Technical Handbook International

fischer

innovative solutions

Introduction

Introduction

Dear Reader

Planners and structural engineers are dealing more and more with increasingly complex construction processes and more sophisticated buildings. This affects new buildings and building renovations equally. Legislation and building materials are becoming more extensive and this development is accompanied by sustainability and energy-efficiency requirements. Our innovative strength is challenged here every day. Safety-relevant anchors are expected to reliably adhere to the object to be fixed, regardless of the building materials used.

The fischer company Group is a family company, which aims to improve every day. Our employees, therefore, take it on themselves to get actively involved in providing you with innovative solutions and the best possible service for your projects. The result is a growing range of products for flexible and professional use. It is our claim that with us on your side, you will feel secure. We create the best possible value with the best corresponding solutions to particular problems, and help you, our customers, users and business partners, to be successful in your competitive field.

The new Technical Handbook will support you in performing fixing tasks in your daily work, so that you are always able to quickly and economically measure a secure anchorage and place it on-site accordingly.

I wish you every success with our products and solutions.

Introduction

The fischer corporate group

The fischer corporate group has set itself lofty goals: it wants to be market leader in its industry sectors. To reach this goal, the fischer process system (fPS) is being used worldwide. It incorporates both technical procedures as well as business processes in sales and administration. Very specifically, this means that fischer makes its customers' requirements the central benchmark in development and production, as well as in sales and logistics. This is the standard to which the processes in the company are aligned in order to avoid waste, for instance, or overproduction and high stock levels. We rely above all on our staff here: they know best where there are opportunities to improve even further for the benefit of our customers, and only they can be quick and flexible in the latter's interest.

The constant search for improvement and modernisation is the foundation for our great success. 13.2 patent applications per year and per 1,000 employees (German industry average: 0.54) are proof of our innovative strength in the business segments of fixing systems, automotive systems and fischer technology. Around 42 per cent of our inventions are implemented in new products, processes and applications.

This thinking and acting is also what has made the family-run company from Waldachtal in the Black Forest an internationally renowned and successful company with 30 subsidiaries and partners in more than 100 countries.

The fischer corporate group is divided into four business segments:

fischer fixing systems: a manufacturer of reliable and economic fixings and accessories for the construction industry worldwide.

fischer automotive systems: a manufacturer of kinematic systems and storage components for the interiors of vehicles such as e.g. navigation systems, cup holders and car CD players.

fischertechnik: a manufacturer of toy construction sets that help to develop creativity and promote learning in an entertaining way.

fischer consulting: consulting and conveying of expertise and experience from the fischer process system to customers and business partners with the goal of improving internal company procedures.

Market leader in the supply of fixing systems

The business segment fischer fixing systems is the global market leader in fixing technology. We see ourselves as problem solvers and offer a comprehensive range of steel, plastic and chemical fixings. fischer develops and produces its products itself and is constantly setting new benchmarks.

We offer comprehensive and continuative services for our customers for all our products. The design software Compufix supports planners and structural designers in the calculation of reliable and economic anchors for all applications. The design software SaMontec provides support in the installation of pipeline sections and the fixing elements required for this purpose. Finally the design software Screw-fix supports planners to calculate case-studies with wood construction screws.

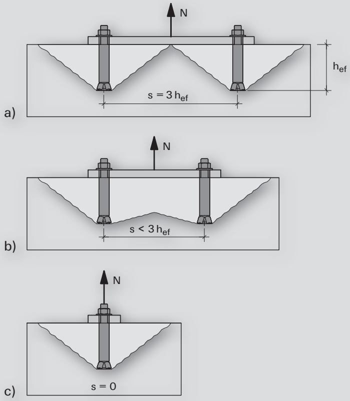
Our competent internal and external consultants inform worldwide about the correct use of our products. Highly qualified technicians and engineers from fischer visit our customers in their offices or on the building sites. They carry out tensile tests and trial loads directly on site, set anchors in trial installations and offer training for all users. And at the fischer ACADEMY, more than 3,000 planners, construction engineers, architects and skilled tradesmen are trained every year.

About this Technical Handbook

This technical manual is a fundamental part of our service offering that helps to make our customers competitive and successful. At the beginning, in the chapter Basic Knowledge about Fixing Technology, the most important construction materials for fixings, installation methods, type of loads, types of failure and the important parameters of influence on the bearing characteristics of fixing aids are explained. In the process, primarily heavy-duty fixings with steel anchors or chemical fixings are dealt with. The experimental tests possible at fischer with state-of-the-art testing equipment are also presented.

Selection tables inform at a glance about the fixings available, the materials, the existing dimensions and the types of installation. An initial selection of fixings can also be done according to the design values indicated. The design model used in the manual is based primarily on a simplified CC-method.

In order to simplify the design procedure and to make the calculation more easy for our customers, we have standardized the design process with two design forms for chemical and mechanical anchors. These standardized design forms can be downloaded under: www.fischer.de/THBint (see section 4 of the Technical Handbook).



Basic principles of fixing technology

2.1 General

Fixing technology has developed at a considerable pace over the previous years. High performance drilling techniques have been responsible for the development of many different post-installed fixing systems. Very often the user finds it difficult to decide which fixing is suitable for his application. He finds it often necessary to understand not only the fixing's performance, but must also consider a series of further influencing parameters such as the properties of the base material, the load bearing capacity of an anchor, anchor spacing, edge distances and also structural component thickness. The condition of the concrete (cracked or non-cracked) needs to be considered during the design process. In the following sections in conjunction with the important explanations of technical terms, the most important parameters which will influence the anchor's behaviour are considered.

2.2 Base Material (anchor base)

In the building process, various materials are used. Concrete, a variety of different masonry, and board materials and their strengths all go towards deciding the type of fixing to be used. These requirements mean, for example, that a fixing for solid materials may not necessarily be suitable for hollow ones.

2.2.1 Concrete

There is a difference between normal concrete and lightweight concrete. Concrete consists of cement and aggregate. The aggregates used for normal concrete may be substituted with other lighter materials such as pulverised fuel ash (PFA) for lightweight concrete.

Normal concrete in the fischer Technical Handbook, is identified based on the ENV 206 (Eurocode 2) by a capital letter C and two further numbers (e.g. C20/25). The first number 20 gives the compressive strength measured in cylinders with a diameter of 150 mm and a height of 300 mm and the second number 25 gives the compressive strength measured in cubes with dimensions 150 x 150 x 150 mm³. Table 2.1 gives the concrete strength classifications and Table 2.2 informs about the concrete strength classes used in different countries.

Almost all fixing systems are suitable for anchorage in concrete. For high load requirements the steel and chemical bonded anchors are used. For small load requirements, nylon fixings may be installed.

fischer has a number of approvals and recommendations for applications in lightweight concrete. Job site tests may also be carried out to establish the anchor performance. Further advice may be obtained from your local, fischer Technical Service Department.

Table 2.1:
Concrete strength classes according to the fischer Technical Handbook

ENV 206	Concrete strength class		C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 40/50	C 45/55	C 50/60
	$f_{ck, cyl}$ [1]	[N/mm²]	12	16	20	25	30	40	45	50
	$f_{ck, cube, 150}$ [2]	[N/mm²]	15	20	25	30	37	50	55	60

[1] Measured with cylinders with a diameter of 150 mm and a height of 300 mm
[2] Measured with cubes with dimensions 150x150x150 mm³

2.2.2 Masonry building Materials

Masonry is a composite material made of bricks and mortar. The main masonry groups are solid masonry units, hollow or perforated masonry units and autoclaved aerated concrete.

2.2.3 Boards and Panels

Board materials such as plasterboard, chipboard, plywood and cement-based boards with low strengths are often encountered during the construction or refurbishment of buildings. These materials require fixings which have a form locking action, i.e. they mostly anchor directly at the reverse of the board in the cavity.

2.3 Anchor Installation

2.3.1 Drill hole

The drilling method to be used depends on the base material. Solid base materials with a compact structure are drilled using impact or hammer drilling. Some perforated bricks, base materials with low strength and autoclaved aerated concrete may be drilled using only the rotary operation, so that the drill-hole will not become too large or the webs will not break away in perforated bricks. A further drilling method is the diamond or core drilling method, which is used chiefly for the production of larger drill-hole diameters or where steel reinforcement is encountered in concrete. The bore-hole diameter is defined in the assembly data of the fixing system and must be adhered to. If there is no extra information regarding diamond drilled holes for a fixing system, then the fixing was only tested using hammer drills which meet the requirements laid down in standards DIN 8035 or NF E 66-079 with regard to dimensional accuracy, symmetry, symmetry of insert tip, height of tip and tolerance on concentricity.

Table 2.2:
Concrete strength classes in different countries

Country	Test specimen	Size [1] [cm]	Concrete strength classes	Unit	Standard
Austria	Cubes	20 x 20 x 20	B5/B80, B10/B120, B15/B160, B20/B225, B25/B300, B30/350, B40/B500, B50/B600, B60/B700	N/mm² / kp/cm²	ÖN B 4200
China	Cubes	15 x 15 x 15	C15, C20, C25, C30, C35, C40, C45, C55, C60	N/mm²	GBJ 10-89
Denmark	Cylinder	15 x 30	5, 10, 15, 25, 35, 45, 55	N/mm²	DS 411
France	Cylinder	16 x 32	C20/25, C25/30, C30/37, C35/45, C40/50, C45/55, C50/60	N/mm²	
Germany	Cubes	15 x 15 x 15	C12/15, C16/20, C20/25, C25/30, C30/37, C40/50, C45/55, C50/60	N/mm²	DIN 1045-1
Great Britain	Cubes	15 x 15 x 15	C25/10	N/mm²	BS 1881: Part 116
Italy	Cubes	15 x 15 x 15 16 x 16 x 16 20 x 20 x 20	C12/15, C20/25, C30/37, C40/50, C50/60	N/mm²	ENV 206
Japan	Cylinder	10 x 20	≧15	N/mm²	JIS A 1108
Korea	Cylinder	10 x 20	C 180, C 210, C 240, C 270, C 300	kg/cm²	KS F 2405
Netherlands	Cubes	15 x 15 x 15	B15, B25, B35, B45, B55, B65	N/mm²	NEN 6720
Spain	Cylinder	15 x 30	non-reinforced: HM-20, HM-25, HM-30, HM-35, HM-40, HM-45, HM-50 reinforced concrete: HA-25, HA-30, HA-35, HA-40, HA-45, HA-50 prestressed concrete: HP-25, HP-30, HP-35, HP-40, HP-45, HP-50	N/mm²	EHE
Sweden	Cubes	15 x 15 x 15	K8, K12, K16, K20, K25, K30, K35, K40, K45, K50, K55, K60, K70, K80	N/mm²	BBK 79
Switzerland	Cubes	20 x 20 x 20	B25/15, B30/20, B35/25, B40/30, B45/35, B50/40	N/mm²	SIA 162
USA	Cylinder	15 x 30	2000, 3000, 4000, 6000	PSI	ACI 318

[1] Conversion: $f_{Cylinder} = 0.85 \times f_{Cubes,\ 20x20x20}$; $f_{Cubes,\ 15x15x15} = 1.05 \times f_{Cubes,\ 20x20x20}$

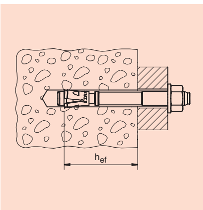
The drill hole depth h_0 depends on the type and size of the fixing. In most cases, the bore-hole is deeper than the anchorage depth. In some cases a special drill bit, such as the fischer universal drill bit FZUB for use with the Zykon anchor, drills the hole to the required depth. In all other cases refer to the Tables "Anchor characteristics" in the respective part of the fischer Technical Handbook.

2.3.2 Anchorage depth

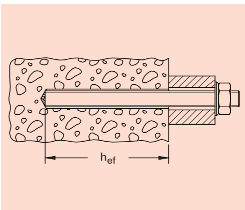
The anchorage depth h_{ef} has an important influence on the load bearing capacity of fixings. With undercut or expansion anchors this is generally the distance from the load bearing surface to the end of the fixing's expansion sleeve (see figure 2.1a).

With resin bonded anchors the anchorage depth is measured to the end of the threaded rod (see figure 2.1b) and with nylon plugs to the end of the expansion sleeve (see figure 2.1c). The anchorage depths for different fixings are given in Section 4 of this fischer Technical Handbook.

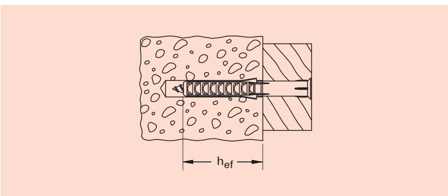
Figure 2.1:
Definition of the anchorage depth h_{ef}



a) Mechanical anchor



b) Bonded anchor

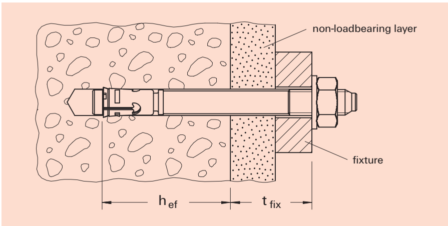


c) Nylon anchor

2.3.3 Fixture thickness

The fixture thickness (clamping thickness) t_{fix} refers to the maximum thickness of the attachment. When a non-load-bearing layer exists, this must be added to the fixture thickness (see figure 2.2). The fixture thickness can be varied for internally threaded anchors by using different screws or threaded rods. This is generally restricted with all other types of anchors, because of the fixed length of the anchor.

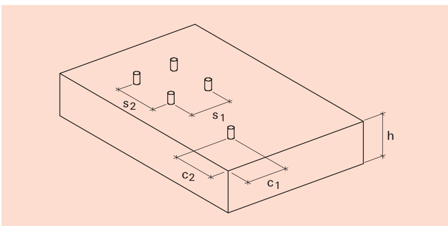
Figure 2.2:
Fixture thickness with non-load-bearing layer (e. g. plaster, tiling)



2.3.4 Edge distances, anchor spacing and member thickness

The anchor spacing s is the distance between two adjacent anchors. The edge distance c is the distance from the fixing to a free edge. The member thickness h is the thickness of the structural element. (see Fig 2.3).

Figure 2.3:
Definition of anchor spacing (s_1, s_2) edge distances (c_1, c_2) and of member thickness h



In order to reach the maximum tensile load bearing capacity of the fixing, defined characteristic anchor spacing $s_{cr,N}$ or $s_{cr,sp}$ and edge distances $c_{cr,N}$ or $c_{cr,sp}$ are necessary. To prevent spalling, cracking and splitting of the base material during installation, minimum values of anchor spacing s_{min}, edge distance c_{min} and member thickness h_{min} must be observed. The values are given in the respective part of this fischer Technical Handbook.

2.3.5 Type of installation

The three different types of installation are as follows:

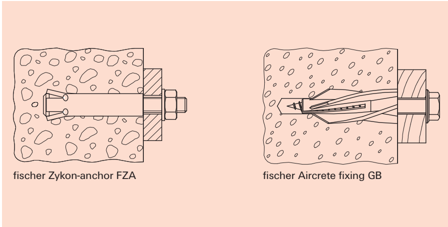
- Pre-positioned fixing
- Through fixing
- Stand-off fixing

A pre-positioned fixing can be seen in figure 2.4a. First of all the hole is drilled, then the fixing is set and finally the attachment is fixed. The drill hole is generally larger than the clearance hole in the attachment.

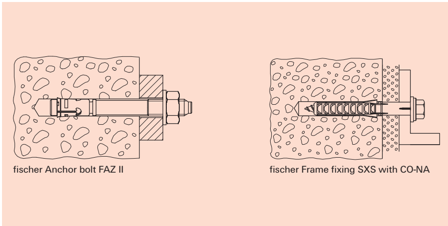
With through fixings the hole is drilled through the clearance hole of the attachment into the anchor base and the anchor is pushed through the hole into position (see Fig. 2.4b). Thus the drill hole in the attachment has to be larger than the drill hole in the anchor base.

Stand-off fixing provides support of the attachment at a distance away from the surface of the anchor base (see figure 2.4c).

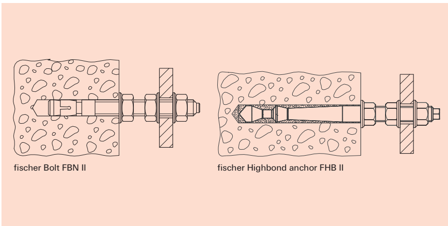
Figure 2.4:
Type of installation



a) Pre-positioned fixing



b) Through fixing



c) Stand-off fixing

2.3.6 Installation procedure

The installation procedure for the different types of fixings is illustrated in the respective part of this fischer Technical Handbook.

2

2.4 Type and direction of the actions

Loads and forces acting on the construction are also known as „actions". The following compilation (Table 2.3) of local actions is taken from /5/. The actions may be classified according to their duration and frequency of occurrence. Further distinction is made between actions with or without forces of inertia.

Forces of inertia are caused either through impact loading, earthquakes or machines with mass acceleration. When the load is either constant or alternates at a low rate and with no mass action, then the action is taken as being static. These are also known as mainly static or predominantly static actions.

If the load constantly alternates with no inertial forces, then this is known as a constantly changing load or fatigue. If forces of inertia are applied, regardless of the number of load changes, then it is considered as being dynamic.

Static loads are the sum of dead loads and slowly changing loads. The dead loads result in the weight of the attachment and permanently static loads such as screeds, flooring or plaster. Slowly, changing loads are due to human traffic, furniture, non-load bearing partition walls, warehouse materials, wind and snow. These loads must be take from the building regulations of each country.

Table 2.3:
Definition of respective actions /5/

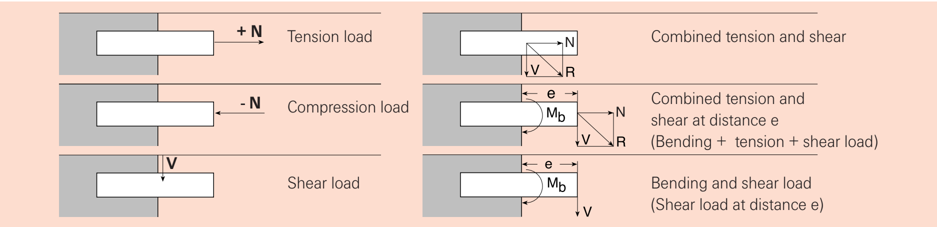
Number of load cycles				
None (constant)	Low		High	
	without inertial forces	with inertial forces	without inertial forces	with inertial forces
• self-weight • partitions • people • fixtures and fittings • stored materials • snow • water • wind • restraint of deformations	• restraint of deformations	• impact • earthquake • explosion	• traffic loads on bridges and basement roofs • crane rails • lifts • machines without inertial acceleration	• machines generating high inertial accelerations (punches, presses, rams, forges)
	• primarly static actions	• dynamic actions	• frequently alternating actions	• dynamic actions

Deformations of the attachment may also take place due to creep or movement in concrete and temperature changes. Temperature changes can be due to the weather, e.g. façades, or usage such as chimneys, silos, hot and cold storage rooms. In preventing these deformations, additional loads are applied to the fixing. The magnitude of these loads depends on the geometry and position of the fixing, and the fixing material. According to the number of temperature changes the level of fatigue may have an effecting influence. With facades for example this can range from 10^4 to $2 \cdot 10^4$ load changes. This means for a working life of 50 years, one load alternation per day on average.

Samples of changing loads (fatigue loads) are due to craneways, bridge traffic, machines and lifts. The magnitude of the actions must be considered in accordance to each countries own relevant standard. In general, the standards regulate whether the action is either static, changeable or fatigue. In accordance to the German Standard DIN 1055, Part 4, a wind load is measured as being static, although both the direction and strength may alter.

The main difference between dynamic and static actions are inertia and damping forces. These forces move in accordance with the induced acceleration and must be considered when calculating the design and anchor forces. Earthquakes induce dynamic forces or shock type loads (explosion and impact) as well as machines with high levels of mass acceleration such as stamping machines. The resulting actions from machines are to be considered as relevant for fatigue loading. To make the correct choice of fixing system and size, the applied loads must be understood. They can be characterised by size, direction and point of application. Figure 2.5 illustrates the different types of load.

Figure 2.5:
Type of actions



2.5 Load-bearing capacity of anchors
2.5.1 Principles of anchor function

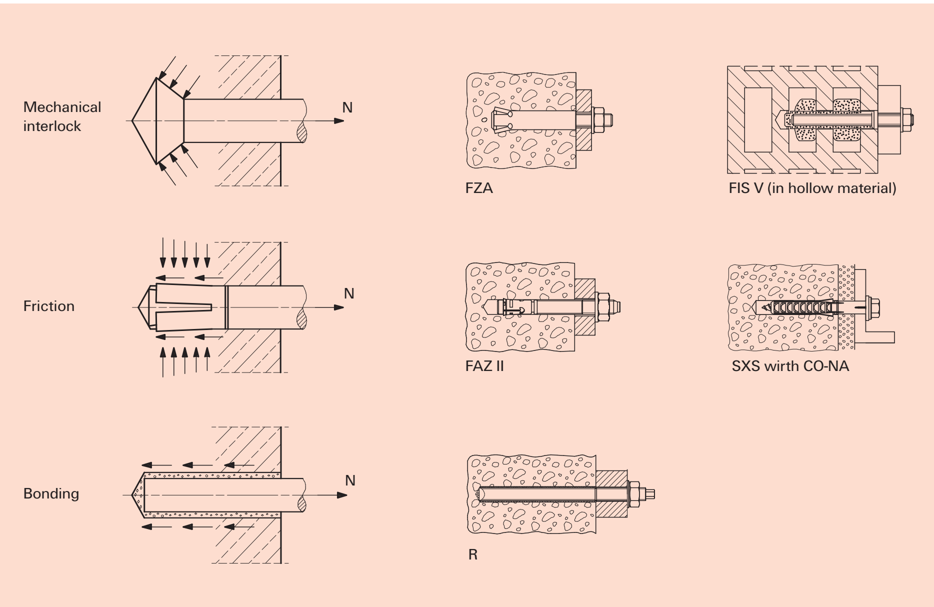
The three basic principles of anchor function (figure 2.6) are as follows: mechanical interlock, friction and bonding.

With undercut anchors such as the fischer Zykon anchor (FZA, FZA-D, FZA-I), or fischer Zykon hammerset anchor (FZEA), the load is transferred by mechanical interlock into the base material. An undercut hole is formed using a special drill bit (FZUB). The anchor locks into the undercut hole.

Friction is the main working principle of expansion anchors. When installing the anchor an expansion force is created which gives rise to a friction force. Two types of expansion may be distinguished: torque-controlled and displacement-controlled. Torque-controlled anchors are expanded by applying a defined torque. Thus the cone is drawn into the sleeve and presses it against the drill hole wall. The anchor is expanded correctly if the torque can be applied (torque-controlled). Displacement-controlled anchors are expanded by hammering a cone into a sleeve. The necessary displacement is controlled using a setting tool. Examples for expansion anchors are the fischer high performance anchor (FH II), fischer anchor bolt (FAZ II), fischer bolt (FBN II) and fischer hammerset anchor (EA II). Further examples are the nylon fischer frame fixings FUR, SXR, SXS and also the fischer hammerfix (N).

The third principle of function is bonding. In this case, the load is transferred from the anchor to the base material by the bond e.g. hardened resin mortar. Examples are the fischer resin bonded anchor (type R Euro-bond) and the fischer injection systems FIS V, FIS VT and FIS EM.

Figure 2.6:
Principles of function



2.5.2 Modes of failure

Fixings can fail due to different types of actions. Importance is given to the understanding of different failure modes according to the various load directions.

2.5.2.1 Tension load

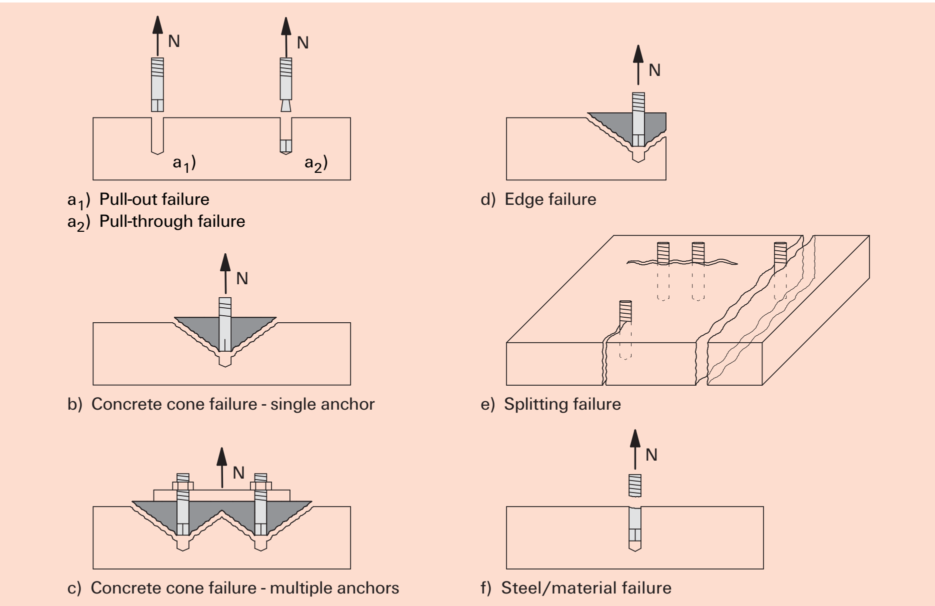
Figure 2.7 illustrates the modes of failure for undercut and expansion anchors in concrete due to axial tension load. With **pull-out** (figure 2.7a1), the anchor is withdrawn from the base material without significant damage to the concrete. Insignificant spalling may occur close to the base material's surface but this has no effect upon the anchor's load bearing capacity. Pull-out may occur with displacement-controlled expansion anchors whereby the expansion force is too low to keep the anchor in its required position until concrete failure occurs.

With **pull-through** (figure 2.7a2) the cone or cone bolt is pulled through the expansion sleeves or segments, which remain in the hole. Pull-through may also occur where the expansion forces are high, and the expansion sleeve is pressed into the concrete.

With **concrete failure** the fixing produces a conical break-out body which begins in the area of expansion or undercut (see figure 2.7b). The spacing of adjacent anchors may lead to a combined overlapping of the break-out bodies (see figure 2.7c). Anchors with small edge distances cause a concrete cone failure with reduced resistance (see figure 2.7d).

Splitting may lead to either a complete split of the structural element, or to cracks between adjacent anchors, or between anchors and the edge (see figure 2.7e). This type of failure occurs only when the dimensions of the structural element and/or the edge distances are too small.

Figure 2.7:
Modes of failure under axial tension load in concrete



Steel failure gives the maximum possible failure load which can lead to failure of either the bolt or the screw (see figure 2.7f).

Similar types of failure as with undercut and expansion anchors can also occur with resin bonded anchors. Pull-out occurs when the bond between the drill hole and the mortar or between the threaded rod and the mortar fails. Normally a mixed failure (pull-out and concrete failure) occurs where the break-out body begins at approximately 0.3 - 0.7 times the anchorage depth.

In masonry the maximum load bearing capacity is usually limited to the way in which the base material fails. In solid bricks, anchors may fail due to pull-out, and the maximum load bearing capacity can in certain cases be due to steel failure.

2.5.2.2 Shear load

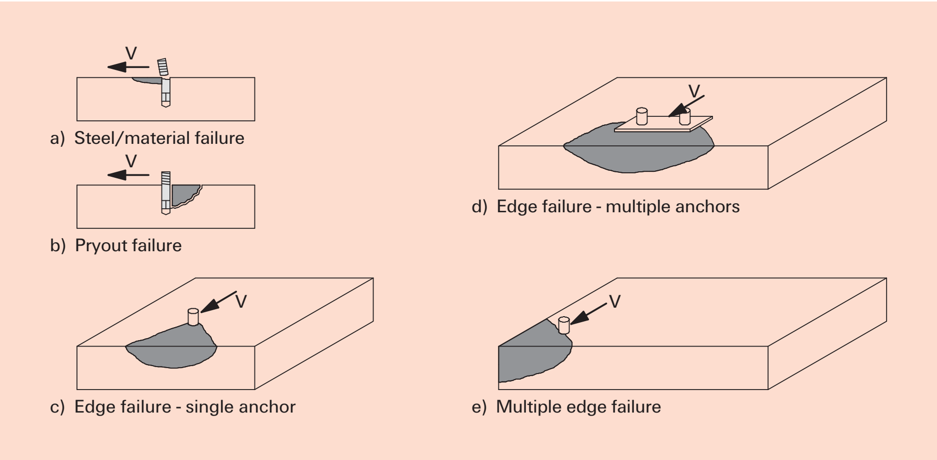
Figure 2.8 illustrates the possible modes of failure of anchors in concrete subjected to shear load.

