy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,p}$, $f_{sy,p}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,p}$, $f_{sy,p}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,p}$, $f_{sy,p}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

1) Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,p} = 0.7 + 0.3\frac{c_x}{c_{cr,p}} \leq 1 \qquad f_{cx,2,p} = f_{cy,p} = \left(1 + \frac{c_{x(y)}}{c_{cr,p}}\right) \cdot \frac{1}{2} \leq 1$$

Table 6: Influence of edge distance on combined pull-out and concrete cone resistance

$c/c_{cr,P}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,p}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,p}$, $f_{cy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-VM 250 WITH THREADED ROD (METRIC)

e. Influence of sustained loads

$$a_{sus} = \frac{N_{sus,d}}{N_{Ed}}$$

$N_{sus,d}$ = design value of sustained actions (permanent actions & permanent component of variable actions)
N_{Ed} = Value of total actions in tension loading at ultimate limit state

Table 7: Influence of sustained loads on combined pull-out and concrete cone resistance

a_{sus}	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
f_{sus}	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.80	0.70	0.60

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases.

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 8: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	23.5	23.3	31.5	38.2	60.6	83.2	101.6	121.2
Cracked concrete										
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	16.4	16.3	22.1	26.7	42.4	58.2	71.1	84.9

Table 9: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Spacing	$s_{cr,N}$	[mm]	240	270	330	375	510	630	720	810
Edge distance	$c_{cr,N}$	[mm]	120	135	165	188	255	315	360	405

Above characteristic spacing and edge distances are given for the typical effective anchorage depths. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,N} = 3\ h_{ef} \text{ and } c_{cr,N} = 1.5\ h_{ef}$$

a. Influence of concrete strength

Table 10: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 11: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 12: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-VM 250 WITH THREADED ROD (METRIC)

4. Design Splitting Resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

Table 13: Design resistance $N_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Concrete cone resistance	$N^0_{Rd,sp}$	[kN]	13.4	18.8	27.6	38.2	60.6	83.2	101.6	121.2

Table 14: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Spacing	$s_{cr,sp}$	[mm]	360	420	528	600	816	1008	1152	1296
Edge distance	$c_{cr,sp}$	[mm]	180	210	264	300	408	504	576	648
Minimum member thickness	h_{min}	[mm]	110	120	140	161	218	266	304	340

Above characteristic spacing and edge distances are given for the typical effective anchorage depth. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,sp} = 2 \cdot c_{cr,sp} \quad \text{and} \quad c_{cr,sp} = \left\{ h_{ef} \le 2\, h_{ef} \cdot \left(2.5 - \left(\frac{h_{min}}{h_{ef}}\right)\right) \le 2.4\, h_{ef} \right\}$$

and h_{min} according to the table „anchor characteristics".

a. Influence of concrete strength

Table 15: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx,\,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 16: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\,\frac{c_x}{c_{cr,sp}} \leq 1 \qquad\qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 17: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1,\,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,\,sp}$ / $f_{cy,\,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.3	2.4	2.7	2.8	2.9
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

WIT-VM 250 WITH THREADED ROD (METRIC)

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot min\ \{N_{Rd,p;} N_{Rd,c}\}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 19: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Thread size				M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
Design steel resistance	5.8	$V_{Rd,s}$	[kN]	8.8	13.9	20.2	37.7	58.8	84.7	110.2	134.6
	8.8		[kN]	12.0	18.4	27.2	50.4	78.4	112.8	147.2	179.2
	A4		[kN]	8.3	12.8	19.2	35.3	55.1	79.5	48.3	58.8

2. Design concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot min\ \{N_{Rd,p};N_{Rd,c}\}$$

Table 20: factor k_8 for calculating design pry-out resistance

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

3. Design Concrete Edge Resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq max\ (10\ h_{ef}\ ;\ 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 21: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	240	270
Non-cracked concrete										
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	3.3	4.8	6.5	10.3	15.3	21.1	25.9	31.1
Cracked concrete										
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.4	3.4	4.6	7.3	10.9	14.9	18.4	22.0

a. Influence of concrete strength

Table 22: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

Table 23: Influence of embedment depth on concrete edge resistance

h_{ef}/d	4	5	6	7	8	9	10	11	≥ 12
$f_{hef,V}$	0.87	0.91	0.94	0.97	1.00	1.02	1.05	1.07	1.08

[1)] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 24: Influence of spacing on concrete edge resistance

s/c_1[1)]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1)] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

WIT-VM 250 WITH THREADED ROD (METRIC)

d. Influence of edge distance c_1

Table 20: Influence of edge distance on concrete edge resistance

$c_{1/d}$	4	8	12	15	20	30	40	50	60	100	150	200
$f_{c1,V}$	0.47	1.19	2.05	2.76	4.05	6.95	10.22	13.76	17.54	34.66	59.52	87.35

e. Influence of edge distance c_2

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\frac{c_2}{1.5c_1}\right) \leq 1$$

Table 26: Influence of edge distance c2 on concrete edge resistance

$c_{2/c1}$ [1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: c1 ≤ c2

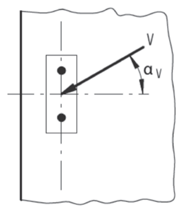
f. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 27: Influence of load direction on concrete edge resistance

α [1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.



g. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 28: Influence of concrete member thickness on edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

WIT-VM 250 M

WIT-VM 250 WITH THREADED ROD (METRIC)

Design bond strength

Service temperature

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +80°C	+50°C	+80°C
Temperature range III	- 40°C to +120°C	+72°C	+120°C

Working life of 50 years

1- Non-cracked concrete

Thread size			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Design bond resistance in non-cracked concrete C20/25, Dry and wet concrete										
Temperature range I	$\tau_{Rd,ucr}$	[N/mm²]	6.7	6.7	6.7	6.7	6.7	6.1	5.6	5.0
Temperature range II			5.0	5.0	5.0	5.0	5.0	4.7	4.2	3.6
Temperature range III			3.7	3.6	3.6	3.6	3.6	3.6	3.1	2.8
Design bond resistance in non-cracked concrete C20/25, Flooded bore hole										
Temperature range I	$\tau_{Rd,ucr}$	[N/mm²]	3.6	4.0	4.0	4.0	not admissible			
Temperature range II			2.6	3.1	3.1	3.1	not admissible			
Temperature range III			1.9	2.4	2.4	2.4	not admissible			

2- Cracked concrete

Thread size			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**	**M30**
Design bond resistance in non-cracked concrete C20/25, Dry and wet concrete										
Temperature range I	$\tau_{Rd,cr}$	[N/mm²]	2.7	2.8	3.1	3.1	3.1	3.1	3.6	3.6
Temperature range II			1.7	1.9	2.2	2.2	2.2	2.2	2.5	2.5
Temperature range III			1.3	1.4	1.7	1.7	1.7	1.7	1.9	1.9
Design bond resistance in non-cracked concrete C20/25, Flooded bore hole										
Temperature range I	$\tau_{Rd,cr}$	[N/mm²]	1.9	1.9	2.6	2.6	not admissible			
Temperature range II			1.2	1.4	1.9	1.9	not admissible			
Temperature range III			1.0	1.2	1.4	1.4	not admissible			

Reduction factors

Working life of 50 years

1- Non-cracked concrete

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Reduction factor for non-cracked concrete C20/25, Dry and wet concrete										
Temperature range I	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II			0.75	0.75	0.75	0.75	0.75	0.77	0.75	0.72
Temperature range III			0.55	0.54	0.54	0.54	0.54	0.59	0.55	0.77
Reduction factor for non-cracked concrete C20/25, Flooded bore hole										
Temperature range I	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	not admissible			
Temperature range II			0.73	0.76	0.76	0.76	not admissible			
Temperature range III			0.53	0.59	0.59	0.59	not admissible			

2- Cracked concrete

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Reduction factor for non-cracked concrete C20/25, Dry and wet concrete										
Temperature range I	$\tau_{Rd,cr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II			0.63	0.70	0.73	0.73	0.73	0.73	0.69	0.69
Temperature range III			0.50	0.50	0.55	0.55	0.55	0.55	0.54	0.78
Reduction factor for non-cracked concrete C20/25, Flooded bore hole										
Temperature range I	$\tau_{Rd,cr}$	[N/mm²]	1.00	1.00	1.00	1.00	not admissible			
Temperature range II			0.63	0.75	0.73	0.73	not admissible			
Temperature range III			0.50	0.63	0.55	0.55	not admissible			

WIT-VM 250 WITH THREADED ROD (METRIC)

Mechanical characteristics

Steel grade	Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210	240	270
	Stressed cross section	A_s	[mm²]	37	58	84	157	245	352	459	561
	Section modulus	W	[mm³]	31	62	109	277	541	935	1387	1874
4.6	Yield strength	f_y	[N/mm²]	240	240	240	240	240	240	240	240
	Tensile strength	f_u	[N/mm²]	400	400	400	400	400	400	400	400
	Design bending moment	$M^0_{Rd,s}$	[Nm]	9.0	18.0	31.1	79.6	155.7	268.9	398.8	538.9
4.8	Yield strength	f_y	[N/mm²]	320	320	320	320	320	320	320	320
	Tensile strength	f_u	[N/mm²]	400	400	400	400	400	400	400	400
	Design bending moment	$M^0_{Rd,s}$	[Nm]	12.0	24.0	41.6	106.4	208.0	359.2	532.8	720.0
5.6	Yield strength	f_y	[N/mm²]	300	300	300	300	300	300	300	300
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	11.4	22.2	38.9	99.4	194.0	335.3	498.8	672.5
5.8	Yield Strength	f_y	[N/mm²]	400	400	400	400	400	400	400	400
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	15.2	29.6	52	132.8	259.2	448	666.4	898.4
8.8	Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640
	Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800
	Design bending moment	$M^0_{Rd,s}$	[Nm]	24.0	48.0	84.0	212.8	415.2	716.8	1066.4	1437.6
A4-50	Yield strength	f_y	[N/mm²]	210	210	210	210	210	210	210	210
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	8.0	15.5	27.7	70.2	136.6	235.7	349.6	472.7
A4-70	Yield strength	f_y	[N/mm²]	450	450	450	450	450	450	-	-
	Tensile strength	f_u	[N/mm²]	700	700	700	700	700	700	-	-
	Design bending moment	$M^0_{Rd,s}$	[Nm]	16.7	33.3	59.0	148.7	291.0	502.6	-	-

Material specifications

Part	Designation	Material				
Steel, zinc plated (Steel acc. to EN 10087:1998 or EN 10263:2001)						
- zinc plated	≥ 5 µm	acc. to EN ISO 4042:1999				
- hot-dip galvanized	≥ 40 µm	acc. to EN ISO 1461:2009 and EN ISO 10684:2004+AC:2009				
- sherardized	≥ 45 µm	acc. to EN ISO 17668:2016				
1	Anchor rod	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 898-1:2013	4.6	f_{uk} = 400 N/mm²	f_{yk} = 240 N/mm²	A5 > 8%
			4.8	f_{uk} = 400 N/mm²	f_{yk} = 320 N/mm²	A5 > 8%
			5.6	f_{uk} = 500 N/mm²	f_{yk} = 300 N/mm²	A5 > 8%
			5.8	f_{uk} = 500 N/mm²	f_{yk} = 400 N/mm²	A5 > 8%
			8.8	f_{uk} = 800 N/mm²	f_{yk} = 640 N/mm²	A5 > 12% [3)]
2	Hexagon nut	acc. to EN ISO 898-2:2012	4	for anchor rod class 4.6 or 4.8		
			5	for anchor rod class 5.6 or 5.8		
			8	for anchor rod class 8.8		
3a	Washer	Steel, zinc plated, hot-dip galvanized or sherardized (e.g.: EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000, or EN ISO 7094:2000)				
3b	Filling washer	Steel, zinc plated, hot-dip galvanized or sherardized				
4	Internal threaded anchor rod	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 898-1:2013	5.8	f_{uk} = 500 N/mm²	f_{yk} = 400 N/mm²	A5 > 8%
			8.8	f_{uk} = 800 N/mm²	f_{yk} = 640 N/mm²	A5 > 8%

WIT-VM 250 WITH THREADED ROD (METRIC)

Part	Designation	Material				
Stainless steel A2 (Material 1.4301 / 1.4303 / 1.4307 / 1.4567 or 1.4541, acc. to EN 1088-1:2014) **Stainless steel A4** (Material 1.4401 / 1.4404 / 1.4571 / 1.4362 or 1.4578, acc. to EN 10088-1:2014) **High corrosion resistance steel** (Material 1.4529 or 1.4565, acc. to EN 10088-1:2014)						
1	Anchor rod [1) 4)]	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 3506-1:2009	50	f_{uk} = 400 N/mm²	f_{yk} = 240 N/mm²	A5 > 12% [3)]
			70	f_{uk} = 400 N/mm²	f_{yk} = 320 N/mm²	A5 > 12% [3)]
			80	f_{uk} = 500 N/mm²	f_{yk} = 300 N/mm²	A5 > 12% [3)]
2	Hexagon nut [1) 4)]	acc. to EN ISO 3506-1:2009	50	for anchor rod class 50		
			70	for anchor rod class 70		
			80	for anchor rod class 80		
3a	Washer	Stainless steel A2 (Material 1.4301 / 1.4303 / 1.4307 / 1.4567 or 1.4541, acc. to EN 1088-1:2014) Stainless steel A4 (Material 1.4401 / 1.4404 / 1.4571 / 1.4362 or 1.4578, acc. to EN 10088-1:2014) HCR: Material 1.4529 or 1.4565, acc. to EN 10088-1:2014 (e.g.: EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000, or EN ISO 7094:2000)				
3b	Filling washer	Stainless steel A4, High corrosion resistance steel				
4	Internal threaded anchor rod [1) 2)]	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 3506-1:2009	50	f_{uk} = 500 N/mm²	f_{yk} = 210 N/mm²	A5 > 8%
			70	f_{uk} = 700 N/mm²	f_{yk} = 450 N/mm²	A5 > 8%

1) Property class 70 for anchor rods up to M24 and Internal threaded anchor rods up to IG-M16

2) for IG-M20 only property class 50

3) A5 > 8% fracture elongation if no requirement for performance category C2 exists

4) Property class 80 only for stainless steel A4

Chemical resistance

Chemical agent	Concentration	Resistant	Not Resistant
Accumulator acid		●	
Acetic acid	40		●
Acetic acid	10	●	
Acetone	10		●
Ammonia, aqueous solution	5	●	
Aniline	100		●
Beer		●	
Benzene (kp 100-140°F)	100	●	
Benzol	100		●
Boric Acid, aqueous solution		●	
Calcium carbonate, suspended in water	all	●	
Calcium chloride, suspended in water		●	
Calcium hydroxide, suspended in water		●	
Carbon tetrachloride	100	●	
Caustic soda solution	10	●	
Citric acid	all	●	
Diesel oil	100	●	
Ethyl alcohol, aqueous solution	50		●
Formic acid	100		●
Formaldehyde, aqueous solution	30	●	
Freon		●	
Fuel Oil		●	
Gasoline (premium grade)	100	●	
Glycol (Ethylene glycol)		●	
Hydraulic fluid	conc.	●	
Hydrochloric acid (Muriatic Acid)	conc.		●
Hydrogen peroxide	30		●
Isopropyl alcohol	100		●
Lactic acid	all	●	
Linseed oil	100	●	
Lubricating oil	100	●	
Magnesium chloride, aqueous solution	all	●	
Methanol	100		●
Motor oil (SAE 20 W-50)	100	●	
Nitric acid	10		●
Oleic acid	100	●	
Perchloroethylene	100	●	
Petroleum	100	●	
Phenol, aqueous solution	8		●
Phosphoric acid	85	●	
Potash lye (Potassium hydroxide)	10	●	
Potassium carbonate, aqueous solution	all	●	
Potassium chlorite, aqueous solution	all	●	
Potassium nitrate, aqueous solution	all	●	
Sodium carbonate	all	●	
Sodium Chloride, aqueous solution	all	●	
Sodium phosphate, aqueous solution	all	●	
Sodium silicate	all	●	
Standard Benzine	100	●	
Sulfuric acid	10	●	
Sulfuric acid	70		●
Tartaric acid	all	●	
Tetrachloroethylene	100	●	
Toluene			●
Trichloroethylene	100		●
Turpentine	100	●	

WIT-VM 250 WITH THREADED ROD (METRIC)

Properties of adhesive

Property		Testing method	Results
Stability			
UV-resistance (sunlight)			not resistant
Temperature resistance			120°C
Water resistance			resistant
Cleaning agents			1% tenside solution: no effect
Physical properties			
Flexural properties	Flexural strength	DIN EN 196-1	after 24 hours: 14.7 N/mm^2
Compressive properties	Compressive strength	DIN EN 196-1	after 24 hours: ≥ 100 N/mm^2
Dynamic modulus of elasticity		DIN EN 12504-4	after 24 hours: 14.09 GPa
Thermal conductivity	Modified transient plane source method		0.66 / 0.63 W/mK
Specific contact resistance		IEC 93	3.6 x 109 Ωcm
Density		DIN 53479	1.77 ± 0.1 g/cm^3
Workability features			
Water tightness / Impermeability		DIN EN 12390-8	after 72 hours at 5 bar: 0 mm
Open time (10-20°C)			15 min
Curing time (10-20°C)			80 min
Shelf-life			18 months

For information use only. Values are not to be considered as a specification and do not reflect the performance of the system. The given values are typical values and are subject to change without notice.

Working and curing times

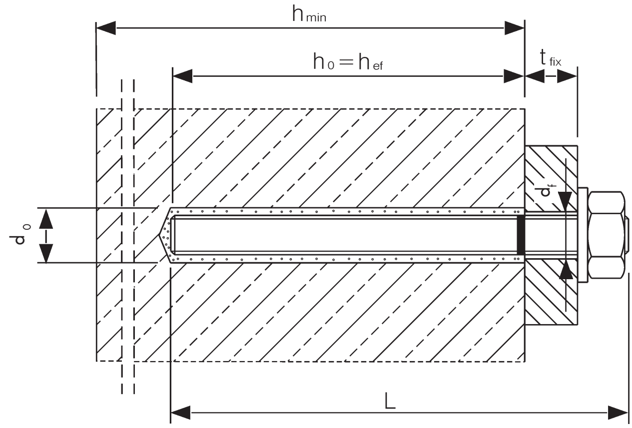
Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1)]
–10°C to –6°C	90 min [2)]	24 h
–5°C to –1°C	90 min	14 h
0°C to 4°C	45 min	7 h
5°C to 9°C	25 min	2 h
10°C to 19°C	15 min	80 min
20°C to 29°C	6 min	45 min
30°C to 34°C	4 min	25 min
35°C to 39°C	2 min	20 min
> 40°C	90 s	15 min

[1)] for wet base material the curing time must be doubled

[2)] Cartridge temperature must be at min. +15°C

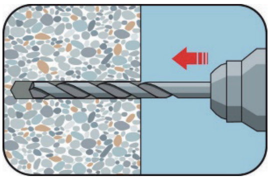
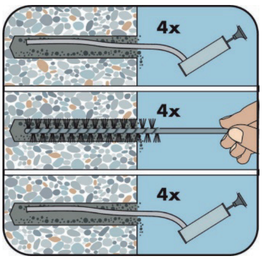
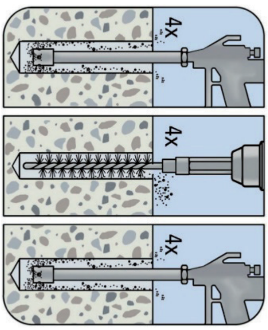
Installation parameters

Anchor size			M8	M10	M12	M16	M20	M24	M27	M30
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	22	28	32	35
Effective anchorage depth	$h_{ef,min}$	[mm]	60	60	70	80	90	96	108	120
	$h_{ef,max}$	[mm]	160	200	240	320	400	480	540	600
Diameter of clearance in hole	$d_f \leq$	[mm]	9	12	14	18	22	26	30	33
Diameter of steel brush	$d_b \leq$	[mm]	12	14	16	20	26	30	34	37
Maximum torque moment	$T_{inst} \leq$	[Nm]	10	20	40	80	120	160	180	200
Thickness of fixture	$t_{fix,min} >$	[mm]	0							
	$t_{fix,max} <$	[mm]	1500							
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 mm			$h_{ef} + 2d_0$				
Minimum spacing	s_{min}	[mm]	40	50	60	80	100	120	135	150
Minimum edge distance	c_{min}	[mm]	40	50	60	80	100	120	135	150



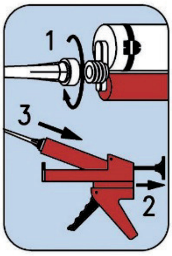
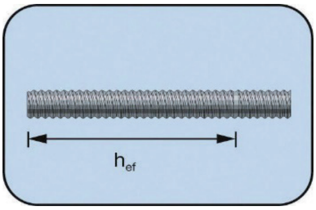
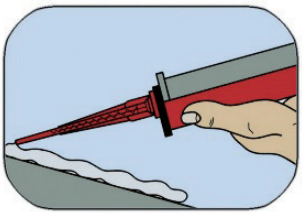
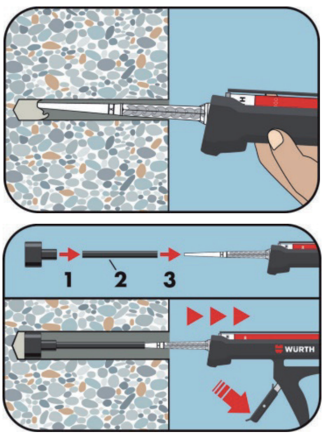
WIT-VM 250 WITH THREADED ROD (METRIC)

Installation instructions

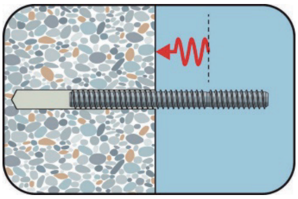
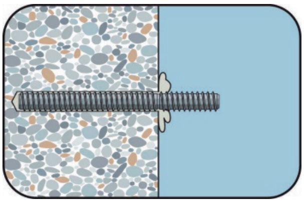
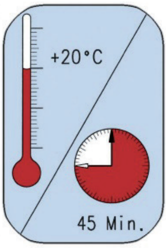
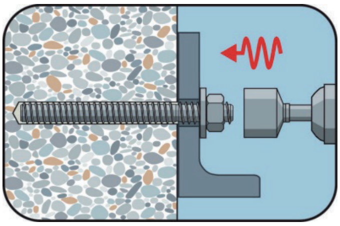
A) Bore hole drilling		
	**1a.**	**Hammer (HD) or compressed air drilling (CD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. In case of aborted drill hole, the drill hole shall be filled with mortar. (Manual Air Cleaning MAC **or** Compressed Air Cleaning CAC is allowed).
B) Bore hole cleaning		
MAC: Cleaning for bore hole diameter $d_0 \leq 20$ mm and bore hole depth $h_0 \leq 10\ d_{nom}$ (non-cracked concrete only!)		
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean using a hand pump[1)] a minimum of four times.
	2b.	Check brush diameter and attach the brush to a drilling machine or a battery screwdriver. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of four times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with a hand pump1) a minimum of four times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
CAC: Cleaning for dry, wet and water-filled bore holes with all diameters (non-cracked and cracked concrete)		
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of four times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $db_{,min}$ a minimum of four times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of four times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.

After cleaning, the bore hole has to be protected against rec-contamination in an appropriate way, until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must not contaminate the bore hole again.

[1)] It is permitted to blow bore holes with diameter between 14 mm and 20 mm and an embedment depth up to 240 mm also in cracked concrete with a hand-pump.

C) Preparation of anchor rod and cartridge		
	**3a.**	Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. Cut off the foil tube clip before use. For every working interruption longer than the recommended working time as well as for every new cartridge, a new static-mixer shall be used.
	**3b.**	Prior to inserting the anchor rod into the filled bore hole, the position of the embedment depth shall be marked.
	**3c.**	Prior to dispensing into the bore hole, squeeze out separately the mortar until it shows a consistent grey colour (minimum of three full strokes) and discard non-uniformly mixed adhesive components. In case of foil tubes, the cartridge must be stroked a minimum of six times.
D) Filling the bore hole		
	**4.**	Starting from the bottom or back of the cleaned bore hole, fill the hole up to approximately two-thirds with adhesive. Slowly withdraw the static mixing nozzle as the hole fills to avoid creating air pockets. For embedment larger than 190 mm, an extension nozzle shall be used. For overhead and horizontal installation, a piston plug and extension nozzle shall be used. Observe the gel-/ working times.

WIT-VM 250 WITH THREADED ROD (METRIC)

E) Setting the anchor rod		
	**5a.**	Push the threaded rod into the bore hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached. The bar should be free of dirt, grease, oil or other foreign material.
	**5b.**	After inserting the anchor, the annular gap between the anchor rod and concrete, in case of a push through installation, additionally also the fixture, must be completely filled with mortar. If excess mortar is not visible at the top of the hole, the requirement is not fulfilled and the application has to be renewed. For overhead application, the anchor rod shall be fixed (e.g. wedges).
	**5c.**	Allow the adhesive to cure to the specified time prior to applying any load or torque. Do not move or load the anchor until it is fully cured.
	**5d.**	After fully curing, the add-on part can be installed with up to the max. torque by using a calibrated torque wrench. In case of prepositioned installation, the annular gap between anchor and fixture can be optionally filled with mortar. Therefore, substitute the washer by the filling washer and connect the mixer reduction nozzle to the tip of the mixer. The annular gap is filled with mortar when mortar oozes out of the washer.

Filling Quantity

Anchor type: M8 - M30

Thread size			M8	M10	M12	M16	M20	M24	M27	M30
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	22	28	32	35
Drill depth	h_0 / h_1	[mm]	= h_{ef}							
Filling volume per 10mm embedment depth		[ml]	0.53	0.70	0.89	1.27	1.78	3.35	4.34	5.10

Assumed waste of 15 % included.

WIT-VM 250 WITH REBAR

300 ml 330 ml 420 ml 825 ml

Ø8 - Ø32

Rebar not supplied by Würth

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, natural stone with dense structure

Cartridge sizes		Art. no.
300 ml	foil-in-tube	**0903 450 201**
420 ml	coaxial	**0903 450 205**
825 ml	side-by-side	**0903 450 206**
WIT-Nordic =	for up to –20°C*:	
330 ml	coaxial	**0903 450 102**

* For more information, please visit our Würth Online Shop

Type of installation		
Pre-positioned	In-place	Stand-off
✓	–	–

Installation condition		
Dry concrete	Wet concrete	Flooded drill hole
✓	✓	✓

Drilling method		
Hammer drill	Diamond drill	Hollow drill
✓	–	✓

Applications




Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt, Berlin	ETAG 001-T5	ETA-12/0164, 12.11.2015
European Technical Assessment	DIBt, Berlin	EAD 330087-00-0601	ETA-12/0166, 27.02.2018
ICC-ES Evaluation Report	ICC	AC 308	ESR-4457, 01.09.2019
Fire resistance (concrete)	TU Kaiserslautern	TR 020	EBB 170019_6, 12.02.2018
LEED	eurofins		30.10.12
VOC Emissions Test report	eurofins	DEVL 1101903D, DEVL 1104875A	13.03.13
NSF International	NSF International	NSF/ANSI Standard61	02.01.20

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness and embedment depth are according to anchor characteristics
- Rebar material is according to specifications, steel grade B500B
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²
- Temperature range I (min. base material temperature -40°C, max long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling

Characterstic resistance

Rebar size				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete												
Tension	C20/25	N_{Rk}	[kN]	20.1	33.9	49.8	66.0	68.8	109.0	149.7	218.2	255.6
	C50/60			22.1	37.3	54.7	72.6	82.9	141.0	199.6	261.3	282.0
Shear	≥ C20/25	V_{Rk}	[kN]	13.8	21.7	31.1	42.4	55.3	86.4	135.0	169.4	221.1
Cracked concrete												
Tension	C20/25	N_{Rk}	[kN]	8.0	14.1	22.8	30.2	34.6	58.7	90.7	152.8	178.9
	C50/60			8.8	15.6	25.1	33.3	38.0	64.6	99.8	169.8	215.6
Shear	≥ C20/25	V_{Rk}	[kN]	13.8	21.7	31.1	42.4	55.3	86.4	135.0	169.4	221.1

Design resistance

Rebar size				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete												
Tension	C20/25	N_{Rd}	[kN]	13.4	18.8	27.6	36.7	38.2	60.6	83.2	121.2	142.0
	C50/60			14.7	20.7	30.4	40.3	46.1	78.3	110.9	145.1	156.7
Shear	≥ C20/25	V_{Rd}	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	90.0	112.9	147.4
Cracked concrete												
Tension	C20/25	N_{Rd}	[kN]	5.4	7.9	12.7	16.8	19.2	32.6	50.4	84.9	99.4
	C50/60			5.9	8.6	13.9	18.5	21.1	35.9	55.4	94.3	119.8
Shear	≥ C20/25	V_{Rd}	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	90.0	112.9	147.4

WIT-VM 250 WITH REBAR

Recommended/allowable loads [1)]

Rebar size				Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete												
Tension	C20/25	N_{rec}	[kN]	9.6	13.5	19.7	26.2	27.3	43.3	59.4	86.6	101.4
	C50/60			10.5	14.8	21.7	28.8	32.9	56.0	79.2	103.7	111.9
Shear	≥ C20/25	V_{rec}	[kN]	6.5	10.3	14.8	20.2	26.3	41.1	64.3	80.7	105.3
Cracked concrete												
Tension	C20/25	N_{rec}	[kN]	3.8	5.6	9.1	12.0	13.7	23.3	36.0	60.6	71.0
	C50/60			4.2	6.2	10.0	13.2	15.1	25.6	39.6	67.4	85.6
Shear	≥ C20/25	V_{rec}	[kN]	6.5	10.3	14.8	20.2	26.3	41.1	64.3	80.7	105.3

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Temperature range 1 (min. base material temperature -40°C, max. long term/short term base material temperature: +24°C/40°C)
- Dry or wet conditions of drill hole, hammer drilling (Installation factors might apply for other drilling methods)
- Rebar material according to specifications, steel grade B500B

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Design steel resistance	$N_{Rd,s}$	[kN]	19.6	31.0	44.4	60.5	79.0	123.4	192.9	242.0	315.9

WIT-VM 250 WITH REBAR

2. Design combined pull-out and concrete cone resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of combined pull-out and concrete cone failure of a single anchor

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete											
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	13.4	18.8	27.6	36.7	41.9	71.2	100.8	131.9	142.4
Cracked concrete											
Combined pull-out and concrete cone resistance	$N^0_{Rd,p}$	[kN]	5.4	7.9	12.7	16.8	19.2	32.6	50.4	85.8	108.9

- $s_{cr,p} = 7.3\, d\, (f_{sus} \cdot \tau_{Rk})^{0.5} \leq 3h_{ef}$
- $c_{cr,p} = s_{cr,p}/2$

Where τ_{Rk} is the value $\tau_{Rk,ucr}$ for non-cracked concrete C20/25

Table 3: Characteristic edge distance $c_{cr,p}$ and spacing $s_{cr,p}$ (f_{sus} = 1)

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Spacing	$s_{cr,p}$	[mm]	185	253	303	354	375	506	605	646	681
Edge distance	$c_{cr,p}$	[mm]	92	126	152	177	188	253	303	323	341

a. Influence of concrete strength

Table 4: Influence of concrete strength on combined pull-out and concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.02	1.04	1.07	1.08	1.09	1.10

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \frac{h_{ef}}{h_{ef,typ}}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „installation parameters“.

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 5: Influence of spacing on combined pull-out and concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ 1)	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,p}$, $f_{sy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,p}$, $f_{sy,p}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,p}$, $f_{sy,p}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,p}$, $f_{sy,p}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

1) Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,p} = 0.7 + 0.3\frac{c_x}{c_{cr,p}} \leq 1 \qquad f_{cx,2,p} = f_{cy,p} = \left(1 + \frac{c_{x(y)}}{c_{cr,p}}\right) \cdot \frac{1}{2} \leq 1$$

Table 6: Influence of edge distance on combined pull-out and concrete cone resistance

$c/c_{cr,P}$	0,10	0,15	0,20	0,25	0,30	0,35	0,40	0,45	0,50	0,55	0,60	0,65	0,70	0,75	0,70	0,75	0,90	0,95	≥ 1
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-VM 250 WITH REBAR

e. Influence of sustained loads

$$a_{sus} = \frac{N_{sus,d}}{N_{Ed}}$$

$N_{sus,d}$ = design value of sustained actions (permanent actions & permanent component of variable actions)
N_{Ed} = Value of total actions in tension loading at ultimate limit state

Table 7: Influence of sustained loads on combined pull-out and concrete cone resistance

a_{sus}	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
f_{sus}	1.00	1.00	1.00	1.00	1.00	1.00	0.90	0.80	0.70	0.60

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases.
b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 8: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete											
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	23.5	23.3	31.5	38.2	38.2	60.6	83.2	121.2	142.0
Cracked concrete											
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	16.4	16.3	22.1	26.7	26.7	42.4	58.2	84.9	99.4

Table 9: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Spacing	$s_{cr,N}$	[mm]	240	270	330	375	375	510	630	810	900
Edge distance	$c_{cr,N}$	[mm]	120	135	165	188	188	255	315	405	450

Above characteristic spacing and edge distances are given for the typical effective anchorage depths. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$s_{cr,N} = 3\ h_{ef}$ and $c_{cr,N} = 1.5\ h_{ef}$

a. Influence of concrete strength

Table 10: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,\,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 11: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\,\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 12: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

WIT-VM 250 WITH REBAR

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

Table 13: Design resistance $N_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete											
Splitting resistance	$N^0_{Rd,sp}$	[kN]	13.4	18.8	27.6	36.7	38.2	60.6	83.2	121.2	142.0

Table 14: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 25**	**Ø 28**	**Ø 32**
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Characteristic spacing	$s_{cr,sp}$	[mm]	360	420	528	600	590	816	1004	1296	1440
Characteristic edge distance	$c_{cr,sp}$	[mm]	180	210	264	300	295	408	502	648	720
Minimum member thickness	h_{min}	[mm]	110	120	142	161	165	218	274	340	380

Above characteristic spacing and edge distances are given for the typical effective anchorage depth. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,sp} = 2 \cdot c_{cr,sp} \quad \text{and} \quad c_{cr,sp} = \left\{ h_{ef} \leq 2\, h_{ef} \cdot \left(2.5 - \left(\frac{h_{min}}{h_{ef}} \right) \right) \leq 2.4\, h_{ef} \right\}$$

and h_{min} according to the table „anchor characteristics".

a. Influence of concrete strength

Table 15: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 16: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1$$

$$f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 17: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

e. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 18: Influence of concrete member thickness on splitting resistance

h/h_{min}	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.3	2.4	2.7	2.8	2.9
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

WIT-VM 250 WITH REBAR

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot min\ \{N_{Rd,p;}\ N_{Rd,c}\}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 19: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Design steel resistance	$V_{Rd,s}$	[kN]	9.2	14.5	20.7	28.2	36.9	57.6	90.0	112.9	147.4

2. Design concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot min\ \{N_{Rd,p};N_{Rd,c}\}$$

Table 20: factor k_8 for calculating design pry-out resistance

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0

3. Design concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq max\ (10\ h_{ef}\ ;\ 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 21: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Effective anchorage length	h_{ef}	[mm]	80	90	110	125	125	170	210	270	300
Non-cracked concrete											
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	3.3	4.8	6.5	8.5	10.3	15.3	22.4	28.3	35.2
Cracked concrete											
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	2.4	3.4	4.6	6.0	7.3	10.9	15.8	20.0	24.9

a. Influence of concrete strength

Table 22: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

Table 23: Influence of embedment depth on concrete edge resistance

h_{ef}/d	4	5	6	7	8	9	10	11	≥ 12
$f_{hef,V}$	0.87	0.91	0.94	0.97	1.00	1.02	1.05	1.07	1.08

c. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 24: Influence of spacing on concrete edge resistance

s/c_1[1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s, when there are different spacings in the row closest to the edge.

d. Influence of edge distance c_1

Table 25: Influence of edge distance c1 on concrete edge resistance

c_1/d	4	8	12	15	20	30	40	50	60	100	150	200
$f_{c1,V}$	0.47	1.19	2.05	2.76	4.05	6.95	10.22	13.76	17.54	34.66	59.52	87.35

WIT-VM 250 WITH REBAR

e. Influence of edge distance c_2

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\frac{c_2}{1.5c_1}\right) \leq 1$$

Table 26: Influence of edge distance c_2 on concrete edge resistance

$c_{2/c1}$ [1)]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1)] Distance to the second edge: $c_1 \leq c_2$

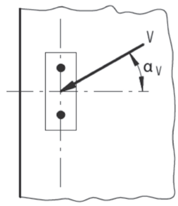
f. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{\cos^2\alpha_V + \left(\frac{\sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 27: Influence of load direction on concrete edge resistance

α [1)]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1)] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.



g. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 28: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

WIT-VM 250 R

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Design bond strength

Service temperature

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +80°C	+50°C	+80°C
Temperature range III	- 40°C to +120°C	+72°C	+120°C

Working life of 50 years

1- Non-cracked concrete

Rebar size			Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø25	Ø28	Ø32
Design bond resistance in non-cracked concrete C20/25, Dry and wet concrete											
Temperature range I	$\tau_{Rd,ucr}$	[N/mm²]	6.7	6.7	6.7	6.7	6.7	6.7	6.1	5.6	4.7
Temperature range II			5.0	5.0	5.0	5.0	5.0	5.0	4.4	3.9	3.3
Temperature range III			3.7	3.6	3.6	3.6	3.6	3.6	3.3	2.8	2.5
Design bond resistance in non-cracked concrete C20/25, Flooded bore hole											
Temperature range I	$\tau_{Rd,ucr}$	[N/mm²]	3.6	4.0	4.0	4.0	4.0	not admissible			
Temperature range II			2.6	3.1	3.1	3.1	3.1	not admissible			
Temperature range III			1.9	2.4	2.4	2.4	2.4	not admissible			