For anchors with large edge distances and sufficient anchorage depth under shear load, normally steel failure occurs. Shortly before reaching the maximum load capacity, a local shell-shaped spalling may occur near the concrete´s surface (see figure 2.8a). Similar to tension, this mode of failure gives the highest possible load bearing capacity of the anchor.

Short and stiff anchors or groups with small anchor spacing can, under shear load, fail due to concrete break-out on the opposite side of the load direction (pry-out failure) (see figure 2.8b).

Anchors with small edge distances can lead to the failure of the concrete´s edge (see figure 2.8c). Anchors near an edge with reduced anchor spacing can lead to a combined break-out body (see figure 2.8d) and anchors positioned close to a corner, can result in the complete failure of the corner (see figure 2.8e).

Figure 2.8:
Modes of failure of steel anchors under shear load in concrete



2.5.3 Influencing parameters
2.5.3.1 Base material strength

With concrete cone failure the ultimate tension load is greatly influenced by the strength of the concrete. Figure 2.9 shows the ultimate load N_u of fischer Zykon anchors in non-cracked concrete as a function of the concrete cube strength. The failure load increases proportionally to the square root of the concrete strength.

The ultimate load at concrete failure is restricted by steel failure (horizontal lines in figure 2.9).

Figure 2.9:

Ultimate load N_u of fischer Zykon anchors subject to tension load in non-cracked concrete in relation to the concrete compressive strength $f_{cc, 200}$

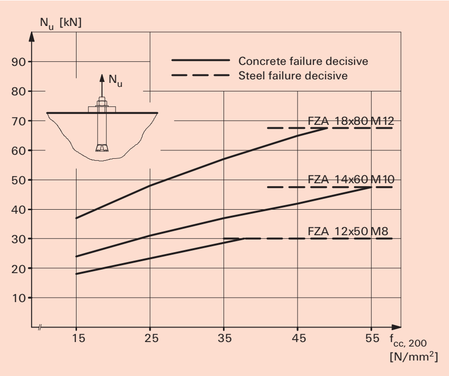
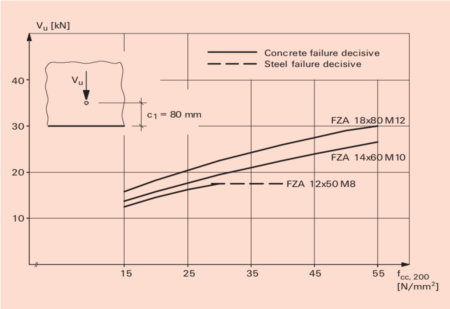


Figure 2.10 shows the relationship of the concrete failure load of fischer Zykon anchors in non-cracked concrete under shear load and the concrete cube strength $f_{cc,200}$. This illustration is valid for anchors that have an edge distance c_1 = 80 mm which are loaded towards a free edge.

Figure 2.10:

Ultimate load V_u of fischer Zykon anchors subject to shear load in non-cracked concrete in relation to the concrete compressive strength $f_{cc, 200}$



As with tension load, the ultimate shear load at concrete edge and pry-out failure is also dependent on the square root of the concrete strength, and is limited by the anchor's steel strength.

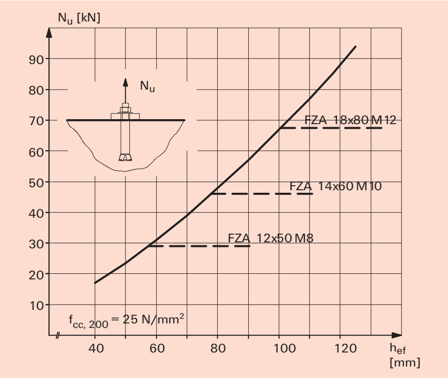
The load bearing capacity of an anchor in other materials such as masonry is also influenced by the strength of the substrates. Fundamentally, there is an increase in ultimate load with increasing strengths of the base material, however, the relationship cannot be measured as accurately as with concrete. Many other parameters such as the type, size and structure of the materials need to be considered.

2.5.3.2 Anchorage depth

The ultimate load of an anchor under tension is over proportionally influenced by its anchorage depth. Figure 2.11 shows the concrete failure load N_u of fischer Zykon anchors due to a tension load in non-cracked concrete in relation to the anchorage depth h_{ef}. The increase in the ultimate load is proportional to the anchorage depth to the power of 1.5, and is restricted again by the anchor's pull-through/ pull-out failure (compare figure 2.7a2) or steel failure.

Figure 2.11:

Ultimate load N_u of fischer Zykon anchors subject to tension load in non-cracked concrete in relation to the anchorage depth h_{ef}



When considering shear loads, the anchorage depth influences the concrete failure load differently for different failure modes. The pry-out failure load increases at a positive rate with increasing anchorage depth. The edge failure load increases at a negative rate with increasing anchorage depth.

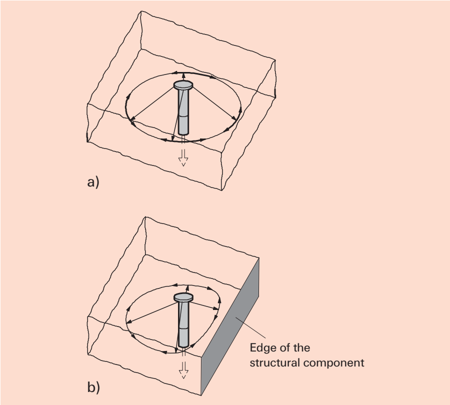
2.5.3.3 Edge distance

Anchors with sufficient undercut and expansion capacity fail due to axial tension load in the form of a concrete failure cone. The failure cone develops from the area of undercut or expansion at an angle of approximately 35° to the concrete surface. This results in the concrete failure cone's surface diameter being 3 times the anchor's embedment depth. The maximum break-out load can only be achieved when the cone can develop without edge effects. Thus, the edge distance must be at least half the surface diameter of the cone (1.5 times the anchorage depth). With reduced edge distances, a truncation of the break-out cone occurs (compare figure 2.7d), and therefore leading to a reduction in the ultimate load.

For anchors with sufficient edge distances the balance between external and internal forces is guaranteed by tensile ring stresses (radially symmetric stress distribution), that means the stresses in the concrete are radially symmetric to the anchor (see figure 2.12a) /5/. A reduction of the edge distance causes a change of the radially symmetric stress distribution and thus a reduction of the concrete failure load (see figure 2.12b). Both parameters, the truncation of the break-out body as well as the disturbance of the stress distribution are self-super-imposing. Figure 2.13 shows the ultimate load N_u of fischer Zykon anchors subject to tension load in non-cracked concrete as a function of the edge distance c_1. The figure is valid for a concrete cube strength $f_{cc,\,200} = 25\ N/mm^2$.

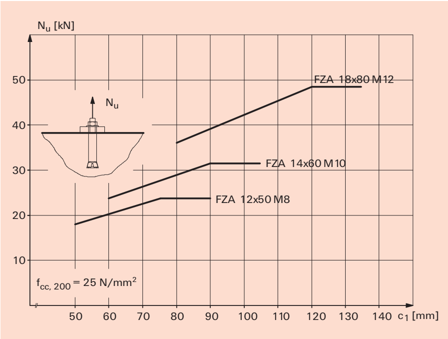
Figure 2.12:

Distribution of forces in the area of a cast-in headed stud subject to axial tension /5/



The figure shows an increase of ultimate load with increasing edge distance. When the edge distance exceeds c_1 = 75, 90 and 120 mm for FZA 12x50 M8, FZA 14x60 M10 and FZA 18x80 M12 respectively which corresponds to 1.5 times the anchorage depths or the radius of the break-out cone, no further increase in the failure load can be expected. This is because the break-out cone can develop completely without edge effects.

Figure 2.13:
Ultimate load N_u of fischer Zykon anchors subject to tension load in non-cracked concrete in relation to the edge distance c_1



An even greater influence of the edge distance can be expected on the shear failure load. Anchors with a shear load perpendicular to the edge fail due to break-out of the edge. The angle between the break-out body and the structural edge is approximately 35° and therefore, the length of the break-out body on the edge is approximately 3 times the edge distance (see figure 2.14). The height of the break-out body is in accordance with test results approximately 1.5 times the edge distance c_1.

Figure 2.14:

Form and dimensions of the concrete break-out body for a single anchor under shear loading close to an edge.

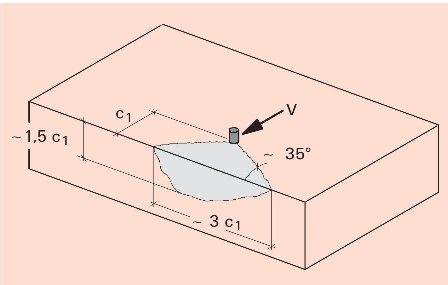
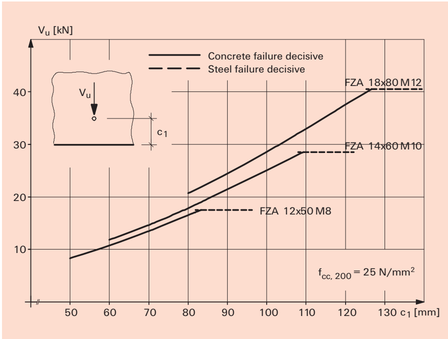


Figure 2.15 shows the concrete failure load Vu of fischer Zykon anchors due to shear load in non-cracked concrete in relation to the edge distance c_1. The increase in the concrete failure load is a function of the edge distance to the power of 1.5, and is restricted again by the anchor's steel failure load.

Figure 2.15:

Ultimate load V_u of fischer Zykon anchors subject to shear load in non-cracked concrete in relation to the edge distance c_1.



2.5.3.4 Anchor spacing

The anchor spacing has a significant influence on the concrete load bearing capacity. The ultimate load of anchors subjected to axial tension load is only achieved when the complete concrete failure cone can develop unrestricted. Figure 2.16 should make this clear with the example of a pair of anchors subject to tension load.

Figure 2.16a shows a pair of anchors with an anchor spacing corresponding to the expected diameter of the break-out cone ($s = 3 \cdot h_{ef}$). In this situation the cones do not intersect and therefore the two anchors achieve the maximum capacity. This means the ultimate load for the pair of anchors is equal to twice the maximum load for a single anchor.

In figure 2.16b, the anchor spacing of the anchors is less than the diameter of the expected failure cone. The failure cones intersect and result in a reduction of the load capacity. Under the purely theoretical assumption that the axial spacing between the two anchors is reduced to s = 0 (figure 2.16c), only one concrete failure cone is available and thus the failure load of this "pair" of anchors is equal to 50 % of that of the pair in accordance to figure 2.16a. To simplify matters, a linear relationship is taken between the extreme values illustrated in figures 2.16a and 2.16c. In practice, the anchor spacing s must not go below s min defined in the technical data sheets of Section 4.

Figure 2.16:

Intersection of the concrete failure cones for anchors subject to axial tension load

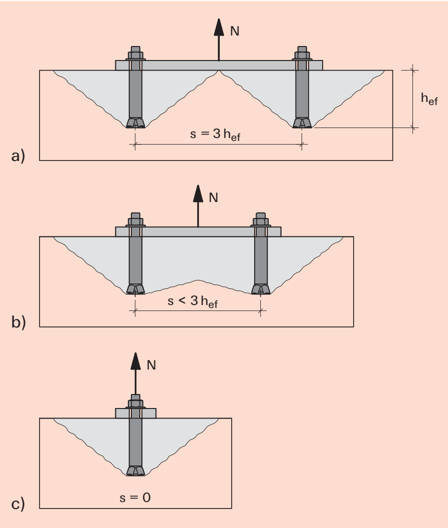
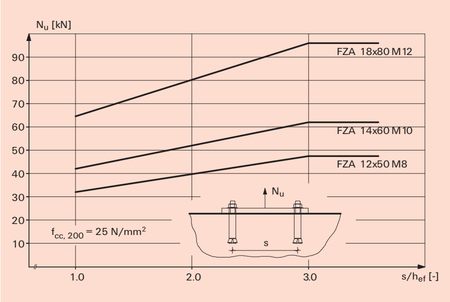


Figure 2.17 shows the effect of the anchor spacing for a pair of fischer Zykon anchors subject to axial tension load in non-cracked concrete with a strength of $f_{cc,\,200}$ = 25 N/mm². The horizontal axis shows the ratios of the axial spacing to the anchorage depth.

An increasing axial spacing to the point where the concrete failure cone's diameter is achieved ($s = 3 \cdot h_{ef}$) causes an increase of failure load. Larger axial spacing do not increase the failure load because the maximum capacity of a pair has already been reached.

Figure 2.17:

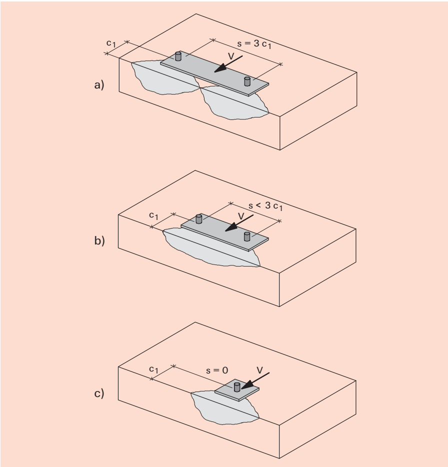
Ultimate load N_u of a pair of fischer Zykon anchors subject to tension load in non-cracked concrete in relation to the ratio of the anchor spacing s and the anchorage depth h_{ef}



When a group of anchors with a large edge distance is loaded by a shear force, normally steel failure may occur, even with small anchor spacing, if the anchorage depth is sufficiently large. With short and stiff anchors and/or groups with small anchor spacing within the group, concrete failure may occur due to breakout on the opposing side of the load direction (pry-out failure) (compare section 2.6.2, figure 2.8b). When the same anchors are located close to an edge and subjected to a shear load directed towards a free edge, the anchor spacing of the anchors has a greater influence. This can be seen in figure 2.18.

Figure 2.18:

Intersection of the break-out bodies of anchors under shear load close to an edge

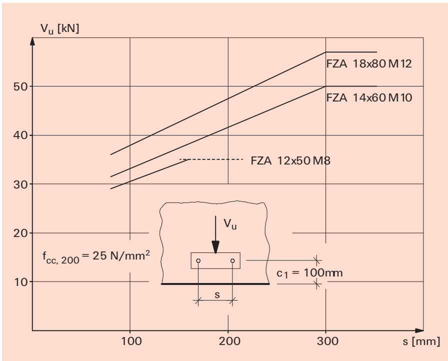


In accordance with Figure 2.14 the angle between the break-out body and the structural edge is approximately 35 °, and therefore, the length of the failure body on its edge is approximately 3 times the edge distance c_1. When the anchor spacing is at least 3 times the edge distance, in this situation the break-out bodies do not intersect and therefore the two anchors achieve the maximum capacity (compare figure 2.18a). This means the ultimate load for the pair of anchors is equal to twice the maximum load for a single anchor with edge distance c_1. If the anchor spacing is reduced (see figure 2.18b) then the expected failure bodies intersect and result in a reduction of the load capacity. Under the purely theoretical assumption that the axial spacing between the two anchors is reduced to s = 0 (see figure 2.18c), only one break-out body is available and thus the failure load of this "pair" of anchors is equal to 50 % of that of the pair in accordance to figure 2.18a. To simplify matters, a linear relationship is taken between the extreme values illustrated in figures 2.18a and 2.18c. In practice the anchor spacing must not go below the min. value of s_{min}, defined in the technical data sheets of Section 4, because of possible concrete splitting when installing the anchor.

Figure 2.19 illustrates this relationship for a pair of fischer Zykon anchors with an edge distance c_1 = 100 mm. The figure is valid in non-cracked concrete with a compressive cube strength $f_{cc,\,200}$ = 25 N/mm² and for fixings in a member with a sufficient thickness. The thickness is sufficient if the break-out body can develop completely on the side face of the substrate (h ≧ 1.5 c_1) (compare figure 2.14).

Figure 2.19:

Ultimate load V_u of pairs of fischer Zykon anchors in non-cracked concrete subject to shear load in relation to the anchor spacing s (edge distance c_1 = 100 mm)



The failure load of an anchor pair increases with increasing anchor spacing until the spacing reaches 3 times the edge distance. For larger anchor spacing, no further increase in ultimate load can be expected because the maximum capacity of the anchor pair cannot exceed twice the maximum failure load of a single anchor with the same edge distance. For the fischer Zykon anchor FZA 12x50 M8, the maximum load bearing capacity of the anchor pair is limited by the steel failure load.

2

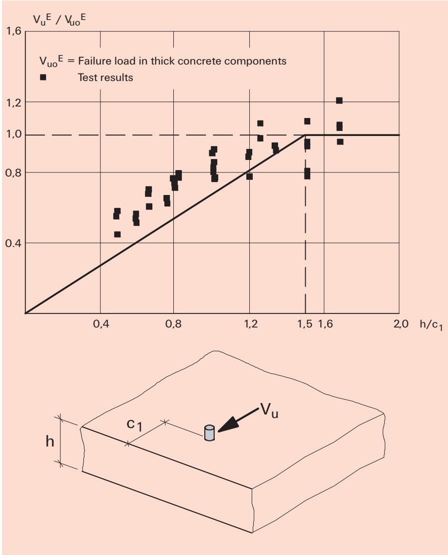
2

2.5.3.5 Concrete member thickness

With axial tension load the concrete member thickness has only an indirect influence on the load bearing capacity of the anchor. Should the thickness, however, be insufficient, problems may arise during installation. In the case of splitting the maximum concrete load bearing capacity is not achieved. In order to prevent these situations occurring, undercut anchors as well as torque-controlled expansion anchors should be installed in a member with at least the minimum thickness h_{min}, which are given in the respective part of the fischer Technical Handbook, Tables "Anchor characteristics". Additionally the load bearing capacity can be reduced due to splitting when the concrete member thickness is too small.

In comparison to the behaviour of anchors under axial tension load, the load bearing capacity of anchors close to an edge under shear load is greatly affected by the concrete member thickness. This can be seen in figure 2.20. The diagram shows on the horizontal axis the ratio between the concrete thickness and the edge distance, and on the vertical axis the ratio of the ultimate load from testing and the calculated value according to the CC-method for anchors in thick concrete members $h \geqq 1.5\,c_1$. It shows that the ultimate load increases with increased thickness of the concrete member, until approximately 1.5 times the edge distance is reached. This can be explained in accordance with figure 2.14. It shows that the height of the concrete failure body on the side surface of the concrete member is about 1.5 times the edge distance c_1. Should the thickness be less than 1.5 times the edge distance, the failure cone is truncated on its lower edge, thus reducing the load bearing capacity (see figure 2.20).

Figure 2.20:
Influence of the component thickness h upon the load bearing capacity of steel anchors subjected to shear load close to an edge



2.5.3.6 Cracks

Concrete has a relatively low tensile strength which may be totally or partially used up by induced stresses in the structure. Therefore, the tensile strength of the concrete must not be taken into consideration when designing reinforced concrete elements. Reinforced concrete is designed under the assumption that the tensile zone is cracked. Experience shows that the crack widths in reinforced concrete elements under predominantly dead loads can reach the values of w~0.3 to 0.4 mm /1/, /2/, /3/.

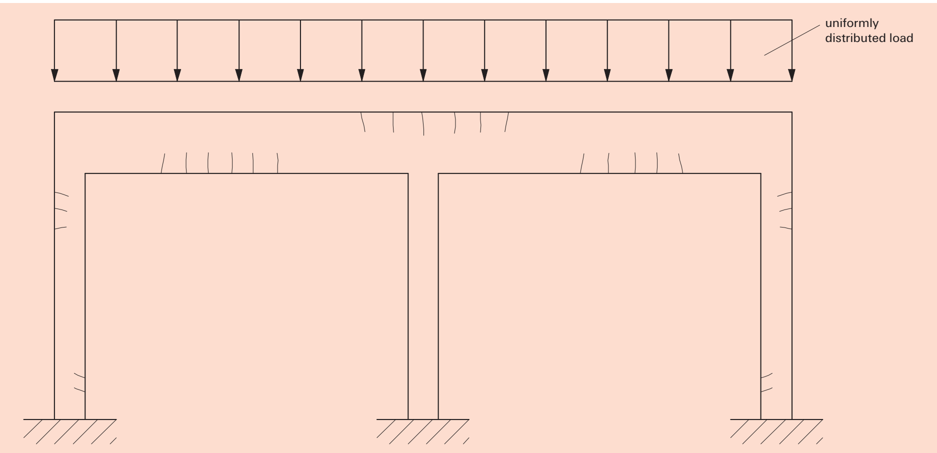
When cracks occur there is a high probability that they either are attracted directly to the anchor or tangentially pass by. In the immediate area of the anchor increased tensile forces are present. These are caused by resulting splitting forces due to the anchor's pre-tension and applied load, the peak of the bending moment as a result of the single point load on the concrete member, as well as the notch effect of the drill hole.

Figure 2.21 shows where cracks may occur for a sample structure with a uniformly distributed load. These cracks can be expected to occur in the tensile zones of the structure and a change in the load may alter the magnitude of the cracks and their location. In the worst case the compressive zones may become tensile zones due to imposed loads. This simple example highlights the difficulty in determining the position of cracks. This applies particularly to complicated multi-framework type structures.

How do anchors behave in cracked concrete?

Figure 2.22a shows load displacement curves for torque controlled expansion anchors in cracked and non-cracked concrete. The anchors have been designed for applications in cracked concrete. The slope of each curve increases continuously the same for cracked as well as non-cracked concrete. The ultimate loads are less in cracked concrete than non-cracked. Should, however, anchors, which are only suitable for use in non-cracked concrete, be used for cracked concrete, then the behaviour of the anchor in cracks is altered signifi-

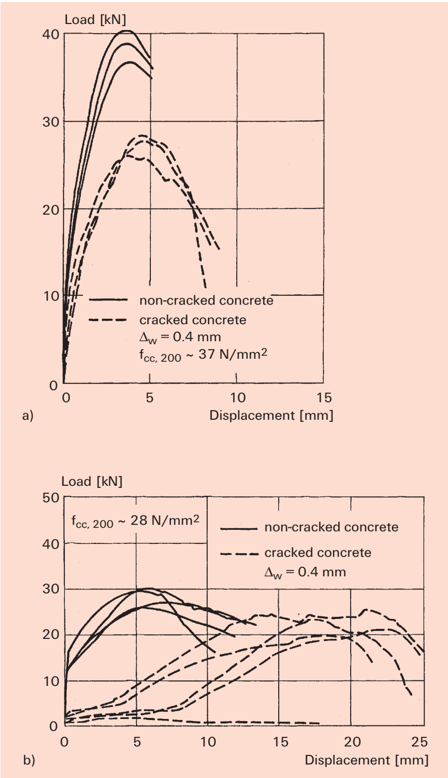
Figure 2.21:
Typical crack pattern in a frame under uniformly distributed load



cantly. (Figure 2.22b) It can be seen that the anchors only in non-cracked concrete have a continuous increase in load displacement behaviour. However, in cracked concrete the load displacement behaviour and maximum load have a large scatter of results with no indication of when failure is likely to occur. In extreme cases with almost no increase in load, the anchor is pulled out of the concrete (see figure 2.22b, lower curve).

Figure 2.22:
Load-displacement curves of torque-contolled expansion anchors (M12, h_{ef} = 80 mm)

a) Anchors suitable for applications in cracked concrete
b) Anchors **not suitable** for applications in cracked concrete



For each fischer anchor system, the condition of use is defined in this handbook. For example the following anchors are suitable for applications in cracked concrete:

- fischer Anchor bolt FAZ II
- fischer High performance anchor FH II
- fischer Zykon anchor FZA (bolt projecting)
- fischer Zykon anchor FZA-D (through bolt)
- fischer Zykon anchor FZA-I (internal thread)
- fischer Zykon drop in anchor FZEA
- fischer Highbond anchor FHB II
- fischer Injection mortar FIS EM
- fischer Long-shaft fixing SXS

2.5.4 Testing of anchors
2.5.4.1 Test conditions and Requirements

Function and load bearing capacity of anchors described in this Technical Handbook are based upon comprehensive testing in accordance with the guideline of the European Organisation for Technical Approvals (EOTA) /4/. However the conditions of use may vary from those of the European Technical Approval.

This is based upon two different groups of tests:

- Tests to prove function (suitability tests)
- Tests to determine the permissible use conditions

Function proving tests consider whether the anchor is sensitive to non-preventable deviations from the installation conditions. This considers the following:

- Deviation from the required installation torque with torque-controlled expansion anchors
- Inadequate undercutting of the drill hole for undercut anchors
- Insufficient expansion of drop in anchors
- Drill hole incorrectly cleaned, wet concrete or drill hole filled with water for resin bonded anchors or injection systems

The approvals normally require that anchors should be positioned so as to avoid drilling of reinforcement. However, in practice, this is often unavoidable on a construction site. Therefore, additional function tests are carried out for anchors in contact with reinforcement.

As already mentioned suitability tests consider whether the anchor is sensitive to non-preventable deviations from installation conditions. However, the influence of excessive installation errors e.g.: the use of drill bits with the incorrect diameter, the use of incorrect drilling or undercutting tools for undercut anchors, incorrect installation (i.e. hammering instead of rotating the threaded rod for resin bonded anchors) is not considered in these tests.

Suitability tests are carried out not only in low strength, but also in high strength concrete. This is necessary as the concrete's actual strength can be higher than its nominal strength.

New drill bits have, for obvious reasons, a greater diameter than that of a worn bit. This difference can be as much as 0.5 mm, for example with a 12 mm bit. In order to measure whether this difference has an influence on load performance, both new and worn bits are used in tests.

Additional suitability tests are carried out with changing loads (not fatigue loads!) as in practice, anchors are often subjected to load changes.

Anchors for use in cracked concrete must function under special conditions. For example the anchors are proven in cracks with widths up to 0.5 mm. The tests are carried out in low and high strength concrete, with new and worn drill bits as follows. Hairline cracks are created in the concrete into which the anchors are installed. These cracks are then opened to widths of 0.5 mm and the anchors are then pulled out.

Should the anchor's base material concrete be subjected to variable loads, this may lead to either an increase or decrease in the crack width. The resulting effect upon the load bearing capacity of the anchors is tested in a further series, whereby the anchors are placed into hairline cracks and loaded with a constant load. With the constant load on the anchor the cracks are opened and closed a thousand times by $w_1 = 0.1$ mm and $w_2 = 0.3$ mm. Once the movement of the cracks has stopped, the anchors are then pulled out from the open crack of 0.3 mm.

All suitability tests of anchors must display a suitable load displacement relationship. The load displacement curves should climb continually until about 70 % (for cracked concrete anchors) or 80 % (for non-cracked concrete anchors) of the ultimate load has been achieved with no horizontal interruptions.

In tests to determine the permissible use conditions, the characteristic loads and the appropriate edge distances and anchor spacing and the minimum material thickness are specified. Therefore, the anchors have to be installed in accordance with the manufacturer's instructions. To determine the characteristic shear load of anchors, anchors are tested subjected to shear.

2.5.4.2 Anchor testing at fischerwerke

In the research and development centre at fischerwerke (figure 2.23) the most modern test equipment and machines are available that allow for all the previously mentioned tests to be conducted in-house.

Figure 2.23:
Research and development centre

Figure 2.24:
Test equipment for small specimens

Tension test machines with various load attachments allow tension tests in small specimens (figure 2.24) or in large concrete elements (figure 2.25) also in cracked and non-cracked concrete. The load can be continually applied (force-controlled or displacement-controlled) and as either static, dynamic shock or fatigue load.

Modern testing equipment (figure 2.26) enables the testing of anchors subjected to loads at various angles (tension, shear or combined tension and shear loads).

Figure 2.25:
Test equipment for high load capacities

Figure 2.26:
Equipment for tests under oblique tension at any angle for cracked and non-cracked concrete

A parallel crack testing machine conducts tests in static and dynamic cracks.

In an open area weathering tests are conducted under atmospheric conditions. For corrosion tests, modern salt spraying equipment is used.

2.5.5 Characteristic values of anchors

Due to the test results and in order to make this applicable to the use conditions, characteristic values for the tested anchors resistance in non-cracked, and in cracked concrete are determined. These values are as follows:

- $N_{Rk,s}$ characteristic resistance of an anchor at steel failure under tension load
- $N^{0}_{Rk,c}$ characteristic resistance of an anchor at concrete cone failure under tension load
- $N_{Rk,p}$ characteristic resistance of an anchor at pull-out/pull-through failure under tension load
- $V_{Rk,s}$ characteristic resistance of an anchor at steel failure under a shear load
- $s_{cr,N}$ characteristic anchor spacing for concrete cone failure under tension load without a reduction of characteristic load $N^{0}_{Rk,c}$
- $c_{cr,N}$ characteristic edge distance for concrete cone failure under tension load

without a reduction of characteristic load $N^0_{Rk,c}$

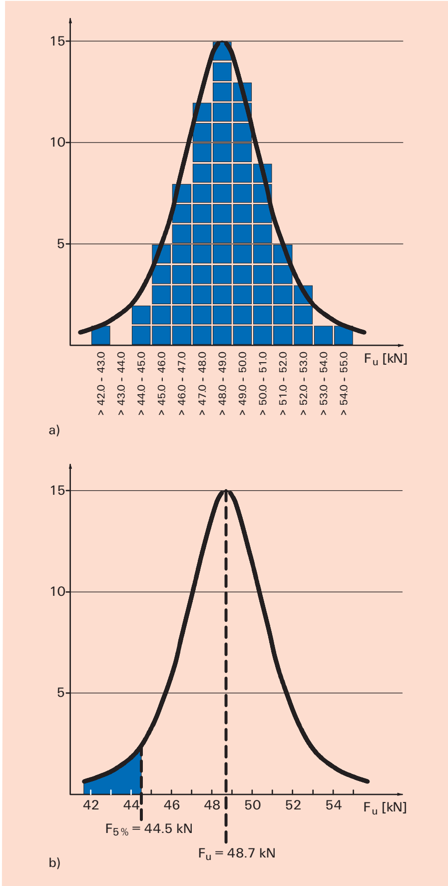
$s_{cr,sp}$ characteristic anchor spacing for splitting faillure under tension load without a reduction of characteristic load $N^0_{Rk,c}$

$c_{cr,sp}$ characteristic edge distance for splitting failure under tension load without a reduction of characteristic load $N^0_{Rk,c}$

In order to prevent splitting during installation, the minimal anchor spacings and edge distances (s_{min}, c_{min}) as well as the minimum base material thickness (h_{min}) must be defined. These values are also determined by tests.

The characteristic loads of anchors for various failure modes are in accordance to the so-called 5% fractile obtained from ultimate load tests. The 5% fractile represents the failure load where 5 % of the tested failure loads fall below and 95 % of them exceed this value with ultimate tests. Figure 2.27a shows the results of a number of tests conducted using undercut anchors, as a function of their probability. For example the first classification contains all test results for ultimate loads between F_u > 42 kN and F_u ≤ 43 kN, and the last classification all the values between F_u > 54 kN and F_u ≤ 55 kN (each square represents one result). The results are suitable evaluated by use of the Gauss curve, as shown in figure 2.27a. Figure 2.27b shows the curve without the individual results. The mean value for the ultimate load is F_u = 48.7 kN and the 5 % fractile of the results $F_{5\%}$ = 44.5 kN. The blue area to the left indicates the 5 % fractile as 5 % of the total area where as to the right hand side lays an area 95 % of the total surface below the curve.

Figure 2.27:
Distribution of peak loads due to concrete cone failure for a series of tests with undercut anchors



The 5 % fractile is determined by the equation. (2.1). The characteristic loads are given as the 5 % fractile in accordance to Owen /6/. It is assumed that the standard deviation of the test results is unknown. The calculation of the k-factor depends upon the number of tests carried out. The greater the number of tests, the larger the information of the series and therefore the smaller the value of the k-factor.

$$F_{5\,\%} = F_u - k \cdot s \qquad (2.1)$$

Where:

F_u = mean value of the test results (tension load or shear load)

s = standard deviation of the test results

k = factor in accordance to Owen /6/

= 3.401 for n = 5 tests

= 2.568 for n = 10 tests

= 2.208 for n = 20 tests

= 1.861 for n = 100 tests

= 1.645 for n = infinite number of tests

2.6 Design method of anchors

Based on the basic principle, that the resistant load is to be higher than the applied load, the design method of anchors in the ultimate limit state has developed as follows:.

In Germany in the nineties, a simplified method of design „The Kappa Method" was applied. The anchor resistance was described using an allowable working load. This allowable working load was calculated by dividing the characteristic resistance with a global safety factor 3.0, obtained by simply multiplying the load factor (1.4) with the resistance factor (1.8). A linear influence of the edge distances and spacing is taken into consideration. The „Kappa Method" is easy to apply, but has the disadvantage that in many cases the results are too conservative and non economical. In many cases the post installed anchor fixings could not be used due to these disadvantages.

In order to increase the application possibilities of post installed fixings, and to provide a more economical solution, the cc-Method (CC = Concrete Capacity) was developed. The CC-Method is based on the partial safety factor principle, for applied loads (dependant on dead and live loads) and resistance (depending on the mode of failure). The CC-Method offers an economical design method, but is very time-consuming if calculating by hand. The design is made easier by using a computer programme (e.g. fischer Compufix programme).

We have derived a simplified CC-Method in order to offer comprehensible calculations by hand. The calculation parameters and examples are given in detail in Section 4.

2.7 References

/1/ Bergmeister, K.: Stochastik in der Befestigungstechnik mit realistischen Einflussgrößen (Stochastics in Fastening Technique Based on Realistic Influence Parameters). Dissertation, Universität Innsbruck, 1988 (in German).

/2/ Eligehausen, R., Bozenhardt, A.: Crack widths as measured in actual structures and conclusions for the testing of fastening elements. Bericht Nr. 1/42-89/9, Institut für Werkstoffe im Bauwesen, Universität Stuttgart, August 1989.

/3/ Schießl, P.: Einfluss von Rissen auf die Dauerhaftigkeit von Stahlbeton- und Spannbetonbauteilen (Influence of Cracks on the Durability of Reinforced and Prestressed Concrete Elements). Schriftenreihe des Deutschen Ausschuss für Stahlbeton, Heft 370, Verlag Wilhelm Ernst&Sohn, Berlin, 1986 (in German).

/4/ European Organisation for Technical Approvals (EOTA) (1994): Guideline for European Technical Approval of Anchors (Metal Anchors) for Use in Concrete. Final Draft, Sept. 1994, Part 1: Anchors in General. Part 2: Torque Controlled Expansion Anchors. Part 3: Undercut Anchors. Annex A: Details of Tests. Annex B: Tests for Admissible Service Conditions, Detailed Information.

Annex C: Design Method for Anchorages.

/5/ Eligehausen, R., Mallée, R., Silva, J. R.: Anchorage in Concrete Construction. Verlag Ernst&Sohn, Berlin, 2006

/6/ Owen, D.: Handbook of Statistical Tables. Addison/Wesley Publishing Company Inc., 1968.

Notes

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Anchor selection

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Anchor selection

3

Anchor type	Page	Material				Principle of function		
		Carbon steel	Stainless steel A4	Hot-dip galvanised	High corrosion resis-tant steel 1.4529	Undercut	Bonding	Expansion
Anchor bolt FAZ II 	66	●	●		●			●
Bolt FBN II 	76	●	●	●				●
High Performance anchor FH II 	88	●	●					●
High Performance anchor FH II-I 	100	●	●					●
Zykon bolt anchor FZA 	112	●	●		●	●		
Zykon through anchor FZA-D 	122	●	●		●	●		
Zykon internally-threaded anchor FZA-I 	130	●	●			●		
Zykon hammerset anchor FZEA II 	138	●	●		●	●		
Heavy duty anchor TAM 	148	●						●
Heavy duty anchor TAM - internal thread 	148	●						●
Hammerset anchor EA II 	158	●	●					●

Anchor selection

Type of installation			Installation characteristics		Screw- or bolt size	Design load in concrete C 20/25				Standard design form	
Through fixing	Pre-positioned fixing	Internal thread	Drill-diameter	Drill depth		non-cracked concrete carbon steel		cracked concrete carbon steel		Expansion / Undercut anchor	Bonded anchor
			[mm]	[mm]		N_{Rd} [kN]	V_{Rd} [kN]	N_{Rd} [kN]	V_{Rd} [kN]		
●	●		8 - 24	55 - 155	M8 - M24	7.2 - 51.8	9.6 - 68.8	6.0 - 33.5	9.6 - 68.8	●	
●	●		6 - 20	40 - 135	M6 - M20	4.0 - 36.2	3.8 - 53.6	-	-	●	
●			10 - 32	55 - 180	M6 - M24	9.4 - 68.0	9.4 - 119.2	5.0 - 44.1	6.1 - 88.2	●	
		●	12 - 15	85 - 95	M6 - M12	6.7 - 19.7	4.0 - 19.2	6.0 - 8.0	4.0 - 19.2	●	
	●		10 - 22	43 - 127	M6 - M16	9.4 - 51.7	6.4 - 50.2	6.1 - 33.5	6.4 - 50.2	●	
●			12 - 22	43 - 105	M8 - M16	9.4 - 37.0	12.2 - 60.2	6.1 - 24.0	7.9 - 60.2	●	
		●	12 - 22	43 - 127	M6 - M12	9.4 - 31.5	5.7 - 18.5	6.1 - 31.5	5.7 - 18.5	●	
		●	10 - 14	43	M8 - M12	6.4 - 8.7	6.6 - 12.2	5.7 - 6.1	6.6 - 7.9	●	
●	●		10 - 18	65 - 105	M6 - M12	5.9 - 18.0	4.6 - 23.8	-	-	●	
		●	10 - 18	65 - 105	M6 - M12	5.9 - 18.0	4.6 - 23.8	-	-	●	
		●	8 - 25	32 - 85	M6 - M20	5.5 - 24.0	4.0 - 40.8	-	-	●	

Anchor selection

Anchor type	Page	Material				Principle of function		
		Carbon steel	Stainless steel A4	Hot-dip galvanised	High corrosion resistant steel 1.4529	Undercut	Bonding	Expansion
Highbond anchor FHB II 	168	●	●		●		●	●
Powerbond-System FPB 	184	●	●		●		●	
Superbond FSB with threaded rod 	200	●	●		●		●	
Superbond FSB with Internal-threaded anchor RG MI 	220	●	●				●	
Superbond FSB with rebars 	236	●	●				●	
Injection mortar FIS EM with threaded rod 	256	●	●	●	●		●	
Injection mortar FIS EM with Internal-threaded anchor RG MI 	282	●	●				●	
Injection mortar FIS EM with rebars 	296	●	●				●	

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Anchor selection

Type of installation			Installation characteristics		Screw- or bolt size	Design load in concrete C 20/25				Standard design form	
Through fixing	Pre-positioned fixing	Internal thread	Drill-diameter	Drill depth		non-cracked concrete carbon steel		cracked concrete carbon steel		Expansion / Undercut anchor	Bonded anchor
			[mm]	[mm]		N_{Rd} [kN]	V_{Rd} [kN]	N_{Rd} [kN]	V_{Rd} [kN]		
●	●		10 - 25	75 - 235	M8 - M24	16.7 - 91.7	11.0 - 101.5	11.2 - 73.0	11.0 - 101.5	●	
●	●		14 - 20	60 - 192	M10 - M16	19.3 - 47.1	12.0 - 50.4	18.8 - 33.5	12.0 - 50.4		●
●	●		10 - 35	60 - 600	M8 - M30	12.7 - 157.7	7.2 - 180.0	8.7 -112.4	7.2 - 180.0		●
		●	14 - 32	90 - 200	M8 - M20	12.7 - 95.2	7.4 - 72.0	11.3 -58.6	7.4 - 72.0		●
	●		10 - 40	60 - 640	Ø 8 - Ø 32 mm	10.7 - 150.8	9.2 - 147.3	6.0 - 120.6	9.2 - 147.3		●
●	●		12 - 50	60 - 630	M8 - M42	12.7 - 269.3	7.2 - 224.2	9.4 - 146.6	7.2 - 224.2		●
		●	14 - 32	90 - 200	M8 - M20	12.7 - 79.4	7.4 - 72.0	12.7 - 56.6	7.4 - 72.0		●
	●		12 - 55	60 - 800	Ø 8 - Ø 40 mm	20.0- 224.4	9.2 - 230.7	9.4 - 139.6	9.2 - 230.7		●

Anchor selection

Anchor type	Page	Material				Principle of function		
		Carbon steel	Stainless steel A4	Hot-dip galvanised	High corrosion resistant steel 1.4529	Undercut	Bonding	Expansion
Injection mortar FIS V, FIS VS, FIS VW with threaded rod 	320	●	●	●	●		●	
Injection mortar FIS V, FIS VS, FIS VW with Internal-threaded anchor RG MI 	336	●	●				●	
Injection mortar FIS V, FIS VS, FIS VW with rebars 	348	●	●				●	
Resin anchor R 	362	●	●		●		●	
Resin anchor R with Internal-threaded anchor RG MI 	374	●	●				●	
Injection mortar FIS VT 	386	●	●	●	●		●	
Injection mortar FIS VT with Internal-threaded anchor RG MI 	400	●	●				●	
Injection mortar FIS VT with rebars 	410	●	●				●	
Long-shaft fixing SXS 	424	●	●					●

Anchor selection

Type of installation			Installation characteristics		Screw- or bolt size	Design load in concrete C 20/25				Standard design form	
Through fixing	Pre-positioned fixing	Internal thread	Drill-diameter	Drill depth		non-cracked concrete carbon steel		cracked concrete carbon steel		Expansion / Undercut anchor	Bonded anchor
			[mm]	[mm]		N_{Rd} [kN]	V_{Rd} [kN]	N_{Rd} [kN]	V_{Rd} [kN]		
●	●		8 - 35	50 - 600	M6 - M30	6.8 - 149.5	4.0 - 112.8	-	-		●
		●	14 - 32	90 - 200	M8 - M20	12.7 - 76.7	7.4 - 60.0	-	-		●
	●		10 - 35	64 - 560	Ø 8 - Ø 28 mm	14.7 - 124.6	9.2 - 113.3	-	-		●
	●		10 - 35	80 - 280	M8 - M30	12.3 - 140.7	5.9 - 102.6	-	-		●
		●	14 - 32	90 - 200	M8 - M20	12.7 - 76.4	7.4 - 49.6	-	-		●
	●		10 - 35	64 - 360	M8 - M30	8.5 - 131.9	7.2 - 112.8	-	-		●
		●	14 - 32	90 - 200	M8 - M20	12.7 - 52.8	7.4 - 49.6	-	-		●
	●		12 - 40	64 - 360	Ø 8 - Ø 30 mm	10.6 - 102.6	9.2 - 130.0	-	-		●
●			10	60	Ø 7.6 mm	3.6 - 5.3	10.3	1.7 - 2.8	4.2 - 5.0	●	

Special note

- Our aim is continuous development and innovation. Therefore the values given in this Technical Handbook are subject to change without notice. The specified data only apply when fischer anchors are used.
- All products must be used, handled and applied strictly in accordance with all current instructions for use published by fischerwerke (i.e. catalogues, technical instructions, manuals, setting instructions, installation manuals and others).
- Construction materials (anchor ground) as well as the conditions (environmental conditions like temperature, humidity) vary in a wide range. Therefore the present condition of the base material and the applicability must be checked by the user. If you are in doubt of the condition of the base material (i.e. strength), contact your nearest fischerwerke organisation or representative.
- The information and recommendations given in this Technical Handbook are based on principles, equations and safety factors defined in technical instructions of fischerwerke, operation manuals, installation instructions and other information that are believed to be correct at the time of establishing. The values are the result of the evaluation of test results under laboratory conditions. The conditions of use in the Technical Handbook (e.g. design resistances, characteristic distances) may vary from those of the technical approvals and evaluation reports. The user has the responsibility to check whether the present conditions on site and the anchors, setting tools etc. intended to use comply with the conditions given in the Technical Handbook. The ultimate responsibility for selecting the product for the individual application is with the customer.
- fischerwerke 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 intention. Implied warranties of merchantability or fitness are expressly excluded.

The used symbols of the different approvals are listed below.

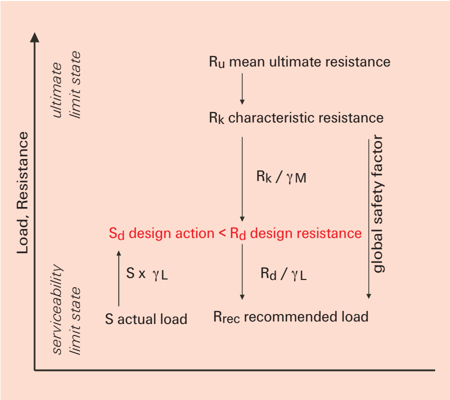
Symbol	Description
ETA / CE	**European Technical Approval** Key document for specifiers. It contains details of the anchor specification, performance characteristics, design method and application limits. It indicates which option is covered for category of use.
CC-ZULASSUNG / Z-21.2-1734	**German Technical Approval** Key document for specifiers. It contains details of the anchor specification, performance characteristics, design method and application limits.
FM APPROVED from thread M 10	**FM Approved** = Factory Mutual Approved. Factory Mutual Research Corporation for Property Conservation: Fire Protection.
ICC ES ESR-2691 See ICC-ES Evaluation Report at www.ic-es.org Inspection agency: AA-707	**ICC = International Code Council, formed from BOCA, ICBO and SBCCI** ICC Evaluation Service Inc. (ICC ES) issues evaluation reports, in this case for the above anchor based upon the Uniform Building Code™ and related codes in the United States of America.
Fire resistance classification R 120 Anchor types see test report	**Fire Resistance classification**
CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE	**Calculation with Compufix calculation software possible**
	For Sprinkler Systems

Design of anchors

4

Safety concept

This Technical Handbook uses the partial safety factor concept. Within this concept, the well known global safety factor is separated in two partial safety factors, namely a partial safety factor for material resistance γ_M and a partial safety factor for load actions γ_L (see figure below).



The partial safety factors for actions γ_L cover uncertainties and scatter of the dead and variable loads. The partial safety factors for the material resistance include scatter of the material resistance, namely the load bearing capacity of the fastening. The partial safety factors for the resistance depend on the quality and the failure mode (i.e. steel failure, pull-out failure, concrete cone failure) of the anchors.

Design method

In order to offer comprehensible calculations a simplified CC-method (concrete capacity method) is used in this section. It is necessary to differentiate between the load direction and the mode of failure. The main advantages of this design method are:

- Design resistance corresponds to different failure modes
- Differentiation of the safety factors based on different failure modes

The used design method is based on the CC-method. The purpose of the simplification is that engineers could use it easily and quickly solve oncoming design in practical day work. In the simplified method an implying of eccentricities of tension and shear loads is not taken into account.

For calculation of the anchor design resistance the most unfavourable anchor should be considered. In most cases this anchor is easy to define (anchor with the most unfavourable combination of highest loading, smallest edge distance and closest spacing to other anchors of the group). If this decision can't be done without further detailed calculation, the proof has to be done for all anchors, which might be decisive. The influences of the edge distances and anchor spacing are considered with different reduction factor separately.

Load distribution in anchor groups with tension and shear actions through the center of gravity of the group

Decisive for the distribution of the loads acting on anchor group to the single anchor within the group is the stiffness of the base plate itself and the connection of the single anchor to the base plate. The base plate has to be stiff enough to ensure equal distribution of the loads. Engineering consideration has to be taken by the responsible designer by defining the dimensions of the base plate. The connection of the single anchor to the base plate has to be ensured by the defined installation torque and by the defined hole clearance in the fixture (base plate). These values are listed for each anchor type in the table “Anchor Installation Data” in the following design section.

For anchor groups with more than 3 anchors in a row which are loaded in shear towards an edge the clearance between the anchor and the base plate has to be filled with adhesive mortar. It is recommended to use FIS V or FIS EM.

Tension loads:

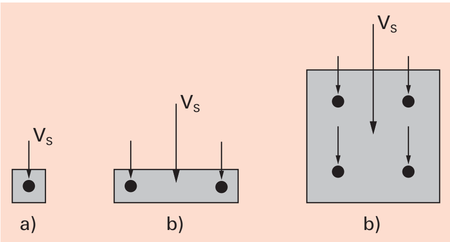
If the conditions mentioned above are met then the tension loads action on the group can be distributed equally to all anchors.

Shear loads:

The distribution of the shear loads depends on the mode of failure. If the hole clearance in the fixture (base plate) are according to the defined installation data of the fischer anchors the distribution can be done as follows:

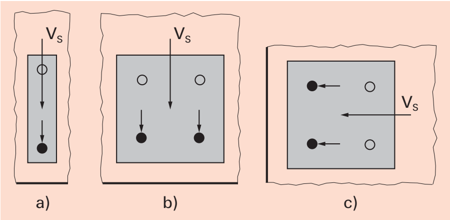
For the design proof of the failure modes steel failure or pryout failure it can be assumed that all loads are distributed equally to the anchors of the group, if the shear loads are through the center of gravity of the anchors. Examples are shown in Figure 4.1.

Figure 4.1:
Examples of load distribution when all anchors take up shear loads



For the design proof of concrete edge failure (generally decisive for anchor groups with small concrete edge distance which are loaded towards the edge) it shall be assumed that only the most unfavourable anchor/s take up the shear loads. Examples are shown in Figure 4.2.

Figure 4.2:
Examples of load distribution, when only the most unfavourable anchors take up shear loads



If the concrete edge distance is large (c ≧ max (60 d_{nom} ; 10 h_{ef})) it can be assumed that concrete edge failure is not decisive. In this case the design proof for concrete edge failure can be omitted.

Load distribution in anchor groups with combined tension, shear and moment actions

To evaluate the distribution of the anchor loads within the group engineering consideration have to be taken. As a simplified approach the distribution of the loads can be determined by applying the method of reinforced concrete sections with the assumption that the anchors don't resist compression forces. If the base plate is stiff enough the compression forces are transferred directly by the base plate into the concrete.

The design proof has to be done for the most unfavourable anchor. This is the anchor with the most unfavourable combination of loading and geometrical constraints (edge distance, spacing). Engineering judgment is necessary. If it is not certain which anchor is the decisive anchor, the design proof has to be done for all anchors which might be decisive.

Handling of the Design Standard Forms

The design method consists of two elements:

- Design values in tables section 4 (tension) and 5 (shear): These values are available for each product type and size.

Design of anchors

Anchor design according to fischer specification

- Design Standard Form: This standard is given for expansion/undercut anchors and for bonded type anchors separately.

The entire design can be done by using these two elements. The Design Standard Form guides through the design process step by step. All relevant anchor values and use conditions can be filled in. The anchor related characteristic values can be taken from the product sections 4 and 5. The relevant formulas are shown and the calculated results can be compared with the required conditions for the design proof directly.

In the following table it is listed, which Design Standard Form shall be used for the design of which anchor system.

Table 4.1: Design standard form for specific anchor system

Anchor system	Design standard form
FAZ II	Design standard form for fischer expansion/undercut anchors
FBN II	Design standard form for fischer expansion/undercut anchors
FH II	Design standard form for fischer expansion/undercut anchors
FZA	Design standard form for fischer expansion/undercut anchors
FZA-D	Design standard form for fischer expansion/undercut anchors
FZA-I	Design standard form for fischer expansion/undercut anchors
FZEA II	Design standard form for fischer expansion/undercut anchors
TA M	Design standard form for fischer expansion/undercut anchors
EA II	Design standard form for fischer expansion/undercut anchors
FHB II	Design standard form for fischer expansion/undercut anchors
FIS EM	Design standard form for fischer bonded anchors
FIS EM with RG MI	Design standard form for fischer bonded anchors
FIS EM with Rebar	Design standard form for fischer bonded anchors
FIS V	Design standard form for fischer bonded anchors
FIS V with RG MI	Design standard form for fischer bonded anchors
FIS V with Rebar	Design standard form for fischer bonded anchors
R RGM	Design standard form for fischer bonded anchors
R RGMI	Design standard form for fischer bonded anchors
FIS VT	Design standard form for fischer bonded anchors
FIS VT with RG MI	Design standard form for fischer bonded anchors
SXS	Design standard form for fischer expansion/undercut anchors

In the following, the design method used in this handbook will be shown by using different calculation examples.

NOTE:

On the following pages you can find the

- Design standard form for fischer expansion/undercut anchors
- Design standard form for fischer bonded anchors

fischer provides these design standard forms also for download as a pdf-file: **www.fischer.de/THBint**

Design standard form for fischer expansion/undercut anchors

Anchor design according to fischer specification

General information

Acting design load in tension on group					N^G_{Sd}		**1**
number of anchors in the group acting in tension; n	n =		tension component of the load acting on single anchor	$N_{Sd} = \frac{N^G_{Sd}}{n}$	N_{Sd}		**2**
Acting design load in shear on group					V^G_{Sd}		**3**
Steel failure and pryout-failure							**4**
number of anchors in the group acting in shear; n	n =		shear component of the load acting on single anchor at steel and pryout failure	$V_{Sd,s} = V_{Sd,cp} = \frac{V^G_{Sd}}{n}$	$V_{Sd,s}$ $V_{Sd,cp}$		**5**
Concrete Edge Failure							**6**
number of anchors in the group considered to act in shear at the edge; n_c • if load is towards the edge only anchors at the edge can be taken • if load is away from the edge or parallel to the edge all anchors can be taken	n_c =		shear component of the load acting on single anchor at concrete edge failure	$V_{Sd,c} = \frac{V^G_{Sd}}{n_c}$	$V_{Sd,c}$		**7**
Anchor and base material data							**8**
type of anchor							**9**
concrete strength class			cracked concrete ☐		non-cracked concrete ☐		**10**

Design standard form for fischer expansion/undercut anchors

Anchor design according to fischer specification

4

Calculation of tension resistance

Tension: Calculation of steel resistance - highest loaded anchor				11
	$N_{Rd,s}$		- basic resistance, section 4.1	12

Tension: Calculation of concrete pull-out resistance - most unfavourable anchor					13
cracked concrete ☐	non-cracked concrete ☐	$N^0_{Rd,p}$		- basic resistance, section 4.2	14
concrete strength class		$f_{b,N}$		- influence of concrete strength section 4.3.1	15
		$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$			16

Tension: Calculation of concrete cone resistance - most unfavourable anchor									17
cracked concrete ☐				non-cracked concrete ☐		$N^0_{Rd,c}$		- basic resistance, section 4.3	18
concrete strength class						$f_{b,N}$		- influence of concrete strength, section 4.3.1	19
$s_1 =$		$s_{cr,N} =$		$s_1 / s_{cr,N} =$		f_{s1}		- characteristic distance, section 4.3.2 - influence of spacing, section 4.3.2.1	20
$s_2 =$				$s_2 / s_{cr,N} =$		f_{s2}			
$s_3 =$				$s_3 / s_{cr,N} =$		f_{s3}			
$c_1 =$		$c_{cr,N} =$		$c_1 / c_{cr,N} =$		$f_{c1,A}$		- characteristic distance, section 4.3.2 - influence of edge distance, section 4.3.2.2 $c_1 < c_2$	21
						$f_{c1,B}$			
$c_2 =$				$c_2 / c_{cr,N} =$		f_{c2}			
						$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c,2}$			22

Tension: Calculation of concrete splitting resistance - most unfavourable anchor									23
cracked concrete ☐	proof of splitting is only necessary for non-cracked concrete; if cracked concrete go to line 32								24
$c_{cr,sp} =$		$c_{cr,N} =$				$c_{cr,sp} > c_{cr,N}$	☐	proof of splitting failure in non-cracked concrete is only necessary if all of the conditions on the left side are met	25
$1.2\ c_{cr,sp} =$		$c_1 =$				$1.2\ c_{cr,sp} > c_1$	☐		

				non-cracked concrete ☐		$N^0_{Rd,c}$		- basic resistance, section 4.3	26
concrete strength class						$f_{b,N}$		- influence of concrete strength, section 4.3.1	27
$s_1 =$		$s_{cr,sp} =$		$s_1 / s_{cr,sp} =$		$f_{s1,sp}$		- characteristic distance, section 4.3.3 - influence of spacing, section 4.3.3.1	28
$s_2 =$				$s_2 / s_{cr,sp} =$		$f_{s2,sp}$			
$s_3 =$				$s_3 / s_{cr,sp} =$		$f_{s3,sp}$			
$c_1 =$		$c_{cr,sp} =$		$c_1 / c_{cr,sp} =$		$f_{c1,sp,A}$		- characteristic distance, section 4.3.3 - influence of edge distance, section 4.3.3.2 $c_1 < c_2$	29
						$f_{c1,sp,B}$			
$c_2 =$				$c_2 / c_{cr,sp} =$		$f_{c2,sp}$			
h =		$h_{min} =$		$h/h_{min} =$		f_h		- influence of member thickness section 4.3.3.3	30
						$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$			31

Decisive resistance in tension - required proof						32
lowest value	$N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$		N_{Rd}			33
tension component of load acting on single anchor	N_{Sd}		$\frac{N_{Sd}}{N_{Rd}}$		≦ 1	34

Design standard form for fischer expansion/undercut anchors

Anchor design according to fischer specification

Calculation of shear resistance

Shear: Calculation of steel resistance - most unfavourable anchor						**35**
			$V_{Rd,s}$		- basic resistance, section 5.1	**36**
shear component of load acting on single anchor at steel resistance	$V_{Sd,s}$		$\frac{V_{Sd,s}}{V_{Rd,s}}$		≦ 1	**37**

Shear: Calculation of concrete pryout resistance - most unfavourable anchor						**38**
			$N_{Rd,c}$		- calculation section 4.3, section 5.2	**39**
			k			
			$V_{Rd,cp} = N_{Rd,c} \cdot k$			**40**
shear component of load acting on single anchor at pryout resistance	$V_{Sd,cp}$		$\frac{V_{Sd,cp}}{V_{Rd,cp}}$		≦ 1	**41**

Shear: Calculation of concrete edge resistance most - unfavourable anchor (proof of resistance towards edge and parallel to edge if necessary)										**42**
cracked concrete ☐		non-cracked concrete ☐			c_1 =		$V^0_{Rd,c}$		- basic resistance, section 5.3	**43**
concrete strength class							$f_{b,V}$		- influence of concrete strength, section 5.3.1	**44**
angle α_V							$f_{\alpha,V}$		- influence of load direction, section 5.3.2	**45**
s_1 =		c_1 =			s_1/c_1 =		$f_{s1,V}$		- influence of spacing, section 5.3.3	**46**
s_2 =					s_2/c_1 =		$f_{s2,V}$			
c_2 =					c_2/c_1 =		$f_{c2,V}$		- influence of edge distance, section 5.3.4, c1 < c2	**47**
h =					h/c_1 =		$f_{h,V}$		- influence of member thickness, section 5.3.5	**48**
n =		s =		c_1 =	s/c_1 =		f_m		- influence of n ≧ 4 anchors in a row at the edge, section 5.3.6	**49**
							$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$			**50**
shear component of load acting on single anchor at concrete edge resistance					$V_{Sd,c}$		$\frac{V_{Sd,c}}{V_{Rd,c}}$		≦ 1	**51**

Shear: Decisive design proof in shear					**52**
highest value	$\frac{V_{Sd,s}}{V_{Rd,s}}$; $\frac{V_{Sd,cp}}{V_{Rd,cp}}$; $\frac{V_{Sd,c}}{V_{Rd,c}}$	$\frac{V_{Sd}}{V_{Rd}}$		≦ 1	**53**

Summary of required proof

Required proof for interaction								**54**
$\frac{N_{Sd}}{N_{Rd}}$		$\frac{V_{Sd}}{V_{Rd}}$		$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}}$		☐	combined tension and shear ≦ 1.2	**55**

Proof of resistance towards edge and parallel to edge, if necessary.