2- Cracked concrete

Rebar size			Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø25	Ø28	Ø32
Design bond resistance in non-cracked concrete C20/25, Dry and wet concrete											
Temperature range I	$\tau_{Rd,ucr}$	[N/mm²]	2.7	2.8	3.1	3.1	3.1	3.1	3.1	3.6	3.6
Temperature range II			1.7	1.9	2.2	2.2	2.2	2.2	2.2	2.5	2.5
Temperature range III			1.3	1.4	1.7	1.7	1.7	1.7	1.7	1.9	1.9
Design bond resistance in non-cracked concrete C20/25, Flooded bore hole											
Temperature range I	$\tau_{Rd,ucr}$	[N/mm²]	1.9	1.9	2.6	2.6	2.6	not admissible			
Temperature range II			1.2	1.4	1.9	1.9	1.9	not admissible			
Temperature range III			1.0	1.2	1.4	1.4	1.4	not admissible			

Reduction factors

Working life of 50 years

1- Non-cracked concrete

Rebar size			**Ø8**	**Ø10**	**Ø12**	**Ø14**	**Ø16**	**Ø20**	**Ø25**	**Ø28**	**Ø32**
Reduction factor for non-cracked concrete C20/25, Dry and wet concrete											
Temperature range I	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II			0.75	0.75	0.75	0.75	0.75	0.75	0.73	0.70	0.71
Temperature range III			0.55	0.54	0.54	0.54	0.54	0.54	0.55	0.50	0.53
Reduction factor for non-cracked concrete C20/25, Flooded bore hole											
Temperature range I	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	not admissible			
Temperature range II			0.73	0.76	0.76	0.76	0.76	not admissible			
Temperature range III			0.53	0.59	0.59	0.59	0.59	not admissible			

2- Cracked concrete

Rebar size			**Ø8**	**Ø10**	**Ø12**	**Ø14**	**Ø16**	**Ø20**	**Ø25**	**Ø28**	**Ø32**
Reduction factor for non-cracked concrete C20/25, Dry and wet concrete											
Temperature range I	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II			0.63	0.70	0.73	0.73	0.73	0.73	0.73	0.69	0.69
Temperature range III			0.50	0.50	0.55	0.55	0.55	0.55	0.55	0.54	0.54
Reduction factor for non-cracked concrete C20/25, Flooded bore hole											
Temperature range I	$\tau_{Rd,ucr}$	[N/mm²]	1.00	1.00	1.00	1.00	1.00	not admissible			
Temperature range II			0.63	0.75	0.73	0.73	0.73	not admissible			
Temperature range III			0.50	0.63	0.55	0.55	0.55	not admissible			

WIT-VM 250 WITH REBAR

Mechanical characteristics

Steel grade	Rebar size			Ø8	Ø10	Ø12	Ø14	Ø16	Ø20	Ø24	Ø25	Ø28	Ø32
	Stressed cross section	A_s	[mm²]	50	79	113	154	201	314	452	491	616	804
	Section modulus	W	[mm³]	50	98	170	269	402	785	1357	1534	2155	3217
460A	Yield strength	f_y	[N/mm²]	460	460	460	460	460	460	460	460	460	460
	Tensile strength	f_u	[N/mm²]	483	483	483	483	483	483	483	483	483	483
	Design bending moment	$M^0_{Rd,s}$	[Nm]	19	38	66	104	155	303	524	593	833	1243
460B	Yield strength	fy	[N/mm²]	460	460	460	460	460	460	460	460	460	460
	Tensile strength	fu	[N/mm²]	497	497	497	497	497	497	497	497	497	497
	Design bending moment	$M^0_{Rd,s}$	[Nm]	20	39	68	107	160	312	540	610	857	1279
B500B	Yield strength	f_y	[N/mm²]	500	500	500	500	500	500	500	500	500	500
	Tensile strength	f_u	[N/mm²]	550	550	550	550	550	550	550	550	550	550
	Design bending moment	$M^0_{Rd,s}$	[Nm]	22	43	75	118	177	345	597	675	948	1415

Material specifications

Product form		**Bars and de-coiled rods**		
Class		**A**	**B**	**C**
Characteristic yield strength f_{yk} or $f_{0.2k}$ (MPa)		400 to 600		
Minimum value of $k = (f_t/f_y)_k$		≥ 1.05	≥ 1.08	≥ 1.15 < 1.35
Characteristic strain at maximum force, ε_{uk} (%)		≥ 2.5	≥ 5.0	≥ 7.5
Bendability		Bend/Rebend test		
Maximum deviation from nominal mass (individual bar or wire) (%)	Nominal bar size (mm) ≤ 8 > 8	+/- 6.0 +/- 4.5		

Chemical resistance

Chemical Agent	Concentration	Resistant	Not Resistant
Accumulator acid		●	
Acetic acid	40		●
Acetic acid	10	●	
Acetone	10		●
Ammonia, aqueous solution	5	●	
Aniline	100		●
Beer		●	
Benzene (kp 100-140°F)	100	●	
Benzol	100		●
Boric Acid, aqueous solution		●	
Calcium carbonate, suspended in water	all	●	
Calcium chloride, suspended in water		●	
Calcium hydroxide, suspended in water		●	
Carbon tetrachloride	100	●	
Caustic soda solution	10	●	
Citric acid	all	●	
Diesel oil	100	●	
Ethyl alcohol, aqueous solution	50		●
Formic acid	100		●
Formaldehyde, aqueous solution	30	●	
Freon		●	
Fuel Oil		●	
Gasoline (premium grade)	100	●	
Glycol (Ethylene glycol)		●	
Hydraulic fluid	conc.	●	
Hydrochloric acid (Muriatic Acid)	conc.		●
Hydrogen peroxide	30		●
Isopropyl alcohol	100		●
Lactic acid	all	●	
Linseed oil	100	●	
Lubricating oil	100	●	
Magnesium chloride, aqueous solution	all	●	
Methanol	100		●
Motor oil (SAE 20 W-50)	100	●	
Nitric acid	10		●
Oleic acid	100	●	
Perchloroethylene	100	●	
Petroleum	100	●	
Phenol, aqueous solution	8		●
Phosphoric acid	85	●	
Potash lye (Potassium hydroxide)	10	●	
Potassium carbonate, aqueous solution	all	●	
Potassium chlorite, aqueous solution	all	●	
Potassium nitrate, aqueous solution	all	●	
Sodium carbonate	all	●	
Sodium Chloride, aqueous solution	all	●	
Sodium phosphate, aqueous solution	all	●	
Sodium silicate	all	●	
Standard Benzine	100	●	
Sulfuric acid	10	●	
Sulfuric acid	70		●
Tartaric acid	all	●	
Tetrachloroethylene	100	●	
Toluene			●
Trichloroethylene	100		●
Turpentine	100	●	

Results shown in the table are applicable to brief periods of chemical contact with full cured adhesive (e.g. temporary contact with adhesive during a spill).

WIT-VM 250 WITH REBAR

Properties of adhesive

Property		Testing method	Result / mean value
Stability			
UV-resistance (sunlight)			not resistant
Temperature resistance			120°C
Water resistance			resistant
Cleaning agents			1% tenside solution: no effect
Physical properties			
Flexural properties	Flexural strength	DIN EN 196-1	after 24 hours: 14.7 N/mm²
Compressive properties	Compressive strength	DIN EN 196-1	after 24 hours: ≥ 100 N/mm²
Dynamic modulus of elasticity		DIN EN 12504-4	after 24 hours: 14,09 GPa
Thermal conductivity	Modified transient plane source method		0,66 / 0,63 W/mK
Specific contact resistance		IEC 93	3,6 x 10^9 Ωcm
Density		DIN 53479	1,77 ± 0,1 g/cm³
Workability features			
Water tightness / Impermeability		DIN EN 12390-8	after 72 hours at 5 bar: 0 mm
Open time (10-20°C)			15 min
Curing time (10-20°C)			80 min
Shelf-life			18 months

For information use only. Values are not to be considered as a specification and do not reflect the performance of the system. The given values are typical values and are subject to change without notice.

Working and curing times

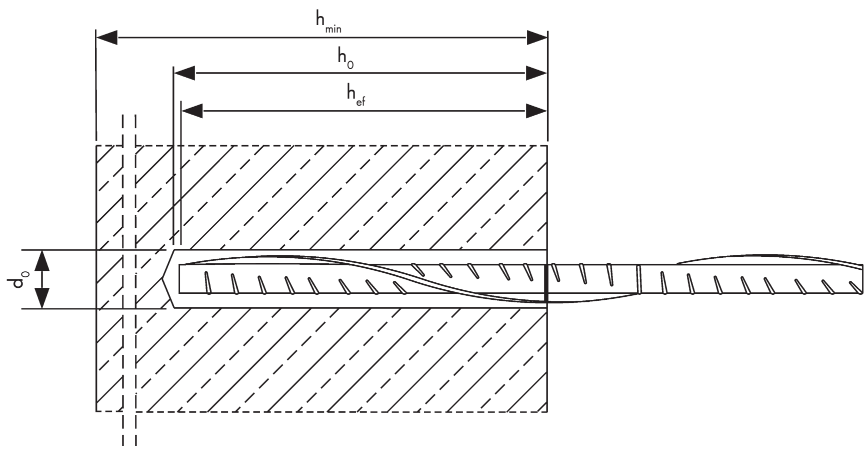
Temperature of base material	Gelling – working time	Min. curing time – dry conditions[1)]
–10°C to –6°C	90 min [2)]	24 h
–5°C to –1°C	90 min	14 h
0°C to 4°C	45 min	7 h
5°C to 9°C	25 min	2 h
10°C to 19°C	15 min	80 min
20°C to 29°C	6 min	45 min
30°C to 34°C	4 min	25 min
35°C to 39°C	2 min	20 min
> 40°C	90 s	15 min

[1)] for wet base material the curing time must be doubled

[2)] Cartridge temperature must be at min. +15°C

Installation parameters

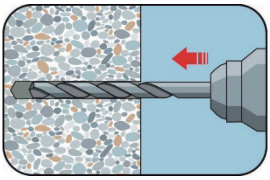
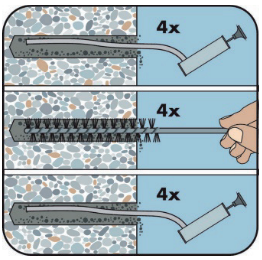
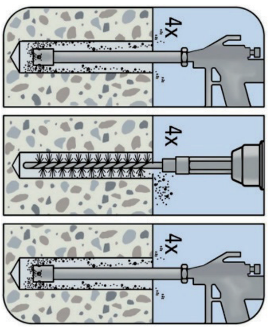
Rebar size			Ø 8	Ø 10	Ø 12	Ø 14	Ø 16	Ø 20	Ø 25	Ø 28	Ø 32
Nominal drill hole diameter	d_0	[mm]	12	14	16	18	20	25	32	35	40
Effective anchorage depth	$h_{ef,min}$	[mm]	60	60	70	75	80	90	100	112	128
	$h_{ef,max}$	[mm]	160	200	240	280	320	400	480	540	640
Diameter of steel brush	$d_b \geq$	[mm]	14	16	18	20	22	26	34	37	41.5
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 mm		$h_{ef} + 2d_0$						
Minimum spacing	s_{min}	[mm]	40	50	60	70	80	100	125	140	160
Minimum edge distance	c_{min}	[mm]	40	50	60	70	80	100	125	140	160

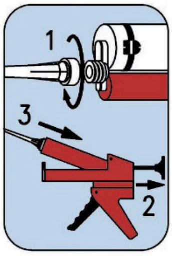
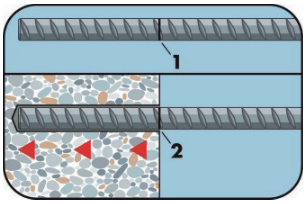
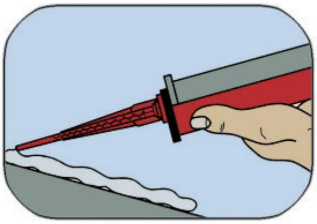
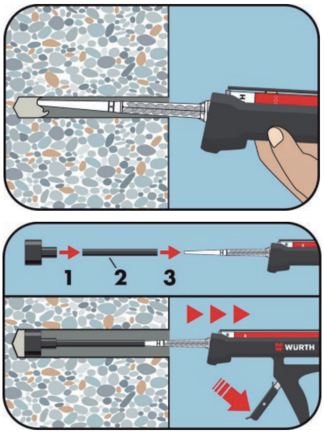


WIT-VM 250 R

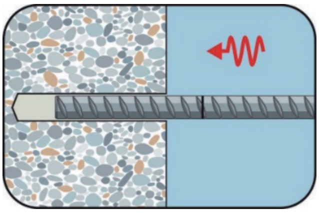
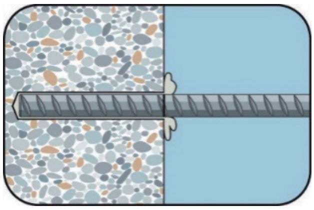
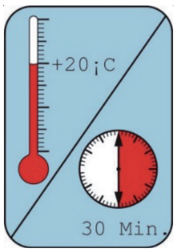
WIT-VM 250 WITH REBAR

Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer (HD) or compressed air drilling (CD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. In case of aborted drill hole, the drill hole shall be filled with mortar.
B) Bore hole cleaning		
MAC: Cleaning for bore hole diameter $d_0 \leq 20$ mm and bore hole depth $h_0 \leq 10$ ds (non-cracked concrete only!)		
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean using a hand pump a minimum of four times.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of four times in a twisting motion. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with a hand pump a minimum of four times.
CAC: Cleaning for dry, wet and water-filled bore holes with all diameters (non-cracked and cracked concrete)		
	**2a.**	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of four times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.
	2b.	Check brush diameter. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of four times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of four times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.

C) Preparation of anchor rod and cartridge		
	**3a.**	Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time as well as for every new cartridge, a new static-mixer shall be used.
	**3b.**	Prior to inserting the reinforcing bar into the filled bore hole, the position of the embedment depth shall be marked (e.g. with tape) on the reinforcing bar. After that, insert the bar in the empty hole to verify hole and depth lv. The anchor should be free of dirt, grease, oil and other foreign material.
	**3c.**	Prior to dispensing into the bore hole, squeeze out separately the mortar until it shows a consistent grey or red color (minimum of three full strokes) and discard non-uniformly mixed adhesive components.
D) Filling the bore hole		
	**4.**	Starting from the bottom or back of the cleaned bore hole, fill the hole with adhesive until the level mark at the mixer extension is visible at the top of the hole. For embedment larger than 190 mm, an extension nozzle shall be used. Slowly withdraw the static mixing nozzle. Using a piston plug during injection of the mortar helps to avoid creating air pockets. For overhead and horizontal installation and bore holes deeper than 240 mm, a piston plug and the appropriate mixer extension must be used. Observe the gel-/ working times.

WIT-VM 250 WITH REBAR

E) Setting the rebar		
	**5a.**	Push the reinforcing bar into the bore hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached. The bar should be free of dirt, grease, oil or other foreign material.
	**5b.**	Be sure that the bar is inserted in the bore hole until the embedment mark is at the concrete surface and that excess mortar is visible at the top of the hole. If these requirements are not maintained, the application has to be renewed. For horizontal and overhead installation, fix embedded part (e.g. with wedges).
	**5c.**	Observe gelling time t_{gel}. Attend that the gelling time can vary according to the base material temperature. Do not move or load the bar until full curing time t_{cure} has elapsed. Allow the adhesive to cure to the specified time prior to applying any load. Do no move or load the bar until it is fully cured. After full curing time tcure has elapsed, the add-on part can be installed.

Filling Quantity

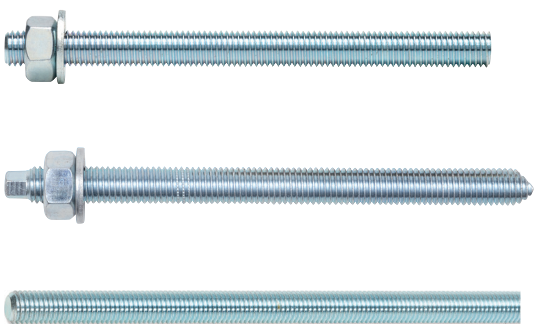
Anchor type: Ø 8 - Ø 32

Rebar size			**Ø 8**	**Ø 10**	**Ø 12**	**Ø 14**	**Ø 16**	**Ø 20**	**Ø 24**	**Ø 25**	**Ø 28**	**Ø 32**
Nominal drill hole diameter	d_0	[mm]	12	14	16	18	20	25	32	32	35	40
Drill depth	h_0 / h_1	[mm]	= l_v									
Filling volume per 10mm embed-ment depth		[ml]	0.81	1.01	1.21	1.43	1.66	2.59	4.85	4.47	5.07	6.62

Assumed waste of 15 % included.

WIT-PM 200 WITH THREADED ROD (METRIC)

300 ml 330 ml 420 ml



Approved for:
Concrete C20/25 to C50/60, non-cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

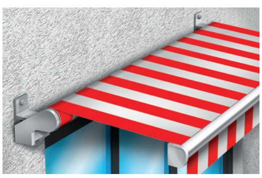
Cartridge sizes		Art. no.
300 ml	foil-in-tube	**5918 242 300**
330 ml	coaxial	**5918 240 330**
420 ml	coaxial	**5918 240 420**

Type of installation		
Pre-positioned	In-place	Stand-off
✓	–	✓

Installation condition		
Dry concrete	Wet concrete	Flooded drill hole
✓	✓	✓

Drilling method		
Hammer drill	Diamond drill	Hollow drill
✓	–	–

Applications



Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	TZUS, Prag	ETAG 001-T5	ETA-12/0569, 25.01.2016
European Technical Assessment	TZUS, Prag	ETAG 029	ETA-13/0037, 28.04.2016
LEED	eurofins		20.12.18
VOC Emissions Test report	eurofins	DEVL 1101903D, DEVL 1104875A	20.12.18

Basic load data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness and embedment depth are according to anchor characteristics
- Anchor material according is to specifications,
- Concrete C 20/25, f_{ck} = 20 N/mm^2
- Concrete C 50/60, f_{ck} = 60 N/mm^2
- Temperature range I (min. base material temperature -40°C, max long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling

Characteristic resistance

Thread size				M8	M10	M12	M16	M20	M24
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210
Non-cracked concrete									
Tension	C20/25	N_{Rk}	[kN]	17.1	22.6	33.2	50.3	85.5	126.7
	C50/60			18.3	24.9	36.5	55.3	94.0	139.3
Shear	≥ C20/25	V_{Rk}	[kN]	11.0	17.4	25.3	47.1	73.5	105.9

Design resistance

Thread size				M8	M10	M12	M16	M20	M24
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210
Non-cracked concrete									
Tension	C20/25	N_{Rd}	[kN]	9.5	12.6	18.4	27.9	47.5	70.4
	C50/60			10.4	13.8	20.3	30.7	52.2	77.4
Shear	≥ C20/25	V_{Rd}	[kN]	8.8	13.9	20.2	37.7	58.8	84.7

Recommended/allowable Loads [1)]

Thread size				M8	M10	M12	M16	M20	M24
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210
Non-cracked concrete									
Tension	C20/25	N_{rec}	[kN]	6.8	9.0	13.2	19.9	33.9	50.3
	C50/60			7.5	9.9	14.5	21.9	37.3	55.3
Shear	≥ C20/25	V_{rec}	[kN]	6.3	9.9	14.5	26.9	42.0	60.5

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

WIT-PM 200 WITH THREADED ROD (METRIC)

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Temperature range 1 (min. base material temperature -40°C, max. long term/short term base material temperature: +24°C/40°C).
- Dry or wet conditions of drill hole, hammer drilling (Installation factors might apply for other drilling methods)
- Anchor material according to specifications, steel grade 5.8 unless otherwise stated in the tables

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size				M8	M10	M12	M16	M20	M24
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210
Design steel resistance	5.8	$N_{Rd,s}$	[kN]	12.2	19.3	28.1	52.3	81.7	117.7
	8.8	$N_{Rd,s}$	[kN]	19.3	30.7	44.7	83.3	130.7	188.0
	A4	$N_{Rd,s}$	[kN]	13.9	21.9	31.6	58.8	91.4	132.1

2. Design combined pull-out and concrete cone resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,p} \cdot f_{sy,p} \cdot f_{cx,1,p} \cdot f_{cx,2,p} \cdot f_{cy,p} \cdot f_{sus}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of combined pull-out and concrete cone failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210
Non-cracked concrete								
Combined pull-outand concrete cone resistance	$N^0_{Rd,p}$	[kN]	9.5	12.6	18.4	27.9	47.5	70.4

- $s_{cr,p} = 7.3\, d\, (f_{sus} \cdot \tau_{Rk})^{0.5} \leq 3h_{ef}$
- $c_{cr,p} = s_{cr,p}/2$

Where τ_{Rk} is the value $\tau_{Rk,ucr}$ for non-cracked concrete C20/25

Table 3: Characteristic edge distance $c_{cr,p}$ and spacing $s_{cr,p}$ (f_{sus} = 1)

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210
Spacing	$s_{cr,p}$	[mm]	170	206	248	330	413	496
Edge distance	$c_{cr,p}$	[mm]	85	103	124	165	206	248

a. Influence of concrete strength

Table 4: Influence of concrete strength on combined pull-out and concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.02	1.04	1.07	1.08	1.09	1.10

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

$$f_{hef} = \frac{h_{ef}}{h_{ef,typ}}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „installation parameters".

WIT-PM 200 WITH THREADED ROD (METRIC)

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right) \frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 5: Influence of spacing on combined pull-out and concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	$f_{sx,p,}$ $f_{sy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,p,}$ $f_{sy,p}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,p,}$ $f_{sy,p}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,p,}$ $f_{sy,p}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1,p} = 0.7 + 0.3 \frac{c_x}{c_{cr,p}} \leq 1 \qquad f_{cx,2,p} = f_{cy,p} = \left(1 + \frac{c_{x(y)}}{c_{cr,p}}\right) \cdot \frac{1}{2} \leq 1$$

Table 6: Influence of edge distance on combined pull-out and concrete cone resistance

$c/c_{cr,P}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,p}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,p}$ / $f_{cy,p}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

e. Influence of sustained loads

$$a_{sus} = \frac{N_{sus,d}}{N_{Ed}}$$

$N_{sus,d}$ = design value of sustained actions (permanent actions & permanent component of variable actions)
N_{Ed} = Value of total actions in tension loading at ultimate limit state

Table 7: Influence of sustained loads on combined pull-out and concrete cone resistance

a_{sus}	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
f_{sus}	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases.

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 8: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210
Non-cracked concrete								
Concrete cone resistance	$N^0_{Rd,c}$	[kN]	19.6	23.3	31.5	38.2	60.6	83.2

Table 9: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210
spacing	$s_{cr,N}$	[mm]	240	270	330	375	510	630
edge distance	$c_{cr,N}$	[mm]	120	135	165	188	255	315

Above characteristic spacing and edge distances are given for the typical effective anchorage depths. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,N} = 3\ h_{ef} \text{ and } c_{cr,N} = 1.5\ h_{ef}$$

a. Influence of concrete strength

Table 10: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

WIT-PM 200 WITH THREADED ROD (METRIC)

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 11: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,p}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

d. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 12: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{hef} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

Table 13: Design resistance $N_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210
Non-cracked concrete								
Concrete splitting failure	$N^0_{Rd,sp}$	[kN]	9.5	12.6	18.4	27.9	47.5	70.4

Table 14: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210
Characteristic spacing	$s_{cr,sp}$	[mm]	360	420	528	600	816	1008
Characteristic edge distance	$c_{cr,sp}$	[mm]	180	210	264	300	408	504
Minimum member thickness	h_{min}	[mm]	110	120	140	161	218	266

Above characteristic spacing and edge distances are given for the typical effective anchorage depth. Calculating for smaller depths leads to conservative load capacities. For calculation with bigger depths, use the following:

$$s_{cr,sp} = 2 \cdot c_{cr,sp} \quad \text{and} \quad c_{cr,sp} = \left\{ h_{ef} \leq 2\, h_{ef} \cdot \left(2.5 - \left(\frac{h_{min}}{h_{ef}}\right)\right) \leq 2.4\, h_{ef} \right\}$$

and h_{min} according to the table „anchor characteristics".

a. Influence of concrete strength

Table 15: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

WIT-PM 200 WITH THREADED ROD (METRIC)

b. Influence of embedment depth

$$f_{hef} = \left(\frac{h_{ef}}{h_{ef,typ}}\right)^{1.5}$$

Consider the approved range of embedment $h_{ef,min} \leq h_{ef} \leq h_{ef,max}$ according to the table „anchor characteristics".

c. Influence of spacing

$$f_{sx,p} = f_{sy,p} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,p}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 16: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 17: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.3	2.4	2.7	2.8	2.9
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot min\ \{N_{Rd,p;}\ N_{Rd,c}\}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 19: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Thread size				M8	M10	M12	M16	M20	M24
Effective anchorage depth		h_{ef}	[mm]	80	90	110	125	170	210
Design steel resistance	5.8	$V_{Rd,s}$	[kN]	8.8	13.9	20.2	37.7	58.8	84.7
	8.8		[kN]	12.0	18.4	27.2	50.4	78.4	112.8
	A4		[kN]	8.3	12.8	19.2	35.3	55.1	79.5

2. Design concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot min\ \{N_{Rd,p};N_{Rd,c}\}$$

Table 20: factor k_8 for calculating design pry-out resistance

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0	2.0	2.0

3. Design concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{hef,V} \cdot f_{s,V} \cdot f_{c1,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq max\ (10\ h_{ef}\ ;\ 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 21: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210
Non-cracked concrete								
Basic design edge resistance	$V^0_{Rd,c}$	[kN]	3.3	4.8	6.5	10.3	15.3	21.1

WIT-PM 200 WITH THREADED ROD (METRIC)

a. Influence of concrete strength

Table 22: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.12	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of embedment depth

Table 23: Influence of embedment depth on concrete edge resistance

h_{ef}/d	4	5	6	7	8	9	10	11	≥ 12
$f_{hef,V}$	0.87	0.91	0.94	0.97	1.00	1.02	1.05	1.07	1.08

c. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 24: Influence of spacing on concrete edge resistance

s/c_1[1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

d. Influence of edge distance c_1

Table 20: Influence of edge distance on concrete edge resistance

$c_{1/d}$	4	8	12	15	20	30	40	50	60	100	150	200
$f_{c1,V}$	0.47	1.19	2.05	2.76	4.05	6.95	10.22	13.76	17.54	34.66	59.52	87.35

e. Influence of edge distance c_2

$$f_{c2,V} = \left(\frac{1}{2}+\frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7+0.3\frac{c_2}{1.5c_1}\right) \leq 1$$

Table 26: Influence of edge distance c2 on concrete edge resistance

c_2/c_1 [1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: c1 ≤ c2

f. Influence of load direction

$$f_{\alpha} = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

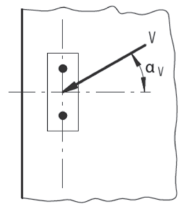


Table 27: Influence of load direction on concrete edge resistance

α [1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.

g. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 28: Influence of concrete member thickness on edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

WIT-PM 200 WITH THREADED ROD (METRIC)

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

Design bond strength

Service temperature

	Base material temperature	Maximum long-term base material temperature	Maximum short-term base material temperature
Temperature range I	- 40°C to +40°C	+24°C	+40°C
Temperature range II	- 40°C to +80°C	+50°C	+80°C

Working life of 50 years

1- Non-cracked concrete

Thread size				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**
Design bond resistance in non-cracked concrete C20/25									
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm^2]	4.7	4.4	4.4	4.4	4.4	4.4
	Flooded bore hole			4.7	4.4	4.4	4.4	4.4	4.4
Temperature range II	Dry and wet concrete			3.6	3.3	3.3	3.3	3.3	3.3
	Flooded bore hole			3.6	3.3	3.3	3.3	3.3	3.3

Reduction factor

Working life of 50 years

1- Non-cracked concrete

Thread size				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**
Reduction factor for non-cracked concrete C20/25									
Temperature range I	Dry and wet concrete	$\tau_{Rd,ucr}$	[N/mm^2]	1.00	1.00	1.00	1.00	1.00	1.00
	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00
Temperature range II	Dry and wet concrete			1.00	1.00	1.00	1.00	1.00	1.00
	Flooded bore hole			1.00	1.00	1.00	1.00	1.00	1.00

WIT-PM 200 WITH THREADED ROD (METRIC)

Mechanical characteristics

Steel grade	Thread size			M8	M10	M12	M16	M20	M24	M27	M30
	Stressed cross section	A_s	[mm²]	37	58	84	157	245	352	459	561
	Section modulus	W	[mm³]	31	62	109	277	541	935	1387	1874
4.6	Yield strength	f_y	[N/mm²]	240	240	240	240	240	240	240	240
	Tensile strength	f_u	[N/mm²]	400	400	400	400	400	400	400	400
	Design bending moment	$M^0_{Rd,s}$	[Nm]	9.0	18.0	31.1	79.6	155.7	268.9	398.8	538.9
4.8	Yield strength	f_y	[N/mm²]	320	320	320	320	320	320	320	320
	Tensile strength	f_u	[N/mm²]	400	400	400	400	400	400	400	400
	Design bending moment	$M^0_{Rd,s}$	[Nm]	12.0	24.0	41.6	106.4	208.0	359.2	532.8	720.0
5.6	Yield strength	f_y	[N/mm²]	300	300	300	300	300	300	300	300
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	11.4	22.2	38.9	99.4	194.0	335.3	498.8	672.5
5.8	Yield strength	f_y	[N/mm²]	400	400	400	400	400	400	400	400
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	15.2	29.6	52	132.8	259.2	448	666.4	898.4
8.8	Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640
	Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800
	Design bending moment	$M^0_{Rd,s}$	[Nm]	24.0	48.0	84.0	212.8	415.2	716.8	1066.4	1437.6
A4-50	Yield strength	f_y	[N/mm²]	210	210	210	210	210	210	210	210
	Tensile strength	f_u	[N/mm²]	500	500	500	500	500	500	500	500
	Design bending moment	$M^0_{Rd,s}$	[Nm]	8.0	15.5	27.7	70.2	136.6	235.7	349.6	472.7
A4-70	Yield strength	f_y	[N/mm²]	450	450	450	450	450	450	-	-
	Tensile strength	f_u	[N/mm²]	700	700	700	700	700	700	-	-
	Design bending moment	$M^0_{Rd,s}$	[Nm]	16.7	33.3	59.0	148.7	291.0	502.6	-	-

Material specifications

Part	Designation	Material				
Steel, zinc plated (Steel acc. to EN 10087:1998 or EN 10263:2001)						
- zinc plated	≥ 5 µm	acc. to EN ISO 4042:1999				
- hot-dip galvanized	≥ 40 µm	acc. to EN ISO 1461:2009 and EN ISO 10684:2004+AC:2009				
- sherardized	≥ 45 µm	acc. to EN ISO 17668:2016				
1	Anchor rod	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 898-1:2013	4.6	f_{uk} = 400 N/mm²	f_{yk} = 240 N/mm²	A5 > 8%
			4.8	f_{uk} = 400 N/mm²	f_{yk} = 320 N/mm²	A5 > 8%
			5.6	f_{uk} = 500 N/mm²	f_{yk} = 300 N/mm²	A5 > 8%
			5.8	f_{uk} = 500 N/mm²	f_{yk} = 400 N/mm²	A5 > 8%
			8.8	f_{uk} = 800 N/mm²	f_{yk} = 640 N/mm²	A5 > 12% [3)]
2	Hexagon nut	acc. to EN ISO 898-2:2012	4	for anchor rod class 4.6 or 4.8		
			5	for anchor rod class 5.6 or 5.8		
			8	for anchor rod class 8.8		
3a	Washer	Steel, zinc plated, hot-dip galvanized or sherardized (e.g.: EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000, or EN ISO 7094:2000)				
3b	Filling washer	Steel, zinc plated, hot-dip galvanized or sherardized				
4	Internal threaded anchor rod	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 898-1:2013	5.8	f_{uk} = 500 N/mm²	f_{yk} = 400 N/mm²	A5 > 8%
			8.8	f_{uk} = 800 N/mm²	f_{yk} = 640 N/mm²	A5 > 8%

WIT-PM 200 WITH THREADED ROD (METRIC)

Part	Designation	Material				
	Stainless steel A2 (Material 1.4301 / 1.4303 / 1.4307 / 1.4567 or 1.4541, acc. to EN 1088-1:2014) **Stainless steel A4** (Material 1.4401 / 1.4404 / 1.4571 / 1.4362 or 1.4578, acc. to EN 10088-1:2014) **High corrosion resistance steel** (Material 1.4529 or 1.4565, acc. to EN 10088-1:2014)					
1	Anchor rod [1,4]	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 3506-1:2009	50	f_{uk} = 400 N/mm^2	f_{yk} = 240 N/mm^2	A5 > 12% [3]
			70	f_{uk} = 400 N/mm^2	f_{yk} = 320 N/mm^2	A5 > 12% [3]
			80	f_{uk} = 500 N/mm^2	f_{yk} = 300 N/mm^2	A5 > 12% [3]
2	Hexagon nut [1,4]	acc. to EN ISO 3506-1:2009	50	for anchor rod class 50		
			70	for anchor rod class 70		
			80	for anchor rod class 80		
3a	Washer	Stainless steel A2 (Material 1.4301 / 1.4303 / 1.4307 / 1.4567 or 1.4541, acc. to EN 1088-1:2014) Stainless steel A4 (Material 1.4401 / 1.4404 / 1.4571 / 1.4362 or 1.4578, acc. to EN 10088-1:2014) HCR: Material 1.4529 or 1.4565, acc. to EN 10088-1:2014 (e.g.: EN ISO 887:2006, EN ISO 7089:2000, EN ISO 7093:2000, or EN ISO 7094:2000)				
3b	Filling washer	Stainless steel A4, High corrosion resistance steel				
4	Internal threaded anchor rod [1,2]	Property class		Characteristic tensile strength	Characteristic yield strength	Elongation at fracture
		acc. to EN ISO 3506-1:2009	50	f_{uk} = 500 N/mm^2	f_{yk} = 210 N/mm^2	A5 > 8%
			70	f_{uk} = 700 N/mm^2	f_{yk} = 450 N/mm^2	A5 > 8%

1) Property class 70 for anchor rods up to M24 and Internal threaded anchor rods up to IG-M16

2) for IG-M20 only property class 50

3) A5 > 8% fracture elongation if no requirement for performance category C2 exists

4) Property class 80 only for stainless steel A4

Chemical resistance

Chemical agent	Concentration	Resistant	Not resistant
Accumulator acid			●
Acetic acid	40		●
Acetic acid	10	●	
Acetone	10		●
Ammonia, aqueous solution	5	●	
Aniline	100		●
Beer		●	
Benzene (kp 100-140°F)	100	●	
Benzole	100		●
Boric Acid, aqueous solution			●
Calcium carbonate, suspended in water	all	●	
Calcium chloride, suspended in water		●	
Calcium hydroxide, suspended in water		●	
Carbon tetrachloride	100	●	
Caustic soda solution	10	●	
Citric acid	all	●	
Diesel oil	100	●	
Ethyl alcohol, aqueous solution	50		●
Formic acid	100		●
Formaldehyde, aqueous solution	30	●	
Freon		●	
Fuel Oil		●	
Gasoline (premium grade)	100	●	
Glycol (Ethylene glycol)		●	
Hydraulic fluid	conc.	●	
Hydrochloric acid (Muriatic Acid)	conc.		●
Hydrogen peroxide	30		●
Isopropyl alcohol	100		●
Lactic acid	all	●	
Linseed oil	100	●	
Lubricating oil	100	●	
Magnesium chloride, aqueous solution	all	●	
Methanol	100		●
Motor oil (SAE 20 W-50)	100	●	
Nitric acid	10		●
Oleic acid	100	●	
Perchloroethylene	100	●	
Petroleum	100	●	
Phenol, aqueous solution	8		●
Phosphoric acid	85	●	
Potash lye (Potassium hydroxide)	10	●	
Potassium carbonate, aqueous solution	all	●	
Potassium chlorite, aqueous solution	all	●	
Potassium nitrate, aqueous solution	all	●	
Sodium carbonate	all	●	
Sodium Chloride, aqueous solution	all	●	
Sodium phosphate, aqueous solution	all	●	
Sodium silicate	all	●	
Standard Benzine	100	●	
Sulfuric acid	10		●
Sulfuric acid	70		●
Tartaric acid	all	●	
Tetrachloroethylene	100	●	
Toluene			●
Trichloroethylene	100		●
Turpentine	100	●	

WIT-PM 200 WITH THREADED ROD (METRIC)

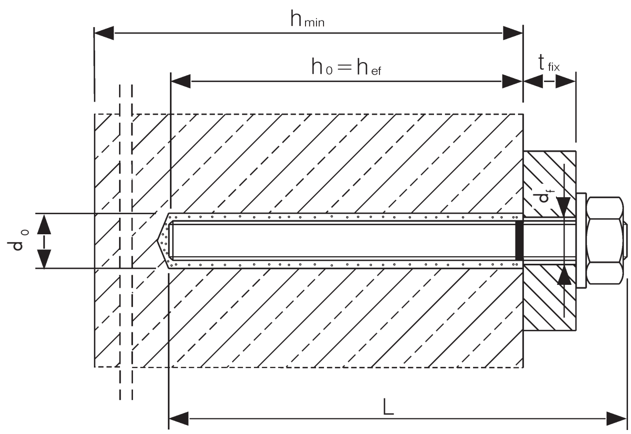
Working and curing times

Temperature of base material (°C)	Gelling - working time (min)	Min. curing time - dry conditions (min) [1]
-5 to -1	90	360
0 to +4	45	180
+5 to +9	25	120
+10 to +14	20	100
+15 to +19	15	80
+20 to 29	6	45
+30 to 34	4	25
+35 to +39	2	20
> 40°C	90 s	15

[1] for wet base material the curing time must be doubled

Installation parameters

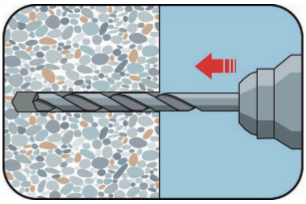
Anchor size			M8	M10	M12	M16	M20	M24
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	24	28
Effective anchorage depth	$h_{ef,min}$	[mm]	60	60	70	80	90	96
	$h_{ef,max}$	[mm]	160	200	240	320	400	480
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	9	12	14	18	22	26
Diameter of steel brush	$d_b \leq$	[mm]	12	14	16	20	26	30
Maximum torque moment	$T_{inst} \leq$	[Nm]	10	20	40	80	120	160
Thickness of fixture	$t_{fix,min} >$	[mm]	0					
	$t_{fix,max} <$	[mm]	1500					
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 30 mm ≥ 100 mm			$h_{ef} + 2d_0$		
Minimum spacing	s_{min}	[mm]	40	50	60	80	100	120
Minimum edge distance	c_{min}	[mm]	40	50	60	80	100	120

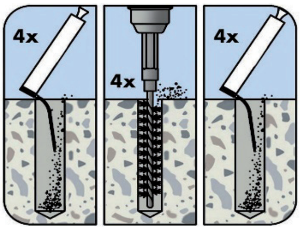
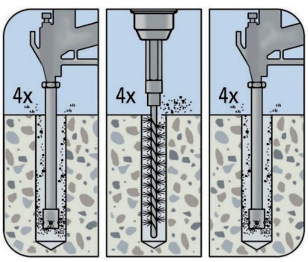


WIT-PM 200 M

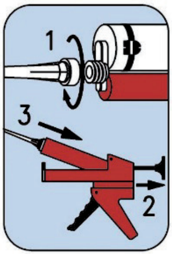
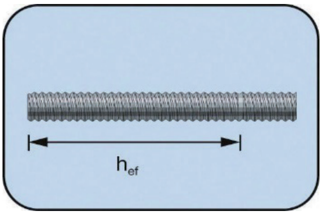
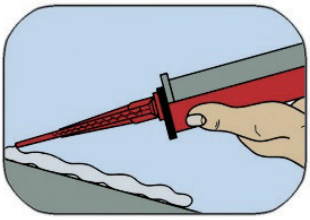
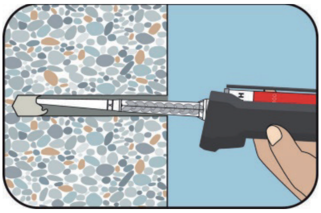
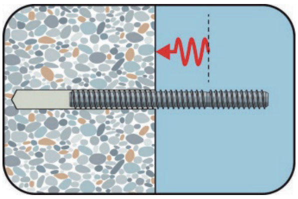
WIT-PM 200 WITH THREADED ROD (METRIC)

Installation instructions

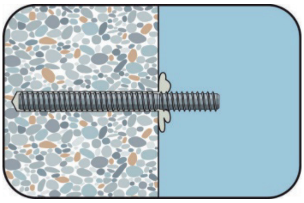
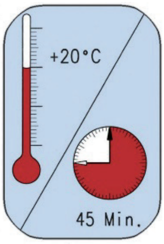
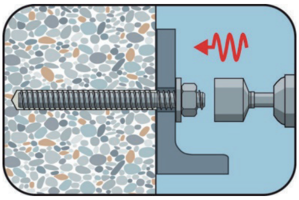
A) Bore hole drilling		
	1a.	**Hammer (HD) or compressed air drilling (CD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. In case of aborted drill hole, the drill hole shall be filled with mortar.