Design standard form for fischer bonded anchors

Anchor design according to fischer specification

General information

Acting design load in tension on group					N^G_{Sd}		1
number of anchors in the group acting in tension; n	n =		tension component of the load acting on single anchor	$N_{Sd} = \frac{N^G_{Sd}}{n}$	N_{Sd}		2
Acting design load in shear on group					V^G_{Sd}		3
Steel failure and pryout-failure							4
number of anchors in the group acting in shear; n	n =		shear component of the load acting on single anchor at steel and pryout failure	$V_{Sd,s} = V_{Sd,cp} = \frac{V^G_{Sd}}{n}$	$V_{Sd,s}$		5
					$V_{Sd,cp}$		
Concrete Edge Failure							6
number of anchors in the group considered to act in shear at the edge; n_c • if load is towards the edge only anchors at the edge can be taken • if load is away from the edge or parallel to the edge all anchors can be taken	n_c =		shear component of the load acting on single anchor at concrete edge failure	$V_{Sd,c} = \frac{V^G_{Sd}}{n_c}$	$V_{Sd,c}$		7

Anchor and base material data						8
type of anchor						9
steel type		embedment depth h_{ef}		temperature range		10
concrete strength class		cracked concrete ☐		non-cracked concrete ☐		11

Drilling method	**Hole condition**	12
hammer ☐	wet or dry ☐	13
diamond ☐	waterfilled ☐	14

Calculation of tension resistance

Tension: Calculation of steel resistance - most unfavourable anchor			15
$N_{Rd,s}$		- basic resistance, section 4.1	16

Tension: Design combined concrete cone / pull-out resistance most unfavourable anchor								17
cracked concrete ☐		non-cracked concrete ☐			$N^0_{Rd,p}$		- basic resistance, section 4.2	18
concrete					$f_{b,N,p}$		- influence of concrete strength, section 4.2.1	19
s_1 =		$s_{cr,Np}$ =		$s_1/s_{cr,Np}$ =	$f_{s1,p}$		- characteristic distance, section 4.2.2 - influence of spacing, section 4.2.2.1	20
s_2 =				$s_2/s_{cr,Np}$ =	$f_{s2,p}$			
s_3 =				$s_3/s_{cr,Np}$ =	$f_{s3,p}$			
c_1 =		$c_{cr,Np}$ =		$c_1/c_{cr,Np}$ =	$f_{c1,p,A}$		- characteristic distance, section 4.2.2 - influence of edge distance, section 4.2.2.2 $c_1 < c_2$	21
					$f_{c1,p,B}$			
c_2 =				$c_2/c_{cr,Np}$ =	$f_{c2,p}$			
$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$								22

continued next page

Design standard form for fischer bonded anchors

Anchor design according to fischer specification

Tension: Calculation of concrete cone resistance - most unfavourable anchor									**23**
cracked concrete ☐			non-cracked concrete ☐			$N^0_{Rd,c}$		- basic resistance, section 4.3	**24**
concrete strength class						$f_{b,N}$		- influence of concrete strength, section 4.3.1	**25**
s_1 =		$s_{cr,N}$ =		$s_1/s_{cr,N}$ =		f_{s1}		- characteristic distance, section 4.3.2 - influence of spacing, section 4.3.2.1	**26**
s_2 =				$s_2/s_{cr,N}$ =		f_{s2}			
s_3 =				$s_3/s_{cr,N}$ =		f_{s3}			
c_1 =		$c_{cr,N}$ =		$c_1/c_{cr,N}$ =		$f_{c1,A}$		- characteristic distance, section 4.3.2 - influence of edge distance, section 4.3.2.2 $c_1 < c_2$	**27**
						$f_{c1,B}$			
c_2 =				$c_2/c_{cr,N}$ =		f_{c2}			
$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$									**28**

Tension: Calculation of concrete splitting resistance - most unfavourable anchor							**29**
cracked concrete ☐	proof of splitting is only necessary for non-cracked concrete; if cracked concrete go to line 36						**30**
h =		h_{ef} =		h/h_{ef} =		- characteristic distance for design, section 4.3.3	**31**
if $h/h_{ef} \geqq 2.0$ or $h/h_{ef} \leqq 1.3$ ☐				if $2.0 > h/h_{ef} > 1.3$ ☐			
				$f_{scr,sp}$ =			
				h_{ef} =			
$s_{cr,sp}$ =				$s_{cr,sp} = f_{scr,sp} \cdot h_{ef}$			
$c_{cr,sp}$ =				$c_{cr,sp} = s_{scr,sp}/2$			
$c_{cr,sp}$ =		$c_{cr,N}$ =		$c_{cr,sp} > c_{cr,N}$ ☐		proof of splitting in non-cracked concrete is only necessary if both conditions on the left are met	**32**
1.2 $c_{cr,sp}$ =		c_1 =		1.2 $c_{cr,sp} > c_1$ ☐			

			non-cracked concrete ☐			$N^0_{Rd,c}$		- basic resistance, section 4.3	**33**
concrete strength class						$f_{b,N,c}$		- influence of concrete strength, section 4.3.1	**34**
s_1 =		$s_{cr,sp}$ =		$s_1/s_{cr,sp}$ =		$f_{s1,sp}$		- characteristic distance, section 4.3.3 - influence of spacing, section 4.3.3.1	**35**
s_2 =				$s_2/s_{cr,sp}$ =		$f_{s2,sp}$			
s_3 =				$s_3/s_{cr,sp}$ =		$f_{s3,sp}$			
c_1 =		$c_{cr,sp}$ =		$c_1/c_{cr,sp}$ =		$f_{c1,sp,A}$		- characteristic distance, section 4.3.3 - influence of edge distance, section 4.3.3.2 $c_1 < c_2$	**36**
						$f_{c1,sp,B}$			
c_2 =				$c_2/c_{cr,sp}$ =		$f_{c2,sp}$			
h =		h_{min} =		h/h_{min} =		f_h		- influence of member thickness section 4.3.3.3	**37**
$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$									**38**

Decisive resistance in tension - required proof						**39**
lowest value	$N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$		N_{Rd}			**40**
tension component of load acting on single anchor	N_{Sd}		$\frac{N_{Sd}}{N_{Rd}}$		≦ 1	**41**

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Design standard form for fischer bonded anchors

Anchor design according to fischer specification

Calculation of shear resistance

Shear: Calculation of steel resistance - most unfavourable anchor						42
			$V_{Rd,s}$		- basic resistance, section 5.1	43
shear component of load acting on single anchor at steel resistance	$V_{Sd,s}$		$\frac{V_{Sd,s}}{V_{Rd,s}}$		$\leqq 1$	44

Shear: Calculation of concrete pryout resistance - most unfavourable anchor							45
$N_{Rd,p}$		$N_{Rd,c}$		$N_{Rd} = min (N_{Rd,c}\ N_{Rd,p})$		- calculation section 4.2 and 4.3, section 5.2	46
				k			
				$V_{Rd,cp} = N_{Rd} \cdot k$			47
shear component of load acting on single anchor at pryout resistance	$V_{Sd,cp}$			$\frac{V_{Sd,cp}}{V_{Rd,cp}}$		$\leqq 1$	48

Shear: Calculation of concrete edge resistance most - unfavourable anchor (proof of resistance towards edge and parallel to edge if necessary)											49
						c_1 =		$V^0_{Rd,c}$		- basic resistance, section 5.3, section 5.3.1	50
cracked concrete f_{cr} = 0.7 ☐				non-cracked concrete f_{cr} = 1.0 ☐				f_{cr}			
concrete strength class								$f_{b,V}$		- influence of concrete strength, section 5.3.2	51
angle α_V								$f_{\alpha,V}$		- influence of load direction, section 5.3.3	52
s_1 =		c_1 =				s_1/c_1 =		$f_{s1,V}$		- influence of spacing, section 5.3.4	53
s_2 =						s_2/c_1 =		$f_{s2,V}$			
c_2 =						c_2/c_1 =		$f_{c2,V}$		- influence of edge distance, section 5.3.5, c1 < c2	54
h =						h/c_1 =		$f_{h,V}$		- influence of member thickness, section 5.3.6	55
n =		s =		c_1 =		s/c_1 =		f_m		- influence of n ≧ 4 anchors in a row at the edge, section 5.3.7	56
								$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$			57
shear component of load acting on single anchor at concrete edge resistance						$V_{Sd,c}$		$\frac{V_{Sd,c}}{V_{Rd,c}}$		$\leqq 1$	58

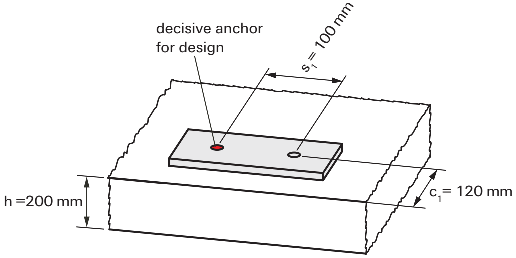
Shear: Decisive design proof in shear					59
highest value	$\frac{V_{Sd,s}}{V_{Rd,s}}$; $\frac{V_{Sd,cp}}{V_{Rd,cp}}$; $\frac{V_{Sd,c}}{V_{Rd,c}}$	$\frac{V_{Sd}}{V_{Rd}}$		$\leqq 1$	60

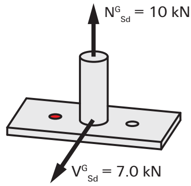
Summary of required proof

Required proof for interaction								61
$\frac{N_{Sd}}{N_{Rd}}$		$\frac{V_{Sd}}{V_{Rd}}$		$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}}$		☐	combined tension and shear $\leqq 1.2$	62

Example 1 - Design standard form for fischer expansion/undercut anchors

Anchor type: **FH II 12 M8 B gvz**
concrete C 16/20
cracked concrete





General information

Acting design load in tension on group					N^G_{Sd}	***10.0 kN***	1
number of anchors in the group acting in tension	n =	***2***	tension component of the load acting on single anchor	$N_{Sd} = \frac{N^G_{Sd}}{n}$	N_{Sd}	***5.0 kN***	2
Acting design load in shear on group					V^G_{Sd}	***7.0 kN***	3
Steel failure and pryout-failure							4
number of anchors in the group acting in shear; n	n =	***2***	shear component of the load acting on single anchor at steel and pryout failure	$V_{Sd,s} = V_{Sd,cp} = \frac{V^G_{Sd}}{n}$	$V_{Sd,s}$ / $V_{Sd,cp}$	***3.5 kN***	5
Concrete Edge Failure							6
number of anchors in the group considered to act in shear at the edge; n_c • if load is towards the edge only anchors at the edge can be taken • if load is away from the edge or parallel to the edge all anchors can be taken	n_c =	***2***	shear component of the load acting on single anchor at concrete edge failure	$V_{Sd,c} = \frac{V^G_{Sd}}{n_c}$	$V_{Sd,c}$	***3.5 kN***	7
Anchor and base material data							8
type of anchor			***FH II 12 M8 B gvz***				9
concrete strength class		***C 16/20***	cracked concrete ☒		non-cracked concrete ☐		10

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Calculation of tension resistance

Tension: Calculation of steel resistance - highest loaded anchor				11
	$N_{Rd,s}$	19.5	- basic resistance, section 4.1	12

Tension: Calculation of concrete pull-out resistance - most unfavourable anchor						13
cracked concrete ☒	non-cracked concrete ☐		$N^0_{Rd,p}$	9.8	- basic resistance, section 4.2	14
concrete strength class	C 16/20		$f_{b,N}$	0.89	- influence of concrete strength section 4.3.1	15
			$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$	8.7		16

Tension: Calculation of concrete cone resistance - most unfavourable anchor									17
cracked concrete ☒		non-cracked concrete ☐				$N^0_{Rd,c}$	11.2	- basic resistance, section 4.3	18
concrete strength class		C 16/20				$f_{b,N}$	0.89	- influence of concrete strength, section 4.3.1	19
$s_1 =$	100	$s_{cr,N} =$	180	$s_1/s_{cr,N} =$	0.56	f_{s1}	0.78	- characteristic distance, section 4.3.2 - influence of spacing, section 4.3.2.1	20
$s_2 =$	-			$s_2/s_{cr,N} =$	-	f_{s2}	-		
$s_3 =$	-			$s_3/s_{cr,N} =$	-	f_{s3}	-		
$c_1 =$	120	$c_{cr,N} =$	90	$c_1/c_{cr,N} =$	1.33	$f_{c1,A}$	1.0	- characteristic distance, section 4.3.2 - influence of edge distance, section 4.3.2.2 $c_1 < c_2$	21
						$f_{c1,B}$	1.0		
$c_2 =$	-			$c_2/c_{cr,N} =$		f_{c2}	-		
						$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c,2}$	7.8		22

Tension: Calculation of concrete splitting resistance - most unfavourable anchor							23
cracked concrete ☒	proof of splitting is only necessary for non-cracked concrete; if cracked concrete go to line 32						24
$c_{cr,sp} =$		$c_{cr,N} =$		$c_{cr,sp} > c_{cr,N}$	☐	proof of splitting failure in non-cracked concrete is only necessary if all of the conditions on the left side are met	25
$1.2\ c_{cr,sp} =$		$c_1 =$		$1.2\ c_{cr,sp} > c_1$	☐		

		non-cracked concrete ☐				$N^0_{Rd,c}$		- basic resistance, section 4.3	26
concrete strength class						$f_{b,N}$		- influence of concrete strength, section 4.3.1	27
$s_1 =$		$s_{cr,sp} =$		$s_1/s_{cr,sp} =$		$f_{s1,sp}$		- characteristic distance, section 4.3.3 - influence of spacing, section 4.3.3.1	28
$s_2 =$				$s_2/s_{cr,sp} =$		$f_{s2,sp}$			
$s_3 =$				$s_3/s_{cr,sp} =$		$f_{s3,sp}$			
$c_1 =$		$c_{cr,sp} =$		$c_1/c_{cr,sp} =$		$f_{c1,sp,A}$		- characteristic distance, section 4.3.3 - influence of edge distance, section 4.3.3.2 $c_1 < c_2$	29
						$f_{c1,sp,B}$			
$c_2 =$				$c_2/c_{cr,sp} =$		$f_{c2,sp}$			
h =		$h_{min} =$		$h/h_{min} =$		f_h		- influence of member thickness section 4.3.3.3	30
						$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$			31

Decisive resistance in tension - required proof						32
lowest value	$N_{Rd,s}; N_{Rd,p}; N_{Rd,c}; N_{Rd,sp}$		N_{Rd}	7.8		33
tension component of load acting on single anchor	N_{Sd}	5.0	$\frac{N_{Sd}}{N_{Rd}}$	0.64	≦ 1	34

Design examples

Anchor design according to fischer specification

Calculation of shear resistance

Shear: Calculation of steel resistance - most unfavourable anchor						35
			$V_{Rd,s}$	**21.6**	- basic resistance, section 5.1	36
shear component of load acting on single anchor at steel resistance	$V_{Sd,s}$	**3.5**	$\frac{V_{Sd,s}}{V_{Rd,s}}$	**0.16**	≦ 1	37

Shear: Calculation of concrete pryout resistance - most unfavourable anchor						38
			$N_{Rd,c}$	**7.8**	- calculation section 4.3, section 5.2	39
			k	**2.0**		
			$V_{Rd,cp} = N_{Rd,c} \cdot k$	**15.6**		40
shear component of load acting on single anchor at pryout resistance	$V_{Sd,cp}$	**3.5**	$\frac{V_{Sd,cp}}{V_{Rd,cp}}$	**0.22**	≦ 1	41

Shear: Calculation of concrete edge resistance most - unfavourable anchor (proof of resistance towards edge and parallel to edge if necessary)											42
cracked concrete ☒		non-cracked concrete ☐			c_1 =	**120**	$V^0_{Rd,c}$	**11.5**	- basic resistance, section 5.3		43
concrete strength class				**C 16/20**			$f_{b,V}$	**0.89**	- influence of concrete strength, section 5.3.1		44
angle α_V				**0°**			$f_{\alpha,V}$	**1.0**	- influence of load direction, section 5.3.2		45
s_1 =	**100**	c_1 =	**120**	s_1/c_1 =		**0.83**	$f_{s1,V}$	**0.63**	- influence of spacing, section 5.3.3		46
s_2 =	**-**			s_2/c_1 =		**-**	$f_{s2,V}$	**-**			
c_2 =	**-**			c_2/c_1 =		**-**	$f_{c2,V}$	**-**	- influence of edge distance, section 5.3.4, c1 < c2		47
h =	**200**			h/c_1 =		**1.67**	$f_{h,V}$	**1.0**	- influence of member thickness, section 5.3.5		48
n =	**2**	s =		c_1 =		s/c_1 =	f_m	**-**	- influence of n ≧ 4 anchors in a row at the edge, section 5.3.6		49
$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$								**6.4**			50
shear component of load acting on single anchor at concrete edge resistance					$V_{Sd,c}$	**3.5**	$\frac{V_{Sd,c}}{V_{Rd,c}}$	**0.55**	≦ 1		51

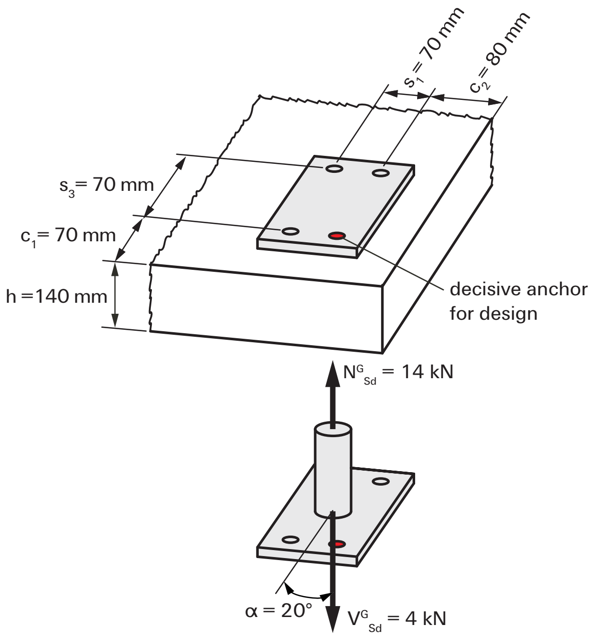
Shear: Decisive design proof in shear					52
highest value	$\frac{V_{Sd,s}}{V_{Rd,s}}$; $\frac{V_{Sd,cp}}{V_{Rd,cp}}$; $\frac{V_{Sd,c}}{V_{Rd,c}}$	$\frac{V_{Sd}}{V_{Rd}}$	**0.55**	≦ 1	53

Summary of required proof

Required proof for interaction								54
$\frac{N_{Sd}}{N_{Rd}}$	**0.64**	$\frac{V_{Sd}}{V_{Rd}}$	**0.55**	$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}}$	**1.19**	☑	combined tension and shear ≦ 1.2	55

Example 2 - Design standard form for fischer expansion/undercut anchors

Anchor type: **FBN II M12 gvz**
h_{ef} = 65 mm
concrete C 30/37
non-cracked concrete



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General information

Acting design load in tension on group					N^G_{Sd}	***14.0 kN***	1
number of anchors in the group acting in tension	n =	***4***	tension component of the load acting on single anchor	$N_{Sd} = \frac{N^G_{Sd}}{n}$	N_{Sd}	***3.5 kN***	2
Acting design load in shear on group					V^G_{Sd}	***4.0 kN***	3
Steel failure and pryout-failure							4
number of anchors in the group acting in shear; n	n =	***4***	shear component of the load acting on single anchor at steel and pryout failure	$V_{Sd,s} = V_{Sd,cp} = \frac{V^G_{Sd}}{n}$	$V_{Sd,s}$ / $V_{Sd,cp}$	***1.0 kN***	5
Concrete Edge Failure							6
number of anchors in the group considered to act in shear at the edge; n_c • if load is towards the edge only anchors at the edge can be taken • if load is away from the edge or parallel to the edge all anchors can be taken	n_c =	***2***	shear component of the load acting on single anchor at concrete edge failure	$V_{Sd,c} = \frac{V^G_{Sd}}{n_c}$	$V_{Sd,c}$	***2.0 kN***	7
Anchor and base material data							8
type of anchor			***FBN II M 12 gvz / h_{ef} = 65 mm***				9
concrete strength class		***C 30/37***	cracked concrete ☐	non-cracked concrete ☒			10

Design examples

Anchor design according to fischer specification

Calculation of tension resistance

Tension: Calculation of steel resistance - highest loaded anchor				11
	$N_{Rd,s}$	25.7	- basic resistance, section 4.1	12

Tension: Calculation of concrete pull-out resistance - most unfavourable anchor						13
cracked concrete ☐	non-cracked concrete ☒		$N^0_{Rd,p}$	17.6	- basic resistance, section 4.2	14
concrete strength class	C 30/37		$f_{b,N}$	1.22	- influence of concrete strength section 4.3.1	15
			$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$	21.5		16

Tension: Calculation of concrete cone resistance - most unfavourable anchor									17
cracked concrete ☐			non-cracked concrete ☒			$N^0_{Rd,c}$	17.6	- basic resistance, section 4.3	18
concrete strength class			C 30/37			$f_{b,N}$	1.22	- influence of concrete strength, section 4.3.1	19
s_1 =	70	$s_{cr,N}$ =	195	$s_1 / s_{cr,N}$ =	0.36	f_{s1}	0.68	- characteristic distance, section 4.3.2 - influence of spacing, section 4.3.2.1	20
s_2 =	-			$s_2 / s_{cr,N}$ =	-	f_{s2}	-		
s_3 =	70			$s_3 / s_{cr,N}$ =	0.36	f_{s3}	0.68		
c_1 =	70	$c_{cr,N}$ =	98	$c_1 / c_{cr,N}$ =	0.71	$f_{c1,A}$	0.91	- characteristic distance, section 4.3.2 - influence of edge distance, section 4.3.2.2 $c_1 < c_2$	21
						$f_{c1,B}$	0.85		
c_2 =	80			$c_2 / c_{cr,N}$ =	0.82	f_{c2}	0.91		
						$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c,2}$	7.0		22

Tension: Calculation of concrete splitting resistance - most unfavourable anchor							23
cracked concrete ☐	proof of splitting is only necessary for non-cracked concrete; if cracked concrete go to line 32						24
$c_{cr,sp}$ =	145	$c_{cr,N}$ =	98	$c_{cr,sp} > c_{cr,N}$	☒	proof of splitting failure in non-cracked concrete is only necessary if all of the conditions on the left side are met	25
$1.2\ c_{cr,sp}$ =	174	c_1 =	70	$1.2\ c_{cr,sp} > c_1$	☒		

			non-cracked concrete ☒			$N^0_{Rd,c}$	17.6	- basic resistance, section 4.3	26
concrete strength class			C 30/37			$f_{b,N}$	1.22	- influence of concrete strength, section 4.3.1	27
s_1 =	70	$s_{cr,sp}$ =	290	$s_1 / s_{cr,sp}$ =	0.24	$f_{s1,sp}$	0.63	- characteristic distance, section 4.3.3 - influence of spacing, section 4.3.3.1	28
s_2 =	-			$s_2 / s_{cr,sp}$ =	-	$f_{s2,sp}$	-		
s_3 =	70			$s_3 / s_{cr,sp}$ =	0.24	$f_{s3,sp}$	0.63		
c_1 =	70	$c_{cr,sp}$ =	145	$c_1 / c_{cr,sp}$ =	0.48	$f_{c1,sp,A}$	0.84	- characteristic distance, section 4.3.3 - influence of edge distance, section 4.3.3.2 $c_1 < c_2$	29
						$f_{c1,sp,B}$	0.73		
c_2 =	80			$c_2 / c_{cr,sp}$ =	0.55	$f_{c2,sp}$	0.78		
h =	140	h_{min} =	120	h / h_{min} =	1.17	f_h	1.11	- influence of member thickness section 4.3.3.3	30
						$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$	4.5		31

Decisive resistance in tension - required proof						32
lowest value	$N_{Rd,s}; N_{Rd,p}; N_{Rd,c}; N_{Rd,sp}$		N_{Rd}	4.5		33
tension component of load acting on single anchor	N_{Sd}	3.5	$\frac{N_{Sd}}{N_{Rd}}$	0.78	≦ 1	34

Calculation of shear resistance

Shear: Calculation of steel resistance - most unfavourable anchor						35
				$V_{Rd,s}$	20.0	- basic resistance, section 5.1	36
shear component of load acting on single anchor at steel resistance	$V_{Sd,s}$	1.0		$\frac{V_{Sd,s}}{V_{Rd,s}}$	0.05	≦ 1	37

Shear: Calculation of concrete pryout resistance - most unfavourable anchor						38
			$N_{Rd,c}$	7.0	- calculation section 4.3, section 5.2	39
			k	2.0		
			$V_{Rd,cp} = N_{Rd,c} \cdot k$	14.0		40
shear component of load acting on single anchor at pryout resistance	$V_{Sd,cp}$	1.0	$\frac{V_{Sd,cp}}{V_{Rd,cp}}$	0.07	≦ 1	41

Shear: Calculation of concrete edge resistance most - unfavourable anchor (proof of resistance towards edge and parallel to edge if necessary)											42
cracked concrete ☐		non-cracked concrete ☒			c_1 =	70	$V^0_{Rd,c}$	8.0	- basic resistance, section 5.3	43
concrete strength class				C 30/37			$f_{b,V}$	1.22	- influence of concrete strength, section 5.3.1	44
angle α_V				20^0			$f_{\alpha,V}$	1.05	- influence of load direction, section 5.3.2	45
s_1 =	70	c_1 =	70		s_1/c_1 =	1.0	$f_{s1,V}$	0.67	- influence of spacing, section 5.3.3	46
s_2 =	-				s_2/c_1 =	-	$f_{s2,V}$	-		
c_2 =	80				c_2/c_1 =	1.14	$f_{c2,V}$	0.82	- influence of edge distance, section 5.3.4, c1 < c2	47
h =	140				h/c_1 =	2	$f_{h,V}$	1.0	- influence of member thickness, section 5.3.5	48
n =	2	s =	-	c_1 = -	s/c_1 =	-	f_m	-	- influence of n ≧ 4 anchors in a row at the edge, section 5.3.6	49
$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$								5.6		50
shear component of load acting on single anchor at concrete edge resistance					$V_{Sd,c}$	2.0	$\frac{V_{Sd,c}}{V_{Rd,c}}$	0.36	≦ 1	51

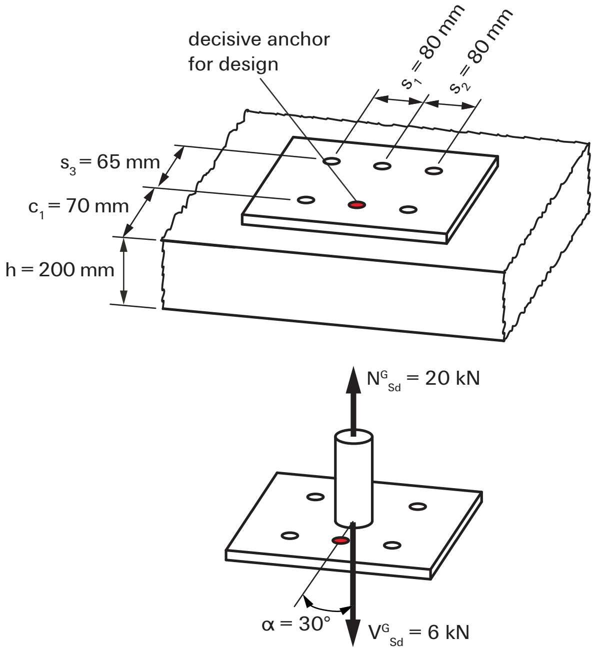
Shear: Decisive design proof in shear					52
highest value	$\frac{V_{Sd,s}}{V_{Rd,s}}$; $\frac{V_{Sd,cp}}{V_{Rd,cp}}$; $\frac{V_{Sd,c}}{V_{Rd,c}}$	$\frac{V_{Sd}}{V_{Rd}}$	0.36	≦ 1	53

Summary of required proof

Required proof for interaction								54
$\frac{N_{Sd}}{N_{Rd}}$	0.78	$\frac{V_{Sd}}{V_{Rd}}$	0.36	$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}}$	1.14	☑	combined tension and shear ≦ 1.2	55

Example 3 - Design standard form for fischer bonded anchors

Anchor type: **FIS V M16 A4**
h_{ef} = 125 mm
temperature range (+80 °C / +50 °C)
concrete C 20/25
non-cracked concrete



Design examples

Anchor design according to fischer specification

General information

Acting design load in tension on group					N^G_{Sd}	**20.0 kN**	1
number of anchors in the group acting in tension	n =	**6**	tension component of the load acting on single anchor	$N_{Sd} = \frac{N^G_{Sd}}{n}$	N_{Sd}	**3.3 kN**	2
Acting design load in shear on group					V^G_{Sd}	**6.0 kN**	3
Steel failure and pryout-failure							4
number of anchors in the group acting in shear; n	n =	**6**	sheer component of the load acting on single anchor at steel and pryout failure	$V_{Sd,s} = V_{Sd,cp} = \frac{V^G_{Sd}}{n}$	$V_{Sd,s}$ / $V_{Sd,cp}$	**1.0 kN**	5
Concrete Edge Failure							6
number of anchors in the group considered to act in shear at the edge; n_c • if load is towards the edge only anchors at the edge can be taken • if load is away from the edge or parallel to the edge all anchors can be taken	n_c =	**3**	sheer component of the load acting on single anchor at concrete edge failure	$V_{Sd,c} = \frac{V^G_{Sd}}{n_c}$	$V_{Sd,c}$	**2.0 kN**	7

Anchor and base material data						8
type of anchor			***FIS V M 16 / h_{ef} = 125 mm***			9
steel type	***A4-70***	embedment depth h_{ef}	***125 mm***	temperature range	***(+80 °C / +50 °C)***	10
concrete strength class			***C 20/25***	cracked concrete ☐	non-cracked concrete ☒	11

Drilling method	**Hole condition**	12
hammer ☒	wet or dry ☒	13
diamond ☐	waterfilled ☐	14

Calculation of tension resistance

Tension: Calculation of steel resistance - most unfavourable anchor			15
$N_{Rd,s}$	***58.8***	- basic resistance, section 4.1	16

Tension: Design combined concrete cone / pull-out resistance most unfavourable anchor								17
cracked concrete ☐		non-cracked concrete ☒			$N^0_{Rd,p}$	***41.9***	- basic resistance, section 4.2	18
concrete		***C 20/25***			$f_{b,N,p}$	***1.0***	- influence of concrete strength, section 4.2.1	19
s_1 =	***80***	$s_{cr,Np}$ = ***370***	$s_1/s_{cr,Np}$ =	***0.22***	$f_{s1,p}$	***0.61***	- characteristic distance, section 4.2.2 - influence of spacing, section 4.2.2.1	20
s_2 =	***80***		$s_2/s_{cr,Np}$ =	***0.22***	$f_{s2,p}$	***0.61***		
s_3 =	***65***		$s_3/s_{cr,Np}$ =	***0.18***	$f_{s3,p}$	***0.59***		
c_1 =	***70***	$c_{cr,Np}$ = ***185***	$c_1/c_{cr,Np}$ =	***0.38***	$f_{c1,p,A}$	***0.81***	- characteristic distance, section 4.2.2 - influence of edge distance, section 4.2.2.2 $c_1 < c_2$	21
					$f_{c1,p,B}$	***0.69***		
c_2 =	-		$c_2/c_{cr,Np}$ =	-	$f_{c2,p}$	-		
$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$						***5.1***		22

continued next page

Tension: Calculation of concrete cone resistance - most unfavourable anchor									23
cracked concrete ☐		non-cracked concrete ☒				$N^0_{Rd,c}$	47.1	- basic resistance, section 4.3	24
concrete strength class		C 20/25				$f_{b,N}$	1.0	- influence of concrete strength, section 4.3.1	25
$s_1 =$	80	$s_{cr,N} =$	375	$s_1/s_{cr,N} =$	0.21	f_{s1}	0.6	- characteristic distance, section 4.3.2 - influence of spacing, section 4.3.2.1	26
$s_2 =$	80			$s_2/s_{cr,N} =$	0.21	f_{s2}	0.6		
$s_3 =$	65			$s_3/s_{cr,N} =$	0.17	f_{s3}	0.59		
$c_1 =$	70	$c_{cr,N} =$	188	$c_1/c_{cr,N} =$	0.37	$f_{c1,A}$	0.81	- characteristic distance, section 4.3.2 - influence of edge distance, section 4.3.2.2 $c_1 < c_2$	27
						$f_{c1,B}$	0.69		
$c_2 =$	-			$c_2/c_{cr,N} =$	-	f_{c2}	-		
						$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$	5.6		28

Tension: Calculation of concrete splitting resistance - most unfavourable anchor									29
cracked concrete ☐	proof of splitting is only necessary for non-cracked concrete; if cracked concrete go to line 36								30
$h =$	200	$h_{ef} =$	125	$h/h_{ef} =$	1.6			- characteristic distance for design, section 4.3.3	31
if $h/h_{ef} \geqq 2.0$ or $h/h_{ef} \leqq 1.3$ ☐				if $2.0 > h/h_{ef} > 1.3$ ☒					
				$f_{scr,sp} =$	3.44				
				$h_{ef} =$	125				
$s_{cr,sp} =$				$s_{cr,sp} = f_{scr,sp} \cdot h_{ef}$	430				
$c_{cr,sp} =$				$c_{cr,sp} = s_{scr,sp}/2$	215				
$c_{cr,sp} =$	215	$c_{cr,N} =$	188			$c_{cr,sp} > c_{cr,N}$	☒	proof of splitting in non-cracked concrete is only necessary if both conditions on the left are met	32
$1.2\ c_{cr,sp} =$	258	$c_1 =$	70			$1.2\ c_{cr,sp} > c_1$	☒		

		non-cracked concrete ☒				$N^0_{Rd,c}$	47.1	- basic resistance, section 4.3	33
concrete strength class		C 20/25				$f_{b,N,c}$	1.0	- influence of concrete strength, section 4.3.1	34
$s_1 =$	80	$s_{cr,sp} =$	430	$s_1/s_{cr,sp} =$	0.19	$f_{s1,sp}$	0.6	- characteristic distance, section 4.3.3 - influence of spacing, section 4.3.3.1	35
$s_2 =$	80			$s_2/s_{cr,sp} =$	0.19	$f_{s2,sp}$	0.6		
$s_3 =$	65			$s_3/s_{cr,sp} =$	0.15	$f_{s3,sp}$	0.58		
$c_1 =$	70	$c_{cr,sp} =$	215	$c_1/c_{cr,sp} =$	0.33	$f_{c1,sp,A}$	0.8	- characteristic distance, section 4.3.3 - influence of edge distance, section 4.3.3.2 $c_1 < c_2$	36
						$f_{c1,sp,B}$	0.66		
$c_2 =$	-			$c_2/c_{cr,sp} =$	-	$f_{c2,sp}$	-		
$h =$	200	$h_{min} =$	161	$h/h_{min} =$	1.25	f_h	1.16	- influence of member thickness section 4.3.3.3	37
						$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$	6.0		38

Decisive resistance in tension - required proof					39
lowest value	$N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$	N_{Rd}	5.1		40
tension component of load acting on single anchor	N_{Sd} 3.3	$\frac{N_{Sd}}{N_{Rd}}$	0.65	≦ 1	41

4

Calculation of shear resistance

Shear: Calculation of steel resistance - most unfavourable anchor						42
			$V_{Rd,s}$	**35.3**	- basic resistance, section 5.1	43
shear component of load acting on single anchor at steel resistance	$V_{Sd,s}$	**1.0**	$\frac{V_{Sd,s}}{V_{Rd,s}}$	**0.03**	≦ 1	44

Shear: Calculation of concrete pryout resistance - most unfavourable anchor							45
$N_{Rd,p}$	**5.1**	$N_{Rd,c}$	**5.6**	$N_{Rd} = \min(N_{Rd,c}\, N_{Rd,p})$	**5.1**	- calculation section 4.2 and 4.3, section 5.2	46
				k	**2.0**		46
				$V_{Rd,cp} = N_{Rd} \cdot k$	**10.2**		47
shear component of load acting on single anchor at pryout resistance	$V_{Sd,cp}$		**1.0**	$\frac{V_{Sd,cp}}{V_{Rd,cp}}$	**0.1**	≦ 1	48

Shear: Calculation of concrete edge resistance most - unfavourable anchor (proof of resistance towards edge and parallel to edge if necessary)										49
					c_1 =	**70**	$V^0_{Rd,c}$	**9.7**	- basic resistance, section 5.3, section 5.3.1	50
cracked concrete f_{cr} = 0.7 ☐			non-cracked concrete f_{cr} = 1.0 ☒				f_{cr}	**1.0**		50
concrete strength class				**C 20/25**			$f_{b,V}$	**1.0**	- influence of concrete strength, section 5.3.2	51
angle α_V				**30°**			$f_{\alpha,V}$	**1.13**	- influence of load direction, section 5.3.3	52
s_1 =	**80**	c_1 =	**70**		s_1/c_1 =	**1.14**	$f_{s1,V}$	**0.69**	- influence of spacing, section 5.3.4	53
s_2 =	**80**				s_2/c_1 =	**1.14**	$f_{s2,V}$	**0.69**		53
c_2 =	**-**				c_2/c_1 =	**-**	$f_{c2,V}$	**-**	- influence of edge distance, section 5.3.5, c1 < c2	54
h =	**200**				h/c_1 =	**2.86**	$f_{h,V}$	**1.0**	- influence of member thickness, section 5.3.6	55
n =	**3**	s =	**-**	c_1 = **-**	s/c_1 =	**-**	f_m	**-**	- influence of n ≧ 4 anchors in a row at the edge, section 5.3.7	56
							$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$	**5.2**		57
shear component of load acting on single anchor at concrete edge resistance					$V_{Sd,c}$	**2.0**	$\frac{V_{Sd,c}}{V_{Rd,c}}$	**0.38**	≦ 1	58

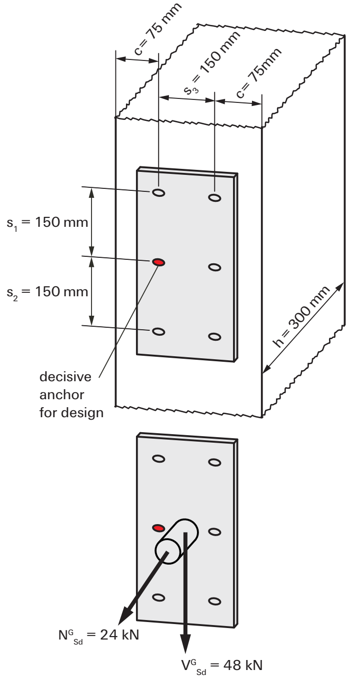
Shear: Decisive design proof in shear					59
highest value	$\frac{V_{Sd,s}}{V_{Rd,s}}$; $\frac{V_{Sd,cp}}{V_{Rd,cp}}$; $\frac{V_{Sd,c}}{V_{Rd,c}}$	$\frac{V_{Sd}}{V_{Rd}}$	**0.38**	≦ 1	60

Summary of required proof

Required proof for interaction								61
$\frac{N_{Sd}}{N_{Rd}}$	**0.65**	$\frac{V_{Sd}}{V_{Rd}}$	**0.38**	$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}}$	**1.03**	☑	combined tension and shear ≦ 1.2	62

Example 4 - Design standard form for fischer expansion/undercut anchors

Anchor type: **FAZ II M16 gvz**
concrete C 25/30
cracked concrete



General information

Acting design load in tension on group					N^G_{Sd}	***24.0 kN***	1
number of anchors in the group acting in tension	n =	***6***	tension component of the load acting on single anchor	$N_{Sd} = \frac{N^G_{Sd}}{n}$	N_{Sd}	***4.0 kN***	2
Acting design load in shear on group					V^G_{Sd}	***48.0 kN***	3
Steel failure and pryout-failure							4
number of anchors in the group acting in shear; n	n =	***6***	shear component of the load acting on single anchor at steel and pryout failure	$V_{Sd,s} = V_{Sd,cp} = \frac{V^G_{Sd}}{n}$	$V_{Sd,s}$ / $V_{Sd,cp}$	***8.0 kN***	5
Concrete Edge Failure							6
number of anchors in the group considered to act in shear at the edge; n_c • if load is towards the edge only anchors at the edge can be taken • if load is away from the edge or parallel to the edge all anchors can be taken	n_c =	***6***	shear component of the load acting on single anchor at concrete edge failure	$V_{Sd,c} = \frac{V^G_{Sd}}{n_c}$	$V_{Sd,c}$	***8.0 kN***	7
Anchor and base material data							8
type of anchor	***FAZ II M 16 gvz***						9
concrete strength class	***C 25/30***	cracked concrete ☒	non-cracked concrete ☐				10

Design examples

Anchor design according to fischer specification

Calculation of tension resistance

Tension: Calculation of steel resistance - highest loaded anchor				11
	$N_{Rd,s}$	44.0	- basic resistance, section 4.1	12

Tension: Calculation of concrete pull-out resistance - most unfavourable anchor						13
cracked concrete ☒	non-cracked concrete ☐		$N^0_{Rd,p}$	18.8	- basic resistance, section 4.2	14
concrete strength class	C 25/30		$f_{b,N}$	1.1	- influence of concrete strength section 4.3.1	15
			$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$	20.7		16

Tension: Calculation of concrete cone resistance - most unfavourable anchor									17
cracked concrete ☒		non-cracked concrete ☐				$N^0_{Rd,c}$	18.8	- basic resistance, section 4.3	18
concrete strength class		C 25/30				$f_{b,N}$	1.1	- influence of concrete strength, section 4.3.1	19
s_1 =	150	$s_{cr,N}$ =	255	$s_1 / s_{cr,N}$ =	0.59	f_{s1}	0.8	- characteristic distance, section 4.3.2 - influence of spacing, section 4.3.2.1	20
s_2 =	150			$s_2 / s_{cr,N}$ =	0.59	f_{s2}	0.8		
s_3 =	150			$s_3 / s_{cr,N}$ =	0.59	f_{s3}	0.8		
c_1 =	75	$c_{cr,N}$ =	128	$c_1 / c_{cr,N}$ =	0.59	$f_{c1,A}$	0.88	- characteristic distance, section 4.3.2 - influence of edge distance, section 4.3.2.2 $c_1 < c_2$	21
						$f_{c1,B}$	0.8		
c_2 =	-			$c_2 / c_{cr,N}$ =	-	f_{c2}	-		
						$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c,2}$	7.5		22

Tension: Calculation of concrete splitting resistance - most unfavourable anchor							23
cracked concrete ☒ proof of splitting is only necessary for non-cracked concrete; if cracked concrete go to line 32							24
$c_{cr,sp}$ =		$c_{cr,N}$ =		$c_{cr,sp} > c_{cr,N}$	☐	proof of splitting failure in non-cracked concrete is only necessary if all of the conditions on the left side are met	25
1.2 $c_{cr,sp}$ =		c_1 =		1.2 $c_{cr,sp} > c_1$	☐		

		non-cracked concrete ☐				$N^0_{Rd,c}$		- basic resistance, section 4.3	26
concrete strength class						$f_{b,N}$		- influence of concrete strength, section 4.3.1	27
s_1 =		$s_{cr,sp}$ =		$s_1 / s_{cr,sp}$ =		$f_{s1,sp}$		- characteristic distance, section 4.3.3 - influence of spacing, section 4.3.3.1	28
s_2 =				$s_2 / s_{cr,sp}$ =		$f_{s2,sp}$			
s_3 =				$s_3 / s_{cr,sp}$ =		$f_{s3,sp}$			
c_1 =		$c_{cr,sp}$ =		$c_1 / c_{cr,sp}$ =		$f_{c1,sp,A}$		- characteristic distance, section 4.3.3 - influence of edge distance, section 4.3.3.2 $c_1 < c_2$	29
						$f_{c1,sp,B}$			
c_2 =				$c_2 / c_{cr,sp}$ =		$f_{c2,sp}$			
h =		h_{min} =		h/h_{min} =		f_h		- influence of member thickness section 4.3.3.3	30
						$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$			31

Decisive resistance in tension - required proof						32
lowest value	$N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$		N_{Rd}	7.5		33
tension component of load acting on single anchor	N_{Sd}	4.0	$\frac{N_{Sd}}{N_{Rd}}$	0.53	≦ 1	34

4

fischer innovative solutions

Calculation of shear resistance

Shear: Calculation of steel resistance - most unfavourable anchor						**35**
			$V_{Rd,s}$	**44.0**	- basic resistance, section 5.1	**36**
shear component of load acting on single anchor at steel resistance	$V_{Sd,s}$	**4.0**	$\frac{V_{Sd,s}}{V_{Rd,s}}$	**0.09**	≦ 1	**37**

Shear: Calculation of concrete pryout resistance - most unfavourable anchor						**38**
			$N_{Rd,c}$	**7.5**	- calculation section 4.3, section 5.2	**39**
			k	**2.8**		
			$V_{Rd,cp} = N_{Rd,c} \cdot k$	**21.0**		**40**
shear component of load acting on single anchor at pryout resistance	$V_{Sd,cp}$	**8.0**	$\frac{V_{Sd,cp}}{V_{Rd,cp}}$	**0.38**	≦ 1	**41**

Shear: Calculation of concrete edge resistance most - unfavourable anchor (proof of resistance towards edge and parallel to edge if necessary)										**42**
cracked concrete ☒		non-cracked concrete ☐		c_1 =	**75**	$V^0_{Rd,c}$		**6.9**	- basic resistance, section 5.3	**43**
concrete strength class				**C 25/30**		$f_{b,V}$		**1.1**	- influence of concrete strength, section 5.3.1	**44**
angle α_V				**90⁰**		$f_{\alpha,V}$		**2.5**	- influence of load direction, section 5.3.2	**45**
s_1 =	**150**	c_1 =	**75**	s_1/c_1 =	**2.0**	$f_{s1,V}$		**0.83**	- influence of spacing, section 5.3.3	**46**
s_2 =	**150**			s_2/c_1 =	**2.0**	$f_{s2,V}$		**0.83**		
c_2 =	-			c_2/c_1 =	-	$f_{c2,V}$		-	- influence of edge distance, section 5.3.4, c1 < c2	**47**
h =	**300**			h/c_1 =	**4.0**	$f_{h,V}$		**1.0**	- influence of member thickness, section 5.3.5	**48**
n =	**3**	s =	-	c_1 = -	s/c_1 = -	f_m		-	- influence of n ≧ 4 anchors in a row at the edge, section 5.3.6	**49**
$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$								**13.1**		**50**
shear component of load acting on single anchor at concrete edge resistance				$V_{Sd,c}$	**8.0**	$\frac{V_{Sd,c}}{V_{Rd,c}}$		**0.61**	≦ 1	**51**

Shear: Decisive design proof in shear					**52**
highest value	$\frac{V_{Sd,s}}{V_{Rd,s}} ; \frac{V_{Sd,cp}}{V_{Rd,cp}} ; \frac{V_{Sd,c}}{V_{Rd,c}}$	$\frac{V_{Sd}}{V_{Rd}}$	**0.61**	≦ 1	**53**

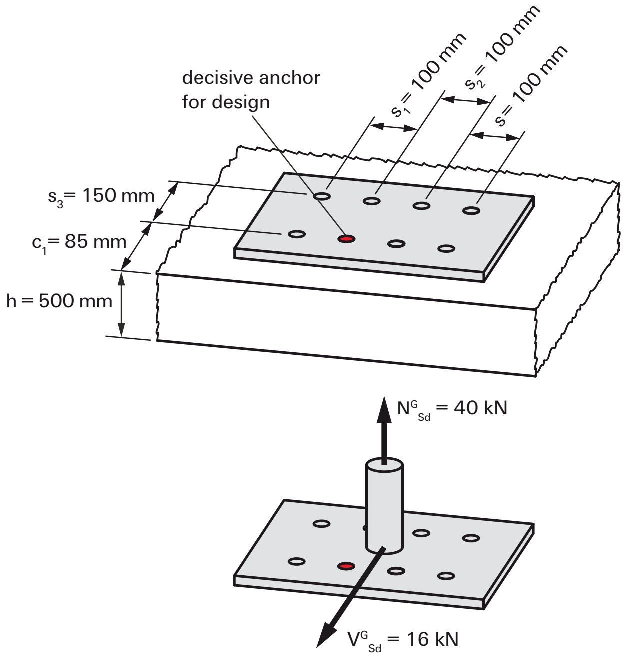
Summary of required proof

Required proof for interaction								**54**
$\frac{N_{Sd}}{N_{Rd}}$	**0.53**	$\frac{V_{Sd}}{V_{Rd}}$	**0.61**	$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}}$	**1.14**	☑	combined tension and shear ≦ 1.2	**55**

4

Example 5 - Design standard form for fischer bonded anchors

Anchor type: **FIS EM M20 5.8**
h_{ef} = 400 mm
temperature range (+60 °C / +35 °C)
concrete C 30/37
cracked concrete
clearance between the anchor and base plate has to be filled with adhesive mortar



Design examples

Anchor design according to fischer specification

General information

Acting design load in tension on group					N^G_{Sd}	**40.0 kN**	1
number of anchors in the group acting in tension	n =	8	tension component of the load acting on single anchor	$N_{Sd} = \frac{N^G_{Sd}}{n}$	N_{Sd}	**5.0 kN**	2
Acting design load in shear on group					V^G_{Sd}	**16.0 kN**	3
Steel failure and pryout-failure							4
number of anchors in the group acting in shear; n	n =	8	shear component of the load acting on single anchor at steel and pryout failure	$V_{Sd,s} = V_{Sd,cp} = \frac{V^G_{Sd}}{n}$	$V_{Sd,s}$ / $V_{Sd,cp}$	**2.0 kN**	5
Concrete Edge Failure							6
number of anchors in the group considered to act in shear at the edge; n_c • if load is towards the edge only anchors at the edge can be taken • if load is away from the edge or parallel to the edge all anchors can be taken	n_c =	4	shear component of the load acting on single anchor at concrete edge failure	$V_{Sd,c} = \frac{V^G_{Sd}}{n_c}$	$V_{Sd,c}$	**4.0 kN**	7

Anchor and base material data						8
type of anchor			*FIS EM M 20 / h_{ef} = 400 mm*			9
steel type	5.8	embedment depth h_{ef}	400 mm	temperature range	(+60 °C / 35 °C)	10
concrete strength class		C 30/37	cracked concrete ☒		non-cracked concrete ☐	11

Drilling method	**Hole condition**	12
hammer ☒	wet or dry ☒	13
diamond ☐	waterfilled ☐	14

Calculation of tension resistance

Tension: Calculation of steel resistance - most unfavourable anchor			15
$N_{Rd,s}$	82.0	- basic resistance, section 4.1	16

Tension: Design combined concrete cone / pull-out resistance most unfavourable anchor									17
cracked concrete ☒		non-cracked concrete ☐				$N^0_{Rd,p}$	100.5	- basic resistance, section 4.2	18
concrete			C 30/37			$f_{b,N,p}$	1.04	- influence of concrete strength, section 4.2.1	19
s_1 =	100	$s_{cr,Np}$ =	527	$s_1/s_{cr,Np}$ =	0.19	$f_{s1,p}$	0.6	- characteristic distance, section 4.2.2 - influence of spacing, section 4.2.2.1	20
s_2 =	100			$s_2/s_{cr,Np}$ =	0.19	$f_{s2,p}$	0.6		
s_3 =	150			$s_3/s_{cr,Np}$ =	0.28	$f_{s3,p}$	0.64		
c_1 =	85	$c_{cr,Np}$ =	263	$c_1/c_{cr,Np}$ =	0.32	$f_{c1,p,A}$	0.8	- characteristic distance, section 4.2.2 - influence of edge distance, section 4.2.2.2 $c_1 < c_2$	21
						$f_{c1,p,B}$	0.65		
c_2 =	-			$c_2/c_{cr,Np}$ =	-	$f_{c2,p}$	-		
$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$							12.5		22

continued next page

Design examples

Anchor design according to fischer specification

Tension: Calculation of concrete cone resistance - most unfavourable anchor									**23**
cracked concrete ☒			non-cracked concrete ☐			$N^0_{Rd,c}$	**192.0**	- basic resistance, section 4.3	**24**
concrete strength class			**C 30/37**			$f_{b,N}$	**1.22**	- influence of concrete strength, section 4.3.1	**25**
s_1 =	**100**	$s_{cr,N}$ =	**1200**	$s_1/s_{cr,N}$ =	**0.08**	f_{s1}	**0.54**	- characteristic distance, section 4.3.2 - influence of spacing, section 4.3.2.1	**26**
s_2 =	**100**			$s_2/s_{cr,N}$ =	**0.08**	f_{s2}	**0.54**		
s_3 =	**150**			$s_3/s_{cr,N}$ =	**0.13**	f_{s3}	**0.56**		
c_1 =	**85**	$c_{cr,N}$ =	**600**	$c_1/c_{cr,N}$ =	**0.14**	$f_{c1,A}$	**0.75**	- characteristic distance, section 4.3.2 - influence of edge distance, section 4.3.2.2 $c_1 < c_2$	**27**
						$f_{c1,B}$	**0.58**		
c_2 =	-			$c_2/c_{cr,N}$ =	-	f_{c2}	-		
$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$							**16.6**		**28**

Tension: Calculation of concrete splitting resistance - most unfavourable anchor							**29**
cracked concrete ☐	proof of splitting is only necessary for non-cracked concrete; if cracked concrete go to line 36						**30**
h =		h_{ef} =		h/h_{ef} =		- characteristic distance for design, section 4.3.3	**31**
if $h/h_{ef} \geq 2.0$ or $h/h_{ef} \leq 1.3$ ☐				if $2.0 > h/h_{ef} > 1.3$ ☐			
				$f_{scr,sp}$ =			
				h_{ef} =			
$s_{cr,sp}$ =				$s_{cr,sp} = f_{scr,sp} \cdot h_{ef}$			
$c_{cr,sp}$ =				$c_{cr,sp} = s_{cr,sp}/2$			
$c_{cr,sp}$ =		$c_{cr,N}$ =		$c_{cr,sp} > c_{cr,N}$ ☐		proof of splitting in non-cracked concrete is only necessary if both conditions on the left are met	**32**
1.2 $c_{cr,sp}$ =		c_1 =		1.2 $c_{cr,sp} > c_1$ ☐			

			non-cracked concrete ☐			$N^0_{Rd,c}$		- basic resistance, section 4.3	**33**
concrete strength class						$f_{b,N,c}$		- influence of concrete strength, section 4.3.1	**34**
s_1 =		$s_{cr,sp}$ =		$s_1/s_{cr,sp}$ =		$f_{s1,sp}$		- characteristic distance, section 4.3.3 - influence of spacing, section 4.3.3.1	**35**
s_2 =				$s_2/s_{cr,sp}$ =		$f_{s2,sp}$			
s_3 =				$s_3/s_{cr,sp}$ =		$f_{s3,sp}$			
c_1 =		$c_{cr,sp}$ =		$c_1/c_{cr,sp}$ =		$f_{c1,sp,A}$		- characteristic distance, section 4.3.3 - influence of edge distance, section 4.3.3.2 $c_1 < c_2$	**36**
						$f_{c1,sp,B}$			
c_2 =				$c_2/c_{cr,sp}$ =		$f_{c2,sp}$			
h =		h_{min} =		h/h_{min} =		f_h		- influence of member thickness section 4.3.3.3	**37**
$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$									**38**