B) Bore hole cleaning		
MAC: Cleaning for bore hole diameter $d_0 \leq 20$ mm and bore hole depth $h_0 \leq 150$ mm (non-cracked concrete only!)		
	2a.	Starting from the bottom or back of the bore hole, blow the hole clean using a hand pump a minimum of four times.
	2b.	Check brush diameter and attach the brush to a drilling machine or a battery screwdriver. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of four times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with a hand pump a minimum of four times. If the bore hole ground is not reached, an extension shall be used.
CAC: Cleaning for dry, wet and water-filled bore holes with all diameters (non-cracked concrete only!)		
	2a.	Starting from the bottom or back of the bore hole, blow the hole clean with compressed air (min. 6 bar) a minimum of four times until return air stream is free of noticeable dust. If the bore hole ground is not reached an extension shall be used.
	2b.	Check brush diameter and attach the brush to a drilling machine or a battery screwdriver. Brush the hole with an appropriate sized wire brush > $d_{b,min}$ a minimum of four times. If the bore hole ground is not reached with the brush, a brush extension shall be used.
	2c.	Finally blow the hole clean again with compressed air (min. 6 bar) a minimum of four times until return air stream is free of noticeable dust. If the bore hole ground is not reached, an extension shall be used.

After cleaning, the bore hole has to be protected against rec-contamination in an appropriate way, until dispensing the mortar in the bore hole. If necessary, the cleaning has to be repeated directly before dispensing the mortar. In-flowing water must not contaminate the bore hole again.

C) Preparation of anchor rod and cartridge		
	**3a.**	Attach the supplied static-mixing nozzle to the cartridge and load the cartridge into the correct dispensing tool. For every working interruption longer than the recommended working time as well as for every new cartridge, a new static-mixer shall be used.
	**3b.**	Prior to inserting the anchor rod into the filled bore hole, the position of the embedment depth shall be marked on the anchor rod.
	**3c.**	Prior to dispensing into the bore hole, squeeze out separately the mortar until it shows a consistent grey or red color (minimum of three full strokes) and discard non-uniformly mixed adhesive components.
D) Filling the bore hole		
	**4.**	Starting from the bottom or back of the cleaned bore hole, fill the hole up to approximately two-thirds with adhesive. Slowly withdraw the static mixing nozzle as the hole fills to avoid creating air pockets. For embedment larger than 190 mm, an appropriate extension nozzle must be used. Observe the gel-/ working times.
E) Setting the anchor rod		
	**5a.**	Push the threaded rod into the bore hole while turning slightly to ensure positive distribution of the adhesive until the embedment depth is reached. The bar should be free of dirt, grease, oil or other foreign material.

WIT-PM 200 WITH THREADED ROD (METRIC)

	**5b.**	Be sure that the anchor is fully seated at the bottom of the hole and that excess mortar is visible at the top of the hole. If these requirements are not maintained, the application has to be renewed. For overhead applications, the anchor rod should be fixed (e.g. wedges).
	**5c.**	Allow the adhesive to cure to the specified time prior to applying any load or torque. Do not move or load the anchor until it is fully cured.
	**5d.**	After fully curing, the add-on part can be installed with up to the max. torque by using a calibrated torque wrench.

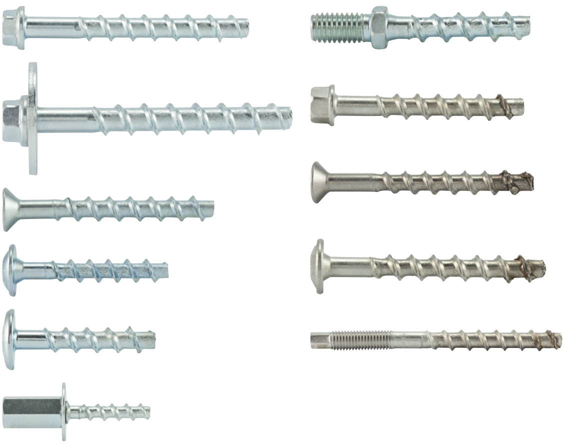
Filling Quantity

Anchor type: M8 - M30

Thread size			**M8**	**M10**	**M12**	**M16**	**M20**	**M24**
Nominal drill hole diameter	d_0	[mm]	10	12	14	18	24	28
Drill depth	h_0 / h_1	[mm]	$= h_{ef}$					
Filling volume per 10mm embedment depth		[ml]	0.53	0.70	0.89	1.27	2.61	3.35

Assumed waste of 15 % included.

CONCRETE SCREW W-BS



Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Type of installation

Pre-positioned	In-place	Stand-off
✓	✓	–

Applications




Approvals and certificates

Description	Authority / laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DiBt, Berlin	EAD 330232-01-0601	ETA-16/0043 / 2019-06-29
European Technical Assessment	DiBt, Berlin	ETAG 001 Part 6	ETA-16/0128 / 2018-04-06
German approval abZ/ aBG	DiBt, Berlin		Z-21.8-2090 / 2020-08-27
Report tension load capacity in hollow slabs	Ing. Büro Thiele, Pirmasens	ETAG 001	21641 / 2016-09-25
Expert Opinion	iBMB MPA, Braunschweig	EN 1363-1:2012-10 / Din 4102-4	2101/173/18 / 2018-08-13

Basic loading data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness is according to anchor characteristics
- Anchor material is as specified in anchor material specification table
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²

Characteristic resistance

Screw size: Ø 6 – Ø 10

Screw size					Ø 6		Ø 8				Ø 10
Effective anchorage depth			h_{ef}	[mm]	31[1]	44	35[1]	43	52	43	60
Non-cracked concrete											
Tension	W-BS-S, SK; /S ; /A4 ; / HCR	C20/25	N_{Rk}	[kN]	4.0	9.0	7.5	12.0	16.0	12.0	20.0
		C50/60			6.3	14.0	11.9	19.0	25.3	19.0	31.6
Shear		C20/25	V_{Rk}	[kN]	7.0	7.0	10.2	13.5	17.0	13.9	34.0
		C50/60			7.0	7.0	13.5	13.5	17.0	21.9	34.0
Cracked concrete											
Tension	W-BS-S, SK; /S ; /A4 ; / HCR	C20/25	N_{Rk}	[kN]	2.0	4.0	5.0	9.0	12.0	9.0	16.0
		C50/60			3.2	6.3	7.9	14.2	19.0	14.2	25.3
Shear		C20/25	V_{Rk}	[kN]	5.9	7.0	7.1	9.7	12.9	9.7	32.0
		C50/60			7.0	7.0	11.3	13.5	17.0	15.4	34.0

Screw size: Ø 10 – Ø 14

Screw size					Ø 10	Ø 12			Ø 14		
Effective anchorage depth			h_{ef}	[mm]	68	50	67	80	58	79	92
Non-cracked concrete											
Tension	W-BS-S, SK; /S ; /A4 ; / HCR	C20/25	N_{Rk}	[kN]	26.0	16.0	27.0	35.2	21.7	34.5	43.4
		C50/60			41.1	25.3	42.7	55.7	34.4	54.6	68.6
Shear		C20/25	V_{Rk}	[kN]	34.0	17.4	40.0	40.0	21.7	56.0	56.0
		C50/60			34.0	27.5	40.0	40.0	34.4	56.0	56.0
Cracked concrete											
Tension	W-BS-S, SK; /S ; /A4 ; / HCR	C20/25	N_{Rk}	[kN]	19.3	12.0	18.9	24.6	15.2	24.2	30.4
		C50/60			30.5	19.0	29.9	39.0	24.1	38.2	48.0
Shear		C20/25	V_{kR}	[kN]	34.0	12.2	37.8	40.0	15.2	48.4	56.0
		C50/60			34.0	19.3	40.0	40.0	24.1	56.0	56.0

[1] Use restricted to anchoring of structural components that are statically indeterminate

CONCRETE SCREW W-BS

Design resistance

Screw size: Ø 6 – Ø 10

Screw size					Ø 6		Ø 8				Ø 10
Effective anchorage depth			h_{ef}	[mm]	31[1)]	44	35[1)]	43	52	43	60
Non-cracked concrete											
Tension	W-BS-S, SK; /S ; /A4 ; / HCR	C20/25	N_{Rd}	[kN]	2.7	6.0	5.0	8.0	10.7	8.0	13.3
		C50/60			4.2	9.3	7.9	12.6	16.9	12.6	21.1
Shear		C20/25	V_{Rd}	[kN]	5.6	5.6	6.8	9.2	12.3	9.2	27.2
		C50/60			5.6	5.6	10.7	10.8	13.6	14.6	27.2
Cracked concrete											
Tension	W-BS-S, SK; /S ; /A4 ; / HCR	C20/25	N_{Rd}	[kN]	1.3	2.7	3.3	6.0	8.0	6.0	10.7
		C50/60			2.1	4.2	5.3	9.5	12.6	9.5	16.9
Shear		C20/25	V_{Rd}	[kN]	4.0	5.6	4.8	6.5	8.6	6.5	21.3
		C50/60			5.6	5.6	7.5	10.2	13.6	10.2	27.2

Screw size: Ø 10 – Ø 14

Screw size					Ø 10	Ø 12			Ø 14		
Effective anchorage depth			h_{ef}	[mm]	68	50	67	80	58	79	92
Non-cracked concrete											
Tension	W-BS-S, SK; /S ; /A4 ; / HCR	C20/25	N_{Rd}	[kN]	17.3	10.7	18.0	23.5	14.5	23.0	28.9
		C50/60			27.4	16.9	28.4	37.1	22.9	36.4	45.8
Shear		C20/25	V_{Rd}	[kN]	27.2	11.6	32.0	32.0	14.5	44.8	44.8
		C50/60			27.2	18.3	32.0	32.0	22.9	44.8	44.8
Cracked concrete											
Tension	W-BS-S, SK; /S ; /A4 ; / HCR	C20/25	N_{Rd}	[kN]	12.9	8.0	12.6	16.4	10.1	16.1	20.3
		C50/60			20.4	12.6	19.9	26.0	16.0	25.5	32.0
Shear		C20/25	V_{Rd}	[kN]	25.7	8.1	25.2	32.0	10.1	32.2	40.5
		C50/60			27.2	12.8	32.0	32.0	16.0	44.8	44.8

[1)] Use restricted to anchoring of structural components that are statically indeterminate

Recommended/allowable loads [1)]

Screw size: Ø 6 – Ø 10

Screw size					**Ø 6**		**Ø 8**				**Ø 10**
Effective anchorage depth			h_{ef}	[mm]	31[2)]	44	35[2)]	43	52	43	60
Non-cracked concrete											
Tension	W-BS-S, SK; /S ; /A4 ; / HCR	C20/25	N_{rec}	[kN]	1.9	4.3	3.6	5.7	7.6	5.7	9.5
		C50/60			3.0	6.7	5.6	9.0	12.0	9.0	15.1
Shear		C20/25	V_{rec}	[kN]	4.0	4.0	4.9	6.6	8.8	6.6	19.4
		C50/60			4.0	4.0	7.7	7.7	9.7	10.4	19.4
Cracked concrete											
Tension	W-BS-S, SK; /S ; /A4 ; / HCR	C20/25	N_{rec}	[kN]	1.0	1.9	2.4	4.3	5.7	4.3	7.6
		C50/60			1.5	3.0	3.8	6.8	9.0	6.8	12.0
Shear		C20/25	V_{rec}	[kN]	2.8	4.0	3.4	4.6	6.1	4.6	15.2
		C50/60			4.0	4.0	5.4	7.3	9.7	7.3	19.4

1) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Screw size: Ø 10 – Ø 14

Screw size					**Ø 10**	**Ø 12**			**Ø 14**		
Effective anchorage depth			h_{ef}	[mm]	68	50	67	80	58	79	92
Non-cracked concrete											
Tension	W-BS-S, SK; /S ; /A4 ; / HCR	C20/25	N_{rec}	[kN]	12.4	7.6	12.8	16.8	10.3	16.4	20.7
		C50/60			19.6	12.0	20.3	26.5	16.4	26.0	32.7
Shear		C20/25	V_{rec}	[kN]	19.4	8.3	22.9	22.9	10.3	32.0	32.0
		C50/60			19.4	13.1	22.9	22.9	16.4	32.0	32.0
Cracked concrete											
Tension	W-BS-S, SK; /S ; /A4 ; / HCR	C20/25	N_{rec}	[kN]	9.2	5.7	9.0	11.7	7.2	11.5	14.5
		C50/60			14.5	9.0	14.2	18.6	11.5	18.2	22.9
Shear		C20/25	V_{rec}	[kN]	18.4	5.8	18.0	22.9	7.2	23.0	28.9
		C50/60			19.4	9.2	22.9	22.9	11.5	32.0	32.0

1) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.
2) Use restricted to anchoring of structural components that are statically indeterminate.

CONCRETE SCREW W-BS

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole, hammer drilling
- Anchor material as specified in anchor material specification table
- Anchorage depths h_{ef} < 40 mm are restricted to use of structural components with which are statically indeterminate and subject to internal exposure conditions only

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Screw size: Ø 6 – Ø 10

Screw size			**Ø 6**		**Ø 8**				**Ø 10**
Effective anchorage depth	h_{ef}	[mm]	31	44	35	43	52	43	60
Design steel resistance	$N_{Rd,s}$	[kN]	9.3	9.3	18.0	18.0	18.0	30.0	30.0

Screw size: Ø 10 – Ø 14

Screw size			**Ø 10**	**Ø 12**			**Ø 14**		
Effective anchorage depth	h_{ef}	[mm]	68	50	67	80	58	79	92
Design steel resistance	$N_{Rd,s}$	[kN]	30.0	44.7	44.7	44.7	62.7	62.7	62.7

2. Design pullout resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of pull-out failure of a single anchor

Screw size: Ø 6 – Ø 10

Screw size			**Ø 6**		**Ø 8**				**Ø 10**
Effective anchorage depth	h_{ef}	[mm]	31	44	35	43	52	43	60
Non-cracked concrete									
Pull-out resistance	$N^0_{Rd,p}$	[kN]	2.7	6.0	5.0	8.0	10.7	8.0	13.3
Cracked concrete									
Pull-out resistance	$N^0_{Rd,p}$	[kN]	1.3	2.7	3.3	6.0	8.0	6.0	10.7

Screw size: Ø 10 – Ø 14

Screw size			**Ø 10**	**Ø 12**			**Ø 14**		
Effective anchorage depth	h_{ef}	[mm]	68	50	67	80	58	79	92
Non-cracked concrete									
Pull-out resistance	$N^0_{Rd,p}$	[kN]	17.3	10.7	18.0	23.5	14.5	23.0	28.9
Cracked concrete									
Pull-out resistance	$N^0_{Rd,p}$	[kN]	12.9	8.0	12.6	16.4	10.1	16.1	20.3

a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

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3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Screw size: Ø 6 – Ø 10

Screw size			**Ø 6**		**Ø 8**				**Ø 10**
Effective anchorage depth	h_{ef}	[mm]	31	44	35	43	52	43	60
Non-cracked concrete									
Cone resistance	$N^0_{Rd,c}$	[kN]	5.7	9.6	6.8	9.2	12.3	9.2	15.2
Cracked concrete									
Cone resistance	$N^0_{Rd,c}$	[kN]	4.0	6.7	4.8	6.5	8.6	6.5	10.7

Screw size: Ø 10 – Ø 14

Screw size			**Ø 10**	**Ø 12**			**Ø 14**		
Effective anchorage depth	h_{ef}	[mm]	68	50	67	80	58	79	92
Non-cracked concrete									
Cone resistance	$N^0_{Rd,c}$	[kN]	18.4	11.6	18.0	23.5	14.5	23.0	28.9
Cracked concrete									
Cone resistance	$N^0_{Rd,c}$	[kN]	12.9	8.1	12.6	16.4	10.1	16.1	20.3

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Screw size: Ø 6 – Ø 10

Screw size			**Ø 6**		**Ø 8**				**Ø 10**
Effective anchorage depth	h_{ef}	[mm]	31	44	35	43	52	43	60
Characteristic spacing	$s_{cr,N}$	[kN]	93	132	105	129	156	129	180
Characteristic edge distance	$c_{cr,N}$	[kN]	47	66	53	65	78	65	90

Screw size: Ø 10 – Ø 14

Screw size			**Ø 10**	**Ø 12**			**Ø 14**		
Effective anchorage depth	h_{ef}	[mm]	68	50	67	80	58	79	92
Characteristic spacing	$s_{cr,N}$	[kN]	204	150	201	240	174	237	276
Characteristic edge distance	$c_{cr,N}$	[kN]	102	75	101	120	87	119	138

a. Influence of concrete strength

Table 6: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

W-BS

c. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 8: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

CONCRETE SCREW W-BS

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 9: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Screw size: Ø 6 – Ø 10

Screw size			Ø 6		Ø 8				Ø 10
Effective anchorage depth	h_{ef}	[mm]	31	44	35	43	52	43	60
Non-cracked concrete									
Splitting resistance	$N^0_{Rd,sp}$	[kN]	2.7	6.0	5.0	8.0	10.7	8.0	13.3

Screw size: Ø 10 – Ø 14

Screw size			Ø 10	Ø 12			Ø 14		
Effective anchorage depth	h_{ef}	[mm]	68	50	67	80	58	79	92
Non-cracked concrete									
Splitting resistance	$N^0_{Rd,sp}$	[kN]	17.3	10.7	18.0	23.5	14.5	23.0	28.9

Table 10: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Screw size: Ø 6 – Ø 10

Screw size			Ø 6		Ø 8				Ø 10
Effective anchorage depth	h_{ef}	[mm]	31	44	35	43	52	43	60
Characteristic spacing	$s_{cr,sp}$	[mm]	120	160	120	140	150	140	180
Characteristic edge distance	$c_{cr,sp}$	[mm]	60	80	60	70	75	70	90
Minimum member thickness	h_{min}	[mm]	100	100	100	100	120	100	130

Screw size: Ø 10 – Ø 14

Screw size			Ø 10	Ø 12			Ø 14		
Effective anchorage depth	h_{ef}	[mm]	68	50	67	80	58	79	92
Characteristic spacing	$s_{cr,sp}$	[mm]	210	150	210	240	180	240	280
Characteristic edge distance	$c_{cr,sp}$	[mm]	105	75	105	120	90	120	140
Minimum member thickness	h_{min}	[mm]	130	120	130	150	130	150	170

a. Influence of concrete strength

Table 11: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 12: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 13: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ / $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Screw size: Ø 6 – Ø 10

Screw size			Ø 6		Ø 8				Ø 10
Effective anchorage depth	h_{ef}	[mm]	31	44	35	43	52	43	60
Design steel resistance	$V_{Rd,s}$	[kN]	5.6	5.6	10.8	10.8	13.6	18.0	27.2

Screw size: Ø 10 – Ø 14

Screw size			Ø 10	Ø 12			Ø 14		
Effective anchorage depth	h_{ef}	[mm]	68	50	67	80	58	79	92
Design steel resistance	$V_{Rd,s}$	[kN]	27.2	26.8	32.0	32.0	44.8	44.8	44.8

2. Concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot N_{Rd,c}$$

Table 16: factor k_8 for calculating design pry-out resistance

Screw size: Ø 6 – Ø 10

Screw size			**Ø 6**		**Ø 8**				**Ø 10**
Effective anchorage depth	h_{ef}	[mm]	31	44	35	43	52	43	60
Concrete pry-out resistance factor	k_8	[-]	1.0	1.0	1.0	1.0	1.0	1.0	2.0

Screw size: Ø 10 – Ø 14

Screw size			**Ø 10**	**Ø 12**			**Ø 14**		
Effective anchorage depth	h_{ef}	[mm]	68	50	67	80	58	79	92
Concrete pry-out resistance factor	k_8	[-]	2.0	1.0	2.0	2.0	1.0	2.0	2.0

3. Concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions c ≥ max (10 h_{ef} ; 60 d). For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

CONCRETE SCREW W-BS

Table 17: Design resistance $V^{0}_{Rd,c}$ in case of concrete edge failure

Screw size: Ø 6 – Ø 10

Screw size	Ø 6				Ø 8						Ø 10			
h_{ef} [mm]	31		44		35		43		52		43		60	
Edge distance c_1	$V^{0}_{Rd,c}$													
[mm]	[kN]													
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
40	2.7	1.9	2.8	2.0	2.8	2.0	-	-	-	-	-	-	-	-
45	3.2	2.2	3.3	2.4	3.3	2.4	-	-	-	-	-	-	-	-
50	3.6	2.6	3.8	2.7	3.9	2.7	4.0	2.8	4.1	2.9	4.1	2.9	4.4	3.1
55	4.2	2.9	4.4	3.1	4.4	3.1	4.5	3.2	4.7	3.3	4.7	3.3	5.0	3.5
60	4.7	3.3	4.9	3.5	4.9	3.5	5.1	3.6	5.3	3.7	5.3	3.7	5.6	3.9
65	5.3	3.7	5.5	3.9	5.5	3.9	5.7	4.0	5.9	4.1	5.9	4.1	6.2	4.4
70	5.8	4.1	6.1	4.3	6.1	4.3	6.3	4.5	6.5	4.6	6.5	4.6	6.8	4.8
75	6.4	4.5	6.7	4.7	6.7	4.8	6.9	4.9	7.1	5.0	7.1	5.0	7.5	5.3
80	7.0	5.0	7.3	5.2	7.4	5.2	7.6	5.4	7.8	5.5	7.8	5.5	8.2	5.8
85	7.6	5.4	8.0	5.6	8.0	5.7	8.2	5.8	8.4	6.0	8.4	6.0	8.9	6.3
90	8.3	5.9	8.6	6.1	8.7	6.1	8.9	6.3	9.1	6.5	9.1	6.5	9.6	6.8
95	8.9	6.3	9.3	6.6	9.3	6.6	9.6	6.8	9.8	7.0	9.8	7.0	10.3	7.3
100	9.6	6.8	10.0	7.1	10.0	7.1	10.3	7.3	10.6	7.5	10.6	7.5	11.1	7.8
110	11.0	7.8	11.4	8.1	11.5	8.1	11.7	8.3	12.0	8.5	12.0	8.5	12.6	8.9
120	12.4	8.8	12.9	9.1	12.9	9.2	13.3	9.4	13.6	9.6	13.6	9.6	14.2	10.1
130	13.9	9.9	14.4	10.2	14.5	10.3	14.8	10.5	15.2	10.7	15.2	10.7	15.8	11.2
140	15.5	11.0	16.0	11.4	16.1	11.4	16.4	11.6	16.8	11.9	16.8	11.9	17.5	12.4
150	17.1	12.1	17.7	12.5	17.7	12.5	18.1	12.8	18.5	13.1	18.5	13.1	19.3	13.7
160	18.7	13.3	19.4	13.7	19.4	13.7	19.8	14.0	20.3	14.3	20.3	14.3	21.1	14.9
170	20.4	14.5	21.1	14.9	21.1	15.0	21.6	15.3	22.0	15.6	22.0	15.6	22.9	16.2
180	22.1	15.7	22.9	16.2	22.9	16.2	23.4	16.6	23.9	16.9	23.9	16.9	24.8	17.6
190	23.9	16.9	24.7	17.5	24.7	17.5	25.3	17.9	25.8	18.3	25.8	18.2	26.8	19.0
200	25.8	18.2	26.6	18.8	26.6	18.8	27.2	19.2	27.7	19.6	27.7	19.6	28.7	20.4
250	35.5	25.1	36.5	25.8	36.6	25.9	37.2	26.4	37.9	26.9	37.9	26.9	39.3	27.8
300	46.1	32.6	47.3	33.5	47.4	33.6	48.3	34.2	49.1	34.8	49.1	34.8	50.7	35.9
350	57.5	40.8	59.0	41.8	59.1	41.9	60.1	42.6	61.1	43.3	61.1	43.3	63.0	44.6
400	-	-	71.5	50.7	71.6	50.7	72.8	51.6	73.9	52.4	73.9	52.3	76.1	53.9
450	-	-	-	-	84.8	60.1	86.2	61.0	87.5	61.9	87.4	61.9	90.0	63.7
500	-	-	-	-	-	-	-	-	101.7	72.0	101.7	72.0	104.5	74.0
550	-	-	-	-	-	-	-	-	-	-	116.5	82.5	119.7	84.8
600	-	-	-	-	-	-	-	-	-	-	132.0	93.5	135.5	96.0

Screw size: Ø 10 – Ø 14

Screw size	**Ø 10**		**Ø 12**						**Ø 14**					
h_{ef} [mm]	68		50		67		80		58		79		92	
Edge distance c_1	$V^0_{Rd,c}$													
[mm]	[kN]													
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
50	4.5	3.2	4.4	3.1	4.6	3.3	-	-	4.6	3.3	-	-	-	-
55	5.1	3.6	4.9	3.5	5.2	3.7	-	-	5.2	3.7	-	-	-	-
60	5.7	4.0	5.5	3.9	5.9	4.2	-	-	5.8	4.1	-	-	-	-
65	6.3	4.5	6.2	4.4	6.5	4.6	-	-	6.5	4.6	-	-	-	-
70	7.0	5.0	6.8	4.8	7.2	5.1	7.4	5.3	7.2	5.1	7.6	5.4	7.9	5.6
75	7.7	5.4	7.5	5.3	7.9	5.6	8.1	5.8	7.8	5.6	8.3	5.9	8.6	6.1
80	8.4	5.9	8.1	5.8	8.6	6.1	8.9	6.3	8.5	6.0	9.1	6.4	9.3	6.6
85	9.1	6.4	8.8	6.3	9.3	6.6	9.6	6.8	9.3	6.6	9.8	6.9	10.1	7.2
90	9.8	6.9	9.5	6.8	10.0	7.1	10.3	7.3	10.0	7.1	10.6	7.5	10.9	7.7
95	10.5	7.5	10.3	7.3	10.8	7.6	11.1	7.9	10.7	7.6	11.4	8.0	11.7	8.3
100	11.3	8.0	11.0	7.8	11.5	8.2	11.9	8.4	11.5	8.2	12.1	8.6	12.5	8.9
110	12.8	9.1	12.5	8.9	13.1	9.3	13.5	9.6	13.1	9.3	13.8	9.8	14.2	10.0
120	14.5	10.2	14.1	10.0	14.8	10.5	15.2	10.8	14.7	10.4	15.5	11.0	15.9	11.3
130	16.1	11.4	15.8	11.2	16.5	11.7	16.9	12.0	16.4	11.6	17.2	12.2	17.7	12.5
140	17.8	12.6	17.5	12.4	18.2	12.9	18.7	13.2	18.1	12.9	19.0	13.5	19.5	13.8
150	19.6	13.9	19.2	13.6	20.0	14.2	20.5	14.5	19.9	14.1	20.9	14.8	21.4	15.2
160	21.4	15.2	21.0	14.9	21.8	15.5	22.4	15.9	21.8	15.4	22.8	16.1	23.4	16.5
170	23.3	16.5	22.8	16.2	23.7	16.8	24.3	17.2	23.7	16.8	24.8	17.5	25.3	17.9
180	25.2	17.9	24.7	17.5	25.7	18.2	26.3	18.6	25.6	18.1	26.8	18.9	27.4	19.4
190	27.2	19.3	26.7	18.9	27.7	19.6	28.3	20.1	27.6	19.5	28.8	20.4	29.4	20.9
200	29.2	20.7	28.6	20.3	29.7	21.0	30.4	21.5	29.6	21.0	30.9	21.9	31.6	22.4
250	39.8	28.2	39.1	27.7	40.4	28.7	41.3	29.3	40.3	28.6	41.9	29.7	42.8	30.3
300	51.4	36.4	50.5	35.8	52.1	36.9	53.2	37.7	52.0	36.9	53.9	38.2	55.0	38.9
350	63.8	45.2	62.8	44.5	64.7	45.8	66.0	46.7	64.6	45.7	66.8	47.3	68.0	48.2
400	77.0	54.6	75.9	53.7	78.1	55.3	79.5	56.3	77.9	55.2	80.5	57.0	81.9	58.0
450	91.0	64.4	89.7	63.5	92.2	65.3	93.8	66.4	92.0	65.2	94.9	67.2	96.5	68.3
500	105.6	74.8	104.2	73.8	107.0	75.8	108.8	77.0	106.8	75.6	110.0	77.9	111.8	79.2
550	120.9	85.7	119.3	84.5	122.4	86.7	124.4	88.1	122.2	86.5	125.8	89.1	127.7	90.5
600	136.9	97.0	135.1	95.7	138.5	98.1	140.7	99.7	138.2	97.9	142.2	100.7	144.3	102.2
650	153.4	108.7	151.5	107.3	155.2	109.9	157.6	111.6	154.9	109.7	159.2	112.8	161.5	114.4
700	-	-	168.4	119.3	172.4	122.1	175.0	124.0	172.2	121.9	176.8	125.3	179.3	127.0
750	-	-	-	-	-	-	193.1	136.8	189.9	134.5	195.0	138.1	197.7	140.0
800	-	-	-	-	-	-	211.6	149.9	208.3	147.5	213.7	151.4	216.6	153.4
850	-	-	-	-	-	-	-	-	-	-	-	-	236.0	167.1
900	-	-	-	-	-	-	-	-	-	-	-	-	255.9	181.3

W-BS

CONCRETE SCREW W-BS

a. Influence of concrete strength

Table 18: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 19: Influence of spacing on concrete edge resistance

s/c_1[1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of edge distance

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\,\frac{c_2}{1.5\,c_1}\right)$$

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1[1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \leq c_2$

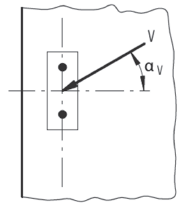
d. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 21: Influence of load direction on concrete edge resistance

α[1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.



e. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1] This verification is not required in case of shear load with lever arm

CONCRETE SCREW W-BS

Mechanical characteristics

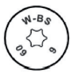
Screw size: Ø 6 – Ø 10

Screw size			Ø 6	Ø 6	Ø 8	Ø 8	Ø 8	Ø 8	Ø 10
Effective anchorage depth	h_{ef}	[mm]	31	44	35	43	52	43	60
Stressed cross section of threaded part									
Stressed cross section	A_s	[mm²]	20.4	20.4	39.6	39.6	39.6	65.0	65.0
Section modulus	W	[mm³]	13.0	13.0	35.1	35.1	35.1	74.0	74.0
Yield strength	f_y	[N/mm²]	560	560	560	560	560	560	560
Tensile strength	f_u	[N/mm²]	700	700	700	700	700	700	700
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	10.9	10.9	26.0	26.0	26.0	56.0	56.0
Partial factor	γ_{Ms}	[-]	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Design bending moment	$M^0_{Rd,s}$	[Nm]	8.7	8.7	20.8	20.8	20.8	44.8	44.8

Screw size: Ø 10 – Ø 14

Screw size			Ø 10	Ø 12	Ø 12	Ø 12	Ø 14	Ø 14	Ø 14
Effective anchorage depth	h_{ef}	[mm]	68	50	67	80	58	79	92
Stressed cross section of threaded part									
Stressed cross section	A_s	[mm²]	65.0	96.8	96.8	96.8	134.8	134.8	134.8
Section modulus	W	[mm³]	74.0	134.3	134.3	134.3	220.7	220.7	220.7
Yield strength	f_y	[N/mm²]	560	560	560	560	560	560	560
Tensile strength	f_u	[N/mm²]	700	700	700	700	700	700	700
Characteristic bending moment	$M^0_{Rk,s}$	[Nm]	56.0	113.0	113.0	113.0	185.0	185.0	185.0
Partial factor	γ_{Ms}	[-]	1.25	1.25	1.25	1.25	1.25	1.25	1.25
Design bending moment	$M^0_{Rd,s}$	[Nm]	44.8	90.4	90.4	90.4	148.0	148.0	148.0

Material specifications

Part	Profile	Head configuration	Product description
1			Configuration with metric stud and hexagon socket e.g. W-BS 8x105 Type ST M10 SW5
2			Configuration with metric stud and hexagon drive e.g. W-BS 8x105 Type ST M10 SW7
3			Configuration with washer and hexagon head e.g. W-BS 8x80 Type S SW13
4			Configuration with washer and hexagon head with TX drive e.g. W-BS 8x80 Type S TX 40
5			Configuration with hexagon head e.g. W-BS 80x80 Type S SW13
6			Configuration with countersunk head and TX drive e.g. W-BS 8x80 Type SK TX 40
7			Configuration with pan head and TX drive e.g. W-BS 8x80 Type P TX 40
8			Configuration with large pan head and TX drive e.g. W-BS 8x80 Type P TX 40
9			Configuration with hexagon drive and metric stud e.g. W-BS 6x55 Type ST M8 SW 10
10			Configuration with internal thread and hexagon drive e.g. W-BS 6x55 Type I M8/M10

Part	Product name	Material
1–10	**W-BS/S**	- Steel EN 10263-42017 galvanized acc. to EN ISO 4042:2018 - Zinc flake coating according to EN ISO 10683:2018 (≥ 5 µm)
	W-BS/A4	1.4401; 1.4404; 1.4571; 1.4578
	W-BS/HCR	1.4529

CONCRETE SCREW W-BS

Installation parameters

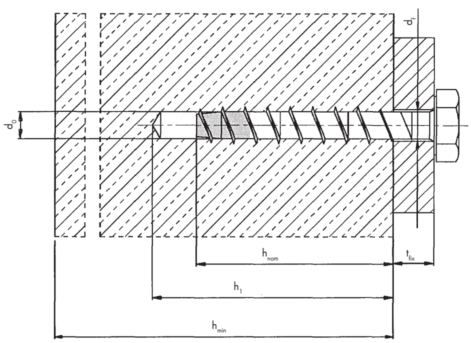
Screw size: Ø 6 – Ø 10

Screw size			**Ø 6**	**Ø 6**	**Ø 8**	**Ø 8**	**Ø 8**	**Ø 10**	**Ø 10**
Nominal embedment depth	h_{nom}	[mm]	40	55	45	55	65	55	75
Nominal drill hole diameter	d_0	[mm]	6		8			10	
Cutting diameter of drill bit	$d_{cut} \geq$	[mm]	6.4		8.45			10.45	
Drill hole depth	$h_1 \geq$	[mm]	45	60	55	65	75	65	85
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	8		12			14	
Installation torque (version with connection thread)	T_{inst}	[Nm]	10		20			40	
Torque impact screw driver [1]	$T_{im.max}$	[Nm]	160		300			400	
Minimum thickness of member	h_{min}	[mm]	100		100		120	100	130
Minimum edge distance	c_{min}	[mm]	40		40	50		50	
Minimum spacing	s_{min}	[mm]	40		40	50		50	

Screw size: Ø 10 – Ø 14

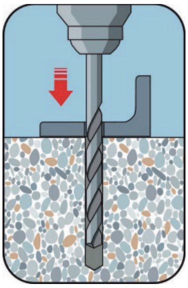
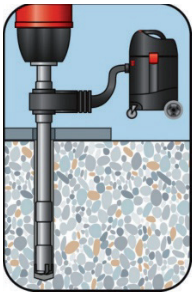
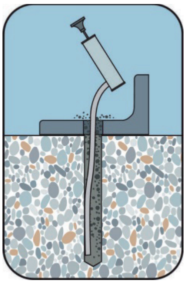
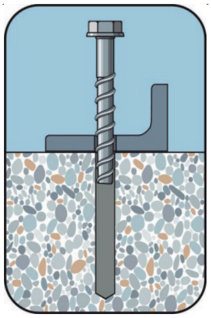
Screw size			**Ø 10**	**Ø 12**	**Ø 12**	**Ø 12**	**Ø 14**	**Ø 14**	**Ø 14**
Nominal embedment depth	h_{nom}	[mm]	85	65	85	100	75	100	115
Nominal drill hole diameter	d_0	[mm]	10	12			14		
Cutting diameter of drill bit	$d_{cut} \geq$	[mm]	10.45	12.5			14.5		
Drill hole depth	$h_1 \geq$	[mm]	95	75	95	110	85	110	125
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	14	16			18		
Installation torque (version with connection thread)	T_{inst}	[Nm]	40	60			80		
Torque impact screw driver [1]	$T_{im.max}$	[Nm]	400	650			650		
Minimum thickness of member	h_{min}	[mm]	130	120	130	150	130	150	170
Minimum edge distance	c_{min}	[mm]	50	50		70	50	70	
Minimum spacing	s_{min}	[mm]	50	50		70	50	70	

[1] Max. torque according to manufacturer's instructions

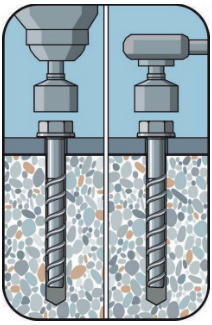
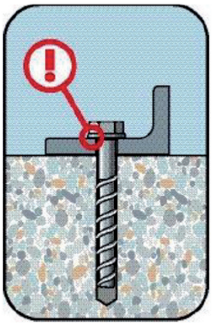
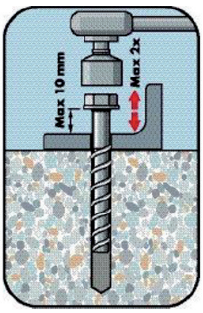
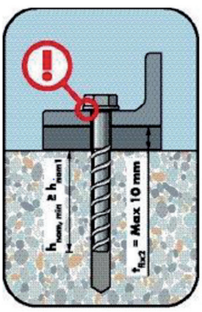


W-BS

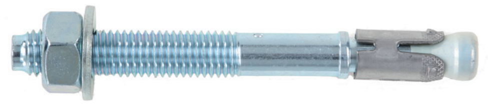
Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer drilling (HD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. Proceed with Step B.
	**1b.**	**Hollow drill bit system (HDB) (only Ø 8-14)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. This drilling system removes the dust and cleans the bore hole during drilling. Proceed with Step C.
B) Bore hole cleaning		
	**2.**	Clean the bore hole from the bottom until the return air stream is without dust.
C) Setting the screw		
	**3a.**	Drive the anchor with some hammer strike or with the machine setting tool into the drill hole. Ensure the specified embedment depth.