Decisive resistance in tension - required proof						**39**
lowest value	$N_{Rd,s}; N_{Rd,p}; N_{Rd,c}; N_{Rd,sp}$		N_{Rd}	**12.5**		**40**
tension component of load acting on single anchor	N_{Sd}	**5.0**	$\frac{N_{Sd}}{N_{Rd}}$	**0.4**	≤ 1	**41**

Calculation of shear resistance

Shear: Calculation of steel resistance - most unfavourable anchor						**42**
			$V_{Rd,s}$	**48.8**	- basic resistance, section 5.1	**43**
shear component of load acting on single anchor at steel resistance	$V_{Sd,s}$	**2.0**	$\frac{V_{Sd,s}}{V_{Rd,s}}$	**0.06**	≦ 0.04	**44**

Shear: Calculation of concrete pryout resistance - most unfavourable anchor							**45**
$N_{Rd,p}$	**12.5**	$N_{Rd,c}$	**16.6**	$N_{Rd} = \min (N_{Rd,c}\, N_{Rd,p})$	**12.5**	- calculation section 4.2 and 4.3, section 5.2	**46**
				k	**2.0**		
				$V_{Rd,cp} = N_{Rd} \cdot k$	**25.0**		**47**
shear component of load acting on single anchor at pryout resistance	$V_{Sd,cp}$	**2.0**		$\frac{V_{Sd,cp}}{V_{Rd,cp}}$	**0.08**	≦ 1	**48**

Shear: Calculation of concrete edge resistance most - unfavourable anchor (proof of resistance towards edge and parallel to edge if necessary)											**49**
						c_1 =	**85**	$V^0_{Rd,c}$	**18.8**	- basic resistance, section 5.3, section 5.3.1	**50**
cracked concrete f_{cr} = 0.7 ☒				non-cracked concrete f_{cr} = 1.0 ☐				f_{cr}	**0.7**		
concrete strength class					**C 30/37**			$f_{b,V}$	**1.22**	- influence of concrete strength, section 5.3.2	**51**
angle α_V					**0°**			$f_{\alpha,V}$	**1.0**	- influence of load direction, section 5.3.3	**52**
s_1 =	**100**	c_1 =	**85**			s_1/c_1 =	**1.17**	$f_{s1,V}$	**0.69**	- influence of spacing, section 5.3.4	**53**
s_2 =	**100**					s_2/c_1 =	**1.17**	$f_{s2,V}$	**0.69**		
c_2 =	**-**					c_2/c_1 =	**-**	$f_{c2,V}$	**-**	- influence of edge distance, section 5.3.5, c1 < c2	**54**
h =	**500**					h/c_1 =	**5.9**	$f_{h,V}$	**1.0**	- influence of member thickness, section 5.3.6	**55**
n =	**4**	s =	**100**	c_1 =	**85**	s/c_1 =	**1.17**	f_m	**0.79**	- influence of n ≧ 4 anchors in a row at the edge, section 5.3.7	**56**
								$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$	**6.0**		**57**
shear component of load acting on single anchor at concrete edge resistance						$V_{Sd,c}$	**4.0**	$\frac{V_{Sd,c}}{V_{Rd,c}}$	**0.67**	≦ 1	**58**

Shear: Decisive design proof in shear					**59**
highest value	$\frac{V_{Sd,s}}{V_{Rd,s}}\,;\,\frac{V_{Sd,cp}}{V_{Rd,cp}}\,;\,\frac{V_{Sd,c}}{V_{Rd,c}}$	$\frac{V_{Sd}}{V_{Rd}}$	**0.75**	≦ 1	**60**

Summary of required proof

Required proof for interaction								**61**
$\frac{N_{Sd}}{N_{Rd}}$	**0.4**	$\frac{V_{Sd}}{V_{Rd}}$	**0.67**	$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}}$	**1.07**	☑	combined tension and shear ≦ 1.2	**62**

4

fischer Anchor bolt FAZ II

Anchor design according to fischer specification

1. Types

FAZ II – (gvz)

FAZ II A4 – (Stainless steel)

FAZ II C – (C-Stainless steel)

FAZ II-GS – (gvz, A4, C) with large washer

ETA-05/0069
ETAG 001-2
Option 1 for cracked concrete *)

Fire resistance classification R 120
Anchor types see test report

ICC ES
ESR-2948
See ICC-ES Evaluation Report at www.ic-es.org
Inspection agency: AA-707 *)

FM APPROVED
from thread M 10

ZTV
1200 °C
anchor types see test report

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

4

Features and Advantages

- European Technical Approval option 1*) for cracked and non-cracked concrete.
- ICC-ES Evaluation Report *) for cracked and non-cracked concrete. Seismic design categories A-F. acc. to IBC 2006/2009
- Suitable for concrete C12/15 and natural stone with dense structure.
- Independent controlled and confirmed product characteristics due to the European Technical Approval.
- Fire resistance classifications according to test report, independently proved gives the safety in case of fire.
- Optimized expansion clip ensures uniformed load distribution which allows smallest spacing and edge distances.

*) The conditions of use in the European Technical Approval or in the ICC-ES Evaluation Report may vary from those of the Technical Handbook.

Materials

Anchor bolt:
- Carbon steel, zinc plated (5 µm) and passivated (gvz)
- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
- Highly corrosion-resistant steel of the corrosion resistance class IV, e.g. 1.4529

2. Ultimate resistance of single anchors with large spacing and large edge distance

Mean values

Anchor type		FAZ II 8			FAZ II 10			FAZ II 12			FAZ II 16			FAZ II 20		FAZ II 24	
		gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	gvz	A4
non-cracked concrete																	
Tension	C 20/25 N_u [kN]		16.6			26.7			38.3			54.7		61.6		87.9	
	C 50/60 N_u [kN]		16.6			28.6			43.6			69.5		97.4		139.0	
Shear	≧ C 20/25 V_u [kN]		12.5			21.6			33.3			70.3		84.3		101.2	
cracked concrete																	
Tension	C 20/25 N_u [kN]		12.8			20.0			27.4			45.7		55.8		75.6	
	C 50/60 N_u [kN]		16.6			28.6			43.4			69.5		88.2		119.5	
Shear	≧ C 20/25 V_u [kN]		12.5			21.6			33.3			70.3		84.3		101.2	

fischer innovative solutions

fischer Anchor bolt FAZ II

Anchor design according to fischer specification

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance

<table>
<tr><th colspan="2" rowspan="2">Anchor type</th><th colspan="3">FAZ II 8</th><th colspan="3">FAZ II 10</th><th colspan="3">FAZ II 12</th><th colspan="3">FAZ II 16</th><th colspan="2">FAZ II 20</th><th colspan="2">FAZ II 24</th></tr>
<tr><th>gvz</th><th>A4</th><th>C</th><th>gvz</th><th>A4</th><th>C</th><th>gvz</th><th>A4</th><th>C</th><th>gvz</th><th>A4</th><th>C</th><th>gvz</th><th>A4</th><th>gvz</th><th>A4</th></tr>
<tr><td colspan="18">non-cracked concrete</td></tr>
<tr><td>Tension</td><td>C 20/25 N_{Rk} [kN]</td><td colspan="3">10.8</td><td colspan="3">17.7</td><td colspan="3">26.6</td><td colspan="3">43.5</td><td colspan="2">55.6</td><td colspan="2">77.6</td></tr>
<tr><td></td><td>C 50/60 N_{Rk} [kN]</td><td colspan="3">16.0</td><td colspan="3">27.0</td><td colspan="3">41.2</td><td colspan="3">66.0</td><td colspan="2">86.1</td><td colspan="2">120.3</td></tr>
<tr><td>Shear</td><td>≧ C 20/25 V_{Rk} [kN]</td><td colspan="3">12.0</td><td colspan="3">20.0</td><td colspan="3">29.5</td><td colspan="3">55.0</td><td colspan="2">70.0</td><td colspan="2">86.0</td></tr>
<tr><td colspan="18">cracked concrete</td></tr>
<tr><td>Tension</td><td>C 20/25 N_{Rk} [kN]</td><td colspan="3">9.0</td><td colspan="3">14.0</td><td colspan="3">20.0</td><td colspan="3">28.2</td><td colspan="2">36.0</td><td colspan="2">50.3</td></tr>
<tr><td></td><td>C 50/60 N_{Rk} [kN]</td><td colspan="3">14.0</td><td colspan="3">21.7</td><td colspan="3">31.0</td><td colspan="3">43.7</td><td colspan="2">55.8</td><td colspan="2">78.0</td></tr>
<tr><td>Shear</td><td>≧ C 20/25 V_{Rk} [kN]</td><td colspan="3">12.0</td><td colspan="3">20.0</td><td colspan="3">29.5</td><td colspan="3">55.0</td><td colspan="2">70.0</td><td colspan="2">86.0</td></tr>
</table>

3.2 Design resistance

<table>
<tr><th colspan="2" rowspan="2">Anchor type</th><th colspan="3">FAZ II 8</th><th colspan="3">FAZ II 10</th><th colspan="3">FAZ II 12</th><th colspan="3">FAZ II 16</th><th colspan="2">FAZ II 20</th><th colspan="2">FAZ II 24</th></tr>
<tr><th>gvz</th><th>A4</th><th>C</th><th>gvz</th><th>A4</th><th>C</th><th>gvz</th><th>A4</th><th>C</th><th>gvz</th><th>A4</th><th>C</th><th>gvz</th><th>A4</th><th>gvz</th><th>A4</th></tr>
<tr><td colspan="18">non-cracked concrete</td></tr>
<tr><td>Tension</td><td>C 20/25 N_{Rd} [kN]</td><td colspan="3">7.2</td><td colspan="3">11.8</td><td colspan="3">17.7</td><td colspan="3">29.0</td><td colspan="2">37.0</td><td colspan="2">51.8</td></tr>
<tr><td></td><td>C 50/60 N_{Rd} [kN]</td><td colspan="3">10.7</td><td colspan="3">18.0</td><td colspan="3">27.5</td><td colspan="3">44.0</td><td colspan="2">57.4</td><td colspan="2">80.2</td></tr>
<tr><td>Shear</td><td>≧ C 20/25 V_{Rd} [kN]</td><td colspan="3">9.6</td><td colspan="3">16.0</td><td colspan="3">23.6</td><td colspan="3">44.0</td><td colspan="2">56.0</td><td colspan="2">68.8</td></tr>
<tr><td colspan="18">cracked concrete</td></tr>
<tr><td>Tension</td><td>C 20/25 N_{Rd} [kN]</td><td colspan="3">6.0</td><td colspan="3">9.3</td><td colspan="3">13.3</td><td colspan="3">18.8</td><td colspan="2">24.0</td><td colspan="2">33.5</td></tr>
<tr><td></td><td>C 50/60 N_{Rd} [kN]</td><td colspan="3">9.3</td><td colspan="3">14.5</td><td colspan="3">20.7</td><td colspan="3">29.2</td><td colspan="2">37.2</td><td colspan="2">52.0</td></tr>
<tr><td>Shear</td><td>≧ C 20/25 V_{Rd} [kN]</td><td colspan="3">9.6</td><td colspan="3">16.0</td><td colspan="3">23.6</td><td colspan="3">44.0</td><td colspan="2">56.0</td><td colspan="2">68.8</td></tr>
</table>

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3.3 Recommended resistance [1)]

<table>
<tr><th colspan="2" rowspan="2">Anchor type</th><th colspan="3">FAZ II 8</th><th colspan="3">FAZ II 10</th><th colspan="3">FAZ II 12</th><th colspan="3">FAZ II 16</th><th colspan="2">FAZ II 20</th><th colspan="2">FAZ II 24</th></tr>
<tr><th>gvz</th><th>A4</th><th>C</th><th>gvz</th><th>A4</th><th>C</th><th>gvz</th><th>A4</th><th>C</th><th>gvz</th><th>A4</th><th>C</th><th>gvz</th><th>A4</th><th>gvz</th><th>A4</th></tr>
<tr><td colspan="18">non-cracked concrete</td></tr>
<tr><td>Tension</td><td>C 20/25 N_R [kN]</td><td colspan="3">5.1</td><td colspan="3">8.4</td><td colspan="3">12.7</td><td colspan="3">20.7</td><td colspan="2">26.5</td><td colspan="2">37.0</td></tr>
<tr><td></td><td>C 50/60 N_R [kN]</td><td colspan="3">7.6</td><td colspan="3">12.9</td><td colspan="3">19.6</td><td colspan="3">31.4</td><td colspan="2">41.0</td><td colspan="2">57.3</td></tr>
<tr><td>Shear</td><td>≧ C 20/25 V_R [kN]</td><td colspan="3">6.9</td><td colspan="3">11.4</td><td colspan="3">16.9</td><td colspan="3">31.4</td><td colspan="2">40.0</td><td colspan="2">49.1</td></tr>
<tr><td colspan="18">cracked concrete</td></tr>
<tr><td>Tension</td><td>C 20/25 N_R [kN]</td><td colspan="3">4.3</td><td colspan="3">6.7</td><td colspan="3">9.5</td><td colspan="3">13.4</td><td colspan="2">17.1</td><td colspan="2">24.0</td></tr>
<tr><td></td><td>C 50/60 N_R [kN]</td><td colspan="3">6.6</td><td colspan="3">10.3</td><td colspan="3">14.8</td><td colspan="3">20.8</td><td colspan="2">26.6</td><td colspan="2">37.1</td></tr>
<tr><td>Shear</td><td>≧ C 20/25 V_R [kN]</td><td colspan="3">6.9</td><td colspan="3">11.4</td><td colspan="3">16.9</td><td colspan="3">31.4</td><td colspan="2">40.0</td><td colspan="2">49.1</td></tr>
</table>

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

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Pull-out / pull-through failure: $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type	FAZ II 8			FAZ II 10			FAZ II 12			FAZ II 16			FAZ II 20		FAZ II 24	
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	gvz	A4
Design resistance $N_{Rd,s}$ [kN]	10.7			18.0			27.7			44.0			74.0		100.0	

4.2 Pull-out/pull-through failure of the highest loaded anchor

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

4

Design resistance of single anchor

Anchor type	FAZ II 8	FAZ II 10	FAZ II 12	FAZ II 16	FAZ II 20	FAZ II 24
non-cracked concrete						
Design resistance $N^0_{Rd,p}$ [kN]	7.2	11.8	17.7	29.0	37.0	51.8
cracked concrete						
Design resistance $N^0_{Rd,p}$ [kN]	6.0	9.3	13.3	18.8	24.0	33.5

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\, c_{cr,sp}$

Design resistance of single anchor

Anchor type	FAZ II 8	FAZ II 10	FAZ II 12	FAZ II 16	FAZ II 20	FAZ II 24
non-cracked concrete						
Design resistance $N^0_{Rd,c}$ [kN]	11.2	17.2	21.7	29.0	37.0	51.8
cracked concrete						
Design resistance $N^0_{Rd,c}$ [kN]	7.2	11.2	14.1	18.8	24.0	33.5

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic edge distance and spacing for design

Anchor type		FAZ II 8	FAZ II 10	FAZ II 12	FAZ II 16	FAZ II 20	FAZ II 24
h_{ef}		45	60	70	85	100	125
$s_{cr,N}$	[mm]	135	180	210	255	300	375
$c_{cr,N}$	[mm]	68	90	105	128	150	188

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic edge distance and spacing for design

Anchor type			FAZ II 8	FAZ II 10	FAZ II 12	FAZ II 16	FAZ II 20	FAZ II 24
	h_{ef}		45	60	70	85	100	125
Application with concrete member thickness h ≧ 2 · h_{ef}	$s_{cr,sp}$	[mm]	135	180	210	255	370	430
	$c_{cr,sp}$	[mm]	68	90	105	128	185	215
	h_{min}	[mm]	100	120	140	170	200	250
Application with concrete member thickness h < 2 · h_{ef}	$s_{cr,sp}$	[mm]	180	240	280	340	480	550
	$c_{cr,sp}$	[mm]	90	120	140	170	240	275
	h_{min}	[mm]	80	100	120	140	160	200

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / concrete splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = N_{Rd,c} \cdot k$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

4

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type	FAZ II 8			FAZ II 10			FAZ II 12			FAZ II 16			FAZ II 20		FAZ II 24	
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	gvz	A4
Design resistance $V_{Rd,s}$ [kN]	9.6			16.0			23.6			44.0			56.0		68.8	

5.2 Pryout failure for the most unfavourable anchor

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

k-factor

Anchor type	FAZ II 8	FAZ II 10	FAZ II 12	FAZ II 16	FAZ II 20	FAZ II 24
k	2.0	2.2	2.4	2.8	2.8	2.8

fischer Anchor bolt FAZ II

Anchor design according to fischer specification

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary, if the following condition is met:

- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

edge distance [mm]	$V^0_{Rd,c}$ [kN]											
	FAZ II 8		FAZ II 10		FAZ II 12		FAZ II 16		FAZ II 20		FAZ II 24	
	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
40	3.3	2.4										
45	3.9	2.8	4.3	3.0								
50	4.5	3.2	4.9	3.5								
55	5.1	3.6	5.6	3.9	5.9	4.2						
60	5.7	4.1	6.2	4.4	6.6	4.7						
65	6.4	4.5	6.9	4.9	7.3	5.2	8.1	5.7				
70	7.1	5.0	7.7	5.4	8.1	5.7	8.9	6.3				
75	7.8	5.5	8.4	5.9	8.9	6.3	9.7	6.9				
80	8.5	6.0	9.2	6.5	9.7	6.8	10.5	7.4				
85	9.2	6.5	9.9	7.0	10.5	7.4	11.4	8.1		8.7		
90	10.0	7.1	10.7	7.6	11.3	8.0	12.2	8.7		9.3		
95	10.8	7.6	11.5	8.2	12.1	8.6	13.1	9.3	14.1	10.0		
100	11.6	8.2	12.4	8.8	13.0	9.2	14.1	10.0	15.1	10.7		11.6
110	13.2	9.4	14.1	10.0	14.8	10.5	15.9	11.3	17.0	12.1		13.1
120	14.9	10.6	15.9	11.2	16.6	11.8	17.9	12.7	19.1	13.5		14.6
130	16.7	11.8	17.7	12.5	18.5	13.1	19.9	14.1	21.2	15.0		16.2
135	17.6	12.4	18.7	13.2	19.5	13.8	20.9	14.8	22.2	15.8	24.0	17.0
140	18.5	13.1	19.6	13.9	20.5	14.5	21.9	15.5	23.3	16.5	25.1	17.8
150	20.4	14.4	21.6	15.3	22.5	15.9	24.1	17.0	25.5	18.1	27.5	19.4
160	22.3	15.8	23.6	16.7	24.6	17.4	26.2	18.6	27.8	19.7	29.8	21.1
180	26.3	18.6	27.8	19.7	28.9	20.5	30.7	21.8	32.5	23.0	34.8	24.6
200	30.5	21.6	32.1	22.8	33.4	23.6	35.4	25.1	37.4	26.5	39.9	28.3
250	41.8	29.6	43.9	31.1	45.5	32.2	48.0	34.0	50.5	35.7	53.6	37.9
300	54.2	38.4	56.7	40.2	58.6	41.5	61.7	43.7	64.6	45.8	68.3	48.4
350	67.5	47.8	70.5	49.9	72.7	51.5	76.3	54.1	79.7	56.5	84.0	59.5
400	81.7	57.9	85.1	60.3	87.7	62.1	91.8	65.1	95.7	67.8	100.6	71.3
450	96.7	68.5	100.6	71.2	103.5	73.3	108.2	76.6	112.6	79.8	118.1	83.7
500	112.4	79.6	116.8	82.7	120.1	85.0	125.3	88.8	130.3	92.3	136.4	96.6
550			133.8	94.8	137.4	97.3	143.2	101.5	148.7	105.3	155.4	110.1
600			151.5	107.3	155.4	110.1	161.8	114.6	167.8	118.8	175.2	124.1
650					174.1	123.4	181.1	128.3	187.6	132.9	195.6	138.6
700					193.5	137.1	201.1	142.4	208.0	147.4	216.7	153.5
750					213.5	151.2	221.6	157.0	229.1	162.3	238.4	168.9
800							242.8	172.0	250.8	177.7	260.8	184.7
850							264.5	187.4	273.1	193.4	283.7	201.0
900							286.8	203.2	296.0	209.6	307.2	217.6
1000							333.1	235.9	343.3	243.2	355.9	252.1
1100									392.8	278.2	406.7	288.1
1200									444.2	314.7	459.5	325.5
1300											514.2	364.3
1400											570.8	404.3
1500											629.2	445.7

4

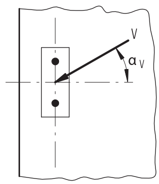
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

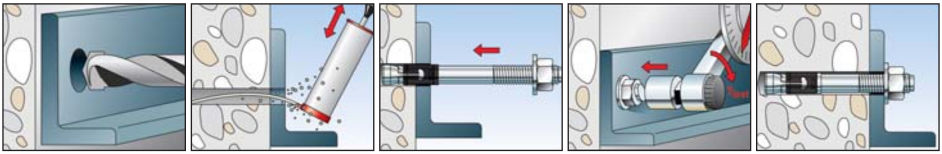
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = **tension/shear component of the design load acting on the most unfavourable single anchor**

N_{Rd} ; V_{Rd} = **tension/shear design resistance including safety factors of the most unfavourable single anchor**

7. Installation details



fischer Anchor bolt FAZ II

Anchor design according to fischer specification

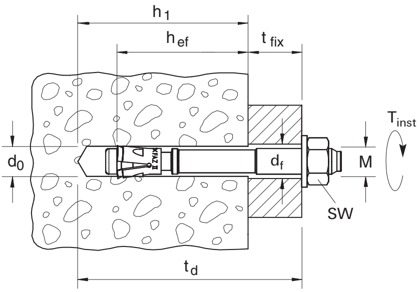
8. Anchor installation data

Anchor type			FAZ II 8	FAZ II 10	FAZ II 12	FAZ II 16	FAZ II 20	FAZ II 24
diameter of thread			M 8	M 10	M 12	M 16	M 20	M 24
nominal drill hole diameter	d_0	[mm]	8	10	12	16	20	24
drill depth	h_1	[mm]	55	75	90	110	125	155
effective anchorage depth	h_{ef}	[mm]	45	60	70	85	100	125
drill hole depth for through fixing	t_d	[mm]	$t_d = h_1 + t_{fix}$					
clearance-hole in fixture to be attached	d_f	[mm]	≦ 9	≦ 12	≦ 14	≦ 18	≦ 22	≦ 26
wrench size	SW	[mm]	13	17	19	24	30	36
required torque	T_{inst}	[Nm]	20	45	60	110	200	270

Minimum member thickness and characteristic edge distance and spacing for design

Anchor type			FAZ II 8	FAZ II 10	FAZ II 12	FAZ II 16	FAZ II 20	FAZ II 24
	h_{ef}		45	60	70	85	100	125
minimum thickness of concrete member	h_{min}	[mm]	100	120	140	170	200	250
Application with concrete member thickness $h \geqq 2 \cdot h_{ef}$	**cracked concrete** [1]							
	s_{min}	[mm]	35	40	45	60	95	100
	for c ≧	[mm]	50	55	70	95	140	170
	c_{min}	[mm]	40	45	55	65	85	100
	for s ≧	[mm]	70	80	110	150	190	220
	non-cracked concrete [1]							
	s_{min}	[mm]	40	40	50	60	95	100
	for c ≧	[mm]	50	60	70	95	180	200
	c_{min}	[mm]	40	45	55	65	95	135
	for s ≧	[mm]	100	80	110	150	190	235
minimum thickness of concrete member	h_{min}	[mm]	80	100	120	140	160	200
Application with concrete member thickness $h < 2 \cdot h_{ef}$	**cracked and non-cracked concrete**							
	s_{min}	[mm]	35	40	50	80	125	150
	for c ≧	[mm]	70	100	90	130	220	230
	c_{min}	[mm]	40	60	60	65	125	135
	for s ≧	[mm]	100	90	120	180	230	235

[1] Intermediate values by linear interpolation.



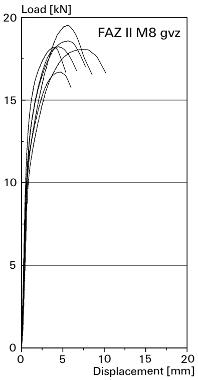
fischer Anchor bolt FAZ II

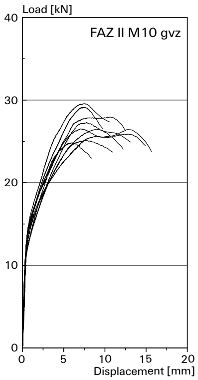
Anchor design according to fischer specification

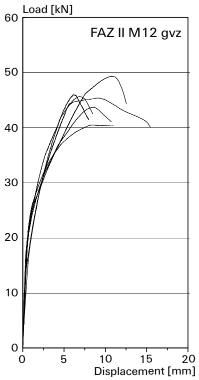
9. Mechanical anchor material characteristics

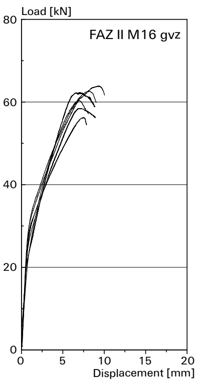
Anchor type			FAZ II 8	FAZ II 10	FAZ II 12	FAZ II 16	FAZ II 20	FAZ II 24
			gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4	gvz / A4
stressed cross sectional area cone bolt	A_S	[mm²]	21.1	36.3	55.4	88.3	156.1	230.0
section modulus cone bolt	W	[mm³]	13.8	30.9	58.2	116.9	275.2	490.9
design value of bending moment	$M^0_{Rd,s}$	[Nm]	20.8	46.4	73.6	186.4	389.6	615.2
yield strength cone bolt	f_{yk}	[N/mm²]	600	600	600	600	560	544
tensile strength cone bolt	f_{uk}	[N/mm²]	750	750	750	750	700	680
stressed cross sectional area threaded part	A_S	[mm²]	36.6	58.0	84.3	157.0	245.0	353.0
section modulus threaded part	W	[mm³]	31.2	62.3	109.2	277.5	540.9	935.5
yield strength threaded part	f_{yk}	[N/mm²]	560	560	560	560	560	544
tensile strength threaded part	f_{uk}	[N/mm²]	700	700	700	700	700	680

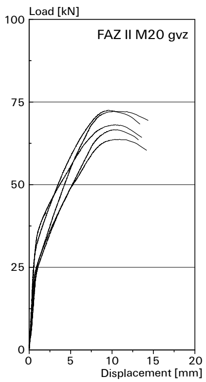
10. Load displacement curves for tension in non-cracked concrete ($f_{ck,cube\ (200)}$ = 30 N/mm²)

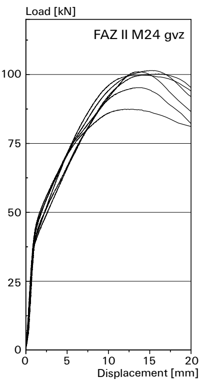












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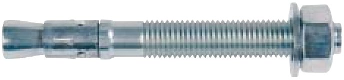
fischer Bolt FBN II

Anchor design according to fischer specification

1. Types



FBN II (gvz)

FBN II (fvz)

FBN II (A4)

FBN II GS (gvz) with large washer

(outside diameter approx. 3.5 x d)

ETA-07/0211
ETAG 001-2
Option 7 for non-cracked concrete *)

Fire resistance classification
R 120
Anchor types see test report

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

4

Features and Advantages

- European Technical Approval option 7*) for non-cracked concrete.
- Fire resistance classification according test report independently proved gives safety in case of fire.
- Independent controlled and confirmed product characteristics due to the European Technical Approval.
- Head imprint to identify the anchor type and length.
- Long thread for stand-off installations. In combination with the variable anchorage depth the FBN II permits a maximum of flexibility.
- The reduced embedment depths minimise the risk of rebar hits.
- The version with large washer is specially adapted for wood constructions and for slotted holes in the anchor plate.
- Drill diameter and thread diameter are the same for economic push-through installation.
- With the permitted small spacing and edge distances small, cost-efficient anchor plates and fixings near to an edge can be realised.

*) The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Anchor bolt:
- Zinc plated steel
- Hot-dip galvanised
- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316

fischer Bolt FBN II

Anchor design according to fischer specification

2. Ultimate resistance of single anchors with large spacing and large edge distance

Mean values

Anchor type		FBN II M6		FBN II M8			FBN II M8			FBN II M10			FBN II M10			FBN II M12		
		gvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
h_{ef}		30	30	30	30	30	40	40	40	40	40	40	50	50	50	50	50	50
non-cracked concrete																		
Tension	C 20/25 N_u [kN]	8.7	9.0	10.0	10.0	10.0	15.0	15.0	15.0	16.0	16.0	16.0	21.0	21.0	21.0	22.0	22.0	22.0
	C 50/60 N_u [kN]	8.7	11.1	15.5	15.5	15.5	17.3	17.3	17.3	24.8	24.8	24.8	28.6	28.6	28.6	34.1	34.1	34.1
Shear	≥ C 20/25 V_u [kN]	6.3	5.6	14.0	14.0	13.4	14.0	14.0	13.4	22.1	22.1	21.3	22.1	22.1	21.3	32.9	32.9	28.8

Anchor type		FBN II M12			FBN II M16			FBN II M16			FBN II M20			FBN II M20		
		gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
h_{ef}		65	65	65	65	65	65	80	80	80	80	80	80	105	105	105
non-cracked concrete																
Tension	C 20/25 N_u [kN]	31.0	31.0	31.0	35.4	35.4	35.4	46.0	46.0	46.0	48.3	48.3	48.3	72.6	72.6	72.6
	C 50/60 N_u [kN]	43.7	43.7	43.7	54.8	54.8	54.8	71.3	71.3	71.3	74.8	74.8	74.8	112.4	112.4	112.5
Shear	≥ C 20/25 V_u [kN]	32.9	32.9	28.8	57.9	57.9	53.6	57.9	57.9	53.6	70.4	70.4	90.3	70.4	70.4	90.3

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3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance

Anchor type		FBN II M6		FBN II M8			FBN II M8			FBN II M10			FBN II M10			FBN II M12		
		gvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
h_{ef}		30	30	30	30	30	40	40	40	40	40	40	50	50	50	50	50	50
non-cracked concrete																		
Tension	C 20/25 N_{Rk} [kN]	6.0	6.0	6.0	6.0	6.0	12.8	12.0	12.8	12.8	12.8	12.8	17.9	16.0	17.9	17.9	17.9	17.9
	C 50/60 N_{Rk} [kN]	8.3	9.3	9.3	9.3	9.3	16.5	16.5	16.5	19.8	19.8	19.8	27.2	24.8	27.2	27.7	27.7	27.7
Shear	≥ C 20/25 V_{Rk} [kN]	6.0	5.3	13.3	13.3	12.8	13.3	13.3	12.8	21.0	21.0	20.3	21.0	21.0	20.3	31.3	31.3	27.4

Anchor type		FBN II M12			FBN II M16			FBN II M16			FBN II M20			FBN II M20		
		gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
h_{ef}		65	65	65	65	65	65	80	80	80	80	80	80	105	105	105
non-cracked concrete																
Tension	C 20/25 N_{Rk} [kN]	26.5	25.0	26.5	26.5	26.5	26.5	36.1	36.1	36.1	36.1	36.1	36.1	54.3	54.3	54.3
	C 50/60 N_{Rk} [kN]	41.0	38.8	41.0	41.0	41.0	41.0	56.0	56.0	56.0	56.0	56.0	56.0	84.2	84.2	84.2
Shear	≥ C 20/25 V_{Rk} [kN]	31.3	31.3	27.4	55.1	55.1	51.0	55.1	55.1	51.0	67.0	67.0	83.1	67.0	67.0	86.0

3.2 Design resistance

Anchor type		FBN II M6		FBN II M8			FBN II M8			FBN II M10			FBN II M10			FBN II M12		
		gvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
h_{ef}		30	30	30	30	30	40	40	40	40	40	40	50	50	50	50	50	50
non-cracked concrete																		
Tension	C 20/25 N_{Rd} [kN]	4.0	4.0	4.0	4.0	4.0	8.5	8.0	8.5	8.5	8.5	8.5	11.9	10.7	11.9	11.9	11.9	11.9
	C 50/60 N_{Rd} [kN]	5.5	6.2	6.2	6.2	6.2	11.8	11.8	11.8	13.2	13.2	13.2	18.4	16.5	18.4	18.4	18.4	18.4
Shear	≥ C 20/25 V_{Rd} [kN]	4.8	4.2	10.0	10.0	10.0	10.6	10.6	10.2	16.8	16.8	16.2	16.8	16.8	16.2	25.0	25.0	21.9

Anchor type		FBN II M12			FBN II M16			FBN II M16			FBN II M20			FBN II M20		
		gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
h_{ef}		65	65	65	65	65	65	80	80	80	80	80	80	105	105	105
non-cracked concrete																
Tension	C 20/25 N_{Rd} [kN]	17.6	16.7	17.6	17.6	17.6	17.6	24.1	24.1	24.1	24.1	24.1	24.1	36.2	36.2	36.2
	C 50/60 N_{Rd} [kN]	27.3	25.8	27.3	27.3	27.3	27.3	37.3	37.3	37.3	37.3	37.3	37.3	56.1	56.1	56.1
Shear	≥ C 20/25 V_{Rd} [kN]	25.0	25.0	21.9	40.6	40.6	40.6	44.1	44.1	40.8	53.6	53.6	55.4	53.6	53.6	68.8

3.3 Recommended resistance [1)]

Anchor type			FBN II M6		FBN II M8			FBN II M8			FBN II M10			FBN II M10			FBN II M12		
			gvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
h_{ef}			30	30	30	30	30	40	40	40	40	40	40	50	50	50	50	50	50
non-cracked concrete																			
Tension	C 20/25 N_R	[kN]	2.9	2.9	2.9	2.9	2.9	6.1	5.7	6.1	6.1	6.1	6.1	8.5	7.6	8.5	8.5	8.5	8.5
	C 50/60 N_R	[kN]	4.0	4.4	4.4	4.4	4.4	8.4	8.4	8.4	9.4	9.4	9.4	13.2	11.8	13.2	13.2	13.2	13.2
Shear	≥ C 20/25 V_R	[kN]	3.4	3.0	7.1	7.1	7.1	7.6	7.6	7.3	12.0	12.0	11.6	12.0	12.0	11.6	17.9	17.9	15.7

Anchor type			FBN II M12			FBN II M16			FBN II M16			FBN II M20			FBN II M20		
			gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
h_{ef}			65	65	65	65	65	65	80	80	80	80	80	80	105	105	105
non-cracked concrete																	
Tension	C 20/25 N_R	[kN]	12.6	11.9	12.6	12.6	12.6	12.6	17.2	17.2	17.2	17.2	17.2	17.2	25.9	25.9	25.9
	C 50/60 N_R	[kN]	19.5	18.5	19.5	19.5	19.5	19.5	26.7	26.7	26.7	26.7	26.7	26.7	40.1	40.1	40.1
Shear	≥ C 20/25 V_R	[kN]	17.9	17.9	15.7	29.0	29.0	29.0	31.5	31.5	29.1	38.3	38.3	39.6	38.3	38.3	49.1

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

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4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Pull-out/pull-through failure: $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FBN II M6		FBN II M8			FBN II M10			FBN II M12			FBN II M16			FBN II M20		
			gvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
Design resistance	$N_{Rd,s}$	[kN]	5.5	7.1	11.8	11.8	11.8	19.4	19.4	19.4	29.7	29.7	29.7	51.9	51.9	55.7	71.3	71.3	74.0

4.2 Pull-out/pull-through failure of the highest loaded anchor

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

Design resistance of single anchor

Anchor type			FBN II M6		FBN II M8			FBN II M8			FBN II M10			FBN II M10			FBN II M12		
			gvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
h_{ef}			30		30			40			40			50			50		
non-cracked concrete																			
Design resistance	$N^0_{Rd,p}$	[kN]	4.0		4.0			8.5	8.0	8.5	8.5			11.9	10.7	11.9	11.9		

Anchor type			FBN II M12			FBN II M16			FBN II M16			FBN II M20			FBN II M20		
			gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
h_{ef}			65			65			80			80			105		
non-cracked concrete																	
Design resistance	$N^0_{Rd,p}$	[kN]	17.6	16.7	17.6	17.6			24.1			24.1			36.2		

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type			FBN II M6	FBN II M8	FBN II M8	FBN II M10	FBN II M10	FBN II M12
h_{ef}			30	30	40	40	50	50
non-cracked concrete								
Design resistance	$N^0_{Rd,c}$	[kN]	5.5	5.5	8.5	8.5	11.9	11.9

Anchor type			FBN II M12	FBN II M16	FBN II M16	FBN II M20	FBN II M20
h_{ef}			65	65	80	80	105
non-cracked concrete							
Design resistance	$N^0_{Rd,c}$	[kN]	17.6	17.6	24.1	24.1	36.2

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic edge distance and spacing for design

Anchor type		FBN II M6	FBN II M8	FBN II M8	FBN II M10	FBN II M10	FBN II M12
h_{ef}		30	30	40	40	50	50
$s_{cr,N}$	[mm]	90	90	120	120	150	150
$c_{cr,N}$	[mm]	45	45	60	60	75	75

Anchor type		FBN II M12	FBN II M16	FBN II M16	FBN II M20	FBN II M20
h_{ef}		65	65	80	80	105
$s_{cr,N}$	[mm]	195	195	240	240	315
$c_{cr,N}$	[mm]	98	98	120	120	158

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fischer Bolt FBN II

Anchor design according to fischer specification

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic edge distance and spacing for design

Anchor type h_{ef}		FBN II M6 30	FBN II M8 30	FBN II M8 40	FBN II M10 40	FBN II M10 50	FBN II M12 50
$s_{cr,sp}$	[mm]	130	190	190	200	200	290
$c_{cr,sp}$	[mm]	65	95	95	100	100	145
h_{min}	[mm]	100	100	100	100	100	100

Anchor type h_{ef}		FBN II M12 65	FBN II M16 65	FBN II M16 80	FBN II M20 80	FBN II M20 105
$s_{cr,sp}$	[mm]	290	350	350	370	370
$c_{cr,sp}$	[mm]	145	175	175	185	185
h_{min}	[mm]	120	120	160	160	200

4.3.3.1 Influence of spacing / Concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / Concrete splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / Concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = N_{Rd,c} \cdot k$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FBN II M6		FBN II M8			FBN II M10			FBN II M12			FBN II M16			FBN II M20		
h_{ef}			gvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
Design resistance	$V_{Rd,s}$	[kN]	4.8	4.2	10.6	10.6	10.2	16.8	16.8	16.2	25.0	25.0	21.9	44.1	44.1	40.8	53.6	53.6	68.8

5.2 Pryout failure of the most unfavourable anchor

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

k-factor

Anchor type	FBN II M6	FBN II M8	FBN II M10	FBN II M12	FBN II M16	FBN II M20
k	1.4	1.8	2.1	2.3	2.3	2.3

5.3 Concrete edge failure of the most unfavourable anchor

$$V_{Rd,c} = V^{o}_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary, if the following condition is met:

- $c < \max(10\ h_{ef}\ ;\ 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

edge distance	$V^{0}_{Rd,c}$ [kN]														
	FBN II M6	FBN II M8				FBN II M10			FBN II M12		FBN II M16			FBN II M20	
	gvz fvz A4	gvz fvz	A4	gvz fvz	A4	gvz fvz A4	gvz fvz	A4	gvz fvz A4	gvz fvz A4	gvz fvz A4	gvz fvz	A4	gvz fvz A4	gvz fvz A4
h_{ef}	30	30	30	40	40	40	50	50	50	65	65	80	80	80	105
edge distance [mm]	non-cracked concrete														
40	3.0	3.1		3.3											
45	3.5	3.6	3.6	3.8	3.8										
50	4.1	4.2	4.2	4.4	4.4		4.7								
55	4.6	4.8	4.8	5.0	5.0		5.4	5.4							
60	5.2	5.4	5.4	5.6	5.6		6.0	6.0							
65	5.8	6.0	6.0	6.3	6.3		6.7	6.7							
70	6.5	6.7	6.7	7.0	7.0		7.4	7.4		8.0					
75	7.1	7.4	7.4	7.7	7.7		8.1	8.1		8.7					
80	7.8	8.1	8.1	8.4	8.4	8.6	8.9	8.9		9.5			10.4		
85	8.5	8.8	8.8	9.1	9.1	9.3	9.7	9.7		10.3			11.2		
90	9.2	9.5	9.5	9.8	9.8	10.1	10.4	10.4		11.2		12.1	12.1		
95	10.0	10.2	10.2	10.6	10.6	10.9	11.2	11.2		12.0		13.0	13.0		
100	10.7	11.0	11.0	11.4	11.4	11.7	12.1	12.1	12.3	12.8		13.9	13.9		
110	12.3	12.6	12.6	13.0	13.0	13.3	13.7	13.7	14.0	14.6		15.8	15.8		
120	13.9	14.2	14.2	14.7	14.7	15.0	15.5	15.5	15.8	16.4	17.0	17.7	17.7	18.2	19.3
130	15.5	15.9	15.9	16.4	16.4	16.8	17.3	17.3	17.6	18.3	19.0	19.7	19.7	20.3	21.4
140	17.3	17.7	17.7	18.2	18.2	18.6	19.2	19.2	19.5	20.3	21.0	21.7	21.7	22.4	23.5
150	19.0	19.5	19.5	20.1	20.1	20.5	21.1	21.1	21.5	22.3	23.0	23.8	23.8	24.5	25.8
160	20.9	21.4	21.4	22.0	22.0	22.5	23.1	23.1	23.5	24.3	25.1	26.0	26.0	26.7	28.1
180	24.7	25.2	25.2	26.0	26.0	26.5	27.2	27.2	27.7	28.6	29.5	30.4	30.4	31.3	32.8
200	28.7	29.3	29.3	30.1	30.1	30.7	31.5	31.5	32.0	33.1	34.1	35.1	35.1	36.1	37.7
250	39.5	40.3	40.3	41.4	41.4	42.1	43.0	43.0	43.7	45.1	46.3	47.6	47.6	48.8	50.8
300	51.4	52.3	52.3	53.6	53.6	54.5	55.7	55.7	56.5	58.1	59.7	61.2	61.2	62.6	65.1
350	64.2	65.3	65.3	66.8	66.8	67.9	69.3	69.3	70.2	72.1	73.9	75.8	75.8	77.4	80.3
400	77.9	79.2	79.2	80.9	80.9	82.1	83.7	83.7	84.8	87.0	89.1	91.2	91.2	93.1	96.4
450		93.8	93.8	95.8	95.8	97.2	99.0	99.0	100.3	102.7	105.1	107.5	107.5	109.6	113.3
500		109.2	109.2	111.5	111.5	113.0	115.0	115.0	116.5	119.2	121.9	124.5	124.5	126.9	131.0
550						129.6	131.8	131.8	133.4	136.5	139.4	142.4	142.4	145.0	149.5
600						146.8	149.3	149.3	151.1	154.4	157.7	160.9	160.9	163.8	168.7
650						164.7	167.5	167.5	169.4	173.1	176.6	180.1	180.1	183.2	188.6
700									188.3	192.3	196.1	199.9	199.9	203.3	209.1
750									207.9	212.2	216.3	220.4	220.4	224.1	230.3
800											237.1	241.5	241.5	245.4	252.1
850											258.5	263.1	263.1	267.3	274.4
900											280.4	285.3	285.3	289.8	297.4
950											302.9	308.1	308.1	312.9	320.9
1000											325.9	331.4	331.4	336.4	344.9
1100														385.2	394.5
1200														435.9	446.1

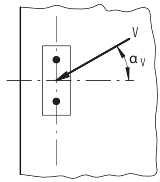
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle α ≧ 90° the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance
Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = lowest value of $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

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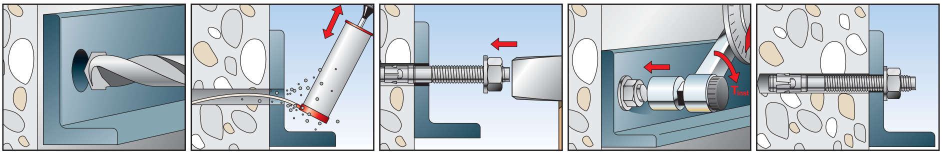
7. Installation details



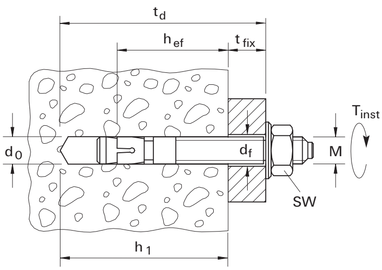
fischer Bolt FBN II

Anchor design according to fischer specification

8. Anchor characteristics

Anchor type			FBN II M6	FBN II M8	FBN II M8	FBN II M10	FBN II M10	FBN II M12
			gvz / A4	gvz / fvz / A4	gvz / fvz / A4	gvz / fvz / A4	gvz / fvz / A4	gvz / fvz / A4
h_{ef}		[mm]	30	30	40	40	50	50
diameter of thread			M6	M8	M8	M10	M10	M12
nominal drill hole diameter	d_0	[mm]	6	8	8	10	10	12
drill depth	h_1	[mm]	40	46	56	58	68	70
drill hole depth for through fixing	t_d	[mm]	$t_d = h_1 + t_{fix}$					
clearance-hole in fixture to be attached	d_f	[mm]	≦ 7	≦ 9	≦ 9	≦ 12	≦ 12	≦ 14
wrench size	SW	[mm]	10	13	13	17	17	19
required torque	T_{inst}	[Nm]	4	15 / 10	15 / 10	30 / 20	30 / 20	50 / 35
minimum thickness of concrete member	h_{min}	[mm]	100	100	100	100	100	100
miminum spacing	s_{min}	[mm]	50	40 / 50	40	50	50 / 70	70
minimum edge distance	c_{min}	[mm]	100	40 / 45	40 / 45	80	50 / 55	100

Anchor type			FBN II M12	FBN II M16	FBN II M16	FBN II M20	FBN II M20
			gvz / fvz / A4	gvz / fvz / A4	gvz / fvz / A4	gvz / fvz / A4	gvz / fvz / A4
h_{ef}		[mm]	65	65	80	80	105
diameter of thread			M12	M16	M16	M20	M20
nominal drill hole diameter	d_0	[mm]	12	16	16	20	20
drill depth	h_1	[mm]	85	89	104	110	135
drill hole depth for through fixing	t_d	[mm]	$t_d = h_1 + t_{fix}$				
clearance-hole in fixture to be attached	d_f	[mm]	≦ 14	≦ 18	≦ 18	≦ 22	≦ 22
wrench size	SW	[mm]	19	24	24	30	30
required torque	T_{inst}	[Nm]	50 / 35	100 / 80	100 / 80	200 / 150	200 / 150
minimum thickness of concrete member	h_{min}	[mm]	120	120	160	160	200
miminum spacing	s_{min}	[mm]	70	90	90 / 120	120 / 140	120
minimum edge distance	c_{min}	[mm]	70	120	90 / 80	120	120



9. Mechanical characteristics

Anchor type			FBN II M6		FBN II M8			FBN II M10			FBN II M12			FBN II M16			FBN II M20		
			gvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4	gvz	fvz	A4
stressed cross sectional area reduced part of the cone bolt	A_s	[mm²]	13.2	13.2	22.9	22.9	22.1	36.3	36.3	36.3	55.4	55.4	55.4	103.9	103.9	103.9	165.1	165.1	158.4
section modulus reduced part of the cone bolt	W	[mm³]	6.8	6.8	15.5	15.5	14.6	30.9	30.9	30.9	58.2	58.2	58.2	149.3	149.3	149.3	299.3	299.3	281.1
design value of bending moment, larger embedment depth	$M^0_{Rd,s}$	[Nm]	7.5	6.4	20.9	20.9	20.8	41.8	41.8	41.6	73.2	73.2	68.0	185.7	185.7	172.8	337.6	337.6	363.2
yield strength reduced part of the cone bolt	f_{yk}	[N/mm²]	480	640	640	640	640	640	640	640	640	640	640	640	640	640	520	520	560
tensile strength reduced part of the cone bolt	f_{uk}	[N/mm²]	600	800	750	750	750	750	750	750	750	750	750	750	750	750	650	650	700
stressed cross sectional area threaded part	A_s	[mm²]	20.1	20.1	36.6	36.6	36.6	58.0	58.0	58.0	84.3	84.3	84.3	157.0	157.0	157.0	245.0	245.0	245.0
section modulus threaded part	W	[mm³]	12.7	12.7	31.2	31.2	31.2	62.3	62.3	62.3	109.2	109.2	109.2	277.5	277.5	277.5	540.9	540.9	540.9
yield strength threaded part	f_{yk}	[N/mm²]	480	420	560	560	560	560	560	560	560	560	520	560	560	520	520	520	560
tensile strength threaded part	f_{uk}	[N/mm²]	600	525	700	700	700	700	700	700	700	700	650	700	700	650	650	650	700

Notes

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fischer High Performance anchor FH II

Anchor design according to fischer specification

1. Types

FH II-S 10 M6 - 32 M24 (gvz) – with hexagon head
FH II-S 10 M6 - 24 M16 (A4) – with hexagon head

FH II-SK 10 M6 - 18 M12 (gvz) – with countersunk head
FH II-SK 10 M6 - 18 M12 (A4) – with countersunk head

FH II-H 10 M6 - 24 M16 (gvz) – with cap nut

FH II-B 10 M6 - 32 M24 (gvz) – with hexagon nut

ETA-07/0025
ETAG 001-2
Option 1 for cracked concrete *)

Fire resistance classification
R 120
Anchor types see test report

ICC ES ESR-2691
See ICC-ES Evaluation Report at www.ic-es.org
Inspection agency: AA-707 *)

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 1*) for cracked and non-cracked concrete.
- ICC-ES Evaluation Report*) for cracked and non-cracked concrete. Seismic categories A-F.
- Highest tensile and shear loads.
- Independent controlled and confirmed product characteristics due to the European Technical Approval.
- Fire resistance classifications according to test report independently proved, gives safety in case of fire.
- The high strength class of the steel (8.8) combined with the optimised interaction of screw (bolt) and sleeve gives very high admissible shear loads.
- With the permitted small spacing and edge distances small, cost-efficient anchor plates and fixings near to the edge can be used.
- The design of the anchor allows a surface flush removal of the fixing.
- The different available head designs gives the opportunity to realise visually high-quality connections.
- Convenient push-through installation.

*) The conditions of use (e.g. design resistances, characteristic distances, ...) in the European Technical Approval or in the ICC-ES Evaluation Report may vary from those of the Technical Handbook.
The ICC-ES ER is currently only valid for several FH II anchors in carbon steel (gvz).

Materials

Threaded rod and components:	- Carbon steel grade 8.8. zinc plated (5 µm) and passivated (gvz) - Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316

fischer High Performance anchor FH II

Anchor design according to fischer specification

2. Ultimate resistance of single anchors with large spacing and large edge distance

Mean values

Anchor type			FH II 10 M6			FH II 12 M8			FH II 15 M10			FH II 18 M12		
			B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4
non-cracked concrete														
tension	C20/25	N_u [kN]	16.9		14.8	28.5		26.9	35.8			48.5		
	C50/60	N_u [kN]	16.9		14.8	30.8		26.9	48.7		42.6	70.8		62.0
shear	≧ C20/25	V_u [kN]	17.7			34.3	42.4	34.2	52.7	71.7	52.5	79.1	96.3	80.6
cracked concrete														
tension	C20/25	N_u [kN]	13.8			20.8			28.9			36.2		
	C50/60	N_u [kN]	16.9		14.8	30.8		26.9	45.7		42.6	57.3		
shear	≧ C20/25	V_u [kN]	13.8			34.3	41.5	34.2	52.7	57.8	52.5	72.5		

Anchor type			FH II 24 M16			FH II 28 M20		FH II 32 M24	
			B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz
non-cracked concrete									
tension	C20/25	N_u [kN]	71.7			106.2		145.9	
	C50/60	N_u [kN]	113.4			167.9		230.7	
shear	≧ C20/25	V_u [kN]	143.4			212.4		210.6	266.4
cracked concrete									
tension	C20/25	N_u [kN]	61.0			88.8		131.7	
	C50/60	N_u [kN]	96.4			140.4		208.3	
shear	≧ C20/25	V_u [kN]	121.9			177.6		210.6	263.4

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3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance

Anchor type			FH II 10 M6			FH II 12 M8			FH II 15 M10			FH II 18 M12		
			B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4
non-cracked concrete														
tension	C20/25	N_{Rk} [kN]	14.1			25.8		25.6	32.5			39.7		
	C50/60	N_{Rk} [kN]	16.1		14.1	29.3		25.6	46.4		40.6	61.6		59.0
shear	≧ C20/25	V_{Rk} [kN]	14.1			27.0	33.0	28.0	41.0	59.0	43.0	62.0	76.0	66.0
cracked concrete														
tension	C20/25	N_{Rk} [kN]	7.5			14.7			21.1			25.6		
	C50/60	N_{Rk} [kN]	11.6			22.8			32.7			39.7		
shear	≧ C20/25	V_{Rk} [kN]	9.1			27.0	33.0	28.0	41.0	42.2	42.2	51.5		

Anchor type			FH II 24 M16			FH II 28 M20		FH II 32 M24	
			B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz
non-cracked concrete									
tension	C20/25	N_{Rk} [kN]	55.6			77.6		102.1	
	C50/60	N_{Rk} [kN]	86.1			120.3		158.2	
shear	≧ C20/25	V_{Rk} [kN]	111.1			146.0	155.3	169.0	204.1
cracked concrete									
tension	C20/25	N_{Rk} [kN]	36.0			50.3		66.1	
	C50/60	N_{Rk} [kN]	55.8			78.0		102.5	
shear	≧ C20/25	V_{Rk} [kN]	72.0			100.6		132.3	

fischer High Performance anchor FH II

Anchor design according to fischer specification

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3.2 Design resistance

Anchor type		FH II 10 M6			FH II 12 M8			FH II 15 M10			FH II 18 M12		
		B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4
non-cracked concrete													
tension	C20/25 N_{Rd} [kN]	9.4			17.2		13.3	21.7			26.5		
	C50/60 N_{Rd} [kN]	10.7		9.4	19.5		17.1	30.9		27.1	41.1		39.3
shear	≥ C20/25 V_{Rd} [kN]	9.4			21.6	26.4	22.4	32.8	43.4	34.4	49.6	53.0	52.8
cracked concrete													
tension	C20/25 N_{Rd} [kN]	5.0			9.8			14.1			17.1		
	C50/60 N_{Rd} [kN]	7.8			15.2			21.8			26.5		
shear	≥ C20/25 V_{Rd} [kN]	6.1			21.6	22.3		28.1			34.3		

Anchor type		FH II 24 M16			FH II 28 M20		FH II 32 M24	
		B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz
non-cracked concrete								
tension	C20/25 N_{Rd} [kN]	37.0			51.8		68.0	
	C50/60 N_{Rd} [kN]	57.4			80.2		105.5	
shear	≥ C20/25 V_{Rd} [kN]	74.1			103.5		135.2	136.1
cracked concrete								
tension	C20/25 N_{Rd} [kN]	24.0			33.5		44.1	
	C50/60 N_{Rd} [kN]	37.2			52.0		68.3	
shear	≥ C20/25 V_{Rd} [kN]	48.0			67.1		88.2	

3.3 Recommended resistance [1]

Anchor type		FH II 10 M6			FH II 12 M8			FH II 15 M10			FH II 18 M12		
		B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	S/SK A4	B/H gvz	S/SK gvz	A4
non-cracked concrete													
tension	C20/25 N_R [kN]	6.7			12.3		9.5	15.5			18.9		
	C50/60 N_R [kN]	7.7		6.7	14.0		12.2	22.1		19.3	29.3		28.1
shear	≥ C20/25 V_R [kN]	6.7			15.4	18.9	16.0	23.4	31.0	24.6	35.4	37.9	37.7
cracked concrete													
tension	C20/25 N_R [kN]	3.6			7.0			10.0			12.2		
	C50/60 N_R [kN]	5.5			10.9			15.6			18.9		
shear	≥ C20/25 V_R [kN]	4.3			15.4	15.9		20.1			24.5		

Anchor type		FH II 24 M16			FH II 28 M20		FH II 32 M24	
		B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz
non-cracked concrete								
tension	C20/25 N_R [kN]	26.5			37.0		48.6	
	C50/60 N_R [kN]	41.0			57.3		75.3	
shear	≥ C20/25 V_R [kN]	52.9			73.9		96.6	97.2
cracked concrete								
tension	C20/25 N_R [kN]	17.1			24.0		31.5	
	C50/60 N_R [kN]	26.6			37.1		48.8	
shear	≥ C20/25 V_R [kN]	34.3			47.9		63.0	

[1] Material safety factors γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on failure mode of the anchor.