CONCRETE SCREW W-BS

	**3b.**	Apply the required torque moment using a calibrated torque wrench. Consider $T_{imp,max}$ and T_{inst}.
	**3c.**	Installation was successful when the head of the anchor is fully supported and in contact to the fixture without damaging it.
Adjustability for only screw sizes Ø 8-14		
	**3d.**	The anchor may be adjusted max. two times while the anchor may turn back at most 10 mm.
	**3e.**	Install the screw again after the adjustment. The total allowed thickness of shims added during the adjustment process is 10 mm. The final embedment depth after adjustment process must be equal or larger than h_{nom}.
Note: Adjustment for seismic loading is not allowed.		

FIXANCHOR W-FAZ/S



Galvanized (5 microns): M8 - M27

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Type of installation		
Pre-positioned	In-place	Stand-off
–	✓	–

Applications




Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt, Berlin	EAD 330232-01-0601	ETA-99/0011 /2018-10-02
ICC-ES Evaluation Report	ICC	AC 193	ESR-2461 /2012-09-01
Fire resistance	DIBt, Berlin	TR 020	ETA-99/0011 /2018-10-12
Sprinkler systems	VdS	VdS CEA 4001:2010-11 (04)	27.03.12
Evaluation Report high strength concrete C80/95	Ing. Büro Thiele, Pirmasens	EAD 330232-01-0601 /ETAG 001	21742_2 /2017-08-10
Shock test, Critical infra-structure protection	BABS, CH-Bern		BZS D 09-0604 /2010-05-18

Basic loading data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness is according to anchor characteristics
- Anchor material is as specified in anchor material specification table
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²

Mean ultimate resistance

Thread size				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**
Effective anchorage depth		h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	13.4	19.4	31.1	41.0	55.0	90.4	84.7
Shear	C20/25	$V_{Ru,m}$	[kN]	14.5	24.0	36.1	60.0	89.0	131.8	181.7
Cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	9.5	13.6	25.7	32.4	49.6	72.8	73.0
Shear	C20/25	$V_{Ru,m}$	[kN]	14.5	24.0	36.1	60.0	89.0	131.8	181.7

Characteristic resistance

Thread size				**M8**	**M10**	**M12**	**M16**	**M20**	**M24**	**M27**
Effective anchorage depth		h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	12.0	16.0	25.0	35.0	49.2	60.7	68.8
	C50/65			16.0	25.3	39.5	55.3	77.8	95.9	108.7
Shear	C20/25	V_{Rk}	[kN]	12.2	20.1	30.0	55.0	69.0	114.0	169.4
	C50/65			12.2	20.1	30.0	55.0	69.0	114.0	169.4
Cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	5.0	9.0	16.0	25.0	34.4	42.5	48.1
	C50/65			7.9	14.2	25.3	39.5	54.4	67.1	76.1
Shear	C20/25	V_{Rk}	[kN]	12.2	20.1	30.0	55.0	69.0	114.0	134.8
	C50/65			12.2	20.1	30.0	55.0	69.0	114.0	169.4

FIXANCHOR W-FAZ/S

Design resistance

Thread size				M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth		h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	8.0	10.7	16.7	23.3	32.8	40.4	45.8
	C50/65			10.5	16.9	26.4	36.9	51.9	63.9	72.5
Shear	C20/25	V_{Rd}	[kN]	9.8	16.1	24.0	44.0	51.9	91.2	128.3
	C50/65			9.8	16.1	24.0	44.0	51.9	91.2	135.5
Cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	3.3	6.0	10.7	16.7	23.0	28.3	32.1
	C50/65			5.3	9.5	16.9	26.4	36.3	44.8	50.7
Shear	C20/25	V_{Rd}	[kN]	9.8	16.1	24.0	43.2	51.9	79.3	89.8
	C50/65			9.8	16.1	24.0	44.0	51.9	91.2	135.5

Recommended/allowable loads [1)]

Thread size				M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth		h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete										
Tension	C20/25	N_{rec}	[kN]	5.7	7.6	11.9	16.7	23.4	28.9	32.7
	C50/65			7.5	12.0	18.8	26.4	37.0	45.7	51.8
Shear	C20/25	V_{rec}	[kN]	7.0	11.5	17.1	31.4	37.1	65.1	91.7
	C50/65			7.0	11.5	17.1	31.4	37.1	65.1	96.8
Cracked concrete										
Tension	C20/25	N_{rec}	[kN]	2.4	4.3	7.6	11.9	16.4	20.2	22.9
	C50/65			3.8	6.8	12.0	18.8	25.9	32.0	36.2
Shear	C20/25	V_{rec}	[kN]	7.0	11.5	17.1	30.8	37.1	56.6	64.2
	C50/65			7.0	11.5	17.1	31.4	37.1	65.1	96.8

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design Method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole, hammer drilling
- Anchor material as specified in anchor material specification table

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Design steel resistance	$N_{Rd,s}$	[kN]	10.5	17.6	26.7	40.0	53.8	84.0	130.7

2. Design pullout resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of pull-out failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete									
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	8.0	10.7	16.7	23.3	32.8	40.4	45.8
Cracked concrete									
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	3.3	6.0	10.7	16.7	23.0	28.3	32.1

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a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete									
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	10.2	15.2	19.2	25.7	32.8	40.4	45.8
Cracked concrete									
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	7.2	10.7	13.4	18.0	23.0	28.3	32.1

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Characteristic spacing	$s_{cr,N}$	[mm]	138	180	210	255	300	345	375
Characteristic edge distance	$c_{cr,N}$	[mm]	69	90	105	128	150	173	188

a. Influence of concrete strength

Table 6: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 8: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

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4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 9: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Non-cracked concrete									
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	6.0	8.0	13.3	20.0	26.7	41.5	33.3

Table 10: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Characteristic spacing	$s_{cr,sp}$	[mm]	138.0	180.0	210.0	255.0	300.0	345.0	375.0
Characteristic edge distance	$c_{cr,sp}$	[mm]	69.0	90.0	105.0	127.5	150.0	172.5	187.5
Minimum member thickness	h_{min}	[mm]	100	120	140	170	200	230	250

a. Influence of concrete strength

Table 11: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders 1)	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube 2)	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

1) strength at 28 days of 150 mm diameter by 300 mm cylinders

2) strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 12: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ 1)	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 13: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

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II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Design steel resistance	$V_{Rd,s}$	[kN]	9.8	16.1	24.0	44.0	51.9	91.2	135.5

2. Concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot N_{Rd,c}$$

Table 16: factor k_8 for calculating design pry-out resistance

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Concrete pry-out resistance factor	k_8	[-]	2.4	2.4	2.4	2.4	2.8	2.8	2.8

3. Concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq \max$ (10 h_{ef} ; 60 d). For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 17: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size	M8		M10		M12		M16		M20		M24		M27	
h_{ef} [mm]	46		60		70		85		100		115		125	
Edge distance c_1	$V^0_{Rd,c}$													
[mm]	[kN]													
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
40	-	2.1	-	-	-	-	-	-	-	-	-	-	-	-
45	-	2.5	-	2.7	-	-	-	-	-	-	-	-	-	-
50	4.0	2.9	4.4	3.1	-	-	-	-	-	-	-	-	-	-
55	4.6	3.2	5.0	3.5	-	-	-	-	-	-	-	-	-	-
60	5.2	3.7	5.6	3.9	-	4.2	-	4.6	-	-	-	-	-	-
65	5.7	4.1	6.2	4.4	-	4.7	-	5.1	-	-	-	-	-	-
70	6.4	4.5	6.8	4.8	-	5.1	-	5.6	-	-	-	-	-	-
75	7.0	4.9	7.5	5.3	7.9	5.6	-	6.1	-	-	-	-	-	-
80	7.6	5.4	8.2	5.8	8.6	6.1	9.4	6.7	-	-	-	-	-	-
85	8.3	5.9	8.9	6.3	9.4	6.6	10.2	7.2	-	-	-	-	-	-
90	9.0	6.4	9.6	6.8	10.1	7.2	11.0	7.8	-	-	-	-	-	-
95	9.7	6.8	10.3	7.3	10.9	7.7	11.8	8.3	-	8.9	-	-	-	-
100	10.4	7.4	11.1	7.8	11.6	8.2	12.6	8.9	-	9.5	14.4	10.2	-	-
110	11.8	8.4	12.6	8.9	13.2	9.4	14.2	10.1	-	10.8	16.2	11.5	-	-
120	13.4	9.5	14.2	10.1	14.9	10.5	16.0	11.3	-	12.1	18.1	12.8	-	-
130	14.9	10.6	15.8	11.2	16.6	11.7	17.8	12.6	18.9	13.4	20.1	14.2	-	-
140	16.6	11.7	17.5	12.4	18.3	13.0	19.6	13.9	20.9	14.8	22.1	15.6	-	-
150	18.3	12.9	19.3	13.7	20.1	14.3	21.5	15.2	22.8	16.2	24.1	17.1	-	-
160	20.0	14.2	21.1	14.9	22.0	15.6	23.5	16.6	24.9	17.6	26.2	18.6	-	-
170	21.8	15.4	22.9	16.2	23.9	16.9	25.5	18.0	26.9	19.1	28.4	20.1	-	-
180	23.6	16.7	24.8	17.6	25.8	18.3	27.5	19.5	29.1	20.6	30.6	21.7	31.6	22.4
190	25.4	18.0	26.8	19.0	27.8	19.7	29.6	20.9	31.2	22.1	32.8	23.3	33.9	24.0
200	27.3	19.4	28.7	20.4	29.9	21.2	31.7	22.5	33.4	23.7	35.1	24.9	36.3	25.7
250	37.5	26.5	39.3	27.8	40.7	28.8	43.0	30.4	45.1	32.0	47.2	33.4	48.7	34.5
300	48.6	34.4	50.7	35.9	52.4	37.1	55.2	39.1	57.8	40.9	60.3	42.7	62.0	43.9
350	60.5	42.8	63.0	44.6	65.0	46.0	68.3	48.4	71.3	50.5	74.2	52.6	76.2	54.0
400	73.2	51.8	76.1	53.9	78.4	55.5	82.1	58.2	85.6	60.7	88.9	63.0	91.2	64.6
450	86.6	61.4	90.0	63.7	92.6	65.6	96.8	68.6	100.7	71.3	104.4	74.0	107.0	75.8
500	-	-	104.5	74.0	107.4	76.1	112.1	79.4	116.5	82.5	120.7	85.5	123.5	87.5
550	-	-	119.7	84.8	122.9	87.1	128.1	90.8	133.0	94.2	137.5	97.4	140.7	99.6
600	-	-	135.5	96.0	139.0	98.5	144.8	102.5	150.1	106.3	155.1	109.8	158.5	112.3

FIXANCHOR W-FAZ/S

Thread size	M8		M10		M12		M16		M20		M24		M27	
h_{ef} [mm]	46		60		70		85		100		115		125	
Edge distance c_1	$V^0_{Rd,c}$													
[mm]	[kN]													
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
650	-	-	-	-	155.8	110.3	162.0	114.8	167.8	118.8	173.2	122.7	176.9	125.3
700	-	-	-	-	173.1	122.6	179.8	127.4	186.1	131.8	192.0	136.0	195.9	138.8
750	-	-	-	-	-	-	198.2	140.4	204.9	145.2	211.3	149.6	215.5	152.7
800	-	-	-	-	-	-	217.1	153.8	224.3	158.9	231.1	163.7	235.7	166.9
850	-	-	-	-	-	-	236.6	167.6	244.3	173.0	251.5	178.1	256.4	181.6
900	-	-	-	-	-	-	256.6	181.7	264.7	187.5	272.4	192.9	277.5	196.6
950	-	-	-	-	-	-	277.0	196.2	285.7	202.3	293.8	208.1	299.2	212.0
1000	-	-	-	-	-	-	-	-	307.1	217.5	315.6	223.6	321.4	227.7
1100	-	-	-	-	-	-	-	-	351.3	248.8	360.8	255.6	367.2	260.1
1200	-	-	-	-	-	-	-	-	397.3	281.4	407.7	288.8	414.7	293.8
1300	-	-	-	-	-	-	-	-	-	-	456.4	323.3	464.0	328.7
1400	-	-	-	-	-	-	-	-	-	-	506.7	358.9	515.0	364.8
1500	-	-	-	-	-	-	-	-	-	-	-	-	567.5	402.0
1600	-	-	-	-	-	-	-	-	-	-	-	-	621.6	440.3

a. Influence of concrete strength

Table 18: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 19: Influence of spacing on concrete edge resistance

s/c_1 [1)]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1)] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of edge distance

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\,\frac{c_2}{1.5\,c_1}\right)$$

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1 [1)]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1)] Distance to the second edge: $c_1 \leq c_2$

d. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \leq 2$$

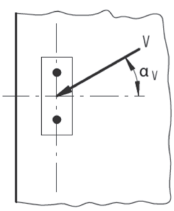


Table 21: Influence of load direction on concrete edge resistance

α [1)]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1)] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.

FIXANCHOR W-FAZ/S

e. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

W-FAZ/S

Mechanical characteristics

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Governing cross section									
Stressed cross section	A_s	[mm²]	21.2	36.3	52.8	91.6	153.9	156.7	244.8
Section modulus	W	[mm³]	13.8	30.9	54.1	123.7	269.4	276.7	540.2
Yield strength	f_y	[N/mm²]	580	580	580	520	420	640	640
Tensile strength	f_u	[N/mm²]	740	740	740	650	560	800	800
Stressed cross section of threaded part									
Stressed cross section	A_s	[mm²]	36.6	58.0	84.3	156.7	244.8	352.5	459.0
Section modulus	W	[mm³]	31.2	62.3	109.2	276.7	540.2	933.5	1387.0
Yield strength	f_y	[N/mm²]	504	504	504	504	420	640	640
Tensile strength	f_u	[N/mm²]	630	630	630	630	560	800	800
Design bending moment	$M^0_{Rd,s}$	[Nm]	18.4	37.6	65.6	167.2	272.9	718.4	1065

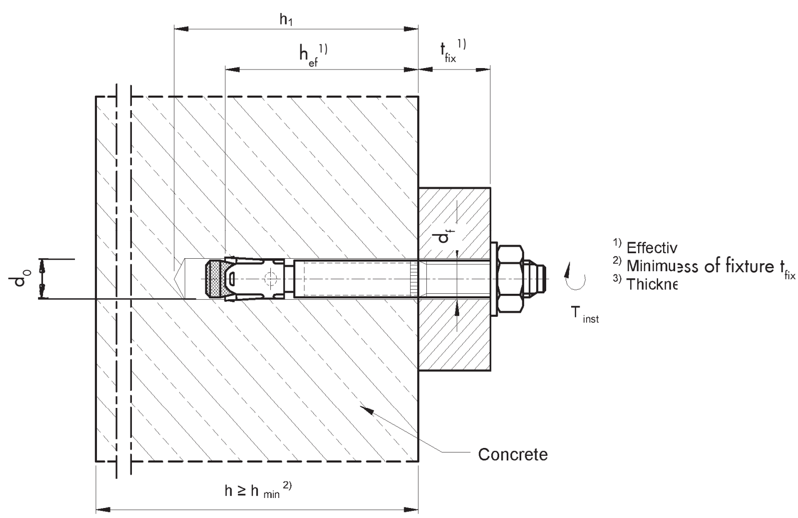
Material specifications

Product description	**Steel, zinc plated**	
	galvanized ≥ 5 µm	**sherardized ≥ 40 µm**
Conical bolt	M8 to M20: Cold formed or machined steel, galvanized, cone plastic coated	M8 to M20: Cold formed or machined steel, sherardized, cone plastic coated
Threaded bolt	M24 and M27: Steel, galvanized	M24 and M27: steel, sherardized
Threaded cone		M24 and M27: Steel, galvanized
Expansion sleeve	M8 to M20: Steel (e.g. 1.4301 or 1.4401) EN 10088:2014, M24 and M27: Steel acc. to EN 10139:1997	M8 to M20: Steel (e.g. 1.4301 or 1.4401) EN 10088:2014, M24 and M27: Steel acc. to EN 10139:1997
Washer	Steel, galvanized	Steel, zinc plated
Filling washer		
Hexagon nut	Steel, galvanized, coated	Steel, zinc plated

FIXANCHOR W-FAZ/S

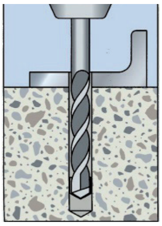
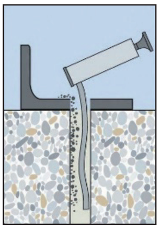
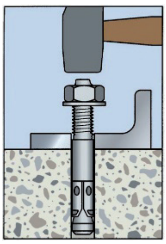
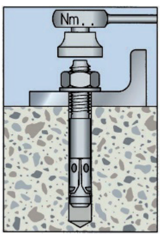
Installation parameters

Thread size			M8	M10	M12	M16	M20	M24	M27
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Depth of drill hole	$h_1 \geq$	[mm]	60	75	90	110	125	145	160
Nominal drill hole diameter	d_0	[mm]	8	10	12	16	20	24	28
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	8,45	10,45	12,5	16,5	20,55	24,55	28,55
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	9	12	14	18	22	26	30
Torque moment	$T_{inst} \leq$	[Nm]	20	25	45	90	160	200	300
Standard thickness of member	h_{min}	[mm]	100	120	140	170	200	230	250
Non-cracked concrete									
Minimum spacing	s_{min}	[mm]	40	45	60	65	90	100	125
	for $c \geq$	[mm]	80	70	120	120	180	180	300
Minimum edge distance	c_{min}	[mm]	50	50	75	80	130	100	180
	for $s \geq$	[mm]	100	100	150	150	240	220	540
Cracked concrete									
Minimum spacing	s_{min}	[mm]	40	45	60	60	95	100	125
	for $c \geq$	[mm]	70	70	100	100	150	180	300
Minimum edge distance	c_{min}	[mm]	40	45	60	60	95	100	180
	for $s \geq$	[mm]	80	90	140	180	200	220	540

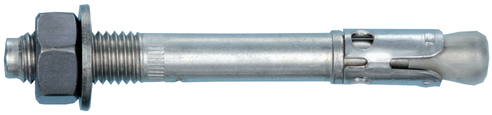


W-FAZ/S

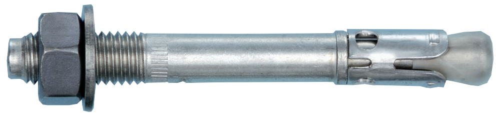
Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer drilling (HD)** Drill the hole with a hammer drill. Drill bit diameter and its working length are determined by the diameter and depth of the drill hole of the selected anchor. (see table anchor characteristics). Positioning of drill holes without damaging the reinforcement.
B) Bore hole cleaning		
	**2.**	Clean the bore hole from the bottom until the return air stream is without dust.
C) Setting the anchor		
	**3a.**	Drive the anchor with some hammer impacts or with the machine setting tool into the drill hole. Anchor installation ensuring the specified embedment depth.
	**3b.**	Application of the required torque moment using a calibrated torque wrench.

FIXANCHOR W-FAZ/A4, W-FAZ/HCR



Stainless steel - A4 (AISI 316): M8-M24



High Corrosion Resistant Steel - HCR (AISI 316): M8-M24

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, natural stone with dense structure

Type of installation		
Pre-positioned	In-place	Stand-off
–	✓	–

Applications

Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DIBt, Berlin	EAD 330232-01-0601	ETA-99/0011 /2018-10-02
ICC-ES Evaluation Report	ICC	AC 193	ESR-2461 /2012-09-01
Fire resistance	DIBt, Berlin	TR 020	ETA-99/0011 /2018-10-12
Sprinkler systems	VdS	VdS CEA 4001:2010-11 (04)	27.03.12
Evaluation Report high strength concrete C80/95	Ing. Büro Thiele, Pirmasens	EAD 330232-01-0601 /ETAG 001	21742_2 /2017-08-10
Shock test. Critical infra-structure protection	BABS, CH-Bern		BZS D 09-0604 /2010-05-18

Basic loading data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness is according to anchor characteristics
- Anchor material is as specified in anchor material specification table
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²

Mean ultimate resistance

Thread size				M8	M10	M12	M16	M20	M24
Effective anchorage depth		h_{ef}	[mm]	46	60	70	85	100	125
Non-cracked concrete									
Tension	C20/25	$N_{Ru,m}$	[kN]	14.2	22.0	30.7	43.8	56.4	105.3
Shear	C20/25	$V_{Ru,m}$	[kN]	16.3	25.5	40.8	60.5	108.4	149.5
Cracked concrete									
Tension	C20/25	$N_{Ru,m}$	[kN]	9.9	15.3	25.1	36.6	49.6	62.8
Shear	C20/25	$V_{Ru,m}$	[kN]	16.3	25.5	40.7	60.4	108.4	149.5

Characteristic resistance

Thread size				M8	M10	M12	M16	M20	M24
Effective anchorage depth		h_{ef}	[mm]	46	60	70	85	100	125
Non-cracked concrete									
Tension	C20/25	N_{Rk}	[kN]	12.0	16.0	25.0	35.0	49.2	68.8
	C50/60			16.0	25.3	39.5	55.3	77.8	108.7
Shear	C20/25	V_{Rk}	[kN]	13.0	20.0	30.0	55.0	86.0	123.6
	C50/60			13.0	20.0	30.0	55.0	86.0	123.6
Cracked concrete									
Tension	C20/25	N_{Rk}	[kN]	12.0	16.0	25.0	35.0	49.2	68.8
	C50/60			16.0	25.3	39.5	55.3	77.8	108.7
Shear	C20/25	V_{Rk}	[kN]	13.0	20.0	30.0	55.0	86.0	123.6
	C50/60			13.0	20.0	30.0	55.0	86.0	123.6

FIXANCHOR W-FAZ/A4, W-FAZ/HCR

Design resistance

Thread size				M8	M10	M12	M16	M20	M24
Effective anchorage depth		h_{ef}	[mm]	46	60	70	85	100	125
Non-cracked concrete									
Tension	C20/25	N_{Rd}	[kN]	8.0	10.7	16.7	23.3	32.8	45.8
	C50/60			10.7	16.9	26.4	36.9	51.9	72.5
Shear	C20/25	V_{Rd}	[kN]	10.4	16.0	24.0	44.0	61.4	98.9
	C50/60			10.4	16.0	24.0	44.0	61.4	98.9
Cracked concrete									
Tension	C20/25	N_{Rd}	[kN]	3.3	6.0	10.7	16.7	23.0	26.7
	C50/60			5.3	9.5	16.9	26.4	36.3	42.2
Shear	C20/25	V_{Rd}	[kN]	10.4	16.0	24.0	43.2	61.4	89.8
	C50/60			10.4	16.0	24.0	44.0	61.4	98.9

Recommended/allowable loads [1)]

Thread size				M8	M10	M12	M16	M20	M24
Effective anchorage depth		h_{ef}	[mm]	46	60	70	85	100	125
Non-cracked concrete									
Tension	C20/25	N_{rec}	[kN]	5.7	7.6	11.9	16.7	23.4	32.7
	C50/60			7.6	12.0	18.8	26.4	37.0	51.8
Shear	C20/25	V_{rec}	[kN]	7.4	11.4	17.1	31.4	43.9	70.6
	C50/60			7.4	11.4	17.1	31.4	43.9	70.6
Cracked concrete									
Tension	C20/25	N_{rec}	[kN]	2.4	4.3	7.6	11.9	16.4	19.0
	C50/60			3.8	6.8	12.0	18.8	25.9	30.1
Shear	C20/25	V_{rec}	[kN]	7.4	11.4	17.1	30.8	43.9	64.2
	C50/60			7.4	11.4	17.1	31.4	43.9	70.6

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole, hammer drilling
- Anchor material as specified in anchor material specification table

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile tesistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	125
Design steel resistance	$N_{Rd,s}$	[kN]	10.7	18.0	26.7	42.7	64.3	73.3

2. Design pullout resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of pull-out failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	125
Non-cracked concrete								
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	8.0	10.7	16.7	23.3	32.8	45.8
Cracked concrete								
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	3.3	6.0	10.7	16.7	23.0	26.7

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a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	125
Non-cracked concrete								
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	10.2	15.2	19.2	25.7	32.8	45.8
Cracked concrete								
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	7.2	10.7	13.4	18.0	23.0	32.1

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	125
Characteristic spacing	$s_{cr,N}$	[mm]	138.0	180.0	210.0	255.0	300.0	375.0
Characteristic edge distance	$c_{cr,N}$	[mm]	69.0	90.0	105.0	127.5	150.0	187.5

a. Influence of concrete strength

Table 6: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 8: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

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4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr.sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 9: Design resistance $N^0_{Rd.sp}$ in case of concrete splitting failure of a single anchor

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	125
Non-cracked concrete								
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	8.0	10.7	16.7	23.3	33.7	47.1

Table 10: Characteristic edge distance $c_{cr.sp}$ and spacing $s_{cr.sp}$

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	125
Characteristic spacing	$s_{cr,\ sp}$	[mm]	230.0	250.0	280.0	400.0	440.0	500.0
Characteristic edge distance	$c_{cr,\ sp}$	[mm]	115.0	125.0	140.0	200.0	220.0	250.0
Minimum member thickness	h_{min}	[mm]	100	120	140	160	200	250

a. Influence of concrete strength

Table 11: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

W-FAZ/A4

b. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 12: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s. when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 13: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

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II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	125
Design steel resistance	$V_{Rd,s}$	[kN]	10.4	16.0	24.0	44.0	61.4	98.9

2. Concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot N_{Rd,c}$$

Table 16: factor k_8 for calculating design pry-out resistance

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	125
Concrete pry-out resistance factor	k_8	[-]	2.4	2.4	2.4	2.4	2.8	2.8

3. Concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions c ≥ max (10 h_{ef} ; 60 d). For anchorages with more than one edge. the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 17: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size	M8		M10		M12		M16		M20		M25	
h_{ef} [mm]	46		60		70		85		100		125	
Edge distance c_1	$V^0_{Rd,c}$											
[mm]	[kN]											
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
40	-	2.1	-	-	-	-	-	-	-	-	-	-
45	-	2.5	-	2.7	-	-	-	-	-	-	-	-
50	4.0	2.9	4.4	3.1	-	-	-	-	-	-	-	-
55	4.6	3.2	5.0	3.5	-	-	-	-	-	-	-	-
60	5.2	3.7	5.6	3.9	-	4.2	-	4.6	-	-	-	-
65	5.7	4.1	6.2	4.4	-	4.7	-	5.1	-	-	-	-
70	6.4	4.5	6.8	4.8	-	5.1	-	5.6	-	-	-	-
75	7.0	4.9	7.5	5.3	7.9	5.6	-	6.1	-	-	-	-
80	7.6	5.4	8.2	5.8	8.6	6.1	9.4	6.7	-	-	-	-
85	8.3	5.9	8.9	6.3	9.4	6.6	10.2	7.2	-	-	-	-
90	9.0	6.4	9.6	6.8	10.1	7.2	11.0	7.8	-	-	-	-
95	9.7	6.8	10.3	7.3	10.9	7.7	11.8	8.3	-	8.9	-	-
100	10.4	7.4	11.1	7.8	11.6	8.2	12.6	8.9	-	9.5	14.7	10.4
110	11.8	8.4	12.6	8.9	13.2	9.4	14.2	10.1	-	10.8	16.5	11.7
120	13.4	9.5	14.2	10.1	14.9	10.5	16.0	11.3	-	12.1	18.5	13.1
130	14.9	10.6	15.8	11.2	16.6	11.7	17.8	12.6	18.9	13.4	20.4	14.5
140	16.6	11.7	17.5	12.4	18.3	13.0	19.6	13.9	20.9	14.8	22.5	15.9
150	18.3	12.9	19.3	13.7	20.1	14.3	21.5	15.2	22.8	16.2	24.6	17.4
160	20.0	14.2	21.1	14.9	22.0	15.6	23.5	16.6	24.9	17.6	26.7	18.9
170	21.8	15.4	22.9	16.2	23.9	16.9	25.5	18.0	26.9	19.1	28.9	20.4
180	23.6	16.7	24.8	17.6	25.8	18.3	27.5	19.5	29.1	20.6	31.1	22.0
190	25.4	18.0	26.8	19.0	27.8	19.7	29.6	20.9	31.2	22.1	33.4	23.6
200	27.3	19.4	28.7	20.4	29.9	21.2	31.7	22.5	33.4	23.7	35.7	25.3
250	37.5	26.5	39.3	27.8	40.7	28.8	43.0	30.4	45.1	32.0	47.9	33.9
300	48.6	34.4	50.7	35.9	52.4	37.1	55.2	39.1	57.8	40.9	61.1	43.3
350	60.5	42.8	63.0	44.6	65.0	46.0	68.3	48.4	71.3	50.5	75.1	53.2
400	73.2	51.8	76.1	53.9	78.4	55.5	82.1	58.2	85.6	60.7	90.0	63.8
450	86.6	61.4	90.0	63.7	92.6	65.6	96.8	68.6	100.7	71.3	105.7	74.8
500	-	-	104.5	74.0	107.4	76.1	112.1	79.4	116.5	82.5	122.0	86.4
550	-	-	119.7	84.8	122.9	87.1	128.1	90.8	133.0	94.2	139.0	98.5
600	-	-	135.5	96.0	139.0	98.5	144.8	102.5	150.1	106.3	156.7	111.0

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Thread size	M8		M10		M12		M16		M20		M25	
h_{ef} [mm]	46		60		70		85		100		125	
Edge distance c_1	$V^0_{Rd,c}$											
[mm]	[kN]											
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
650	-	-	-	-	155,8	110,3	162,0	114,8	167,8	118,8	175,0	123,9
700	-	-	-	-	173,1	122,6	179,8	127,4	186,1	131,8	193,8	137,3
750	-	-	-	-	-	-	198,2	140,4	204,9	145,2	213,3	151,1
800	-	-	-	-	-	-	217,1	153,8	224,3	158,9	233,2	165,2
850	-	-	-	-	-	-	236,6	167,6	244,3	173,0	253,8	179,8
900	-	-	-	-	-	-	256,6	181,7	264,7	187,5	274,8	194,6
950	-	-	-	-	-	-	277,0	196,2	285,7	202,3	296,3	209,9
1000	-	-	-	-	-	-	-	-	307,1	217,5	318,3	225,5
1100	-	-	-	-	-	-	-	-	351,3	248,8	363,8	257,7
1200	-	-	-	-	-	-	-	-	397,3	281,4	411,0	291,1
1300	-	-	-	-	-	-	-	-	-	-	460,0	325,8
1400	-	-	-	-	-	-	-	-	-	-	510,6	361,6
1500	-	-	-	-	-	-	-	-	-	-	567.5	402.0
1600	-	-	-	-	-	-	-	-	-	-	621.6	440.3

a. Influence of concrete strength

Table 18: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 19: Influence of spacing on concrete edge resistance

s/c_1 [1)]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1)] Always choose the lowest value of the spacing s. when there are different spacing in the row closest to the edge.

c. Influence of edge distance

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\,\frac{c_2}{1.5\,c_1}\right)$$

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1 [1)]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1)] Distance to the second edge: $c_1 \leq c_2$

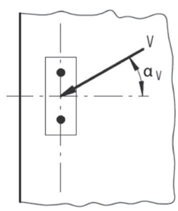
d. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{\cos^2\alpha_V + \left(\frac{\sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 21: Influence of load direction on concrete edge resistance

α [1)]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1)] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.



FIXANCHOR W-FAZ/A4, W-FAZ/HCR

e. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1] This verification is not required in case of shear load with lever arm

Mechanical characteristics

Thread size			M8	M10	M12	M16	M20	M24	M24
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	115	125
Governing cross section									
Stressed cross section	A_s	[mm²]	21.2	36.3	52.8	91.6	153.9	156.7	156.7
Section modulus	W	[mm³]	13.8	30.9	54.1	123.7	269.4	276.7	276.7
Yield strength	f_y	[N/mm²]	600	600	600	560	500	560	560
Tensile strength	f_u	[N/mm²]	750	750	750	700	700	700	700
Stressed cross section of threaded part									
Stressed cross section	A_s	[mm²]	36.6	58.0	84.3	156.7	244.8	352.5	352.5
Section modulus	W	[mm³]	31.2	62.3	109.2	276.7	540.2	933.5	933.5
Yield strength	f_y	[N/mm²]	560	560	560	480	500	560	560
Tensile strength	f_u	[N/mm²]	700	700	700	600	700	700	700
Design bending moment	$M^0_{Rd,s}$	[Nm]	20.8	41.6	73.6	186.4	324.3	628.3	628.23

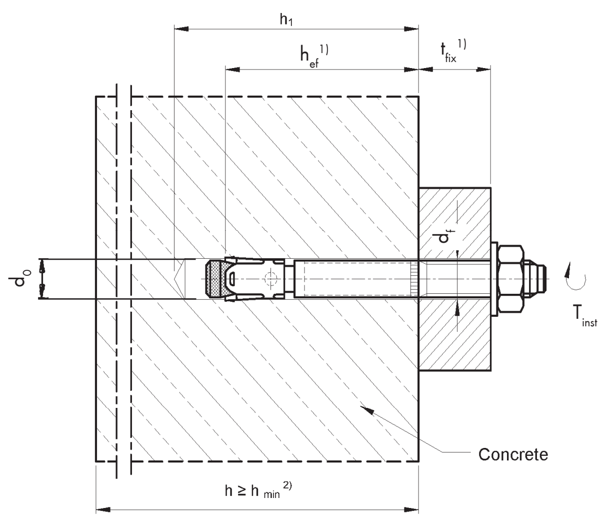
Material specifications

Part	W-FAZ/A4	W-FAZ/HCR
	Stainless steel A4	**High corrosion resistant steel (HCR)**
Conical bolt	M8 to M20: Stainless steel (e.g. 1.4401, 1.4404, 1.4578, 1.4571) EN 10088:2014, cone plastic coated	M8 to M20: High corrosion resistant steel 1.4529 or 1.4565, EN 10088:2014, cone plastic coated
Threaded bolt **Threaded cone**	M24: Stainless steel (e.g. 1.4401, 1.4404) EN 10088:2014	M24: High corrosion resistant steel 1.4529 or 1.4565 EN 10088:2014
Expansion sleeve	Stainless steel (e.g. 1.4401, 1.4404, 1.4571) EN 10088:2014	Stainless steel (e.g. 1.4401, 1.4404, 1.4571) EN 10088:2014
Washer **Filling washer**	Stainless steel (e.g. 1.4401, 1.4571) EN 10088:2014	High corrosion resistant steel 1.4529 or 1.4565, EN 10088:2014
Hexagon nut	Stainless steel (e.g. 1.4401, 1.4571) EN 10088:2014	High corrosion resistant steel 1.4529 or 1.4565, EN 10088:2014, coated

FIXANCHOR W-FAZ/A4, W-FAZ/HCR

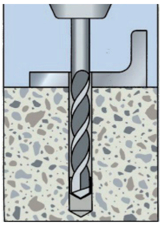
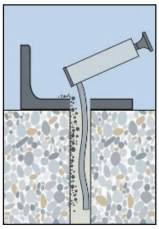
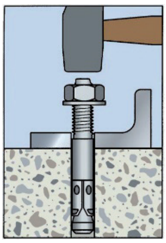
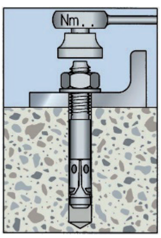
Installation parameters

Thread size			M8	M10	M12	M16	M20	M24
Effective anchorage depth	h_{ef}	[mm]	46	60	70	85	100	125
Depth of drill hole	$h_1 \geq$	[mm]	60	75	90	110	125	155
Nominal drill hole diameter	d_0	[mm]	8	10	12	16	20	24
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	8.45	10.45	12.5	16.5	20.55	24.55
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	9	12	14	18	22	26
Torque moment	$T_{inst} \leq$	[Nm]	20	35	50	110	200	290
Standard thickness of member	h_{min}	[mm]	100	120	140	160	200	250
Non-cracked concrete								
Minimum spacing	s_{min}	[mm]	40	50	60	65	90	125
	for c ≥	[mm]	80	75	120	120	180	125
Minimum edge distance	c_{min}	[mm]	50	60	75	80	130	125
	for s ≥	[mm]	100	120	150	150	240	125
Cracked concrete								
Minimum spacing	s_{min}	[mm]	40	50	60	60	95	125
	for c ≥	[mm]	70	75	100	100	150	125
Minimum edge distance	c_{min}	[mm]	40	55	60	60	95	125
	for s ≥	[mm]	80	90	140	180	200	125



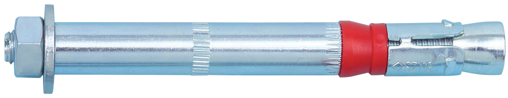
1) Effectiv
2) Minimuɜss of fixture t_{fix}
3) Thickne

Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer drilling (HD)** Drill the hole with a hammer drill. Drill bit diameter and its working length are determined by the diameter and depth of the drill hole of the selected anchor. (see table anchor characteristics). Positioning of drill holes without damaging the reinforcement.
B) Bore hole cleaning		
	**2.**	Clean the bore hole from the bottom until the return air stream is without dust.
C) Setting the anchor		
	**3a.**	Drive the anchor with some hammer impacts or with the machine setting tool into the drill hole. Anchor installation ensuring the specified embedment depth.
	**3b.**	Application of the required torque moment using a calibrated torque wrench.

HIGH PERFORMANCE ANCHOR W-HAZ/S

W-HAZ-B/S

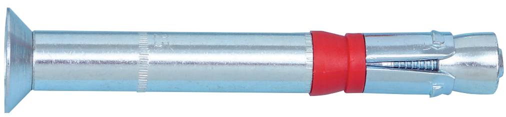


Galvanized (5 microns): M6 - M20

W-HAZ-S/S

Galvanized (5 microns): M6 - M20

W-HAZ-SK/S



Galvanized (5 microns): M6 – M12

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Variable effective anchorage depths possible!

Type of installation		
Pre-positioned	In-place	Stand-off
-	✓	-

Applications

Approvals and certificates

Description	Authority / laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DiBt, Berlin	EAD 330232-01-0601	ETA-02/0031 / 2021-28-01
Shock test, Critical infra-structure protection	BABS, CH-Bern		BZS D 09-0605 /2010-04-28

Basic loading data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness is according to anchor characteristics
- Anchor material is as specified in anchor material specification table
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²

Mean ultimate resistance

Thread size					10/M6	12/M8	15/M10	18/M12	24/M16	24/16L	28/M20	32/M24
Effective anchorage depth			h_{ef}	[mm]	50	60	71	80	100	115	125	150
Non-cracked concrete												
Tension	S / SK / B	C20/25	$N_{Ru,m}$	[kN]	16.1	27.6	39.4	49.0	71.9	90.4	84.7	139.7
Shear	S / SK	C20/25	$V_{Ru,m}$	[kN]	19.0	33.4	58.6	83.7	143.7	143.7	198.5	213.9
	B	C20/25			18.0	28.3	42.0	71.3	106.0	106.0	151.4	213.9
Cracked concrete												
Tension	S / SK / B	C20/25	$N_{Ru,m}$	[kN]	16.1	19.3	29.9	38.8	55.5	72.8	73.0	122.7
Shear	S / SK	C20/25	$V_{Ru,m}$	[kN]	19.0	33.4	58.6	83.7	143.7	143.7	198.5	213.9
	B	C20/25			18.0	28.3	42.0	71.3	106.0	106.0	151.4	213.9

Characteristic resistance

Thread size					10/M6	12/M8	15/M10	18/M12	24/M16	24/16L	28/M20	32/M24
Effective anchorage depth			h_{ef}	[mm]	50	60	71	80	100	115	125	150
Non-cracked concrete												
Tension	S / SK / B	C20/25	N_{Rk}	[kN]	16.0	20.0	29.4	35.2	49.2	60.7	68.8	90.4
		C50/60			16.0	29.0	46.0	55.7	77.8	95.9	108.7	142.9
Shear	S / SK	C20/25	V_{Rk}	[kN]	18.0	30.0	48.0	70.4	98.4	121.3	137.5	180.7
		C50/60			18.0	30.0	48.0	73.0	126.0	126.0	150.0	200.0
	B	C20/25			16.0	25.0	36.0	63.0	91.0	91.0	122.0	180.7
		C50/60			16.0	25.0	36.0	63.0	91.0	91.0	122.0	200.0
Cracked concrete												
Tension	S / SK / B	C20/25	N_{Rk}	[kN]	5.0	12.0	16.0	24.6	34.4	42.5	48.1	63.3
		C50/60			7.9	19.0	25.3	39.0	54.4	67.1	76.1	100.0
Shear	S / SK	C20/25	V_{Rk}	[kN]	18.0	30.0	41.2	49.3	68.9	84.9	96.3	126.5
		C50/60			18.0	30.0	48.0	73.0	108.9	126.0	150.0	200.0
	B	C20/25			16.0	25.0	36.0	49.3	68.9	84.9	96.3	126.5
		C50/60			16.0	25.0	36.0	63.0	91.0	91.0	122.0	200.0

HIGH PERFORMANCE ANCHOR W-HAZ/S

Design resistance

Thread size					10/M6	12/M8	15/M10	18/M12	24/M16	24/16L	28/M20	32/M24
Effective anchorage depth			h_{ef}	[mm]	50	60	71	80	100	115	125	150
Non-cracked concrete												
Tension	S / SK / B	C20/25	N_{Rd}	[kN]	10.7	13.3	19.6	23.5	32.8	40.4	45.8	60.2
		C50/60			10.7	19.3	30.7	37.1	51.9	63.9	72.5	95.3
Shear	S / SK	C20/25	V_{Rd}	[kN]	14.4	24.0	38.4	46.9	65.6	80.9	91.7	120.5
		C50/60			14.4	24.0	38.4	58.4	100.8	100.8	120.0	160.0
	B	C20/25			12.8	20.0	28.8	46.9	65.6	72.8	91.7	120.5
		C50/60			12.8	20.0	28.8	50.4	72.8	72.8	97.6	160.0
Cracked concrete												
Tension	S / SK / B	C20/25	N_{Rd}	[kN]	3.3	8.0	10.7	16.4	23.0	28.3	32.1	42.2
		C50/60			5.3	12.6	16.9	26.0	36.3	44.8	50.7	66.7
Shear	S / SK	C20/25	V_{Rd}	[kN]	14.4	21.3	27.5	32.9	45.9	56.6	64.2	84.3
		C50/60			14.4	24.0	38.4	51.9	72.6	89.5	101.5	133.4
	B	C20/25			12.8	20.0	27.5	32.9	45.9	56.6	64.2	84.3
		C50/60			12.8	20.0	28.8	50.4	72.6	72.8	97.6	133.4

Recommended/allowable Loads [1)]

Thread size					10/M6	12/M8	15/M10	18/M12	24/M16	24/16L	28/M20	32/M24
Effective anchorage depth			h_{ef}	[mm]	50	60	71	80	100	115	125	150
Non-cracked concrete												
Tension	S / SK / B	C20/25	N_{rec}	[kN]	7.6	9.5	14.0	16.8	23.4	28.9	32.7	43.0
		C50/60			7.6	13.8	21.9	26.5	37.0	45.7	51.8	68.0
Shear	S / SK	C20/25	V_{rec}	[kN]	10.3	17.1	27.4	33.5	46.9	57.8	65.5	86.1
		C50/60			10.3	17.1	27.4	41.7	72.0	72.0	85.7	114.3
	B	C20/25			9.1	14.3	20.6	33.5	46.9	52.0	65.5	86.1
		C50/60			9.1	14.3	20.6	36.0	52.0	52.0	69.7	114.3
Cracked concrete												
Tension	S / SK / B	C20/25	N_{rec}	[kN]	2.4	5.7	7.6	11.7	16.4	20.2	22.9	30.1
		C50/60			3.8	9.0	12.0	18.6	25.9	32.0	36.2	47.6
Shear	S / SK	C20/25	V_{rec}	[kN]	10.3	15.2	19.6	23.5	32.8	40.4	45.8	60.2
		C50/60			10.3	17.1	27.4	37.1	51.9	63.9	72.5	95.3
	B	C20/25			9.1	14.3	19.6	23.5	32.8	40.4	45.8	60.2
		C50/60			9.1	14.3	20.6	36.0	51.9	52.0	69.7	95.3

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole, hammer drilling
- Anchor material as specified in anchor material specification table
- Tables calculated for standard effective anchorage depths. Larger effective anchorage depths possible

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size			10/M6	12/M8	15/M10	18/M12	24/M16	24/16L	28/M20	32/M24
Effective anchorage depth	h_{ef}	[mm]	50	60	71	80	100	115	125	150
Design steel resistance	$N_{Rd,s}$	[kN]	10.7	19.3	30.7	44.7	84.0	84.0	130.7	188.0

2. Design pullout resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of pull-out failure of a single anchor

Thread size			10/M6	12/M8	15/M10	18/M12	24/M16	24/16L	28/M20	32/M24
Effective anchorage depth	h_{ef}	[mm]	50	60	71	80	100	115	125	150
Non-cracked concrete										
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	11.3	13.3	20.0	24.0	33.3	40.4	46.7	60.2
Cracked concrete										
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	3.3	8.0	10.7	16.7	24.0	29.3	33.3	43.3

HIGH PERFORMANCE ANCHOR W-HAZ/S

a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size			10/M6	12/M8	15/M10	18/M12	24/M16	24/16L	28/M20	32/M24
Effective anchorage depth	h_{ef}	[mm]	50	60	71	80	100	115	125	150
Non-cracked concrete										
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	11.6	15.2	19.6	23.5	32.8	40.4	45.8	60.2
Cracked concrete										
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	8.1	10.7	13.7	16.4	23.0	28.3	32.1	42.2

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size			10/M6	12/M8	15/M10	18/M12	24/M16	24/16L	28/M20	32/M24
Effective anchorage depth	h_{ef}	[mm]	50	60	71	80	100	115	125	150
Characteristic spacing	$s_{cr,N}$	[mm]	150	180	213	240	300	345	375	450
Characteristic edge distance	$c_{cr,N}$	[mm]	75	90	107	120	150	173	188	225

a. Influence of concrete strength

Table 6: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 8: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

HIGH PERFORMANCE ANCHOR W-HAZ/S

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 9: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size			10/M6	12/M8	15/M10	18/M12	24/M16	24/16L	28/M20	32/M24
Effective anchorage depth	h_{ef}	[mm]	50	60	71	80	100	115	125	150
Non-cracked concrete										
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	8.0	10.7	16.7	20.0	26.7	46.7	33.3	46.7

Table 10: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Thread size			10/M6	12/M8	15/M10	18/M12	24/M16	24/16L	28/M20	32/M24
Effective anchorage depth	h_{ef}	[mm]	50	60	71	80	100	115	125	150
Characteristic spacing	$s_{cr,sp}$	[mm]	150	180	213	240	300	345	375	450
Characteristic edge distance	$c_{cr,sp}$	[mm]	125	150	178	200	250	173	313	300
Minimum member thickness	h_{min}	[mm]	100	120	140	160	200	230	250	300

a. Influence of concrete strength

Table 11: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 12: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 13: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ / $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

HIGH PERFORMANCE ANCHOR W-HAZ/S

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Screw size				10/M6	12/M8	15/10	18/12	24/16	24/16L	28/20	32/24
Effective anchorage depth		h_{ef}	[mm]	50	60	71	80	100	115	125	150
Design steel resistance	S and SK	$V_{Rd,s}$	[kN]	14.4	24.0	38.4	58.4	100.8	100.8	120.0	160.0
	B	$V_{Rd,s}$	[kN]	12.8	20.0	28.8	50.4	72.8	72.8	97.6	160.0

2. Concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot N_{Rd,c}$$

Table 16: factor k_8 for calculating design pry-out resistance

Screw size			10/M6	12/M8	15/10	18/12	24/16	24/16L	28/20	32/24
Effective anchorage depth	h_{ef}	[mm]	50	60	71	80	100	115	125	150
Concrete pry-out resistance factor	k_8	[-]	1.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0

3. Concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq \max(10\ h_{ef}\ ;\ 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 17: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size	10/M6		12/M8		15/M10		18M12		24/M16		24/M16L		28/M20		32/M24	
h_{ef} [mm]	50		60		71		80		100		115		125		150	
Edge distance c_1	$V^0_{Rd,c}$															
[mm]	[kN]															
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
50	4.2	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55	4.8	3.4	-	3.6	-	-	-	-	-	-	-	-	-	-	-	-
60	5.4	3.8	5.7	4.1	6.2	4.4	-	-	-	-	-	-	-	-	-	-
65	6.0	4.3	6.4	4.5	6.8	4.8	-	-	-	-	-	-	-	-	-	-
70	6.6	4.7	7.0	5.0	7.5	5.3	8.0	5.6	-	-	-	-	-	-	-	-
75	7.3	5.2	7.7	5.5	8.2	5.8	8.7	6.2	-	-	-	-	-	-	-	-
80	8.0	5.6	8.4	6.0	9.0	6.3	9.5	6.7	-	-	-	-	-	-	-	-
85	8.6	6.1	9.1	6.5	9.7	6.9	10.2	7.2	-	-	-	-	-	-	-	-
90	9.3	6.6	9.8	7.0	10.5	7.4	11.0	7.8	-	-	-	-	-	-	-	-
95	10.0	7.1	10.6	7.5	11.2	8.0	11.8	8.4	-	-	-	-	-	-	-	-
100	10.8	7.6	11.3	8.0	12.0	8.5	12.6	9.0	13.9	9.8	14.4	10.2	-	-	-	-
110	12.3	8.7	12.9	9.1	13.7	9.7	14.3	10.2	15.7	11.1	16.2	11.5	-	-	-	-
120	13.8	9.8	14.5	10.3	15.3	10.9	16.1	11.4	17.6	12.4	18.1	12.8	-	-	-	-
130	15.5	11.0	16.2	11.5	17.1	12.1	17.9	12.7	19.5	13.8	20.1	14.2	-	-	-	-
140	17.1	12.1	17.9	12.7	18.9	13.4	19.7	14.0	21.4	15.2	22.1	15.6	-	-	-	-
150	18.9	13.4	19.7	13.9	20.7	14.7	21.6	15.3	23.4	16.6	24.1	17.1	-	-	26.9	19.0
160	20.6	14.6	21.5	15.2	22.6	16.0	23.6	16.7	25.5	18.1	26.2	18.6	-	-	29.1	20.6
170	22.4	15.9	23.4	16.6	24.6	17.4	25.6	18.1	27.6	19.6	28.4	20.1	-	-	31.4	22.3
180	24.3	17.2	25.3	17.9	26.5	18.8	27.6	19.6	29.8	21.1	30.6	21.7	31.8	22.5	33.8	23.9
190	26.2	18.6	27.3	19.3	28.6	20.2	29.7	21.0	32.0	22.7	32.8	23.3	34.1	24.2	36.2	25.7
200	28.2	19.9	29.3	20.7	30.7	21.7	31.9	22.6	34.2	24.3	35.1	24.9	36.5	25.8	38.7	27.4
250	38.5	27.3	39.9	28.3	41.7	29.5	43.2	30.6	46.1	32.7	47.2	33.4	48.9	34.6	51.6	36.5
300	49.8	35.3	51.5	36.5	53.6	38.0	55.4	39.2	59.0	41.8	60.3	42.7	62.3	44.1	65.4	46.4
350	61.9	43.9	64.0	45.3	66.4	47.0	68.5	48.5	72.7	51.5	74.2	52.6	76.5	54.2	80.2	56.8
400	74.9	53.0	77.2	54.7	80.0	56.7	82.5	58.4	87.2	61.8	88.9	63.0	91.6	64.9	95.8	67.8
450	88.5	62.7	91.2	64.6	94.4	66.9	97.1	68.8	102.5	72.6	104.4	74.0	107.4	76.1	112.1	79.4
500	102.9	72.9	105.9	75.0	109.5	77.5	112.5	79.7	118.5	83.9	120.7	85.5	124.0	87.8	129.2	91.5
550	117.9	83.5	121.2	85.9	125.2	88.7	128.6	91.1	135.2	95.8	137.5	97.4	141.2	100.0	146.9	104.0
600	133.5	94.6	137.2	97.2	141.5	100.2	145.2	102.9	152.5	108.0	155.1	109.8	159.0	112.7	165.3	117.1

HIGH PERFORMANCE ANCHOR W-HAZ/S

Thread size	10/M6		12/M8		15/M10		18M12		24/M16		24/M16L		28/M20		32/M24	
h_{ef} [mm]	50		60		71		80		100		115		125		150	
Edge distance c_1	$V^0_{Rd,c}$															
[mm]	[kN]															
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
650	-	-	153.8	108.9	158.5	112.3	162.5	115.1	170.4	120.7	173.2	122.7	177.5	125.7	184.3	130.5
700	-	-	170.9	121.0	176.0	124.7	180.4	127.8	188.9	133.8	192.0	136.0	196.6	139.3	203.9	144.4
750	-	-	-	-	194.1	137.5	198.8	140.8	208.0	147.3	211.3	149.6	216.2	153.2	224.0	158.7
800	-	-	-	-	212.8	150.7	217.8	154.3	227.6	161.2	231.1	163.7	236.4	167.5	244.8	173.4
850	-	-	-	-	231.9	164.3	237.3	168.1	247.8	175.5	251.5	178.1	257.2	182.2	266.0	188.4
900	-	-	-	-	251.6	178.2	257.3	182.3	268.5	190.2	272.4	192.9	278.4	197.2	287.8	203.9
950	-	-	-	-	-	-	277.8	196.8	289.6	205.2	293.8	208.1	300.2	212.6	310.1	219.6
1000	-	-	-	-	-	-	298.8	211.6	311.3	220.5	315.6	223.6	322.4	228.4	332.9	235.8
1100	-	-	-	-	-	-	-	-	356.0	252.1	360.8	255.6	368.2	260.8	379.8	269.0
1200	-	-	-	-	-	-	-	-	402.4	285.1	407.7	288.8	415.9	294.6	428.6	303.6
1300	-	-	-	-	-	-	-	-	450.6	319.2	456.4	323.3	465.3	329.6	479.1	339.4
1400	-	-	-	-	-	-	-	-	500.5	354.5	506.7	358.9	516.4	365.8	531.3	376.3
1500	-	-	-	-	-	-	-	-	-	-	-	-	569.0	403.1	585.0	414.4
1600	-	-	-	-	-	-	-	-	-	-	-	-	623.2	441.4	640.3	453.6
1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	697.2	493.8
1800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	755.4	535.1
1900	-	-	-	-	-	-	-	-	-	-	-	-	-	-	815.1	577.4

a. Influence of concrete strength

Table 18: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 19: Influence of spacing on concrete edge resistance

s/c_1 [1)]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

1) Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of edge distance

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\,\frac{c_2}{1.5\,c_1}\right)$$

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1 [1)]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

1) Distance to the second edge: $c_1 \leq c_2$

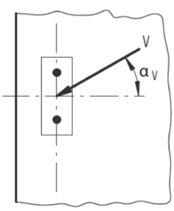
d. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{\cos^2\alpha_V + \left(\frac{\sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 21: Influence of load direction on concrete edge resistance

α [1)]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

1) For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.



e. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

Mechanical characteristics

Thread size			10/M6	12/M8	15/M10	18/M12	24/M16	24/M16L	28/M20	32/M24
Effective anchorage depth	h_{ef}	[mm]	50	60	71	80	100	115	125	150
Governing cross section (bolt and screw)										
Stressed cross section	A_s	[mm²]	20.1	36.6	58	84.3	157	157	244.8	352.5
Section modulus	W	[mm³]	12.7	31.2	62.3	109	277	277	541	935
Yield strength	f_y	[N/mm²]	640	640	640	640	640	640	640	640
Tensile strength	f_u	[N/mm²]	800	800	800	800	800	800	800	800
Design bending moment	$M^0_{Rd,s}$	[Nm]	9.6	24	48	84	212.8	212.8	415.2	718.4

*For larger effective anchorage depths, design bending moments are higher

Material specifications

Product description	**Steel, zinc plated**
	galvanized ≥ 5 µm
Threaded bolt	Steel, Strength class 8.8, EN ISO 898-1:2013
Washer	Steel, EN 10139:2016
Washer	Steel, galvanized
Hexagon nut	Steel, galvanized, coated
Distance sleeve	Steel tube EN 10305-2:2016
Ring	Polyethylene
Expansion sleeve	Steel, EN 10139:2016
Threaded cone	Steel EN 10083-2:2006
Hexagon nut	Steel, Strength class 8, EN ISO 898-2:2012
Hexagon head screw	Steel, Strength class 8.8, EN ISO 898-2:2013
Countersunk screw	Steel, Strength class 8.8, EN ISO 898-1:2013
Countersunk washer	Steel, EN 10083-2:2006

HIGH PERFORMANCE ANCHOR W-HAZ/S

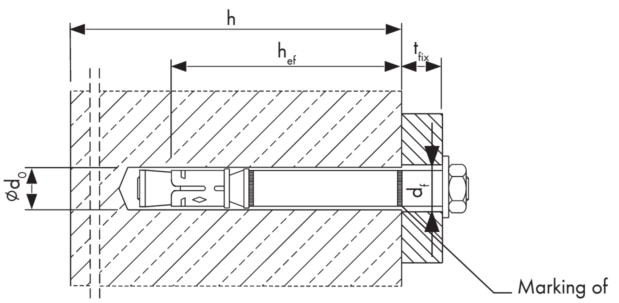
Installation parameters

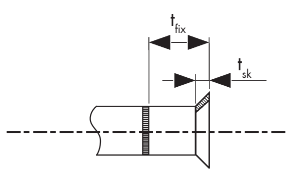
Thread size			10/M6	12/M8	15/10	18/12	24/16	24/16 L	28/20	32/24
Minimum effective anchorage depth	$h_{ef,min}$	[mm]	50	60	71	80	100	115	125	150
	$h_{ef,max}$	[mm]	76	100	110	130	114	150	185	210
Nominal drill hole diameter	d_0	[mm]	10	12	15	18	24	24	28	32
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	10.45	12.5	15.5	18.5	24.55	24.55	28.55	32.7
Depth of drill hole	$h_1 \geq$	[mm]	h_{ef} + 15	h_{ef} + 20	h_{ef} + 24	h_{ef} + 25	h_{ef} + 30	h_{ef} + 30	h_{ef} + 35	h_{ef} + 30
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	12	14	17	20	26	26	31	35
Thickness of countersunk washer W-HAZ-SK	t_{sk}	[mm]	4	5	6	7	-	-	-	-
Minimum thickness of fixture W-HAZ-SK	$t_{fix,min}$ 2)	[mm]	8	10	14	18	-	-	-	-
Installation torque T_{inst} (W-HAZ-B, W-HAZ-S)	T_{inst} =	[Nm]	15	30	50	80	160	160	280	280
Installation torque T_{inst} (W-HAZ-SK)	T_{inst} =	[Nm]	10	25	55	70	-	-	-	-
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 50	h_{ef} + 60	h_{ef} + 69	h_{ef} + 80	h_{ef} + 100	h_{ef} + 115	h_{ef} + 125	h_{ef} + 150
Uncracked concrete										
Minimum spacing 1) 3)	s_{min}	[mm]	50	60	60	70	100	100	125	150
	for c ≥	[mm]	80	100	120	140	180	180	300	300
Minimum edge distance 1) 3)	c_{min}	[mm]	50	60	60	70	100	100	180	150
	for s ≥	[mm]	100	120	120	160	220	220	540	300
Cracked concrete										
Minimum spacing 1) 3)	s_{min}	[mm]	50	50	60	70	100	100	125	150
	for c ≥	[mm]	50	80	120	140	180	180	300	300
Minimum edge distance 1) 3)	c_{min}	[mm]	50	55	60	70	100	100	180	150
	for s ≥	[mm]	50	100	120	160	220	220	540	300

1) Intermediate values by linear interpolation

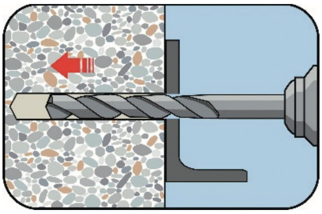
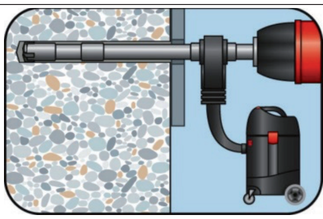
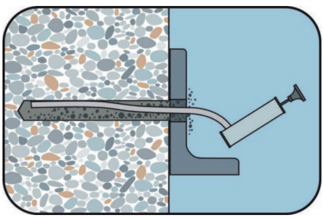
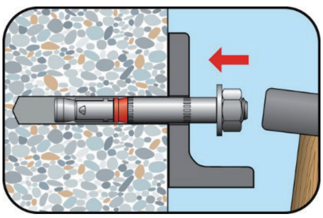
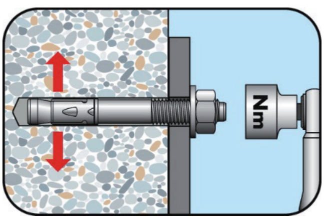
2) Depending on the existing shear load, the thickness of the fixture may be reduced to the thickness of the countersunk washer tsk. It must be verified that the present shear load can be transferred completely into the distance sleeve (bearing of hole).

3) For fire exposure from more than one side c ≥ 300 mm or c_{min} ≥ 300 mm applies.





Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer drilling (HD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. In case of aborted drill hole, the drill hole shall be filled with mortar.
	**1b.**	**Hollow drill bit system (HDB)** Drill a hole into the base material to the size and embedment depth required by the selected anchor. This drilling system removes the dust and cleans the bore hole during drilling (all conditions). Proceed with Step 3.
B) Bore hole cleaning		
	**2.**	Clean the bore hole from the bottom until the return air stream is without dust.
C) Setting the fastener		
	**3a.**	Drive the anchor with hammer impact into the drill hole and check the specified embedment depth.
	**3b.**	Application of the required torque moment using a calibrated torque wrench.

HIGH PERFORMANCE ANCHOR W-HAZ/A4, W-HAZ/HCR

W-HAZ-B/A4

Stainless steel - A4 (AISI 316): M8 - M16

W-HAZ-S/A4

Stainless steel - A4 (AISI 316): M8 - M16

W-HAZ-SK/A4

Stainless steel - A4 (AISI 316): M8 - M12

Approved for:
Concrete C20/25 to C50/60, non-cracked & cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Variable effective anchorage depths possible!

Type of installation

Pre-positioned	In-place	Stand-off
-	✓	-

Applications

Approvals and certificates

ETA CE

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DiBt, Berlin	EAD 330232-01-0601	ETA-02/0031 / 2021-28-01
Shock test, Critical infra-structure protection	BABS, CH-Bern		BZS D 09-0605 /2010-04-28

Basic loading data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness is according to anchor characteristics
- Anchor material is as specified in anchor material specification table
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²

Mean ultimate resistance

Thread size				**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth		h_{ef}	[mm]	60	71	80	100
Non-cracked concrete							
Tension	C20/25	$N_{Ru,m}$	[kN]	21.6	33.2	42.3	76.6
Shear	C20/25	$V_{Ru,m}$	[kN]	32.4	47.9	72.9	111.1
Cracked concrete							
Tension	C20/25	$N_{Ru,m}$	[kN]	18.1	28.9	33.9	62.8
Shear	C20/25	$V_{Ru,m}$	[kN]	32.4	47.9	72.9	111.1

Characteristic resistance

Thread size				**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth		h_{ef}	[mm]	60	71	80	100
Non-cracked concrete							
Tension	C20/25	N_{Rk}	[kN]	16.0	25.0	35.0	49.2
	C50/60			25.3	39.5	55.3	77.8
Shear	C20/25	V_{Rk}	[kN]	24.0	37.0	62.0	92.0
	C50/60			24.0	37.0	62.0	92.0
Cracked concrete							
Tension	C20/25	N_{Rk}	[kN]	9.0	16.0	24.6	34.4
	C50/60			14.2	25.3	39.0	54.4
Shear	C20/25	V_{Rk}	[kN]	24.0	37.0	49.3	68.9
	C50/60			24.0	37.0	62.0	92.0

HIGH PERFORMANCE ANCHOR W-HAZ/A4, W-HAZ/HCR

Design resistance

Thread size					12/M8	15/M10	18M12	24/M16
Effective anchorage depth			h_{ef}	[mm]	60	71	80	100
Non-cracked concrete								
Tension	S and SK	C20/25	N_{Rd}	[kN]	10.7	16.7	23.3	32.8
		C50/60			13.9	21.9	32.1	51.9
	B	C20/25			10.7	16.7	23.3	32.8
		C50/60			16.9	26.4	36.9	51.9
Shear	S and SK	C20/25	V_{Rd}	[kN]	17.6	27.2	45.6	65.6
		C50/60			17.6	27.2	45.6	67.6
	B	C20/25			19.2	29.6	46.9	65.6
		C50/60			19.2	29.6	49.6	73.6
Cracked concrete								
Tension	S and SK	C20/25	N_{Rd}	[kN]	6.0	10.7	16.4	23.0
		C50/60			9.5	16.9	26.0	36.3
	B	C20/25			6.0	10.7	16.4	23.0
		C50/60			9.5	16.9	26.0	36.3
Shear	S and SK	C20/25	V_{Rd}	[kN]	17.6	27.2	32.9	45.9
		C50/60			17.6	27.2	45.6	67.6
	B	C20/25			19.2	27.5	32.9	45.9
		C50/60			19.2	29.6	49.6	72.6

Recommended/allowable loads [1)]

Thread size					12/M8	15/M10	18M12	24/M16
Effective anchorage depth			h_{ef}	[mm]	60	71	80	100
Non-cracked concrete								
Tension	S and SK	C20/25	N_{rec}	[kN]	7.6	11.9	16.7	23.4
		C50/60			9.9	15.7	22.9	37.0
	B	C20/25			7.6	11.9	16.7	23.4
		C50/60			12.0	18.8	26.4	37.0
Shear	S and SK	C20/25	V_{rec}	[kN]	12.6	19.4	32.6	46.9
		C50/60			12.6	19.4	32.6	48.3
	B	C20/25			13.7	21.1	33.5	46.9
		C50/60			13.7	21.1	35.4	52.6
Cracked concrete								
Tension	S and SK	C20/25	N_{rec}	[kN]	4.3	7.6	11.7	16.4
		C50/60			6.8	12.0	18.6	25.9
	B	C20/25			4.3	7.6	11.7	16.4
		C50/60			6.8	12.0	18.6	25.9
Shear	S and SK	C20/25	V_{rec}	[kN]	12.6	19.4	23.5	32.8
		C50/60			12.6	19.4	32.6	48.3
	B	C20/25			13.7	19.6	23.5	32.8
		C50/60			13.7	21.1	35.4	51.9

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

HIGH PERFORMANCE ANCHOR W-HAZ/A4, W-HAZ/HCR

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole, hammer drilling
- Anchor material as specified in anchor material specification table
- Tables calculated for standard effective anchorage depths. Larger effective anchorage depths possible

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size			12/M8	15/M10	18M12	24/M16
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
SK	$N_{Rd,s}$	[kN]	13.9	21.9	32.1	-
S			13.9	21.9	32.1	58.8
B			17.3	27.3	40.0	73.3

2. Design pullout resistance

$$N_{Rd,p} = N_{Rd,p}^{0} \cdot f_{b,N}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of pull-out failure of a single anchor

Thread size			**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
Non-cracked concrete						
SK	$N^0_{Rd,p}$	[kN]	10.7	16.7	23.3	-
S and B			10.7	16.7	23.3	33.3
Cracked concrete						
SK	$N^0_{Rd,p}$	[kN]	6.0	10.7	16.7	-
S and B			6.0	10.7	16.7	24.0

a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders[1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

3. Design concrete cone resistance

$$N_{Rd,c} = N_{Rd,c}^{0} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size			**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
Non-cracked concrete						
SK	$N^0_{Rd,c}$	[kN]	15.2	19.6	23.5	-
S and B			15.2	19.6	23.5	32.8
Cracked concrete						
SK	$N^0_{Rd,c}$	[kN]	10.7	13.7	16.4	-
S and B			10.7	13.7	16.4	23.0

HIGH PERFORMANCE ANCHOR W-HAZ/A4, W-HAZ/HCR

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size			12/M8	15/M10	18M12	24/M16
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
Characteristic spacing	$s_{cr, N}$	[mm]	180	213	240	300
Characteristic edge distance	$c_{cr, N}$	[mm]	90	107	120	150

a. Influence of concrete strength

Table 6: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders 1)	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube 2)	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

1) strength at 28 days of 150 mm diameter by 300 mm cylinders

2) strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ 1)	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

1) Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 8: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 9: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size			**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
Non-cracked concrete						
Splitting resistance	$N^0_{Rd,sp}$	[kN]	10.7	16.7	23.3	32.8

Table 10: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Thread size			**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
Characteristic spacing	$s_{cr,sp}$	[mm]	360	470	530	600
Characteristic edge distance	$c_{cr,sp}$	[mm]	180	235	265	300
Minimum member thickness	h_{min}	[mm]	120	140	160	200

a. Influence of concrete strength

Table 11: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 12: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 13: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ / $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Screw size			**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
SK	$V_{Rd,s}$	[kN]	17.6	27.2	45.6	-
S			17.6	27.2	45.6	67.6
B			19.2	29.6	49.6	73.6

2. Concrete pry-out pesistance

$$V_{Rd,c} = k_8 \cdot N_{Rd,c}$$

Table 16: factor k_8 for calculating design pry-out resistance

Screw size			**12/M8**	**15/M10**	**18M12**	**24/M16**
Effective anchorage depth	h_{ef}	[mm]	60	71	80	100
Concrete pry-out resistance factor	k_8	[-]	2.0	2.0	2.0	2.0

HIGH PERFORMANCE ANCHOR W-HAZ/A4, W-HAZ/HCR

3. Concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions c ≥ max (10 h_{ef} ; 60 d). For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 17: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size	12/M8				15/M10				18M12				24/M16			
h_{ef} [mm]	60		100		71		110		80		130		100		150	
Edge distance c_1	$V^0_{Rd,c}$															
[mm]	[kN]															
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
50	4.5	3.2	5.1	3.6	-	-	-	-	-	-	-	-	-	-	-	-
55	5.1	3.6	5.7	4.1	-	-	-	-	-	-	-	-	-	-	-	-
60	5.7	4.1	6.4	4.5	-	4.4	-	4.9	-	-	-	-	-	-	-	-
65	6.4	4.5	7.1	5.0	-	4.8	-	5.4	-	-	-	-	-	-	-	-
70	7.0	5.0	7.8	5.5	-	5.3	-	5.9	8.0	5.6	9.0	6.4	-	-	-	-
75	7.7	5.5	8.5	6.0	-	5.8	-	6.4	8.7	6.2	9.8	6.9	-	-	-	-
80	8.4	6.0	9.3	6.6	-	6.3	-	7.0	9.5	6.7	10.6	7.5	-	7.4	-	8.3
85	9.1	6.5	10.0	7.1	9.7	6.9	10.6	7.5	10.2	7.2	11.5	8.1	-	8.0	-	8.9
90	9.8	7.0	10.8	7.6	10.5	7.4	11.4	8.1	11.0	7.8	12.3	8.7	-	8.6	-	9.6
95	10.6	7.5	11.6	8.2	11.2	8.0	12.3	8.7	11.8	8.4	13.2	9.3	-	9.2	-	10.2
100	11.3	8.0	12.4	8.8	12.0	8.5	13.1	9.3	12.6	9.0	14.1	10.0	-	9.8	-	10.9
110	12.9	9.1	14.1	10.0	13.7	9.7	14.8	10.5	14.3	10.2	15.9	11.2	-	11.1	-	12.3
120	14.5	10.3	15.8	11.2	15.3	10.9	16.6	11.8	16.1	11.4	17.7	12.6	-	12.4	-	13.7
130	16.2	11.5	17.6	12.4	17.1	12.1	18.5	13.1	17.9	12.7	19.7	13.9	-	13.8	-	15.1
140	17.9	12.7	19.4	13.7	18.9	13.4	20.4	14.4	19.7	14.0	21.6	15.3	-	15.2	-	16.6
150	19.7	13.9	21.3	15.1	20.7	14.7	22.3	15.8	21.6	15.3	23.7	16.8	-	16.6	-	18.1
160	21.5	15.2	23.2	16.4	22.6	16.0	24.3	17.2	23.6	16.7	25.7	18.2	-	18.1	-	19.7
170	23.4	16.6	25.2	17.8	24.6	17.4	26.3	18.7	25.6	18.1	27.9	19.7	-	19.6	-	21.2
180	25.3	17.9	27.2	19.3	26.5	18.8	28.4	20.1	27.6	19.6	30.0	21.3	29.8	21.1	32.3	22.9
190	27.3	19.3	29.3	20.7	28.6	20.2	30.6	21.6	29.7	21.0	32.3	22.8	32.0	22.7	34.6	24.5
200	29.3	20.7	31.4	22.2	30.7	21.7	32.7	23.2	31.9	22.6	34.5	24.4	34.2	24.3	37.0	26.2
250	39.9	28.3	42.5	30.1	41.7	29.5	44.2	31.3	43.2	30.6	46.4	32.9	46.1	32.7	49.5	35.1
300	51.5	36.5	54.7	38.7	53.6	38.0	56.7	40.2	55.4	39.2	59.3	42.0	59.0	41.8	63.0	44.6
350	64.0	45.3	67.7	47.9	66.4	47.0	70.0	49.6	68.5	48.5	73.1	51.8	72.7	51.5	77.3	54.8
400	77.2	54.7	81.4	57.7	80.0	56.7	84.2	59.6	82.5	58.4	87.7	62.1	87.2	61.8	92.5	65.5
450	91.2	64.6	96.0	68.0	94.4	66.9	99.1	70.2	97.1	68.8	103.0	73.0	102.5	72.6	108.4	76.8
500	105.9	75.0	111.2	78.8	109.5	77.5	114.7	81.2	112.5	79.7	119.1	84.3	118.5	83.9	125.1	88.6
550	121.2	85.9	127.1	90.1	125.2	88.7	130.9	92.8	128.6	91.1	135.8	96.2	135.2	95.8	142.4	100.9
600	137.2	97.2	143.7	101.8	141.5	100.2	147.9	104.7	145.2	102.9	153.2	108.5	152.5	108.0	160.4	113.6
650	153.8	108.9	160.8	113.9	158.5	112.3	165.4	117.1	162.5	115.1	171.1	121.2	170.4	120.7	179.0	126.8
700	170.9	121.0	178.5	126.5	176.0	124.7	183.5	130.0	180.4	127.8	189.7	134.4	188.9	133.8	198.2	140.4
750	-	-	196.8	139.4	194.1	137.5	202.1	143.2	198.8	140.8	208.8	147.9	208.0	147.3	217.9	154.4
800	-	-	215.7	152.8	212.8	150.7	221.3	156.8	217.8	154.3	228.5	161.8	227.6	161.2	238.2	168.7

Thread size	12/M8				15/M10				18M12				24/M16			
h_{ef} [mm]	60		100		71		110		80		130		100		150	
Edge distance c_1	$V^0_{Rd,c}$															
[mm]	[kN]															
	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
850	-	-	235.0	166.5	231.9	164.3	241.1	170.7	237.3	168.1	248.7	176.1	247.8	175.5	259.0	183.5
900	-	-	254.9	180.5	251.6	178.2	261.3	185.1	257.3	182.3	269.4	190.8	268.5	190.2	280.4	198.6
950	-	-	275.2	194.9	-	-	282.0	199.8	277.8	196.8	290.6	205.8	289.6	205.2	302.2	214.1
1000	-	-	296.0	209.7	-	-	303.2	214.8	298.8	211.6	312.3	221.2	311.3	220.5	324.6	229.9
1100	-	-	-	-	-	-	347.0	245.8	-	-	357.1	252.9	356.0	252.1	370.6	262.5
1200	-	-	-	-	-	-	-	-	-	-	403.6	285.9	402.4	285.1	418.5	296.5
1300	-	-	-	-	-	-	-	-	-	-	451.9	320.1	450.6	319.2	468.1	331.6
1400	-	-	-	-	-	-	-	-	-	-	-	-	500.5	354.5	519.4	367.9
1500	-	-	-	-	-	-	-	-	-	-	-	-	-	-	572.3	405.3
1600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1700	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1800	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1900	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

a. Influence of concrete strength

Table 18: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

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Table 19: Influence of spacing on concrete edge resistance

s/c_1 [1)]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1)] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of edge distance

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\,\frac{c_2}{1.5\,c_1}\right)$$

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1 [1)]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1)] Distance to the second edge: $c_1 \leq c_2$

d. Influence of load direction

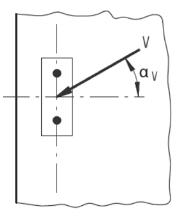
$$f_\alpha = \sqrt{\frac{1}{\cos^2\alpha_V + \left(\frac{\sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 21: Influence of load direction on concrete edge resistance

α [1)]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1)] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.

e. Influence of concrete member thickness



$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1] This verification is not required in case of shear load with lever arm

W-HAZ/A4

HIGH PERFORMANCE ANCHOR W-HAZ/A4, W-HAZ/HCR

Mechanical characteristics

Thread size				12/M8	15/M10	18/M12	24/M16
Effective anchorage depth		h_{ef}	[mm]	60	71	80	100
Governing cross section (bolt)							
Stressed cross section		A_s	[mm²]	36.6	58	84.3	157
Section modulus		W	[mm³]	31.2	62.3	109.1	276.6
Yield strength		f_y	[N/mm²]	560	560	560	560
Tensile strength		f_u	[N/mm²]	700	700	700	700
Governing cross section (screw)							
Stressed cross section		A_s	[mm²]	36.6	58	84.3	157
Section modulus		W	[mm³]	31.2	62.3	109.1	276.6
Yield strength		f_y	[N/mm²]	450	450	450	450
Tensile strength		f_u	[N/mm²]	700	700	700	700
Design bending moment	B	$M^0_{Rd,s}$	[Nm]	20.8	41.6	73.6	185.6
	S and SK			16.7	33.3	59.0	148.7

*For larger effective anchorage depths, design bending moments are higher

Material specifications

Product description	**Stainless steel A4**
Threaded bolt	Stainless steel, 1.4401, 1.4404 or 1.4571, EN 10088:2014
Washer	Stainless steel, EN 10088:2014
Distance sleeve	Steel tube stainless steel, 1.4401, 1.4404 or 1.4571; EN 10217-7:2014, EN 10216-5:2013
Ring	Polyethylene
Expansion sleeve	Stainless steel, 1.4401, 1.4404 or 1.4571, EN 10088:2014
Threaded cone	Stainless steel, 1.4401, 1.4404 or 1.4571, EN 10088:2014
Hexagon nut	Stainless steel, strength class 70, EN ISO 3506-2:2009
Hexagon head screw	Stainless steel, strength class 70, EN ISO 3506-1:2009
Countersunk screw	Stainless steel, strength class 70, EN ISO 3506-1:2009
Countersunk washer	Stainless steel, 1.4401, 1.4404 or 1.4571, EN 10088:2014, zinc plated

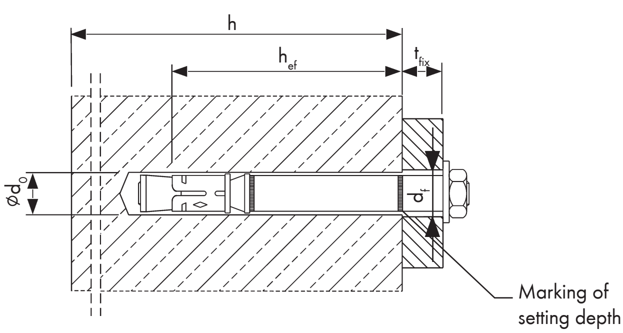
Installation parameters

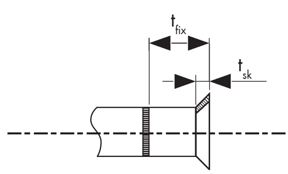
Thread size			12/M8	15/M10	18/M12	24/M16
Size of thread		[-]	M8	M10	M12	M16
Minimum effective anchorage depth	$h_{ef,min}$	[mm]	60	71	80	100
	$h_{ef,max}$	[mm]	100	110	130	150
Nominal drill hole diameter	d_0	[mm]	12	15	18	24
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	12.5	15.5	18.5	24.5
Depth of drill hole	$h_1 \geq$	[mm]	h_{ef} + 20	h_{ef} + 24	h_{ef} + 25	h_{ef} + 30
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	14	17	20	26
Thickness of countersunk washer W-HAZ-SK	t_{sk}	[mm]	5	6	7	-
Minimum thickness of fixture W-HAZ-SK	$t_{fix,min}$ 2)	[mm]	10	14	18	-
Installation torque T_{inst} (W-HAZ-B)	T_{inst} =	[Nm]	35	55	90	170
Installation torque T_{inst} (W-HAZ-S)	T_{inst} =	[Nm]	30	50	80	170
Installation torque T_{inst} (W-HAZ-SK)	T_{inst} =	[Nm]	17.5	42.5	50	-
Minimum thickness of member	h_{min}	[mm]	h_{ef} + 60	h_{ef} + 69	h_{ef} + 80	h_{ef} + 100
Uncracked concrete						
Minimum spacing 1) 3)	s_{min}	[mm]	50	60	70	80
	for c ≥	[mm]	80	120	140	180
Minimum edge distance 1) 3)	c_{min}	[mm]	50	85	70	180
	for s ≥	[mm]	80	185	160	80
Cracked concrete						
Minimum spacing 1) 3)	s_{min}	[mm]	50	60	70	80
	for c ≥	[mm]	80	120	140	180
Minimum edge distance 1) 3)	c_{min}	[mm]	50	60	70	80
	for s ≥	[mm]	80	120	160	200

1) Intermediate values by linear interpolation

2) Depending on the existing shear load, the thickness of the fixture may be reduced to the thickness of the countersunk washer t_{sk}. It must be verified that the present shear load can be transferred completely into the distance sleeve (bearing of hole).

3) For fire exposure from more than one side c ≥ 300 mm or c_{min} ≥ 300 mm applies.

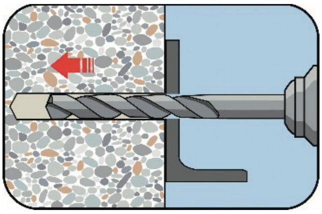
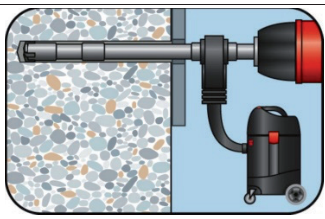
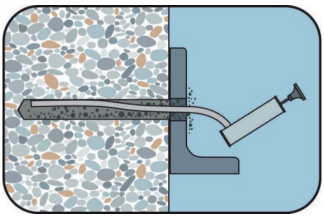
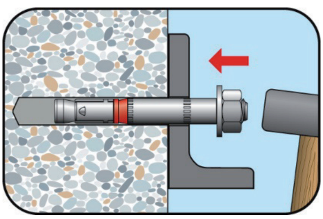
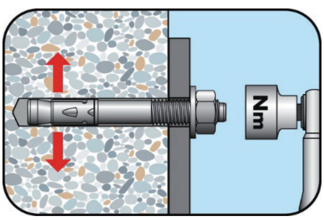




W-HAZ/A4

HIGH PERFORMANCE ANCHOR W-HAZ/A4, W-HAZ/HCR

Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer drilling (HD)** Drill a hole into the base material to the size and embedment depth required by the selected reinforcing bar. In case of aborted drill hole, the drill hole shall be filled with mortar.
	**1b.**	**Hollow drill bit system (HDB)** Drill a hole into the base material to the size and embedment depth required by the selected anchor. This drilling system removes the dust and cleans the bore hole during drilling (all conditions). Proceed with Step C.
B) Bore hole cleaning		
	**2.**	Clean the bore hole from the bottom until the return air stream is without dust.
C) Setting the fastener		
	**3a.**	Drive the anchor with hammer impact into the drill hole and check the specified embedment depth.
	**3b.**	Application of the required torque moment using a calibrated torque wrench.

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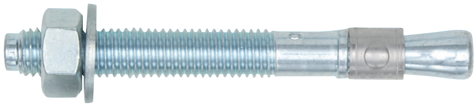
W-FA/S

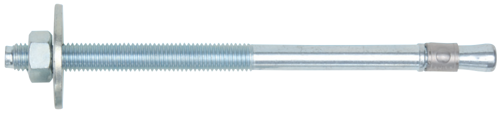


Galvanized (5 microns): M6 – M20

Approved for:
Concrete C20/25 to C50/60, non-cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

W-FA/S WITH BIG WASHER



Galvanized (5 microns): M6 – M20

Type of installation		
Pre-positioned	In-place	Stand-off
–	✓	–

W-FA/F

Hot-dipped (≥ 40 microns): M6 – M16

Applications

Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DiBt, Berlin	EAD 330232-01-0601	ETA-02/0001 /2017-08-10
European Technical Assessment	DiBt, Berlin	ETAG 001 Part 6	ETA-06/0162 /2018-05-17
Report fire resistance	Ing. Büro Thiele, Pirmasens	EN 1363-1:2012-10 / TR 020	21730_2/2017-06-21

Basic loading data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness is according to anchor characteristics
- Anchor material is as specified in anchor material specification table
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²

Mean ultimate resistance

Thread size: M6 – M10

Thread size				M6			M8			M10		
Effective anchorage depth		h_{ef}	[mm]	30[1]	40	60	35[1]	44	70	42	48	80
Non-cracked concrete												
Tension	C20/25	$N_{Ru,m}$	[kN]	9.1	9.1	9.1	12.3	14.7	14.7	18.4	19.1	19.1
Shear	C20/25	$V_{Ru,m}$	[kN]	7.2	7.2	7.2	13.2	13.2	13.2	20.9	20.9	20.9

Thread size: M12 – M20

Thread size				M12			M16			M20		
Effective anchorage depth		h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Non-cracked concrete												
Tension	C20/25	$N_{Ru,m}$	[kN]	18.4	19.1	19.1	34.6	45.4	45.4	46.5	63.9	63.9
Shear	C20/25	$V_{Ru,m}$	[kN]	20.9	20.9	20.9	52.7	52.7	52.7	82.3	82.3	82.3

[1] Use restricted to anchoring of structural components that are statically indeterminate

Characteristic resistance

Thread size: M6 – M10

Thread size				M6			M8			M10		
Effective anchorage depth		h_{ef}	[mm]	30[1]	40	60	35[1]	44	70	42	48	80
Non-cracked concrete												
Tension	C20/25	N_{Rk}	[kN]	6.5	8.7	8.7	10.2	13.0	13.0	13.4	16.4	16.4
	C50/60			8.7	8.7	8.7	15.3	15.3	15.3	21.2	25.9	25.9
Shear	≥ C20/25	V_{Rk}	[kN]	5.0	5.0	5.0	11.0	11.0	11.0	17.0	17.0	17.0

Thread size: M12 – M20

Thread size				M12			M16			M20		
Effective anchorage depth		h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Non-cracked concrete												
Tension	C20/25	N_{Rk}	[kN]	17.4	25.8	26.0	25.2	36.5	40.0	33.9	49.2	55.0
	C50/60			22.7	33.7	33.9	34.1	49.4	54.1	53.6	77.8	87.0
Shear	≥ C20/25	V_{Rk}	[kN]	25.0	25.0	25.0	44.0	44.0	44.0	69.0	69.0	69.0

[1] Use restricted to anchoring of structural components that are statically indeterminate

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Design resistance

Thread size: M6 – M10

Thread size				M6			M8			M10		
Effective anchorage depth		h_{ef}	[mm]	30[1)]	40	60	35[1)]	44	70	42	48	80
Non-cracked concrete												
Tension	C20/25	N_{Rd}	[kN]	4.3	5.8	5.8	6.8	8.7	8.7	8.9	10.9	10.9
	C50/60			5.8	5.8	5.8	10.2	10.2	10.2	14.1	17.2	17.3
Shear	≥ C20/25	V_{Rd}	[kN]	4.0	4.0	4.0	8.8	8.8	8.8	13.6	13.6	13.6

Thread size: M12 – M20

Thread size				M12			M16			M20		
Effective anchorage depth		h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Non-cracked concrete												
Tension	C20/25	N_{Rd}	[kN]	11.6	17.2	17.3	16.8	24.3	26.7	22.6	32.8	36.7
	C50/60			15.1	22.4	22.6	22.7	32.9	36.1	35.7	51.9	58.0
Shear	≥ C20/25	V_{Rd}	[kN]	20.0	20.0	20.0	33.1	33.1	33.1	51.9	51.9	51.9

[1)] Use restricted to anchoring of structural components that are statically indeterminate

Recommended/allowable Loads [1)]

Thread size: M6 – M10

Thread size				M6			M8			M10		
Effective anchorage depth		h_{ef}	[mm]	30[2)]	40	60	35[2)]	44	70	42	48	80
Non-cracked concrete												
Tension	C20/25	N_{rec}	[kN]	3.1	4.1	4.1	4.9	6.2	6.2	6.4	7.8	7.8
	C50/60			4.1	4.1	4.1	7.3	7.3	7.3	10.1	12.3	12.3
Shear	≥ C20/25	V_{rec}	[kN]	2.9	2.9	2.9	6.3	6.3	6.3	9.7	9.7	9.7

Thread size: M12 – M20

Thread size				M12			M16			M20		
Effective anchorage depth		h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Non-cracked concrete												
Tension	C20/25	N_{rec}	[kN]	8.3	12.3	12.4	12.0	17.4	19.0	16.1	23.4	26.2
	C50/60			10.8	16.0	16.1	16.2	23.5	25.8	25.5	37.0	41.4
Shear	≥ C20/25	V_{rec}	[kN]	14.3	14.3	14.3	23.6	23.6	23.6	37.1	37.1	37.1

[1)] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.
[2)] Use restricted to anchoring of structural components that are statically indeterminate

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole, hammer drilling
- Anchor material as specified in anchor material specification table
- Anchorage depths hef < 40 mm are restricted to use of structural components with which are statically intdeterminate and subject to internal exposure conditions only

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Design steel resistance	$N_{Rd,s}$	[kN]	5.8	5.8	5.8	10.2	10.2	10.2	17.3	17.3	17.3

Thread size: M12 – M20

Thread size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Design steel resistance	$N_{Rd,s}$	[kN]	23.3	23.3	23.3	40.6	40.6	40.6	66.9	66.9	66.9

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2. Design pullout resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of pull-out failure of a single anchor

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	4.3	6.7	6.7	6.8	8.7	8.7	8.9	10.9	10.9

Thread size: M12 – M20

Thread size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	11.6	17.2	17.3	16.8	24.3	26.7	22.6	32.8	36.7

a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	5.4	8.3	15.2	6.8	9.6	19.2	8.9	10.9	23.5

Thread size: M12 – M20

Thread size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	11.6	17.2	32.8	16.8	24.4	43.1	22.6	32.8	40.4

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Characteristic spacing	$s_{cr,N}$	[mm]	90	120	180	105	132	210	126	144	240
Characteristic edge distance	$c_{cr,N}$	[mm]	45	60	90	53	66	105	63	72	120

Thread size: M12 – M20

Thread size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Characteristic spacing	$s_{cr,N}$	[mm]	150	195	300	192	246	360	234	300	345
Characteristic edge distance	$c_{cr,N}$	[mm]	75	98	150	96	123	180	117	150	173

a. Influence of concrete strength

Table 6: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

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c. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3 \frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 8: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 9: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Design splitting resistance	$N^0_{Rd,sp}$	[mm]	4.3	6.7	6.7	6.8	8.7	8.7	8.9	10.9	10.9

Thread size: M12 – M20

Thread size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Design splitting resistance	$N^0_{Rd,sp}$	[mm]	11.6	17.2	17.3	16.8	24.3	26.7	22.6	32.8	36.7

Table 10: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Characteristic spacing	$s_{cr,sp}$	[mm]	180	160	360	180	220	240	180	240	480
Characteristic edge distance	$c_{cr,sp}$	[mm]	90	80	180	90	110	210	90	120	240
Minimum member thickness	h_{min}	[mm]	80	100	120	80	100	126	100	100	132

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Characteristic spacing	$s_{cr,\,sp}$	[mm]	180	340	600	180	410	720	180	560	690
Characteristic edge distance	$c_{cr,\,sp}$	[mm]	90	170	300	90	205	360	90	280	345
Minimum member thickness	h_{min}	[mm]	100	130	165	130	170	208	160	200	215

a. Influence of concrete strength

Table 11: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 12: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

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c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 13: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,\ sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,\ sp}$ / $f_{cy,\ sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Thread size: M6 – M10

Screw size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Design steel resistance	$V_{Rd,s}$	[kN]	4.0	4.0	4.0	8.8	8.8	8.8	13.6	13.6	13.6

Thread size: M12 – M20

Screw size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Design steel resistance	$V_{Rd,s}$	[kN]	20.0	20.0	20.0	33.1	33.1	33.1	51.9	51.9	51.9

2. Concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot N_{Rd,c}$$

Table 16: factor k_8 for calculating design pry-out resistance

Thread size: M6 – M10

Screw size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Concrete pry-out resistance factor	k_8	[-]	1.0	1.0	1.0	2.3	2.3	2.3	2.5	2.5	2.5

Thread size: M12 – M20

Screw size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Concrete pry-out resistance factor	k_8	[-]	2.9	2.9	2.9	2.8	2.8	2.8	3.1	3.1	3.1

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3. Concrete edge resistance

$$V_{Rd,c} = V^{0}_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_{a} \cdot f_{h}$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq \max(10\ h_{ef}\ ;\ 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 17: Design resistance $V^{0}_{Rd,c}$ in case of concrete edge failure

Thread size	M6			M8			M10			M12			M16			M20		
h_{ef} [mm]	30	40	60	35	44	70	42	48	80	50	65	100	64	82	120	78	100	115
Edge distance c_1	$V^{0}_{Rd,c}$																	
[mm]	[kN]																	
	non-cracked concrete																	
40	2.7	2.8	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	3.1	3.3	3.5	3.3	3.5	3.8	-	-	-	-	-	-	-	-	-	-	-	-
50	3.6	3.8	4.0	3.9	4.0	4.3	-	-	-	-	-	-	-	-	-	-	-	-
55	4.1	4.3	4.6	4.4	4.5	4.9	-	-	-	-	-	-	-	-	-	-	-	-
60	4.7	4.9	5.2	4.9	5.1	5.5	-	-	-	-	-	-	-	-	-	-	-	-
65	5.2	5.4	5.7	5.5	5.7	6.2	5.8	6.0	6.5	-	-	-	-	-	-	-	-	-
70	5.8	6.0	6.4	6.1	6.3	6.8	6.5	6.6	7.2	-	-	-	-	-	-	-	-	-
75	6.4	6.6	7.0	6.7	6.9	7.5	7.1	7.2	7.9	-	-	-	-	-	-	-	-	-
80	7.0	7.2	7.6	7.4	7.6	8.1	7.7	7.9	8.6	-	-	-	-	-	-	-	-	-
85	7.6	7.9	8.3	8.0	8.2	8.8	8.4	8.6	9.3	-	-	-	-	-	-	-	-	-
90	8.3	8.5	9.0	8.7	8.9	9.5	9.1	9.3	10.1	-	10.0	10.8	-	-	-	-	-	-
95	8.9	9.2	9.7	9.3	9.6	10.3	9.8	10.0	10.8	-	10.7	11.6	-	-	-	-	-	-
100	9.6	9.9	10.4	10.0	10.3	11.0	10.5	10.7	11.6	11.0	11.5	12.4	11.9	-	-	-	-	-
110	11.0	11.3	11.8	11.5	11.8	12.5	12.0	12.2	13.2	12.5	13.1	14.1	13.5	14.2	15.3	-	-	-
120	12.4	12.8	13.4	12.9	13.3	14.1	13.5	13.8	14.8	14.1	14.7	15.8	15.2	15.9	17.1	-	-	-
130	13.9	14.3	14.9	14.5	14.9	15.8	15.1	15.4	16.5	15.8	16.4	17.6	16.9	17.7	19.0	-	18.9	19.5
140	15.4	15.9	16.6	16.1	16.5	17.4	16.8	17.0	18.3	17.5	18.1	19.4	18.7	19.5	20.9	19.9	20.9	21.4
150	17.0	17.5	18.3	17.7	18.2	19.2	18.5	18.8	20.1	19.2	19.9	21.3	20.6	21.4	22.9	21.8	22.8	23.5
160	18.7	19.2	20.0	19.4	19.9	21.0	20.2	20.5	21.9	21.0	21.8	23.2	22.4	23.3	24.9	23.8	24.9	25.5
170	20.4	20.9	21.8	21.1	21.6	22.8	22.0	22.3	23.8	22.8	23.6	25.2	24.4	25.3	27.0	25.8	26.9	27.6
180	22.1	22.7	23.6	22.9	23.5	24.7	23.8	24.2	25.8	24.7	25.6	27.2	26.3	27.3	29.1	27.9	29.1	29.8
190	23.9	24.5	25.4	24.7	25.3	26.6	25.7	26.1	27.8	26.7	27.6	29.3	28.4	29.4	31.3	30.0	31.2	32.0
200	25.7	26.3	27.4	26.6	27.2	28.6	27.6	28.0	29.8	28.6	29.6	31.4	30.4	31.5	33.5	32.1	33.4	34.3
250	35.4	36.2	37.5	36.6	37.3	39.1	37.8	38.3	40.6	39.1	40.3	42.5	41.4	42.8	45.2	43.5	45.1	46.1
300	46.0	47.0	48.6	47.4	48.4	50.5	49.0	49.6	52.3	50.5	52.0	54.7	53.3	54.9	57.8	55.8	57.8	59.0
350	57.4	58.6	60.5	59.1	60.2	62.8	61.0	61.7	64.9	62.8	64.5	67.7	66.0	68.0	71.4	69.0	71.3	72.7
400	-	71.0	73.2	71.6	72.9	75.8	73.7	74.6	78.2	75.9	77.8	81.4	79.6	81.8	85.7	83.0	85.6	87.2
450	-	-	86.7	84.8	86.3	89.6	87.3	88.2	92.4	89.7	91.9	96.0	93.9	96.4	100.8	97.8	100.7	102.5
500	-	-	100.8	-	-	104.1	101.5	102.6	107.2	104.2	106.7	111.2	108.9	111.7	116.6	113.2	116.5	118.5
550	-	-	115.6	-	-	119.3	116.3	117.5	122.7	119.3	122.1	127.1	124.5	127.6	133.0	129.3	133.0	135.2
600	-	-	131.0	-	-	135.1	131.8	133.1	138.8	135.1	138.1	143.7	140.8	144.2	150.1	146.1	150.1	152.5
650	-	-	-	-	-	151.4	-	-	155.5	151.5	154.8	160.8	157.7	161.4	167.8	163.5	167.8	170.4
700	-	-	-	-	-	168.4	-	-	172.8	168.4	172.0	178.5	175.2	179.2	186.1	181.4	186.1	188.9
750	-	-	-	-	-	-	-	-	190.6	-	-	196.8	193.2	197.6	205.0	199.9	204.9	208.0
800	-	-	-	-	-	-	-	-	209.0	-	-	215.7	211.8	216.4	224.4	219.0	224.3	227.6

Thread size	M6			M8			M10			M12			M16			M20		
h_{ef} [mm]	30	40	60	35	44	70	42	48	80	50	65	100	64	82	120	78	100	115
Edge distance c_1	$V^0_{Rd,c}$																	
[mm]	[kN]																	
	non-cracked concrete																	
850	-	-	-	-	-	-	-	-	-	-	-	235.0	230.9	235.8	244.3	238.5	244.3	247.7
900	-	-	-	-	-	-	-	-	-	-	-	254.9	250.5	255.8	264.7	258.6	264.7	268.4
950	-	-	-	-	-	-	-	-	-	-	-	275.2	270.6	276.2	285.7	279.2	285.7	289.5
1000	-	-	-	-	-	-	-	-	-	-	-	296.0	-	-	307.1	300.3	307.1	311.2
1100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	351.3	343.8	351.3	355.8
1200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	397.3	389.0	397.3	402.3

a. Influence of concrete strength

Table 18: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 19: Influence of spacing on concrete edge resistance

s/c_1[1)]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1)] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

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c. Influence of edge distance

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\,\frac{c_2}{1.5\,c_1}\right)$$

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1 [1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \leq c_2$

d. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{\cos^2\alpha_V + \left(\frac{\sin\alpha_V}{2}\right)^2}} \leq 2$$

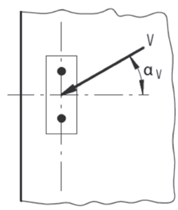

Table 21: Influence of load direction on concrete edge resistance

α [1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For a ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.

e. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1] This verification is not required in case of shear load with lever arm

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Mechanical characteristics

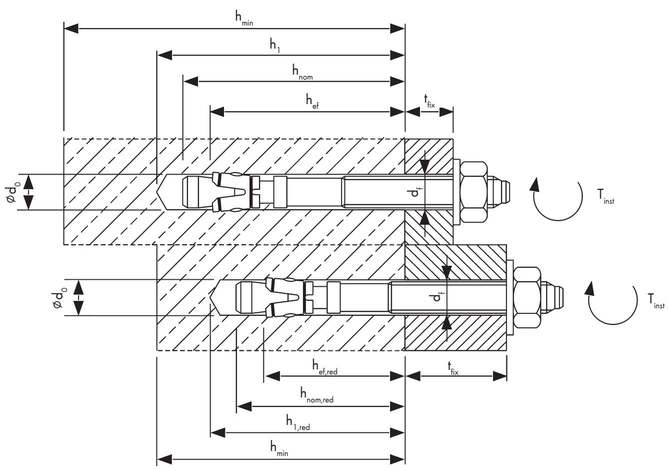
Thread size			M6	M6	M8	M8	M10	M10	M12	M12	M16	M16	M20	M20
Effective anchorage depth	h_{ef}	[mm]	30	40	35	44	42	48	50	65	64	82	78	100
Governing cross section														
Stressed cross section	A_s	[mm²]	14.5	14.5	25.5	25.5	43.0	43.0	58.1	58.1	116.9	116.9	191.1	191.1
Section modulus	W	[mm³]	7.8	7.8	18.2	18.2	39.8	39.8	62.4	62.4	178.3	178.3	372.7	372.7
Yield strength	f_y	[N/mm²]	480	480	480	480	480	480	480	480	420	420	420	420
Tensile strength	f_u	[N/mm²]	600	600	600	600	600	600	600	600	560	560	560	560
Non-cracked concrete														
Stressed cross section	A_s	[mm²]	20.1	20.1	36.6	36.6	58.0	58.0	84.3	84.3	156.7	156.7	244.8	244.8
Section modulus	W	[mm³]	12.7	12.7	31.2	31.2	62.3	62.3	109.2	109.2	276.7	276.7	540.2	540.2
Yield strength	f_y	[N/mm²]	480	480	480	480	480	480	480	480	420	420	420	420
Tensile strength	f_u	[N/mm²]	600	600	600	600	600	600	600	600	560	560	560	560
Design bending moment	$M^0_{Rd,s}$	[Nm]	18.4	37.6	65.6	167.2	272.9	718.4	1065	1065	62.4	148.8	148.8	272.9

Material specifications

Part	W-FA/S	
	Steel, electroplated ≥ 40 µm acc. to EN ISO 4042:1999	**Steel, hot-dip galvanized ≥ 40 µm, acc. to EN ISO 1461:2009**
Conical bolt	Cold formed or machined steel	Cold formed or machined steel
Expansion sleeve	Steel acc. to EN 10088:2005, material No. 1.4301 or 1.4303	Steel acc. to EN 10088:2005, material No. 1.4301 or 1.4303
Washer	Steel	Steel
Hexagon nut	Property class 8 acc. to EN ISO 898-2:2012	Property class 8 acc. to EN ISO 898-2:2012

Installation parameters

Fastener size			M6	M8	M10	M12	M16	M20
Nominal drill hole diameter	d_0	[mm]	6	8	10	12	16	20
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	6.4	8.45	10.45	12.5	16.5	20.55
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	7	9	12	14	18	22
Installation torque (Wedge Anchor B electroplated)	$T_{inst} =$	[Nm]	8	15	30	50	100	200
Installation torque (Wedge Anchor B hot-dip galvanised)	$T_{inst} =$	[Nm]	-	15	30	40	90	120
Embedment depth $h_{ef,1}$								
Effective anchorage depth	$h_{ef,1} \geq$	[mm]	30	35	42	50	64	78
Depth of drill hole	$h_{1,1} \geq$	[mm]	45	55	65	75	95	110
Embedment depth	$h_{nom,1} \geq$	[mm]	39	47	56	67	84	99
Minimum thickness of member	h_{min}	[mm]	80	80	100	100	130	160
Minimum spacing	s_{min}	[mm]	35	40	55	100	100	140
Minimum edge distance	c_{min}	[mm]	40	45	65	100	100	140
Embedment depth $h_{ef,2}$								
Effective anchorage depth	$h_{ef,2} \geq$	[mm]	40	44	48	65	82	100
Depth of drill hole	$h_{1,2} \geq$	[mm]	55	65	70	90	110	130
Embedment depth	$h_{nom,2} \geq$	[mm]	49	56	62	82	102	121
Minimum thickness of member	h_{min}	[mm]	100	100	100	130	170	200
Minimum spacing	s_{min}	[mm]	35	40	55	75	90	105
Minimum edge distance	c_{min}	[mm]	40	45	65	90	105	125
Embedment depth $h_{ef,3}$								
Effective anchorage depth	$h_{ef,3} \geq$	[mm]	60	70	80	100	120	115
Depth of drill hole	$h_{1,3} \geq$	[mm]	75	91	102	125	148	145
Embedment depth	$h_{nom,3} \geq$	[mm]	69	82	94	117	140	136
Minimum thickness of member	h_{min}	[mm]	120	126	132	165	208	215
Minimum spacing	s_{min}	[mm]	35	40	55	75	90	105
Minimum edge distance	c_{min}	[mm]	40	45	65	90	105	125



W-FA/S

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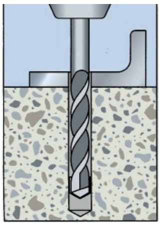
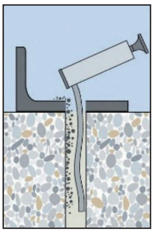
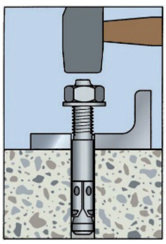
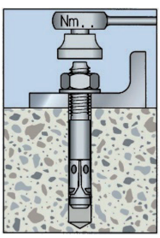
Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer drilling (HD)** Drill the hole with a hammer drill. Drill bit diameter and its working length are determined by the diameter and depth of the drill hole of the selected anchor. (see table anchor characteristics). Positioning of drill holes without damaging the reinforcement.
B) Bore hole cleaning		
	**2.**	Clean the bore hole from the bottom until the return air stream is without dust.
C) Setting the screw		
	**3a.**	Drive the anchor with some hammer impacts or with the machine setting tool into the drill hole. Anchor installation ensuring the specified embedment depth.
	**3b.**	Application of the required torque moment using a calibrated torque wrench.

FIXANCHOR W-FA/A4

W-FA/A4

A4 (AISI 316): M6 - M20

Approved for:
Concrete C20/25 to C50/60, non-cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

W-FA/HCR

A4 (AISI 316): M8 - M20 (on demand)

Type of installation		
Pre-positioned	In-place	Stand-off
–	✓	–

Applications




Approvals and certificates

ETA CE

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DiBt, Berlin	EAD 330232-01-0601	ETA-02/0001 /2017-08-10
European Technical Assessment	DiBt, Berlin	ETAG 001 Part 6	ETA-06/0162 /2018-05-17
Report fire resistance	Ing. Büro Thiele, Pirmasens	EN 1363-1:2012-10 / TR 020	21730_2/2017-06-21

Basic loading data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness is according to anchor characteristics
- Anchor material is as specified in anchor material specification table
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²

Mean ultimate resistance

Thread size: M6 – M10

Thread size				M6			M8			M10		
Effective anchorage depth		h_{ef}	[mm]	30[1]	40	60	35[1]	44	70	42	48	80
Non-cracked concrete												
Tension	C20/25	$N_{Ru,m}$	[kN]	10.2	9.5	9.5	12.4	17.5	17.5	17.5	21.4	21.4
Shear	C20/25	$V_{Ru,m}$	[kN]	9.1	9.1	9.1	16.7	16.7	16.7	26.4	26.4	26.4

Thread size: M12 – M20

Thread size				M12			M16			M20		
Effective anchorage depth		h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Non-cracked concrete												
Tension	C20/25	$N_{Ru,m}$	[kN]	22.6	27.3	27.3	34.6	48.9	48.9	46.5	67.5	67.5
Shear	C20/25	$V_{Ru,m}$	[kN]	38.4	38.4	38.4	65.8	65.8	65.8	102.8	102.8	102.8

[1] Use restricted to anchoring of structural components that are statically indeterminate

Characteristic resistance

Thread size: M6 – M10

Thread size				M6			M8			M10		
Effective anchorage depth		h_{ef}	[mm]	30[1]	40	60	35[1]	44	70	42	48	80
Non-cracked concrete												
Tension	C20/25	N_{Rk}	[kN]	6.5	8.0	8.0	9.0	14.4	15.0	12.0	16.4	16.4
	C50/60			10.0	10.0	10.0	14.2	18.0	18.0	19.0	25.9	25.9
Shear	≥ C20/25	V_{Rk}	[kN]	7.0	7.0	7.0	12.0	12.0	12.0	19.0	19.0	19.0

Thread size: M12 – M20

Thread size				M12			M16			M20		
Effective anchorage depth		h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Non-cracked concrete												
Tension	C20/25	N_{Rk}	[kN]	17.4	25.0	25.0	25.2	35.2	42.0	33.9	49.2	60.0
	C50/60			27.5	39.5	39.5	39.8	55.7	66.4	53.6	77.8	94.9
Shear	≥ C20/25	V_{Rk}	[kN]	27.0	27.0	27.0	50.0	50.0	50.0	86.0	86.0	86.0

[1] Use restricted to anchoring of structural components that are statically indeterminate

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Design resistance

Thread size: M6 – M10

Thread size				M6			M8			M10		
Effective anchorage depth		h_{ef}	[mm]	30[1]	40	60	35[1]	44	70	42	48	80
Non-cracked concrete												
Tension	C20/25	N_{Rd}	[kN]	4.3	5.3	5.3	6.0	9.6	10.0	8.0	10.9	10.9
	C50/60			6.7	6.7	6.7	9.5	12.0	12.0	12.6	17.2	17.3
Shear	≥ C20/25	V_{Rd}	[kN]	5.4	5.6	5.6	9.6	9.6	9.6	15.2	15.2	15.2

Thread size: M12 – M20

Thread size				M12			M16			M20		
Effective anchorage depth		h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Non-cracked concrete												
Tension	C20/25	N_{Rd}	[kN]	11.6	16.7	16.7	16.8	23.5	28.0	22.6	32.8	40.0
	C50/60			18.3	26.4	26.4	26.5	37.1	44.3	35.7	51.9	63.2
Shear	≥ C20/25	V_{Rd}	[kN]	21.6	21.6	21.6	40.0	40.0	40.0	61.4	61.4	61.4

[1] Use restricted to anchoring of structural components that are statically indeterminate

Recommended/allowable Loads [1]

Thread size: M6 – M10

Thread size				M6			M8			M10		
Effective anchorage depth		h_{ef}	[mm]	30[2]	40	60	35[2]	44	70	42	48	80
Non-cracked concrete												
Tension	C20/25	N_{rec}	[kN]	4.1	4.1	4.1	7.3	7.3	7.3	10.1	12.3	12.3
	C50/60			4.8	4.8	4.8	6.8	8.6	8.6	9.0	12.3	12.3
Shear	≥ C20/25	V_{rec}	[kN]	3.8	4.0	4.0	6.9	6.9	6.9	10.9	10.9	10.9

Thread size: M12 – M20

Thread size				M12			M16			M20		
Effective anchorage depth		h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Non-cracked concrete												
Tension	C20/25	N_{rec}	[kN]	10.8	16.0	16.1	16.2	23.5	25.8	25.5	37.0	41.4
	C50/60			13.1	18.8	18.8	19.0	26.5	31.6	25.5	37.0	45.2
Shear	≥ C20/25	V_{rec}	[kN]	15.4	15.4	15.4	28.6	28.6	28.6	43.9	43.9	43.9

[1] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

[2] Use restricted to anchoring of structural components that are statically indeterminate

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole, hammer drilling
- Anchor material as specified in anchor material specification table
- Anchorage depths hef < 40 mm are restricted to use of structural components with which are statically intdeterminate and subject to internal exposure conditions only

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Design steel resistance	$N_{Rd,s}$	[kN]	6.7	6.7	6.7	12.0	12.0	12.0	20.0	20.0	20.0

Thread size: M12 – M20

Thread size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Design steel resistance	$N_{Rd,s}$	[kN]	29.3	29.3	29.3	58.7	58.7	58.7	79.8	79.8	79.8

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2. Design pullout resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of pull-out failure of a single anchor

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	4.3	5.3	5.3	6.0	10.0	10.0	8.0	10.9	10.9

Thread size: M12 – M20

Thread size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	11.6	16.7	16.7	16.8	23.5	28.0	22.6	32.8	40.0

a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	5.4	8.3	15.2	6.8	9.6	19.2	8.9	10.9	23.5

Thread size: M12 – M20

Thread size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	11.6	17.2	32.8	16.8	24.4	43.1	22.6	32.8	40.4

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Characteristic spacing	$s_{cr,N}$	[mm]	90	120	180	105	132	210	126	144	240
Characteristic edge distance	$c_{cr,N}$	[mm]	45	60	90	53	66	105	63	72	120

Thread size: M12 – M20

Thread size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Characteristic spacing	$s_{cr,N}$	[mm]	150	195	300	192	246	360	234	300	345
Characteristic edge distance	$c_{cr,N}$	[mm]	75	98	150	96	123	180	117	150	173

a. Influence of concrete strength

Table 6: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacing s, when there are different spacings in one row

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c. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3 \frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 8: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 9: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Design splitting resistance	$N^0_{Rd,sp}$	[mm]	4.3	5.3	5.3	6.0	9.6	10.0	8.0	10.9	10.9

Thread size: M12 – M20

Thread size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Design splitting resistance	$N^0_{Rd,sp}$	[mm]	11.6	16.7	16.7	16.8	23.5	28.0	22.6	32.8	40.0

Table 10: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Thread size: M6 – M10

Thread size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Characteristic spacing	$s_{cr, sp}$	[mm]	180	160	360	180	220	240	180	240	480
Characteristic edge distance	$c_{cr, sp}$	[mm]	90	80	180	90	110	210	90	120	240
Minimum member thickness	h_{min}	[mm]	80	100	120	80	100	126	100	100	132

Thread size: M6 – M10

Thread size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Characteristic spacing	$s_{cr, sp}$	[mm]	180	340	600	180	410	720	180	560	690
Characteristic edge distance	$c_{cr, sp}$	[mm]	90	170	300	90	205	360	90	280	345
Minimum member thickness	h_{min}	[mm]	100	130	165	130	170	208	160	200	215

a. Influence of concrete strength

Table 11: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

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b. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 12: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 13: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ / $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Thread size: M6 – M10

Screw size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Design steel resistance	$V_{Rd,s}$	[kN]	5.6	5.6	5.6	9.6	9.6	9.6	15.2	15.2	15.2

Thread size: M12 – M20

Screw size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Design steel resistance	$V_{Rd,s}$	[kN]	21.6	21.6	21.6	40.0	40.0	40.0	61.4	61.4	61.4

2. Concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot N_{Rd,c}$$

Table 16: factor k_8 for calculating design pry-out resistance

Thread size: M6 – M10

Screw size			M6			M8			M10		
Effective anchorage depth	h_{ef}	[mm]	30	40	60	35	44	70	42	48	80
Concrete pry-out resistance factor	k_8	[-]	1.0	1.0	1.0	2.3	2.3	2.3	2.8	2.8	2.8

Thread size: M12 – M20

Screw size			M12			M16			M20		
Effective anchorage depth	h_{ef}	[mm]	50	65	100	64	82	120	78	100	115
Concrete pry-out resistance factor	k_8	[-]	2.8	2.8	2.8	3.0	3.0	3.0	3.3	3.3	3.3

FIXANCHOR W-FA/A4

3. Concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq \max(10\ h_{ef}\ ;\ 60\ d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 17: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size	M6			M8			M10			M12			M16			M20		
h_{ef} [mm]	30	40	60	35	44	70	42	48	80	50	65	100	64	82	120	78	100	115
Edge distance c_1	$V^0_{Rd,c}$																	
[mm]	[kN]																	
	non-cracked concrete																	
40	2.7	2.8	3.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45	3.1	3.3	3.5	-	3.5	3.8	-	-	-	-	-	-	-	-	-	-	-	-
50	3.6	3.8	4.0	-	4.0	4.3	-	-	-	-	-	-	-	-	-	-	-	-
55	4.1	4.3	4.6	-	4.5	4.9	-	4.8	5.3	-	-	-	-	-	-	-	-	-
60	4.7	4.9	5.2	4.9	5.1	5.5	-	5.4	5.9	-	-	-	-	-	-	-	-	-
65	5.2	5.4	5.7	5.5	5.7	6.2	5.8	6.0	6.5	-	-	-	-	-	-	-	-	-
70	5.8	6.0	6.4	6.1	6.3	6.8	6.5	6.6	7.2	-	7.1	7.8	-	-	-	-	-	-
75	6.4	6.6	7.0	6.7	6.9	7.5	7.1	7.2	7.9	-	7.8	8.5	-	-	-	-	-	-
80	7.0	7.2	7.6	7.4	7.6	8.1	7.7	7.9	8.6	-	8.5	9.3	-	9.3	10.2	-	-	-
85	7.6	7.9	8.3	8.0	8.2	8.8	8.4	8.6	9.3	-	9.2	10.0	-	10.1	11.0	-	-	-
90	8.3	8.5	9.0	8.7	8.9	9.5	9.1	9.3	10.1	-	10.0	10.8	-	10.9	11.8	-	-	-
95	8.9	9.2	9.7	9.3	9.6	10.3	9.8	10.0	10.8	-	10.7	11.6	-	11.7	12.7	-	-	-
100	9.6	9.9	10.4	10.0	10.3	11.0	10.5	10.7	11.6	11.0	11.5	12.4	-	12.5	13.5	-	13.5	13.9
110	11.0	11.3	11.8	11.5	11.8	12.5	12.0	12.2	13.2	12.5	13.1	14.1	13.5	14.2	15.3	-	15.2	15.7
120	12.4	12.8	13.4	12.9	13.3	14.1	13.5	13.8	14.8	14.1	14.7	15.8	15.2	15.9	17.1	-	17.1	17.6
130	13.9	14.3	14.9	14.5	14.9	15.8	15.1	15.4	16.5	15.8	16.4	17.6	16.9	17.7	19.0	-	18.9	19.5
140	15.4	15.9	16.6	16.1	16.5	17.4	16.8	17.0	18.3	17.5	18.1	19.4	18.7	19.5	20.9	19.9	20.9	21.4
150	17.0	17.5	18.3	17.7	18.2	19.2	18.5	18.8	20.1	19.2	19.9	21.3	20.6	21.4	22.9	21.8	22.8	23.5
160	18.7	19.2	20.0	19.4	19.9	21.0	20.2	20.5	21.9	21.0	21.8	23.2	22.4	23.3	24.9	23.8	24.9	25.5
170	20.4	20.9	21.8	21.1	21.6	22.8	22.0	22.3	23.8	22.8	23.6	25.2	24.4	25.3	27.0	25.8	26.9	27.6
180	22.1	22.7	23.6	22.9	23.5	24.7	23.8	24.2	25.8	24.7	25.6	27.2	26.3	27.3	29.1	27.9	29.1	29.8
190	23.9	24.5	25.4	24.7	25.3	26.6	25.7	26.1	27.8	26.7	27.6	29.3	28.4	29.4	31.3	30.0	31.2	32.0
200	25.7	26.3	27.4	26.6	27.2	28.6	27.6	28.0	29.8	28.6	29.6	31.4	30.4	31.5	33.5	32.1	33.4	34.3
250	35.4	36.2	37.5	36.6	37.3	39.1	37.8	38.3	40.6	39.1	40.3	42.5	41.4	42.8	45.2	43.5	45.1	46.1
300	46.0	47.0	48.6	47.4	48.4	50.5	49.0	49.6	52.3	50.5	52.0	54.7	53.3	54.9	57.8	55.8	57.8	59.0
350	57.4	58.6	60.5	59.1	60.2	62.8	61.0	61.7	64.9	62.8	64.5	67.7	66.0	68.0	71.4	69.0	71.3	72.7
400	-	71.0	73.2	71.6	72.9	75.8	73.7	74.6	78.2	75.9	77.8	81.4	79.6	81.8	85.7	83.0	85.6	87.2
450	-	-	86.7	84.8	86.3	89.6	87.3	88.2	92.4	89.7	91.9	96.0	93.9	96.4	100.8	97.8	100.7	102.5
500	-	-	100.8	-	-	104.1	101.5	102.6	107.2	104.2	106.7	111.2	108.9	111.7	116.6	113.2	116.5	118.5
550	-	-	115.6	-	-	119.3	116.3	117.5	122.7	119.3	122.1	127.1	124.5	127.6	133.0	129.3	133.0	135.2
600	-	-	131.0	-	-	135.1	131.8	133.1	138.8	135.1	138.1	143.7	140.8	144.2	150.1	146.1	150.1	152.5
650	-	-	-	-	-	151.4	-	-	155.5	151.5	154.8	160.8	157.7	161.4	167.8	163.5	167.8	170.4
700	-	-	-	-	-	168.4	-	-	172.8	168.4	172.0	178.5	175.2	179.2	186.1	181.4	186.1	188.9
750	-	-	-	-	-	-	-	-	190.6	-	-	196.8	193.2	197.6	205.0	199.9	204.9	208.0
800	-	-	-	-	-	-	-	-	209.0	-	-	215.7	211.8	216.4	224.4	219.0	224.3	227.6

Thread size	M6			M8			M10			M12			M16			M20		
h_{ef} [mm]	30	40	60	35	44	70	42	48	80	50	65	100	64	82	120	78	100	115
Edge distance c_1	$V^0_{Rd,c}$																	
[mm]	[kN]																	
	non-cracked concrete																	
850	-	-	-	-	-	-	-	-	-	-	-	235.0	230.9	235.8	244.3	238.5	244.3	247.7
900	-	-	-	-	-	-	-	-	-	-	-	254.9	250.5	255.8	264.7	258.6	264.7	268.4
950	-	-	-	-	-	-	-	-	-	-	-	275.2	270.6	276.2	285.7	279.2	285.7	289.5
1000	-	-	-	-	-	-	-	-	-	-	-	296.0	-	-	307.1	300.3	307.1	311.2
1100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	351.3	343.8	351.3	355.8
1200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	397.3	389.0	397.3	402.3

a. Influence of concrete strength

Table 18: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 19: Influence of spacing on concrete edge resistance

s/c_1[1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

FIXANCHOR W-FA/A4

c. Influence of edge distance

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\,\frac{c_2}{1.5\,c_1}\right)$$

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1 [1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \le c_2$

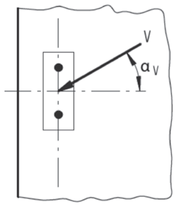
d. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{cos^2\alpha_V + \left(\frac{sin\alpha_V}{2}\right)^2}} \le 2$$

Table 21: Influence of load direction on concrete edge resistance

α [1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For α ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.



e. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1] This verification is not required in case of shear load with lever arm

W-FA/A4

FIXANCHOR W-FA/A4

Mechanical characteristics

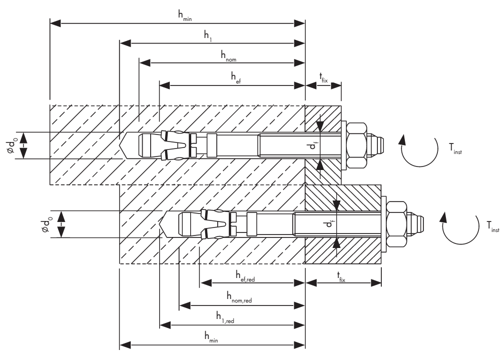
Thread size			M6	M6	M8	M8	M10	M10	M12	M12	M16	M16	M20	M20
Effective anchorage depth	h_{ef}	[mm]	30	40	35	44	42	48	50	65	64	82	78	100
Governing cross section														
Stressed cross section	A_s	[mm²]	14.5	14.5	25.5	25.5	43.0	43.0	58.1	58.1	116.9	116.9	191.1	191.1
Section modulus	W	[mm³]	7.8	7.8	18.2	18.2	39.8	39.8	62.4	62.4	178.3	178.3	372.7	372.7
Yield strength	f_y	[N/mm²]	560	560	560	560	5600	560	600	600	600	600	560	560
Tensile strength	f_u	[N/mm²]	700	700	700	700	700	700	750	750	750	750	700	700
Non-cracked concrete														
Stressed cross section	A_s	[mm²]	20.1	20.1	36.6	36.6	58.0	58.0	84.3	84.3	156.7	156.7	244.8	244.8
Section modulus	W	[mm³]	12.7	12.7	31.23	31.23	62.3	62.3	109.17	109.17	276.67	276.67	540.23	540.23
Yield strength	f_y	[N/mm²]	480	480	480	480	480	480	480	480	420	420	420	420
Tensile strength	f_u	[N/mm²]	600	600	600	600	600	600	600	600	560	560	560	560
Design bending moment	$M^0_{Rd,s}$	[Nm]	18.4	37.6	65.6	167.2	272.9	718.4	1065	1065	62.4	148.8	148.8	272.9

Material specifications

Part	W-FA/A4; W-FA/HCR	
	Stainless steel A4	High corrosion resistant steel HCR
Conical bolt	Stainless steel 1.4401, 1.4404, 1.4571, 1.4578, 1.4362, EN 10088:2005, coated	High corrosion resistant steel 1.4529, 1.4565, EN 10088:2005, coated
Expansion sleeve	Stainless steel 1.4401, 1.4571, 1.4362, EN 10088:2005	
Washer	Stainless steel 1.4401, 1.4571, 1.4362, EN 10088:2005	High corrosion resistant steel 1.4529, 1.4565, EN 10088:2005, coated
Hexagon nut	ISO 3506:2009, A4-70, stainless steel 1.4401, 1.4571, 1.4362, EN 10088:2005, coated	ISO 3506:2009, strength class 70, high corrosion resistant steel 1.4529, 1.4565, EN 10088:2005, coated

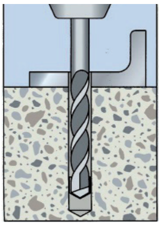
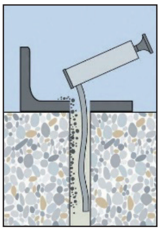
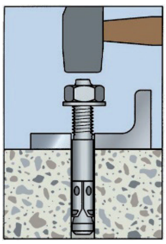
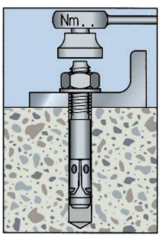
Installation parameters

Fastener size			M6	M8	M10	M12	M16	M20
Nominal drill hole diameter	d_0	[mm]	6	8	10	12	16	20
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	6,4	8,45	10,45	12,5	16,5	20,55
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	7	9	12	14	18	22
Installation torque (Wedge Anchor B electroplated)	T_{inst} =	[Nm]	8	15	30	50	100	200
Installation torque (Wedge Anchor B hot-dip galvanised)	T_{inst} =	[Nm]	-	15	30	40	90	120
Embedment depth $h_{ef,1}$								
Effective anchorage depth	$h_{ef,1} \geq$	[mm]	30	35	42	50	64	78
Depth of drill hole	$h_{1,1} \geq$	[mm]	45	55	65	75	95	110
Embedment depth	$h_{nom,1} \geq$	[mm]	39	47	56	67	84	99
Minimum thickness of member	h_{min}	[mm]	80	80	100	100	130	160
Minimum spacing	s_{min}	[mm]	35	60	55	100	100	140
Minimum edge distance	c_{min}	[mm]	40	60	65	100	110	140
Embedment depth $h_{ef,2}$								
Effective anchorage depth	$h_{ef,2} \geq$	[mm]	40	44	48	65	80	100
Depth of drill hole	$h_{1,2} \geq$	[mm]	55	65	70	90	110	130
Embedment depth	$h_{nom,2} \geq$	[mm]	49	56	62	82	102	121
Minimum thickness of member	h_{min}	[mm]	100	100	100	130	160	200
Minimum spacing	s_{min}	[mm]	35	35	45	60	80	100
	for c ≥	[mm]	40	65	70	100	120	150
Minimum edge distance	c_{min}	[mm]	35	45	55	70	80	100
	for s ≥	[mm]	60	110	80	100	140	180
Embedment depth $h_{ef,3}$								
Effective anchorage depth	$h_{ef,3} \geq$	[mm]	60	70	80	100	120	115
Depth of drill hole	$h_{1,3} \geq$	[mm]	75	91	102	125	148	145
Embedment depth	$h_{nom,3} \geq$	[mm]	69	82	94	117	140	136
Minimum thickness of member	h_{min}	[mm]	120	126	132	165	200	215
Minimum spacing	s_{min}	[mm]	35	35	45	60	80	100
	for c ≥	[mm]	40	65	70	100	120	1050
Minimum edge distance	c_{min}	[mm]	35	45	55	70	80	100
	for s ≥	[mm]	60	110	80	100	140	180

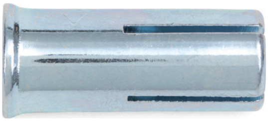


FIXANCHOR W-FA/A4

Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer drilling (HD)** Drill the hole with a hammer drill. Drill bit diameter and its working length are determined by the diameter and depth of the drill hole of the selected anchor. (see table anchor characteristics). Positioning of drill holes without damaging the reinforcement.
B) Bore hole cleaning		
	**2.**	Clean the bore hole from the bottom until the return air stream is without dust.
C) Setting the screw		
	**3a.**	Drive the anchor with some hammer impacts or with the machine setting tool into the drill hole. Anchor installation ensuring the specified embedment depth.
	**3b.**	Application of the required torque moment using a calibrated torque wrench.

DROP-IN ANCHOR W-ED/S



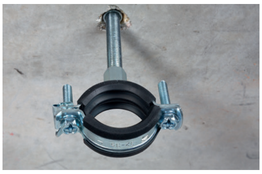
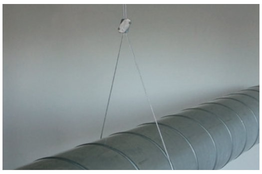
Galvanized (5 microns): M6 - M20

Approved for:
Concrete C20/25 to C50/60, non-cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Type of installation		
Pre-positioned	In-place	Stand-off
✓	–	–

Applications

Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DiBt, Berlin	ETAG 001 Part 4	ETA-02/0044 / 2016-03-01
European Technical Assessment	DiBt, Berlin	ETAG 001 Part 6	ETA-05/0120 / 2017-02-14
Expert's Opinion tension load capacity in hollow slabs	Ing. Büro Thiele, Pirmasens		21732_2 / 2017-06-26
Expert's Opinion tension load capacity in COBIAX hollow slabs	MFPA Leipzig	TR020 ; DIN EN 1992-1-2:2010-12	GS 3.2/17-249-1 / 2017-07-31
Evaluation report fire resistance	Ing. Büro Thiele, Pirmasens	EN 1363-1:2012-10 / TR 020	21741_2 / 2017-08-12

Basic loading data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness is according to anchor characteristics
- Anchor material is as specified in anchor material specification table
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²

Mean ultimate resistance

Thread size				M6x30 [1]	M8x30 [1]	M8x40	M10x30 [1]	M10x40	M12x50	M12x80	M16x65 M16x80	M 20x80
Effective anchorage depth		h_{ef}	[mm]	30	30	40	30	40	50	50	65	80
Non-cracked concrete												
Tension	C20/25	$N_{Ru,m}$	[kN]	12.1	11.3	14.3	12.7	18.0	25.3	25.3	37.9	50.2
Shear	C20/25	$V_{Ru,m}$	[kN]	5.9	12.6	14.5	12.8	9.9	27.7	27.7	56.9	72.4

[1] Use restricted to anchoring of structural components that are statically indeterminate

Characteristic resistance

Thread size				M6x30 [1]	M8x30 [1]	M8x40	M10x30 [1]	M10x40	M12x50	M12x80	M16x65 M16x80	M 20x80
Effective anchorage depth		h_{ef}	[mm]	30	30	40	30	40	50	50	65	80
Non-cracked concrete												
Tension	C20/25	N_{Rk}	[kN]	8.1	8.1	9.0	8.1	12.4	17.4	17.4	25.8	35.2
	C50/60			10.0	12.8	14.2	12.8	19.7	27.5	27.5	40.8	55.7
Shear	C20/25	V_{Rk}	[kN]	5.0	6.9	6.9	8.1	7.2	19.4	21.1	33.5	53.2
	C50/60			5.0	6.9	6.9	10.1	7.2	19.4	21.1	33.5	53.2

[1] Use restricted to anchoring of structural components that are statically indeterminate

DROP-IN ANCHOR W-ED/S

Design resistance

Thread size				M6x30 [1]	M8x30 [1]	M8x40	M10x30 [1]	M10x40	M12x50	M12x80	M16x65 M16x80	M 20x80
Effective anchorage depth		h_{ef}	[mm]	30	30	40	30	40	50	50	65	80
Non-cracked concrete												
Tension	C20/25	N_{Rd}	[kN]	4.5	4.5	5.0	4.5	6.9	9.7	9.7	14.3	19.6
	C50/60			6.7	7.1	7.9	7.1	10.9	15.3	15.3	22.6	30.9
Shear	C20/25	V_{Rd}	[kN]	4.0	4.5	5.5	4.5	5.8	14.5	14.5	25.2	39.1
	C50/60			4.0	5.5	5.5	7.1	5.8	15.5	16.9	25.2	40.0

[1] Use restricted to anchoring of structural components that are statically indeterminate

Recommended/allowable loads [2]

Thread size				M6x30 [1]	M8x30 [1]	M8x40	M10x30 [1]	M10x40	M12x50	M12x80	M16x65 M16x80	M 20x80
Effective anchorage depth		h_{ef}	[mm]	30	30	40	30	40	50	50	65	80
Non-cracked concrete												
Tension	C20/25	N_{rec}	[kN]	3.2	3.2	3.6	3.2	4.9	6.9	6.9	10.2	14.0
	C50/60			4.8	5.1	5.6	5.1	7.8	10.9	10.9	16.2	22.1
Shear	C20/25	V_{rec}	[kN]	2.9	3.2	3.9	3.2	4.1	10.4	10.4	18.0	27.9
	C50/60			2.9	3.9	3.9	5.1	4.1	11.1	12.1	18.0	28.6

[1] Use restricted to anchoring of structural components that are statically indeterminate.

[2] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole, hammer drilling
- Anchor material as specified in anchor material specification table
- Anchorage depths hef < 40 mm are restricted to use of structural components with which are statically intdeterminate and subject to internal exposure conditions only

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size			**M6x30**	**M8x30**	**M8x40**	**M10x30**	**M10x40**	**M12x50**	**M12x80**	**M16x65 M16x80**	**M20x80**
Effective anchorage depth	h_{ef}	[mm]	30	30	40	30	40	50	50	65	80
Design steel resistance	$N_{Rd,s}$	[kN]	6.7	11.7	12.2	12.0	13.5	26.8	28.1	41.9	66.5

DROP-IN ANCHOR W-ED/S

2. Design pullout resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of pull-out failure of a single anchor

Thread size			M6x30	M8x30	M8x40	M10x30	M10x40	M12x50	M12x80	M16x65 M16x80	M20x80
Effective anchorage depth	h_{ef}	[mm]	30	30	40	30	40	50	50	65	80
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	4.5	4.5	5.0	4.5	6.9	9.7	9.7	14.3	19.6

a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

3. Design concrete cone resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size			M6x30	M8x30	M8x40	M10x30	M10x40	M12x50	M12x80	M16x65 M16x80	M20x80
Effective anchorage depth	h_{ef}	[mm]	30	30	40	30	40	50	50	65	80
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	4.5	4.5	6.9	4.5	6.9	9.7	9.7	14.3	19.6

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size			M6x30	M8x30	M8x40	M10x30	M10x40	M12x50	M12x80	M16x65 M16x80	M20x80
Effective anchorage depth	h_{ef}	[mm]	30	30	40	30	40	50	50	65	80
Characteristic spacing	$s_{cr,N}$	[mm]	90	90	120	90	120	150	150	195	240
Characteristic edge distance	$c_{cr,N}$	[mm]	45	45	60	45	60	75	75	98	120

a. Influence of concrete strength

Table 6: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacings, when there are different spacings in one row

DROP-IN ANCHOR W-ED/S

c. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 8: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 9: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size			**M6x30**	**M8x30**	**M8x40**	**M10x30**	**M10x40**	**M12x50**	**M12x80**	**M16x 65/80**	**M20x80**
Effective anchorage depth	h_{ef}	[mm]	30	30	40	30	40	50	50	65	80
Non-cracked concrete											
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	4.5	4.5	5.0	4.5	6.9	9.7	9.7	14.3	19.6

Table 10: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Thread size			**M6x30**	**M8x30**	**M8x40**	**M10x30**	**M10x40**	**M12x50**	**M12x80**	**M16x 65/80**	**M20x80**
Effective anchorage depth	h_{ef}	[mm]	30	30	40	30	40	50	50	65	80
Characteristic spacing	$s_{cr, sp}$	[mm]	190	190	190	230	270	330	330	400	520
Characteristic edge distance	$c_{cr, sp}$	[mm]	95	95	95	115	135	165	165	200	260
Minimum member thickness	h_{min}	[mm]	100	100	100	120	120	130	130	160	200

a. Influence of concrete strength

Table 11: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1)] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2)] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 12: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 13: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ / $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Thread size			**M6x30**	**M8x30**	**M8x40**	**M10x30**	**M10x40**	**M12x50**	**M12x80**	**M16x 65/80**	**M20x80**
Effective anchorage depth	h_{ef}	[mm]	30	30	40	30	40	50	50	65	80
Design steel resistance	$V_{Rd,s}$	[mm]	4.0	5.5	5.5	8.1	5.8	15.5	16.9	25.2	40.0

2. Concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot N_{Rd,c}$$

Table 16: factor k_8 for calculating design pry-out resistance

Thread size			**M6x30**	**M8x30**	**M8x40**	**M10x30**	**M10x40**	**M12x50**	**M12x80**	**M16x 65/80**	**M20x80**
Effective anchorage depth	h_{ef}	[mm]	30	30	40	30	40	50	50	65	80
Concrete pry-out resistance factor	k_8	[-]	1.0	1.0	1.0	1.0	1.0	1.5	1.5	2.0	2.0

3. Concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions c ≥ max (10 h_{ef} ; 60 d). For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 17: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size	M6x30	M8x30	M8x40	M10x30	M10x40	M12x50	M12x80	M16x 65/80	M20x80
h_{ef} [mm]	30	30	40	30	40	50	50	65	80
Edge distance c_1	$V^0_{Rd,c}$								
[mm]	[kN]								
	non-cracked concrete								
95	9,2	9,4	9,7	-	-	-	-	-	-
100	9,8	10,1	10,4	-	-	-	-	-	-
110	11,3	11,5	11,9	-	-	-	-	-	-
120	12,7	13,0	13,4	13,2	-	-	-	-	-
130	14,2	14,5	15,0	14,8	-	-	-	-	-
140	15,8	16,1	16,7	16,4	17,0	-	-	-	-
150	17,4	17,8	18,3	18,0	18,7	-	-	-	-
160	19,1	19,5	20,1	19,7	20,4	-	-	-	-
170	20,8	21,2	21,9	21,5	22,2	23,4	23,4	-	-
180	22,6	23,0	23,7	23,3	24,1	25,3	25,3	-	-
190	24,4	24,8	25,6	25,2	26,0	27,2	27,2	-	-
200	26,2	26,7	27,5	27,0	27,9	29,3	29,3	31,2	-
250	36,1	36,6	37,6	37,1	38,2	39,9	39,9	42,4	-
300	46,8	47,5	48,8	48,1	49,4	51,5	51,5	54,5	57,3
350	58,4	59,2	60,7	59,9	61,5	63,9	63,9	67,5	70,8
400	70,8	71,7	73,4	72,5	74,4	77,2	77,2	81,2	85,0
450	83,9	85,0	86,9	85,9	87,9	91,1	91,1	95,8	100,0
500	-	98,9	101,1	99,9	102,2	105,8	105,8	111,0	115,8
550	-	113,5	115,9	114,6	117,2	121,1	121,1	126,9	132,1
600	-	128,6	131,3	129,9	132,7	137,1	137,1	143,4	149,2
650	-	-	-	145,8	148,9	153,7	153,7	160,5	166,8
700	-	-	-	162,2	165,6	170,8	170,8	178,2	185,0
750	-	-	-	-	-	188,5	188,5	196,5	203,8
800	-	-	-	-	-	206,7	206,7	215,3	223,2
850	-	-	-	-	-	225,5	225,5	234,6	243,0
900	-	-	-	-	-	244,7	244,7	254,5	263,4
950	-	-	-	-	-	-	-	274,8	284,3
1000	-	-	-	-	-	-	-	295,6	305,6
1100	-	-	-	-	-	-	-	338,6	349,7
1200	-	-	-	-	-	-	-	383,4	395,6
1300	-	-	-	-	-	-	-	-	443,2
1400	-	-	-	-	-	-	-	-	492,4
1500	-	-	-	-	-	-	-	-	543,2

DROP-IN ANCHOR W-ED/S

a. Influence of concrete strength

Table 18: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 19: Influence of spacing on concrete edge resistance

s/c_1[1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of edge distance

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\,\frac{c_2}{1.5\,c_1}\right)$$

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1[1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \leq c_2$

W-ED/S

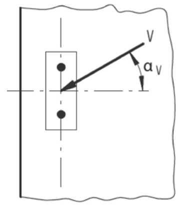
d. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{\cos^2\alpha_V + \left(\frac{\sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 21: Influence of load direction on concrete edge resistance

α[1)]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1)] For α ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.



e. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1)]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1)] This verification is not required in case of shear load with lever arm

DROP-IN ANCHOR W-ED/S

Mechanical characteristics

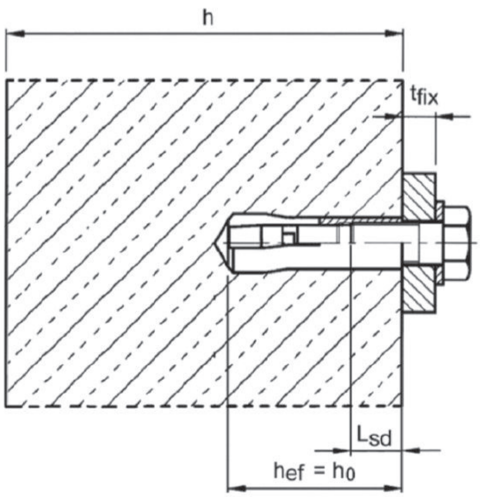
Thread size			M6x30	M8x30	M8x40	M10x30	M10x40	M12x50	M12x80	M16x65 M16x80	M 20x80
Screw											
Stressed cross section	A_s	[mm²]	20.1	36.6	36.6	58.0	58.0	84.3	84.3	156.7	244.8
Section modulus	W	[mm³]	12.7	31.2	31.2	62.3	62.3	109.1	109.1	276.6	540.2
Design bending moment (steel 4.6)	$M^0_{Rd,s}$	[Nm]	3.7	9	9	17.9	17.9	31.4	31.4	79.7	155.6
Design bending moment (steel 5.6)	$M^0_{Rd,s}$	[Nm]	4.6	11.2	11.2	22.4	22.4	39.3	39.3	99.6	194.5
Design bending moment (steel 5.8)	$M^0_{Rd,s}$	[Nm]	6.1	15.0	15.0	29.9	29.9	52.4	52.4	132.8	259.3
Design bending moment (steel 8.8)	$M^0_{Rd,s}$	[Nm]	9.8	24.0	24.0	47.8	47.8	83.8	83.8	212.4	414.9
Sleeve											
Stressed cross section	A_s	[mm²]	25.0	33.2	33.2	42.0	42.0	71.7	71.7	119.7	190.0
Section modulus	W	[mm³]	37.5	65.5	65.5	102.7	102.7	212.2	212.2	473.9	940.7
Yield strength	f_{yk}	[N/mm²]	480	480	480	384	384	480	480	420	420
Tensile strength	f_{uk}	[N/mm²]	600	600	600	480	480	600	600	560	560
Design bending moment	$M^0_{Rd,s}$	[Nm]	21.6	37.7	37.7	47.3	47.3	122.3	122.3	238.8	474.1

Material specifications

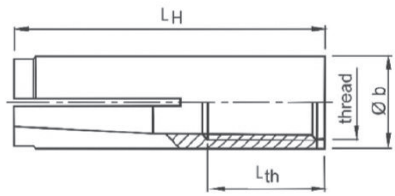
Part	**Steel, zinc plated**
Anchor sleeve	Cold formed or machining steel, zinc plated, EN ISO 4042:1999
Cone	Steel for cold forming acc. to EN 10263-2:2001

Installation parameters

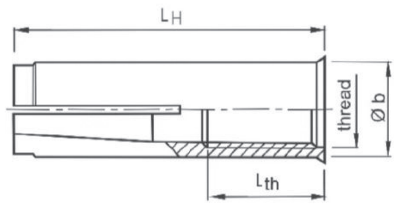
Thread size			M6x30	M8x30	M8x40	M10x30	M10x40	M12x50	M12x80	M16x65	M16x80	M20x80
Depth of drill hole	h_0	[mm]	30	30	40	30	40	50	80	65	80	80
Nominal drill hole diameter	d_0	[mm]	8	10	10	12	12	15	15	20	20	25
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	8.45	10.45	10.45	12.5	12.5	15.5	15.5	20.55	20.55	25.55
Installation torque	$T_{inst} \leq$	[Nm]	4	8	8	15	15	35	35	60	60	120
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	7	9	9	12	12	14	14	18	18	22
Available thread length	L_{th}	[mm]	13	13	20	12	15	18	45	23	38	34
Minimum screw-in depth	$L_{sd,min}$	[mm]	7	9	9	10	11	13	13	18	18	22
Minimum thick-ness of member	h_{min}	[mm]	100	100	100	120	120	130	130	160	160	200
Minimum spacing	s_{min}	[mm]	55	60	80	100	100	120	120	150	150	160
Minimum edge distance	c_{min}	[mm]	95	95	95	115	135	165	165	200	200	260



Anchor version without shoulder



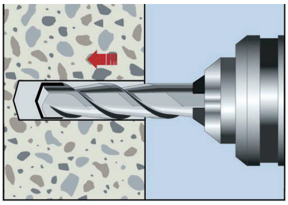
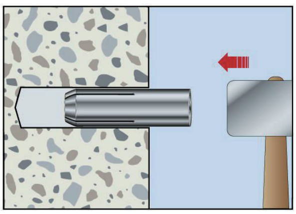
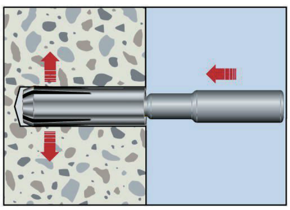
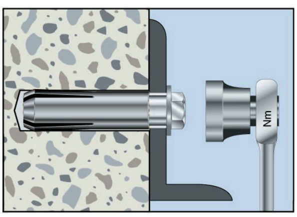
Anchor version with shoulder Type BND



W-ED/S

DROP-IN ANCHOR W-ED/S

Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer (HD) or compressed air drilling (CD)** Drill the hole with a hammer drill. Drill bit diameter and its working length are determined by the diameter and depth of the drill hole of the selected anchor.
B) Bore hole cleaning		
	**2.**	Clean the bore hole from the bottom until the return air stream is dust free.
C) Setting the screw		
	**3a.**	Drive the anchor with some hammer strike or with the machine setting tool into the drill hole. Ensure the specified embedment depth.
	**3b.**	Drive in cone by using setting tool. Shoulder of setting tool must fit on anchor rim.
	**3c.**	Apply the required torque moment using a calibrated torque wrench.

DROP-IN ANCHOR W-ED/A4

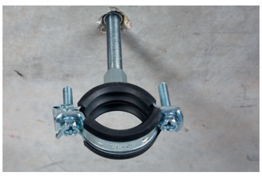
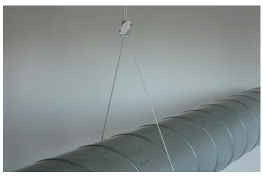
Stainless Steel - A4 (AISI 316): M6-M20

Approved for:
Concrete C20/25 to C50/60, non-cracked

Suitable for:
Concrete C12/15, Natural stone with dense structure

Type of installation		
Pre-positioned	In-place	Stand-off
✓	–	–

Applications

Approvals and certificates

Description	Authority/laboratory	Guideline for assessment	No./date of issue
European Technical Assessment	DiBt, Berlin	ETAG 001 Part 4	ETA-02/0044 / 2016-03-01
European Technical Assessment	DiBt, Berlin	ETAG 001 Part 6	ETA-05/0120 / 2017-02-14
Expert's Opinion tension load capacity in hollow slabs	Ing. Büro Thiele, Pirmasens		21732_2 / 2017-06-26
Expert's Opinion tension load capacity in COBIAX hollow slabs	MFPA Leipzig	TR020 ; DIN EN 1992-1-2:2010-12	GS 3.2/17-249-1 / 2017-07-31
Evaluation report fire resistance	Ing. Büro Thiele, Pirmasens	EN 1363-1:2012-10 / TR 020	21741_2 / 2017-08-12

Basic loading data (for a single anchor)

All data in this section applies when:

- Installation is correct (see installation instructions)
- No edge distance and spacing influence
- Base material thickness is according to anchor characteristics
- Anchor material is as specified in anchor material s pecification table
- Concrete C 20/25, f_{ck} = 20 N/mm²
- Concrete C 50/60, f_{ck} = 60 N/mm²

Mean ultimate resistance

Thread size				M6x30 [1]	M8x30 [1]	M8x40	M10x40 [1]	M12x50 M12x80	M16x65 M16x80	M20x80
Effective anchorage depth		h_{ef}	[mm]	30	30	40	40	50	65	80
Non-cracked concrete										
Tension	C20/25	$N_{Ru,m}$	[kN]	11.1	13.3	16.4	18.7	27.0	37.6	58.9
Shear	C20/25	$V_{Ru,m}$	[kN]	8.5	11.6	12.1	15.9	28.6	45.0	83.7

[1] Use restricted to anchoring of structural components that are statically indeterminate

Characteristic resistance

Thread size				M6x30 [1]	M8x30 [1]	M8x40	M10x40 [1]	M12x50 M12x80	M16x65 M16x80	M20x80
Effective anchorage depth		h_{ef}	[mm]	30	30	40	40	50	65	80
Non-cracked concrete										
Tension	C20/25	N_{Rk}	[kN]	8.1	8.1	9.0	12.4	17.4	25.8	35.2
	C50/60			12.8	12.8	14.2	19.7	27.5	40.8	55.7
Shear	C20/25	V_{Rk}	[kN]	7.0	10.6	10.6	13.4	25.1	41.9	66.5
	C50/60			7.0	10.6	10.6	13.4	25.1	41.9	66.5

[1] Use restricted to anchoring of structural components that are statically indeterminate

DROP-IN ANCHOR W-ED/A4

Design resistance

Thread size				M6x30 1)	M8x30 1)	M8x40	M10x40 1)	M12x50 M12x80	M16x65 M16x80	M20x80
Effective anchorage depth		h_{ef}	[mm]	30	30	40	40	50	65	80
Non-cracked concrete										
Tension	C20/25	N_{Rd}	[kN]	5.4	5.4	6.0	8.3	11.6	17.2	23.5
	C50/60			7.5	8.5	9.5	13.1	18.3	27.2	37.1
Shear	C20/25	V_{Rd}	[kN]	4.5	6.8	6.8	8.6	16.1	26.9	42.6
	C50/60			4.5	6.8	6.8	8.6	16.1	26.9	42.6

1) Use restricted to anchoring of structural components that are statically indeterminate

Recommended/allowable loads 2)

Thread size				M6x30 1)	M8x30 1)	M8x40	M10x40 1)	M12x50 M12x80	M16x65 M16x80	M20x80
Effective anchorage depth		h_{ef}	[mm]	30	30	40	40	50	65	80
Non-cracked concrete										
Tension	C20/25	N_{rec}	[kN]	3.8	3.8	4.3	5.9	8.3	12.3	16.8
	C50/60			5.4	6.1	6.8	9.4	13.1	19.4	26.5
Shear	C20/25	V_{rec}	[kN]	3.2	4.9	4.9	6.1	11.5	19.2	30.4
	C50/60			3.2	4.9	4.9	6.1	11.5	19.2	30.4

1) Use restricted to anchoring of structural components that are statically indeterminate.
2) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. The material safety factor depends on the failure mode.

Design method (simplified)

Simplified version of the design method according to Eurocode 2 - Design of concrete structures - Part 4: Design of fastenings for use in concrete (EN 1992-4):

- Influence factors related to concrete strength, edge distance, spacing and others must be considered when applicable
- Valid for a group of anchors. The influencing factors must then be considered for each edge distance and spacing. The calculated design resistances are on the safe side. They will be lower than the exact values according to EN 1992-4. For an economical optimization, we recommend using the anchor design module of the Würth Technical Software II
- The design method is based on the simplification that no different loads are acting on individual anchors (no eccentricity)
- Concrete strength for design load values is C20/25 unless stated otherwise
- Dry or wet conditions of drill hole, hammer drilling
- Anchor material as specified in anchor material specification table
- Anchorage depths hef < 40 mm are restricted to use of structural components with which are statically intdeterminate and subject to internal exposure conditions only

I. Tension loading

The decisive design resistance in tension is the lowest value of the following failure modes:

1. Steel failure $N_{Rd,s}$
2. Pull-out failure $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$
3. Concrete cone failure $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$
4. Concrete splitting failure $N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$

1. Design steel tensile resistance

Table 1: Design value of steel resistance under tension load $N_{Rd,s}$ of a single anchor

Thread size			M6x30	M8x30	M8x40	M10x40	M12x50 M12x80	M16x65 M16x80	M20x80
Effective anchorage depth	h_{ef}	[mm]	30	30	40	40	50	65	80
Design Steel resistance	$N_{Rd,s}$	[kN]	7.5	12.5	12.5	15.7	26.8	44.8	71.1

2. Design pullout resistance

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$$

Table 2: Basic design resistance $N^0_{Rd,p}$ in case of pull-out failure of a single anchor

Thread size			M6x30	M8x30	M8x40	M10x40	M12x50 M12x80	M16x65 M16x80	M20x80
Effective anchorage depth	h_{ef}	[mm]	30	30	40	40	50	65	80
Design pull-out resistance	$N^0_{Rd,p}$	[kN]	5.4	5.4	6.0	8.3	11.6	17.2	23.5

DROP-IN ANCHOR W-ED/A4

a. Influence of concrete strength

Table 3: Influence of concrete strength on pull-out resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1)]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2)]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

1) strength at 28 days of 150 mm diameter by 300 mm cylinders

2) strength at 28 days of 150 mm cubes

3. Design Concrete Cone Resistance

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{sx} \cdot f_{sy} \cdot f_{cx,1} \cdot f_{cx,2} \cdot f_{cy}$$

Table 4: Basic design resistance $N^0_{Rd,c}$ in case of concrete cone failure of a single anchor

Thread size			M6x30	M8x30	M8x40	M10x40	M12x50 M12x80	M16x65 M16x80	M20x80
Effective anchorage depth	h_{ef}	[mm]	30	30	40	40	50	65	80
Design concrete cone resistance	$N^0_{Rd,c}$	[kN]	5.4	5.4	8.3	8.3	11.6	17.2	23.5

Table 5: Characteristic edge distance $c_{cr,N}$ and spacing $s_{cr,N}$

Thread size			M6x30	M8x30	M8x40	M10x40	M12x50 M12x80	M16x65 M16x80	M20x80
Effective anchorage depth	h_{ef}	[mm]	30	30	40	40	50	65	80
Characteristic spacing	$s_{cr,N}$	[mm]	90	90	120	120	150	195	240
Characteristic edge distance	$c_{cr,N}$	[mm]	45	45	60	60	75	98	120

a. Influence of concrete strength

Table 6: Influence of concrete strength on concrete cone resistance

Concrete strength classes (EN 206:2000)			**C12/15**	**C16/20**	**C20/25**	**C25/30**	**C30/37**	**C35/45**	**C40/50**	**C45/55**	**C50/60**
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

$$f_{sx} = f_{sy} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,N}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 7: Influence of spacing on concrete cone resistance

Number of fixing per direction	$s/s_{cr,N}$ [1]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	f_{sx}, f_{sy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	f_{sx}, f_{sy}	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	f_{sx}, f_{sy}	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	f_{sx}, f_{sy}	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1] Choose always the lowest value of the spacings, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1} = 0.7 + 0.3\frac{c_x}{c_{cr,N}} \leq 1 \qquad f_{cx,2} = f_{cy} = \left(1 + \frac{c_{x(y)}}{c_{cr,N}}\right) \cdot \frac{1}{2} \leq 1$$

Table 8: Influence of edge distance on concrete cone resistance

$c/c_{cr,N}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2}$ / f_{cy}	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

DROP-IN ANCHOR W-ED/A4

4. Design splitting resistance

$$N_{Rd,sp} = N^0_{Rd,sp} \cdot f_{b,N} \cdot f_{sx,sp} \cdot f_{sy,sp} \cdot f_{cx,1,sp} \cdot f_{cx,2,sp} \cdot f_{cy,sp} \cdot f_h$$

No verification of splitting is required if at least one of the conditions is fulfilled:

a) The edge distance in all directions is $c \geq c_{cr,sp}$ for single fasteners and $c \geq 1.2\ c_{cr,sp}$ for fastener groups and the member depth is $h \geq h_{min}$ in both cases

b) The characteristic resistance for concrete cone failure and pull-out failure is calculated for cracked concrete and reinforcement resists the splitting forces and limits the crack width to $w_k \leq 0.3$ mm

Table 9: Design resistance $N^0_{Rd,sp}$ in case of concrete splitting failure of a single anchor

Thread size			M6x30	M8x30	M8x40	M10x40	M12x50 M12x80	M16x65 M16x80	M20x80
Effective anchorage depth	h_{ef}	[mm]	30	30	40	40	50	65	80
Non-cracked concrete									
Design splitting resistance	$N^0_{Rd,sp}$	[kN]	5.4	5.4	6.0	8.3	11.6	17.2	23.5

Table 10: Characteristic edge distance $c_{cr,sp}$ and spacing $s_{cr,sp}$

Thread size			M6x30	M8x30	M8x40	M10x40	M12x50 M12x80	M16x65 M16x80	M20x80
Effective anchorage depth	h_{ef}	[mm]	30	30	40	40	50	65	80
Characteristic Spacing	$s_{cr,sp}$	[mm]	160	190	190	270	330	400	520
Characteristic Edge Distance	$c_{cr,sp}$	[mm]	80	95	95	135	165	200	260
Minimum Member Thickness	h_{min}	[mm]	100	100	100	130	140	160	250

a. Influence of concrete strength

Table 11: Influence of concrete strength on splitting resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders [1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube [2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

W-ED/A4

b. Influence of spacing

$$f_{sx,sp} = f_{sy,sp} = \left(1 + \left(n_{x(y)} - 1\right)\frac{s_{x(y)}}{s_{cr,sp}}\right) \cdot \frac{1}{n_{x(y)}} \leq 1$$

Table 12: Influence of spacing on splitting resistance

Number of fixing per direction	$s/s_{cr,sp}$ [1)]	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
2	$f_{sx,sp}$, $f_{sy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00
3	$f_{sx,sp}$, $f_{sy,sp}$	0.40	0.43	0.47	0.50	0.53	0.57	0.60	0.63	0.67	0.70	0.73	0.77	0.80	0.83	0.80	0.83	0.93	0.97	1.00
4	$f_{sx,sp}$, $f_{sy,sp}$	0.33	0.36	0.40	0.44	0.48	0.51	0.55	0.59	0.63	0.66	0.70	0.74	0.78	0.81	0.78	0.81	0.93	0.96	1.00
5	$f_{sx,sp}$, $f_{sy,sp}$	0.28	0.32	0.36	0.40	0.44	0.48	0.52	0.56	0.60	0.64	0.68	0.72	0.76	0.80	0.76	0.80	0.92	0.96	1.00

[1)] Choose always the lowest value of the spacing s, when there are different spacings in one row

c. Influence of edge distance

$$f_{cx,1,sp} = 0.7 + 0.3\frac{c_x}{c_{cr,sp}} \leq 1 \qquad f_{cx,2,sp} = f_{cy,sp} = \left(1 + \frac{c_{x(y)}}{c_{cr,sp}}\right) \cdot \frac{1}{2} \leq 1$$

Table 13: Influence of edge distance on splitting resistance

$c/c_{cr,sp}$	0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.70	0.75	0.90	0.95	≥ 1.0
$f_{cx,1,sp}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.90	0.91	0.93	0.91	0.93	0.97	0.99	1.00
$f_{cx,2,sp}$ $f_{cy,sp}$	0.55	0.58	0.60	0.63	0.65	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.85	0.88	0.85	0.88	0.95	0.98	1.00

d. Influence of concrete member thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leq max\left(1; \left(\frac{h_{ef} + 1.5c_1}{h_{min}}\right)^{2/3}\right)$$

Table 14: Influence of concrete member thickness on splitting resistance

h/h_{min}	1.00	1.10	1.20	1.30	1.40	1.50	1.60	1.70	1.80	1.90	2.00	2.10	2.20	2.30	2.40	2.30	2.40	2.70	2.80	2.90
f_h	1.00	1.07	1.13	1.19	1.25	1.31	1.37	1.42	1.48	1.53	1.59	1.64	1.69	1.74	1.79	1.74	1.79	1.94	1.99	2.00

DROP-IN ANCHOR W-ED/A4

II. Shear loading

The decisive design resistance in shear is the lowest value of the following failure modes:

1. Steel failure V_{Rds}
2. Concrete pry-out failure $V_{Rd,c} = k \cdot N_{Rd,c}$
3. Concrete edge failure $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$

1. Design steel shear resistance

Table 15: Design value of steel resistance $V_{Rd,s}$ of a single anchor

Thread size			M6x30	M8x30	M8x40	M10x40	M12x50 M12x80	M16x65 M16x80	M20x80
Effective anchorage depth	h_{ef}	[mm]	30	30	40	40	50	65	80
Design steel resistance	$V_{Rd,s}$	[mm]	4.5	6.8	6.8	8.6	16.1	26.9	42.6

2. Concrete pry-out resistance

$$V_{Rd,c} = k_8 \cdot N_{Rd,c}$$

Table 16: factor k_8 for calculating design pry-out resistance

Thread size			M6x30	M8x30	M8x40	M10x40	M12x50 M12x80	M16x65 M16x80	M20x80
Effective anchorage depth	h_{ef}	[mm]	30	30	40	40	50	65	80
Concrete pry-out resistance factor	k_8	[-]	1.0	1.7	1.7	1.7	1.7	2.0	2.0

3. Concrete edge resistance

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{s,V} \cdot f_{c2,V} \cdot f_a \cdot f_h$$

Verification of concrete edge failure may be omitted for single fasteners and groups with an edge distance in all directions $c \geq \max(10\,h_{ef}\,;\,60\,d)$. For anchorages with more than one edge, the resistance for all edges shall be calculated. The smallest value should be used in the verification.

Table 17: Design resistance $V^0_{Rd,c}$ in case of concrete edge failure

Thread size	**M6x30**	**M8x30**	**M8x40**	**M10x40**	**M12x50 M12x80**	**M16x65 M16x80**	**M20x80**
h_{ef} [mm]	30	30	40	40	50	65	80
Edge distance c_1	$V^0_{Rd,c}$						
[mm]	[kN]						
	non-cracked concrete						
80	7.2	-	-	-	-	-	-
85	7.8	-	-	-	-	-	-
90	8.5	-	-	-	-	-	-
95	9.2	9.4	9.7	-	-	-	-
100	9.8	10.1	10.4	-	-	-	-
110	11.3	11.5	11.9	-	-	-	-
120	12.7	13.0	13.4	-	-	-	-
130	14.2	14.5	15.0	-	-	-	-
140	15.8	16.1	16.7	17.0	-	-	-
150	17.4	17.8	18.3	18.7	-	-	-
160	19.1	19.5	20.1	20.4	-	-	-
170	20.8	21.2	21.9	22.2	23.4	-	-
180	22.6	23.0	23.7	24.1	25.3	-	-
190	24.4	24.8	25.6	26.0	27.2	-	-
200	26.2	26.7	27.5	27.9	29.3	31.2	-
250	36.1	36.6	37.6	38.2	39.9	42.4	-
300	46.8	47.5	48.8	49.4	51.5	54.5	57.3
350	58.4	59.2	60.7	61.5	63.9	67.5	70.8
400	70.8	71.7	73.4	74.4	77.2	81.2	85.0
450	83.9	85.0	86.9	87.9	91.1	95.8	100.0
500	-	98.9	101.1	102.2	105.8	111.0	115.8
550	-	113.5	115.9	117.2	121.1	126.9	132.1
600	-	128.6	131.3	132.7	137.1	143.4	149.2
650	-	-	-	148.9	153.7	160.5	166.8
700	-	-	-	165.6	170.8	178.2	185.0
750	-	-	-	-	188.5	196.5	203.8
800	-	-	-	-	206.7	215.3	223.2
850	-	-	-	-	225.5	234.6	243.0
900	-	-	-	-	244.7	254.5	263.4
950	-	-	-	-	-	274.8	284.3
1000	-	-	-	-	-	295.6	305.6
1100	-	-	-	-	-	338.6	349.7
1200	-	-	-	-	-	383.4	395.6
1300	-	-	-	-	-	-	443.2
1400	-	-	-	-	-	-	492.4
1500	-	-	-	-	-	-	543.2

a. Influence of concrete strength

Table 18: Influence of concrete strength on concrete edge resistance

Concrete strength classes (EN 206:2000)			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Characteristic compressive strength of concrete determined by testing cylinders[1]	f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Characteristic compressive strength of concrete determined by testing cube[2]	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influencing factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.32	1.41	1.50	1.58

[1] strength at 28 days of 150 mm diameter by 300 mm cylinders

[2] strength at 28 days of 150 mm cubes

b. Influence of spacing

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{s,V} = \frac{1}{3} \cdot \frac{s}{c_1} + 1 \leq 2$$

Table 19: Influence of spacing on concrete edge resistance

s/c_1[1]	0.50	0.60	0.70	0.80	0.90	1.00	1.20	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	2.60	2.80
$f_{s,V}$	1.17	1.20	1.23	1.27	1.30	1.33	1.40	1.47	1.53	1.60	1.67	1.73	1.80	1.87	1.93	1.87	1.93

[1] Always choose the lowest value of the spacing s, when there are different spacing in the row closest to the edge.

c. Influence of edge distance

In groups loaded perpendicular to the edge only two adjacent anchors closest and parallel to the edge carry the load. The smallest spacing should be used for the verification.

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3}\frac{c_2}{c_1}\right)\left(0.7 + 0.3\,\frac{c_2}{1.5\,c_1}\right)$$

Table 20: Influence of edge distance on concrete edge resistance

c_2/c_1[1]	1	1.1	1.2	1.3	1.4	1.5
$f_{c,V}$	0.75	0.80	0.85	0.90	0.95	1.00

[1] Distance to the second edge: $c_1 \leq c_2$

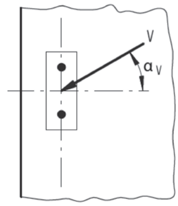
d. Influence of load direction

$$f_\alpha = \sqrt{\frac{1}{\cos^2\alpha_V + \left(\frac{\sin\alpha_V}{2}\right)^2}} \leq 2$$

Table 21: Influence of load direction on concrete edge resistance

α[1]	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.11	1.20	1.34	1.51	1.72	1.92	2.00

[1] For α ≥ 90° the component of the shear load acting away from the edge may be neglected and the verification may be done with component acting parallel to the edge only.



e. Influence of concrete member thickness

$$f_{h,V} = \left(\frac{h}{1.5c_1}\right)^{1/2}$$

Table 22: Influence of concrete member thickness on concrete edge resistance

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	≥ 1.50
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.86	0.89	0.93	0.97	1.00

Structural verification

N_{Ed} = Design value of tension load acting on a fastener
V_{Ed} = Design value of a shear load acting on a fastener

	Failure mode	Verification
1	Steel failure of fastener [1]	$\left(\frac{N_{Ed}}{N_{Rd}}\right)^2 + \left(\frac{V_{Ed}}{V_{Rd}}\right)^2 \leq 1$ If N_{Ed} and V_{Ed} are different for the individual fasteners of the group, the interaction shall be verified for all fasteners.
2	Failure modes other than steel failure	$\left(\frac{N_{Ed}}{N_{Rd,i}}\right)^{1.5} + \left(\frac{V_{Ed}}{V_{Rd,i}}\right)^{1.5} \leq 1$ or $\left(\frac{N_{Ed}}{N_{Rd,i}}\right) + \left(\frac{V_{Ed}}{V_{Rd,i}}\right) \leq 1.2$ With $N_{Ed} / N_{Rd,i} \leq 1$ and $V_{Ed} / V_{Rd,i} \leq 1$ The largest value of $N_{Ed} / N_{Rd,i}$ and $V_{Ed} / V_{Rd,i}$ for the different failure modes shall be taken.

[1] This verification is not required in case of shear load with lever arm

W-ED/A4

DROP-IN ANCHOR W-ED/A4

Mechanical characteristics

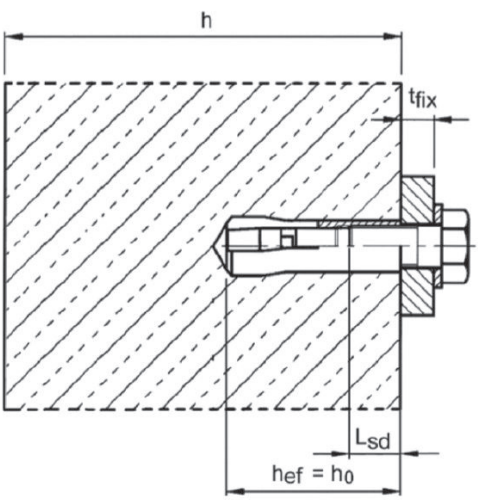
Thread size			M6x30	M8x30	M8x40	M10x40	M12x50 M12x80	M16x65 M16x80	M20x80	M16x65	M16x80	M20x80
Screw												
Stressed cross section	A_s	[mm²]	20.1	36.6	58.0	84.3	156.7	244.8	84.3	156.7	156.7	244.8
Section Modulus	W_{el}	[mm³]	12.7	31.2	62.3	109.1	276.6	540.2	109.1	276.6	276.6	540.2
Design bending moment (A4-70)	$M^0_{Rd,s}$	[Nm]	6.9	16.9	33.6	58.9	149.3	291.7	31.4	79.7	79.7	155.6
Design bending moment (A4-80)	$M^0_{Rd,s}$	[Nm]	9.2	22.5	44.8	78.5	199.1	388.9	39.3	99.6	99.6	194.5
Sleeve												
Stressed cross section	A_s	[mm²]	23.7	30.1	38.3	71.7	119.7	190.0	71.7	119.7	119.7	190.0
Section Modulus	W	[mm³]	35.5	59.1	93.2	212.2	473.9	940.7	212.2	473.9	473.9	940.7
Yield strength	f_{yk}	[N/mm²]	640	640	600	450	450	450	480	420	420	420
Tensile strength	f_{uk}	[N/mm²]	800	800	750	700	700	700	600	560	560	560
Design bending moment	$M^0_{Rd,s}$	[Nm]	27.3	45.4	67.1	114.6	255.9	508.0	122.3	238.8	238.8	474.1

Material specifications

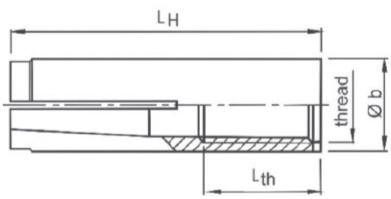
Part	Stainless steel A4	High corrosion resistant steel HCR
Anchor sleeve	Stainless steel, 1.4401, 1.4404, 1.4571, 1.4362, EN 10088:2005, Property class 70, acc. to EN ISO 3506:2010	Stainless steel, 1.4529, 1.4565, EN 10088:2005, Property class 70, acc. to EN ISO 3506:2010
Cone	Stainless steel, 1.4401, 1.4404, 1.4571, 1.4362, EN 10088:2005	

Installation parameters

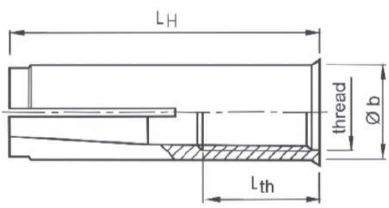
Thread size			M6x30	M8x30	M8x40	M10x40	M12x50	M12x80	M16x65	M16x80	M20x80	M20x80
Depth of drill hole	h_0	[mm]	30	30	40	40	50	80	65	80	80	80
Nominal drill hole diameter	d_0	[mm]	8	10	10	12	15	15	20	20	25	25
Cutting diameter of drill bit	$d_{cut} \leq$	[mm]	8.45	10.45	10.45	12.5	15.5	15.5	20.55	20.55	25.55	25.55
Installation torque	$T_{inst} \leq$	[Nm]	4	8	8	15	35	35	60	60	120	120
Diameter of clearance in hole in the fixture	$d_f \leq$	[mm]	7	9	9	12	14	14	18	18	22	22
Available thread length	L_{th}	[mm]	13	13	20	15	18	45	23	38	34	34
Minimum screw-in depth	$L_{sd,min}$	[mm]	7	9	9	11	13	13	18	18	22	22
Minimum thick-ness of member	h_{min}	[mm]	100	100	100	130	140	140	160	160	250	250
Minimum spacing	s_{min}	[mm]	50	60	80	100	120	120	150	150	160	160
Minimum edge distance	c_{min}	[mm]	80	95	95	135	165	165	200	200	260	260



Anchor version without shoulder

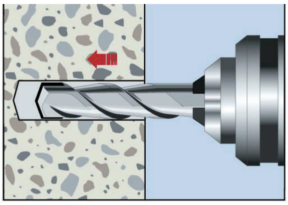
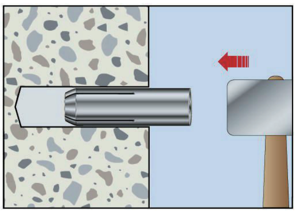
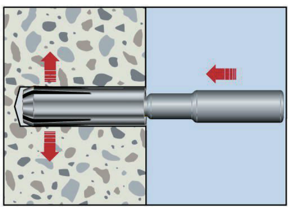
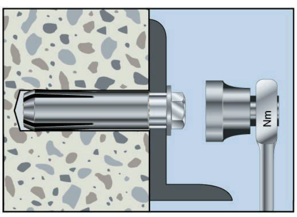


Anchor version with shoulder Type BND

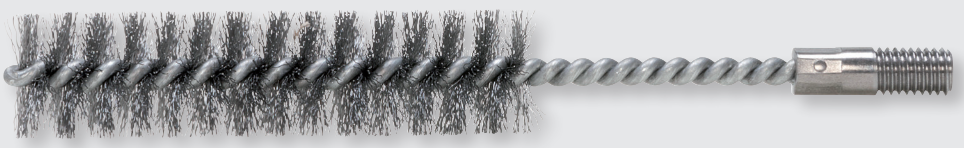


DROP-IN ANCHOR W-ED/A4

Installation instructions

A) Bore hole drilling		
	**1a.**	**Hammer (HD) or compressed air drilling (CD)** Drill the hole with a hammer drill. Drill bit diameter and its working length are determined by the diameter and depth of the drill hole of the selected anchor.
B) Bore hole cleaning		
	**2.**	Clean the bore hole from the bottom until the return air stream is dust free.
C) Setting the screw		
	**3a.**	Drive the anchor with some hammer strike or with the machine setting tool into the drill hole. Ensure the specified embedment depth.
	**3b.**	Drive in cone by using setting tool. Shoulder of setting tool must fit on anchor rim.
	**3c.**	Apply the required torque moment using a calibrated torque wrench.

ACCESSORIES



ACCESSORIES

Drill-hole cleaning

WIT-RB - Cleaning brush for concrete and rebar
Connection thread M8

WIT-UH 300, WIT-PE 1000, WIT-VM 250, WIT-PE 510

Thread size	Rebar size	Drill-hole dia. d_0	Cleaning brush Art. no. PU [qty.] = 1	Extension Art. no. PU [qty.] = 1	Machine chuck M8 SDS-Plus PU [qty.] = 1
M8	-	10	0903 489 510	0905 489 111	0903 489 101
M10	∅ 8	12	0903 489 512		
M12	∅ 10	14	0903 489 514		
-	∅ 12	16	0903 489 516		
M16	∅ 14	18	0903 489 518		
-	∅ 16	20	0903 489 520		
M20		22	0903 489 522		
-	∅ 20	25	0903 489 525		
M24	-	28	0903 489 528		
	∅ 24/25	32	0903 489 532		
M30	∅ 28	35	0903 489 535		
-	∅ 32	40	0903 489 540		

WIT-RMB - Cleaning brush for concrete, masonry, and rebar
Connection thread M6

WIT-UH 300, WIT-PE 1000, WIT-VM 250, WIT-PE 510, WIT-VIZ



Thread size	Rebar size	Drill-hole dia. d_0	Cleaning brush Art. no. PU [qty.] = 1	Handle Art. no. PU [qty.] = 1	Machine chuck M6 PU [qty.] = 1
M8		10	0903 489 610	0905 499 103	hexagonal: 0905 499 101 SDS plus: 0905 499 102
M10/M12	∅ 8	12	0903 489 612		
M12	∅ 10	14	0903 489 614		
M12	∅ 12	16	0903 489 616		
M16	∅ 14	18	0903 489 618		
-	∅ 16	20	0903 489 620		
M20		22	0903 489 622		
M20		24	0903 489 624		
M24	∅ 20	26	0903 489 626		
M24	∅ 22	28	0903 489 628		
M27	∅ 24/25	32	0903 489 632		
M30	∅ 28	35	0903 489 635		

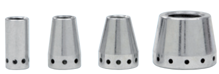
*Please check the Online-Shop for products related to masonry

Blow out pump	
	
Art. no.	**PU [qty.]**
0903 990 001	1

M8 reducer pipe To reduce the diameter of the blow out pump from 10 mm to 8 mm	
Art. no.	**PU [qty.]**
0905 499 202	1

Suction bell	
Art. no.	**PU [qty.]**
0903 990 010	1

Accessories for cleaning with compressed air

REBAR dia. [mm]	**Threaded rod dia.**	**Drill-hole dia. d_0 [mm]**	**Compressed air nozzle WIT-DD Art. no.** PU [qty.] = 1 (only for WIT-PE 500)	**Pneumatic hose WIT-SDD** (pre-assembled) **Art. no.** PU [qty.] = 1	**Thread connection for compressed air nozzle Art. no.** PU [qty.] = 1	**Hand slide valve** (pre-assembled) **Art. no.** PU [qty.] = 1
8		12	**0903 489 210**	Dia. 10 mm x 2 m **0699 903 7**	**0903 489 291 M8**	**0699 903 38**
10		14				
12		16	**0903 489 214**			
14		18				
16		20	**0903 489 217**			
	M20	24				
20		25				
22		28				
	M24	28	**0903 489 227**	Dia. 20 mm x 3 m **0699 903 13**	**0903 489 292 M16**	
24	**M27**	32				
25		32				
	M30	35				
32		40				

Mortar injection

Piston plug (only REBAR)

WIT-UH 300, WIT-PE 1000, WIT-VM 250, WIT-PE 510

REBAR dia. [mm]	Piston plug	Drill-hole dia. HD = Hammer drilling CD = Compressed air drilling HDB = Hollow drill bit system DD = Diamond drilling	Piston plug No.	Art. no.	PU [qty.]
8	**-**	**d_0 = 10 mm** (HD, HDB, DD)	-	**Not required**	-
	-	**d_0 = 12 mm** (HD, HDB, DD)	-		-
10	**-**	**d_0 = 12 mm** (HD, HDB, DD)	-	**Not required**	-
	WIT-VS 14	**d_0 = 14 mm** (HD, HDB, DD)	No. 14	**0903 488 055**	
12	**WIT-VS 14**	**d_0 = 14 mm** (HD, HDB, DD)	No. 14	**0903 488 055**	
	WIT-VS 16	**d_0 = 16 mm** (HD, CD, HDB, DD)	No. 16	**0903 488 056**	
14	**WIT-VS 18**	**d_0 = 18 mm** (HD, CD, HDB, DD)	No. 18	**0903 488 057**	
16	**WIT-VS 20**	**d_0 = 20 mm** (HD, CD, HDB, DD)	No. 20	**0903 488 058**	
20	**WIT-VS 25**	**d_0 = 25 mm** (HD, HDB, DD)	No. 25	**0903 488 059**	10
		d_0 = 26 mm (CD)			
22	**WIT-VS 28**	**d_0 = 28 mm** (HD, CD, HDB, DD)	No. 28	**0903 488 052**	
24	**WIT-VS 32**	**d_0 = 32 mm** (HD, CD, HDB, DD)	No. 32	**0903 488 053**	
25	**WIT-VS 32**	**d_0 = 32 mm** (HD, CD, HDB, DD)	No. 32	**0903 488 053**	
28	**WIT-VS 35**	**d_0 = 35 mm** (HD, CD, HDB, DD)	No. 35	**0903 488 060**	
32	**WIT-VS 40**	**d_0 = 40 mm** (HD, CD, HDB, DD)	No. 40	**0903 488 061**	
34	**WIT-VS 40**	**d_0 = 40 mm** (HD, CD, HDB, DD)	No. 40	**0903 488 061**	
36	**WIT-VS 45**	**d_0 = 45 mm** (HD, CD, DD)	No. 45	**Special request**	-
40	**WIT-VS 52**	**d_0 = 52 mm** (HD, CD)	No. 52	**Special request**	-
	WIT-VS 55	**d_0 = 55 mm** (HD, CD)	No. 55	**Special request**	-

Mixer nozzles

		Suitable for cartridge size	Art. no.	PU [qty.]
Mixer nozzle for WIT-VM 250		coaxial (1:10): 150 ml, 330 ml, 420 ml foil-tube (1:10): 300 ml	**0903 420 001**	10
Mixer nozzle for WIT-PE 1000, WIT-PE 510 & WIT-UH 300		coaxial (1:10): 320 ml, 420 ml peeler (1:10): 280 ml side-by-side (1:10): 360 ml, 825 ml side-by-side (1:3): 440 ml, 585 ml, 1400 ml	**0903 488 103**	20

Extensions for mixer nozzles			
		Art. no.	PU [qty.]
Mixer nozzle extension – rigid WIT-MV 10 x 200 mm		**0903 420 004**	10
Mixer nozzle extension – rigid WIT-MV 10 x 2000 mm		**0903 488 121**	20
Mixer nozzle extension – flexible, WIT-MV 10 x 2000 mm		**0903 488 123**	10
Mixer nozzle extension – rigid, WIT-MV 16 x 2000 mm		**0903 488 122**	20
Mixer nozzle extension – flexible, WIT-MV 16 x 2000 mm		**0895 812**	1

Application guns

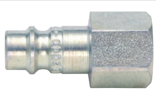
Application guns, manual				
		Suitable for cartridges	**Art. no.**	**PU [qty.]**
Application gun WIT, 330 ml		coaxial (1:10): 150 ml, 320 ml, 330 ml foil-tube (1:10): 300 ml	**0891 003**	
Application gun HandyMax		coaxial (1:10): 150 ml, 330 ml foil-tube (1:10): 300 ml	**0891 007**	
Application gun for foil-tube		foil-tube (1:10): 300 ml	**0891 000 001**	1
Application gun WIT, 420 ml		coaxial (1:10): 420 ml	**0891 038 0**	
Application gun WIT-Multi		coaxial (1:10): 150 ml, 320 ml, 330 ml, 420 ml foil-tube (1:10): 300 ml side-by-side (1:3): 385 ml, 440ml, 585 ml	**0891 003 105**	

ACCESSORIES

Application gun, cordless				
		Suitable for cartridges	**Art. no.**	**PU [qty.]**
Cordless application gun WIT		coaxial (1:10): 150 ml, 330 ml foil-tube (1:10): 300 ml	**0891 003 330***	1
		coaxial (1:10): 420 ml	**0891 003 420***	
		side-by-side (1:3): 385 ml, 585 ml	**0891 003 585***	
		side-by-side (1:10): 825 ml	**0891 003 825***	

Memory function: By actuating the memory function, the application gun repeats a pre-recorded application cycle, ensuring that exactly the right quantity of mortar is injected into the drill hole in series application
Adjustable speed :Infinitely controllable with adjustment wheel in handle
* incl. battery and charger 18 V 2.0 Ah-Li-Ion (in case)

Application guns, pneumatic				
		Suitable for cartridges	**Art. no.**	**PU [qty.]**
Pneumatic application gun		side-by-side (1:3): 385 ml, 585 ml	**0891 017**	1
		side-by-side (1:3): 1400 ml	**0891 015**	
		coaxial (1:10): 420 ml	**0891 004 420**	
		side-by-side (1:10): 825 ml	**0891 004 825**	

		Suitable for application gun	**Art. no.**	**PU [qty.]**
Female thread plug-in nipple series 2000		Pneumatic application gun 385, 585, 1400, 420,825 ml	**0699 100 514**	1

ANCHOR DESIGN MANUAL

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