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Pull-out / pull-through failure: $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FH II 10 M6		FH II 12 M8		FH II 15 M10		FH II 18 M12		FH II 24 M16		FH II 28 M20	FH II 32 M24
			gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	gvz
Design resistance	$N_{Rd,s}$	[kN]	10.7	9.4	19.5	17.1	30.9	27.1	44.9	39.3	83.5	73.1	130.5	188.0

4.2 Pull-out/pull-through failure of the highest loaded anchor

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

Design resistance of single anchor

Anchor type			FH II 10 M6		FH II 12 M8		FH II 15 M10		FH II 18 M12		FH II 24 M16		FH II 28 M20	FH II 32 M24
			gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	gvz
non-cracked concrete														
Design resistance	$N^0_{Rd,p}$	[kN]	9.4		17.2	13.3	21.7		26.5		37.0		51.8	68.0
cracked concrete														
Design resistance	$N^0_{Rd,p}$	[kN]	5.0		9.8		14.1		17.1		24.0		33.5	44.1

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\, c_{cr,sp}$

Design resistance of single anchor

Anchor type			FH II 10 M6		FH II 12 M8		FH II 15 M10		FH II 18 M12		FH II 24 M16		FH II 28 M20	FH II 32 M24
			gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	gvz
non-cracked concrete														
Design resistance	$N^0_{Rd,c}$	[kN]	9.4		17.2		21.7		26.5		37.0		51.8	68.0
cracked concrete														
Design resistance	$N^0_{Rd,c}$	[kN]	6.1		11.2		14.1		17.2		24.0		33.5	44.1

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic edge distance and spacing for design

Anchor type		FH II 10 M6	FH II 12 M8	FH II 15 M10	FH II 18 M12	FH II 24 M16	FH II 28 M20	FH II 32 M24
h_{ef}	[mm]	40	60	70	80	100	125	150
$s_{cr.N}$	[mm]	120	180	210	240	300	375	450
$c_{cr.N}$	[mm]	60	90	105	120	150	187.5	225

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr.N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s.1}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

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4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0$$

$$f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr.N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1.A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1.B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic edge distance and spacing for design

Anchor type		FH II 10 M6	FH II 12 M8	FH II 15 M10	FH II 18 M12	FH II 24 M16	FH II 28 M20	FH II 32 M24
h_{ef}	[mm]	40	60	70	80	100	125	150
$s_{cr.sp}$	[mm]	190	300	320	340	380	480	570
$c_{cr.sp}$	[mm]	95	150	160	170	190	240	285
h_{min}	[mm]	80	120	140	160	200	250	300

4.3.3.1 Influence of spacing / Concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr.sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s.sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / Concrete splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0$$

$$f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr.sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1.sp.A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1.sp.B}$ $f_{c2.sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

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4.3.3.3 Influence of concrete thickness / Concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = N_{Rd,c} \cdot k$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FH II 10 M6			FH II 12 M8			FH II 15 M10			FH II 18 M12		
			B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	A4
Design resistance	$V_{Rd,s}$	[kN]	12.4	14.4	14.4	21.6	26.4	22.4	32.8	47.2	34.4	49.6	60.8	52.8

Anchor type			FH II 24 M16			FH II 28 M20		FH II 32 M24	
			B/H gvz	S/SK gvz	A4	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz
Design resistance	$V_{Rd,s}$	[kN]	95.2	116.8	95.2	116.8	139.2	135.2	173.6

5.2 Pryout failure of the most unfavourable anchor

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

k-factor

Anchor type	FH II 10 M6	FH II 12 M8 - FH II 32 M24
k	1.0	2.0

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5.3 Concrete edge failure of the most unfavourable anchor

$$V_{Rd,c} = V^{o}_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_{m}$$

Proof of concrete edge failure is only necessary. if the following condition is met:

- $c < \max(10\, h_{ef}\,;\, 60\, d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

edge distance	$V^{o}_{Rd,c}$ [kN]							
	FH II 10 M6		FH II 12 M8		FH II 15 M10		FH II 18 M12	
[mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
40	3.4	2.4						
45	3.9	2.8						
50	4.5	3.2		3.6				
55	5.2	3.7		4.1				
60	5.8	4.1	6.4	4.5		4.9		
65	6.5	4.6	7.1	5.0		5.4		
70	7.2	5.1	7.9	5.6	8.4	5.9		6.3
75	7.9	5.6	8.6	6.1	9.2	6.5		6.9
80	8.6	6.1	9.4	6.7	10.0	7.1	10.6	7.5
85	9.3	6.6	10.2	7.2	10.8	7.7	11.4	8.1
90	10.1	7.2	11.0	7.8	11.7	8.3	12.3	8.7
95	10.9	7.7	11.8	8.4	12.5	8.9	13.2	9.4
100	11.7	8.3	12.7	9.0	13.4	9.5	14.1	10.0
120	15.0	10.6	16.2	11.5	17.1	12.1	18.0	12.7
130	16.8	11.9	18.1	12.8	19.1	13.5	20.0	14.2
135	17.7	12.5	19.1	13.5	20.1	14.2	21.0	14.9
140	18.6	13.2	20.0	14.2	21.1	14.9	22.1	15.6
160	22.5	15.9	24.1	17.0	25.2	17.9	26.4	18.7
180	26.5	18.8	28.3	20.0	29.6	21.0	30.9	21.9
200	30.7	21.8	32.7	23.2	34.2	24.2	35.6	25.2
250	42.1	29.8	44.6	31.6	46.5	32.9	48.2	34.2
300	54.5	38.6	57.6	40.8	59.8	42.4	61.9	43.9
350	67.9	48.1	71.5	50.7	74.1	52.5	76.6	54.3
400	82.1	58.2	86.3	61.2	89.3	63.3	92.2	65.3
450	97.2	68.8	102.0	72.2	105.4	74.6	108.6	76.9
500	113.0	80.0	118.4	83.8	122.2	86.6	125.8	89.1
550	129.6	91.8	135.5	96.0	139.8	99.0	143.7	101.8
600	146.8	104.0	153.4	108.6	158.0	111.9	162.4	115.0
650			171.9	121.8	177.0	125.3	181.7	128.7
700			191.1	135.3	196.6	139.2	201.7	142.9
750					216.8	153.5	222.3	157.5
800					237.6	168.3	243.5	172.5
850					259.0	183.4	265.3	187.9
900					280.9	199.0	287.7	203.8
950							310.6	220.0
1000							334.0	236.6
1100							382.5	270.9

continued next page

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Anchor design according to fischer specification

edge distance [mm]	$V^0_{Rd,c}$ [kN]					
	FH II 24 M16		FH II 28 M20		FH II 32 M24	
[mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
80		8.3				
85		9.0				
90		9.6				
95		10.3				
100	15.5	11.0		12.0		
120	19.6	13.9	21.2	15.0		16.1
130	21.8	15.4	23.5	16.6		17.8
135	22.9	16.2	24.6	17.4		18.6
140	24.0	17.0	25.8	18.2		19.5
160	28.5	20.2	30.6	21.6		23.1
180	33.3	23.6	35.6	25.2	37.8	26.8
200	38.3	27.1	40.8	28.9	43.2	30.6
250	51.6	36.5	54.7	38.7	57.7	40.8
300	65.9	46.7	69.6	49.3	73.2	51.8
350	81.3	57.6	85.5	60.6	89.7	63.5
400	97.5	69.1	102.4	72.5	107.1	75.8
450	114.6	81.2	120.1	85.1	125.3	88.8
500	132.5	93.9	138.6	98.2	144.4	102.3
550	151.1	107.1	157.8	111.8	164.2	116.3
600	170.5	120.8	177.8	126.0	184.8	130.9
650	190.5	135.0	198.5	140.6	206.0	145.9
700	211.2	149.6	219.8	155.7	227.9	161.5
750	232.6	164.7	241.8	171.3	250.5	177.4
800	254.5	180.3	264.3	187.2	273.7	193.8
850	277.0	196.2	287.5	203.7	297.4	210.7
900	300.2	212.6	311.3	220.5	321.8	227.9
950	323.8	229.4	335.6	237.7	346.7	245.6
1000	348.0	246.5	360.4	255.3	372.1	263.6
1100	398.0	281.9	411.7	291.6	424.6	300.8
1200	450.0	318.7	465.0	329.4	479.2	339.4
1300	503.8	356.9	520.2	368.5	535.6	379.4
1400	559.6	396.4	577.3	408.9	594.0	420.7
1500			636.2	450.6	654.1	463.3
1600			696.8	493.5	715.9	507.1
1700					779.4	552.1
1800					844.6	598.3
1900					911.3	645.5

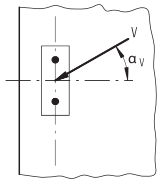
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h.V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

$$f_m$$

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

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6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd.s}$; $N_{Rd.p}$; $N_{Rd.c}$; $N_{Rd.sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd.s}$; $V_{Rd.cp}$; $V_{Rd.c}$

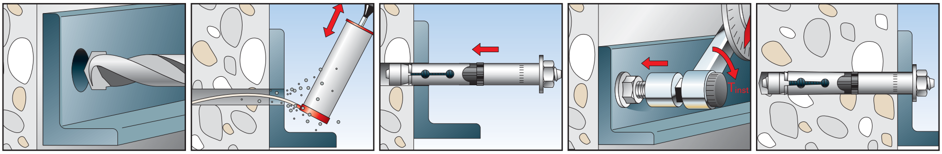
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details



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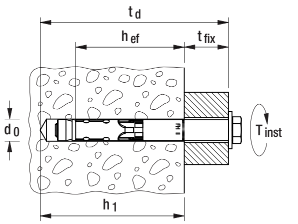
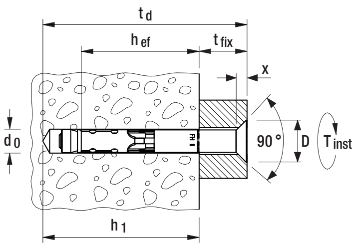
Anchor design according to fischer specification

8. Anchor characteristics

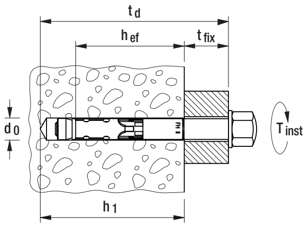
Anchor type			FH II 10 M6 gvz	FH II 10 M6 A4	FH II 12 M8 gvz	FH II 12 M8 A4	FH II 15 M10 gvz	FH II 15 M10 A4	FH II 18 M12 gvz	FH II 18 M12 A4	FH II 24 M16 gvz	FH II 24 M16 A4	FH II 28 M20 gvz	FH II 32 M24 gvz
diameter of thread			M6		M8		M10		M12		M16		M20	M24
nominal drill hole diameter	d_0	[mm]	10		12		15		18		24		28	32
drill depth	h_1	[mm]	55		80		90		105		125		155	180
effective anchorage depth	h_{ef}	[mm]	40		60		70		80		100		125	150
clearance-hole in fixture to be attached	d_f	[mm]	12		14		17		20		26		31	35
drill hole depth for through fixing	t_d	[mm]	$t_d = h_1 + t_{fix}$											
wrench size type H	SW	[mm]	13	10	17	13	17		19		24		-	-
wrench size type SK [1]	SW	[mm]	4		5		6		8		-		-	-
wrench size type S/B	SW	[mm]	10		13		17		19		24		30	36
required installation torque type B	T_{inst}	[Nm]	10	15	17.5	25	38	40	80	100	120	160	180	200
required installation torque type H	T_{inst}	[Nm]	10	15	22.5	25	40	40	80	100	90	160	-	-
required installation torque type S	T_{inst}	[Nm]	10	15	22.5	25	40	40	80	100	160	160	180	200
required installation torque type SK	T_{inst}	[Nm]	10	10	22.5	25	40	40	80	100	-	-	-	-
min. thickness of concrete member	h_{min}	[mm]	80		120		140		160		200		250	300
non-cracked concrete [2]														
minimum spacing	s_{min}	[mm]	40		60		70		80		100		120	160
for required edge distances	for c	[mm]	70		100		100		160		200		220	360
minimum edge distances	c_{min}	[mm]	40		60		70		80		100		120	180
for required spacing	for s	[mm]	70		100		140		200		220		240	380
cracked concrete [2]														
minimum spacing	s_{min}	[mm]	40		50		60		70		80		100	120
for required edge distances	for c	[mm]	40		80		120		140		180		200	260
minimum edge distances	c_{min}	[mm]	40		50		60		70		80		100	120
for required spacing	for s	[mm]	40		80		120		160		200		220	280

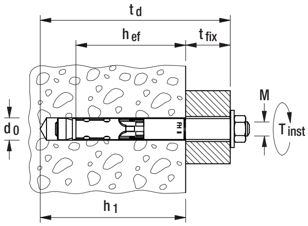
[1] Internal hexagon
[2] Intermediate values by linear interpolation.





	X [mm]	⌀ D [mm]	counter bore [°]
FH II 10 M6 SK	5	18	90°
FH II 12 M8 SK FH II 12 M8 SK A4	5.8	22	90°
FH II 15 M10 SK FH II 15 M10 SK A4	5.8	25	90°
FH II 18 M12 SK FH II 18 M12 SK A4	8	32	90°





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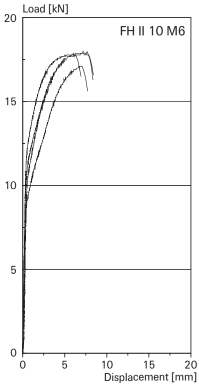
fischer High Performance anchor FH II

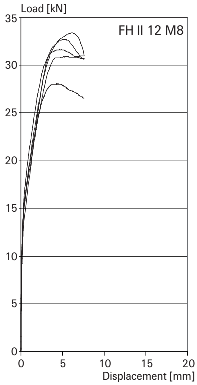
Anchor design according to fischer specification

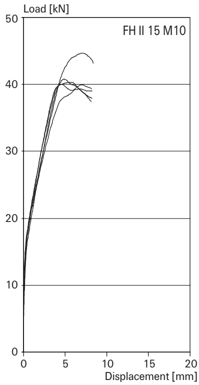
9. Mechanical characteristics

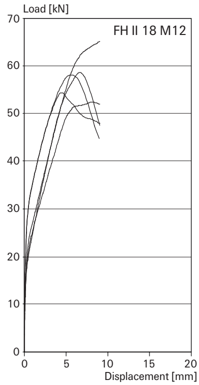
Anchor type			FH II 10 M6		FH II 12 M8		FH II 15 M10		FH II 18 M12		FH II 24 M16		FH II 28 M20	FH II 32 M24
			gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	gvz
stressed cross sectional area threaded rod	A_s	[mm²]	20.1		36.6		58.0		84.3		157.0		245.0	353.0
resisting moment threaded rod	W	[mm³]	12.7		31.2		62.3		109.2		277.5		541.0	935.0
design value of bending moment	$M^0_{Rd,s}$	[N/m]	9,6	8,4	24,0	20,8	48,0	42,0	84,0	73,6	212,8	186,4	414,4	716,8
yield strength threaded rod	f_{yk}	[N/mm²]	640	560	640	560	640	560	640	560	640	560	640	640
tensile strength threaded rod	f_{uk}	[N/mm²]	800	700	800	700	800	700	800	700	800	700	800	800

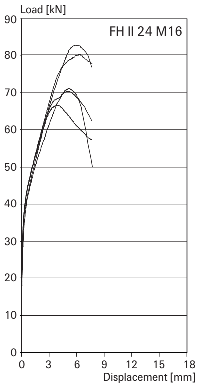
10. Load displacement curves for tension in non-cracked concrete ($f_{ck.cube\ (200)}$ = 30 N/mm²)

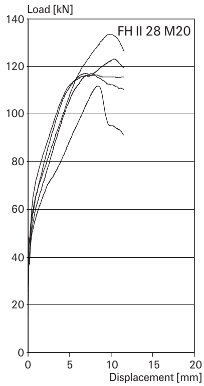


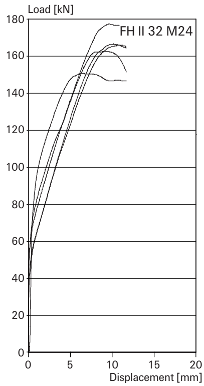












4

fischer High Performance anchor FH II-I

Anchor design according to fischer specification

1. Types

FH II-I (gvz)

FH II-I (A4)

Features and Advantages

- European Technical Approval option 1*) for cracked concrete.
- Independent controlled and confirmed product characteristics due to the European Technical Approval.
- Fire resistance classifications according to test report independently proved, gives safety in case of fire.
- The design of the anchor allows a surface flush removal of the fixing.
- The functional principle of the FH II-I enables fast, deformation-controlled expansion with a hexagon wrench, thus ensuring top installation comfort.
- The visual setting control with a predefined gap U between the anchor and the concrete surface allows a compliant approved setting process without a torque wrench.
- The metric internal thread allows for the use of standard screws and threaded rods for perfect adaptation in line with the attachment.
- The FH II-I enables surface-flush removal and the reuse of the undamaged fixing point, thus offering optimum flexibility.

*) The conditions of use (e.g. design resistances, characteristic distances, ...) in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Threaded rod and components:	- Carbon steel grade 5.8, 6.8 and 8.8. zinc plated (5 µm) and passivated (gvz) - Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316

fischer High Performance anchor FH II-I

Anchor design according to fischer specification

2. Ultimate resistance of single anchors with large spacing and large edge distance

Mean values

Anchor type	FH II 12 M6 I						FH II 12 M8 I					
	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80
non-cracked concrete												
tension C20/25 N_u [kN]	10.5	12.6	16.8	10.5	14.7	16.8	20.0	24.2	25.3	20.0	25.3	25.3
C50/60 N_u [kN]	10.5	12.6	16.8	10.5	14.7	16.8	20.0	24.2	28.4	20.0	27.3	30.5
shear ≧ C20/25 V_u [kN]	5.3	6.3	8.4	5.3	7.4	8.4	10.0	12.1	14.2	10.0	13.7	15.2
cracked concrete												
tension C20/25 N_u [kN]	10.5	12.6	16.8	10.5	14.7	16.8	20.0	21.6	21.6	20.0	21.6	21.6
C50/60 N_u [kN]	10.5	12.6	16.8	10.5	14.7	16.8	20.0	24.2	28.4	20.0	27.3	30.5
shear ≧ C20/25 V_u [kN]	5.3	6.3	8.4	5.3	7.4	8.4	10.0	12.1	14.2	10.0	13.7	15.2

Anchor type	FH II 15 M10 I						FH II 15 M12 I					
	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80
non-cracked concrete												
tension C20/25 N_u [kN]	30.5	36.8	38.7	30.5	38.7	38.7	38.7	38.7	38.7	38.7	38.7	38.7
C50/60 N_u [kN]	30.5	36.8	46.2	30.5	43.1	48.3	45.2	46.2	46.2	45.2	56.7	48.3
shear ≧ C20/25 V_u [kN]	15.2	18.4	23.1	15.2	21.5	24.2	22.6	23.1	23.1	22.6	28.4	24.2
cracked concrete												
tension C20/25 N_u [kN]	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2
C50/60 N_u [kN]	30.5	36.8	42.2	30.5	42.2	42.2	42.2	42.2	42.2	42.2	42.2	42.2
shear ≧ C20/25 V_u [kN]	15.2	18.4	23.1	15.2	21.5	24.2	22.6	23.1	23.1	22.6	28.4	24.2

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance

Anchor type	FH II 12 M6 I						FH II 12 M8 I					
	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80
non-cracked concrete												
tension C20/25 N_{Rk} [kN]	10.0	12.0	16.0	10.0	14.0	16.0	19.0	20.0	20.0	19.0	20.0	20.0
C50/60 N_{Rk} [kN]	10.0	12.0	16.0	10.0	14.0	16.0	19.0	23.0	27.0	19.0	26.0	29.0
shear ≧ C20/25 V_{Rk} [kN]	5.0	6.0	8.0	5.0	7.0	8.0	9.0	11.0	14.0	9.0	13.0	15.0
cracked concrete												
tension C20/25 N_{Rk} [kN]	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
C50/60 N_{Rk} [kN]	10.0	12.0	14.0	10.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
shear ≧ C20/25 V_{Rk} [kN]	5.0	6.0	8.0	5.0	7.0	8.0	9.0	11.0	14.0	9.0	13.0	15.0

Anchor type	FH II 15 M10 I						FH II 15 M12 I					
	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80
non-cracked concrete												
tension C20/25 N_{Rk} [kN]	29.0	29.6	29.6	29.0	29.6	29.6	29.6	29.6	29.6	29.6	29.6	29.6
C50/60 N_{Rk} [kN]	29.0	35.0	44.0	29.0	41.0	45.8	43.0	44.0	44.0	43.0	45.8	45.8
shear ≧ C20/25 V_{Rk} [kN]	15.0	18.0	23.0	15.0	20.0	23.0	21.0	24.0	24.0	21.0	30.0	32.0
cracked concrete												
tension C20/25 N_{Rk} [kN]	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
C50/60 N_{Rk} [kN]	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6	18.6
shear ≧ C20/25 V_{Rk} [kN]	15.0	18.0	23.0	15.0	20.0	23.0	21.0	24.0	24.0	21.0	30.0	32.0

fischer High Performance anchor FH II-I

Anchor design according to fischer specification

3.2 Design resistance

Anchor type		FH II 12 M6 I						FH II 12 M8 I					
		gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80
non-cracked concrete													
tension	C20/25 N_{Rd} [kN]	6.7	8.0	10.7	3.5	7.5	10.0	12.7	13.3	13.3	6.6	13.3	13.3
	C50/60 N_{Rd} [kN]	6.7	8.0	10.7	3.5	7.5	10.0	12.7	15.3	18.0	6.6	13.9	18.1
shear	≧ C20/25 V_{Rd} [kN]	4.0	4.8	6.4	2.1	4.5	6.0	7.2	8.8	11.2	3.8	8.3	11.3
cracked concrete													
tension	C20/25 N_{Rd} [kN]	6.0	6.0	6.0	3.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
	C50/60 N_{Rd} [kN]	6.7	8.0	9.3	3.5	7.5	9.3	9.3	9.3	9.3	6.6	9.3	9.3
shear	≧ C20/25 V_{Rd} [kN]	4.0	4.8	6.4	2.1	4.5	6.0	7.2	8.8	11.2	3.8	8.3	11.3

Anchor type		FH II 15 M10 I						FH II 15 M12 I					
		gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80
non-cracked concrete													
tension	C20/25 N_{Rd} [kN]	19.3	19.7	19.7	10.1	19.7	19.7	19.7	19.7	19.7	15.0	19.7	19.7
	C50/60 N_{Rd} [kN]	19.3	23.3	29.3	10.1	21.9	28.8	28.7	29.3	29.3	15.0	28.9	28.8
shear	≧ C20/25 V_{Rd} [kN]	12.0	14.4	18.4	6.3	12.8	17.3	16.8	19.2	19.2	8.8	19.2	24.1
cracked concrete													
tension	C20/25 N_{Rd} [kN]	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
	C50/60 N_{Rd} [kN]	12.4	12.4	12.4	10.1	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
shear	≧ C20/25 V_{Rd} [kN]	12.0	14.4	18.4	6.3	12.8	17.3	16.8	19.2	19.2	8.8	19.2	24.1

4

3.3 Recommended resistance [1)]

Anchor type		FH II 12 M6 I						FH II 12 M8 I					
		gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80
non-cracked concrete													
tension	C20/25 N_R [kN]	4.8	5.7	7.6	2.5	5.3	7.1	9.0	9.5	9.5	4.7	9.5	9.5
	C50/60 N_R [kN]	4.8	5.7	7.6	2.5	5.3	7.1	9.0	11.0	12.9	4.7	9.9	12.9
shear	≧ C20/25 V_R [kN]	2.9	3.4	4.6	1.5	3.2	4.3	5.1	6.3	8.0	2.7	6.0	8.1
cracked concrete													
tension	C20/25 N_R [kN]	4.3	4.3	4.3	2.5	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
	C50/60 N_R [kN]	4.8	5.7	6.6	2.5	5.3	6.6	6.6	6.6	6.6	4.7	6.6	6.6
shear	≧ C20/25 V_R [kN]	2.9	3.4	4.6	1.5	3.2	4.3	5.1	6.3	8.0	2.7	6.0	8.1

Anchor type		FH II 15 M10 I						FH II 15 M12 I					
		gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80
non-cracked concrete													
tension	C20/25 N_R [kN]	13.8	14.1	14.1	7.2	14.1	14.1	14.1	14.1	14.1	10.7	14.1	14.1
	C50/60 N_R [kN]	13.8	16.7	21.0	7.2	15.7	20.5	20.5	21.0	21.0	10.7	20.6	20.5
shear	≧ C20/25 V_R [kN]	8.6	10.3	13.1	4.5	9.2	12.4	12.0	13.7	13.7	6.3	13.7	17.2
cracked concrete													
tension	C20/25 N_R [kN]	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7	5.7
	C50/60 N_R [kN]	8.9	8.9	8.9	7.2	8.9	8.9	8.9	8.9	8.9	8.9	8.9	8.9
shear	≧ C20/25 V_R [kN]	8.6	10.3	13.1	4.5	9.2	12.4	12.0	13.7	13.7	6.3	13.7	17.2

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

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Pull-out / pull-through failure: $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FH II 12 M6 I						FH II 12 M8 I					
			gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80
Design resistance	$N_{Rd,s}$	[kN]	6.7	8.0	10.7	3.5	7.5	10.0	12.7	15.3	18.0	6.6	13.9	18.1

Anchor type			FH II 15 M10 I						FH II 15 M12 I					
			gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80
Design resistance	$N_{Rd,s}$	[kN]	19.3	23.3	29.3	10.1	21.9	28.8	28.7	29.3	29.3	15.0	28.9	28.8

4.2 Pull-out/pull-through failure of the highest loaded anchor

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

Design resistance of single anchor

Anchor type			FH II 12 M6 I	FH II 12 M8 I	FH II 15 M10 I	FH II 15 M12 I
non-cracked concrete						
Design resistance	$N^0_{Rd,p}$	[kN]	13.3	13.3	19.7	19.7
cracked concrete						
Design resistance	$N^0_{Rd,p}$	[kN]	6.0	6.0	8.0	8.0

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type			FH II 12 M6 I	FH II 12 M8 I	FH II 15 M10 I	FH II 15 M12 I
non-cracked concrete						
Design resistance	$N^0_{Rd,c}$	[kN]	15.6	15.6	19.7	19.7
cracked concrete						
Design resistance	$N^0_{Rd,c}$	[kN]	11.2	11.2	14.1	14.1

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic edge distance and spacing for design

Anchor type		FH II 12 M6 I	FH II 12 M8 I	FH II 15 M10 I	FH II 15 M12 I
h_{ef}	[mm]	60	60	70	70
$s_{cr,N}$	[mm]	180	180	210	210
$c_{cr,N}$	[mm]	90	90	105	105

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr.N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s.1}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

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4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0$$

$$f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr.N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1.A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1.B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic edge distance and spacing for design

Anchor type		FH II 12 M6 I	FH II 12 M8 I	FH II 15 M10 I	FH II 15 M12 I
h_{ef}	[mm]	60	60	70	70
$s_{cr,sp}$	[mm]	300	300	320	320
$c_{cr,sp}$	[mm]	150	150	160	160
h_{min}	[mm]	125	125	150	150

4.3.3.1 Influence of spacing / Concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr.sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s.sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / Concrete splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0$$

$$f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr.sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1.sp.A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1.sp.B}$ $f_{c2.sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / Concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = N_{Rd,c} \cdot k$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type	FH II 12 M6 I						FH II 12 M8 I					
	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80
Design resistance $V_{Rd,s}$ [kN]	4.0	4.8	6.4	2.1	4.5	6.0	7.2	8.8	11.2	3.8	8.3	11.3

Anchor type	FH II 15 M10 I						FH II 15 M12 I					
	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80	gvz 5.8	gvz 6.8	gvz 8.8	A4-50	A4-70	A4-80
Design resistance $V_{Rd,s}$ [kN]	12.0	14.4	18.4	6.3	12.8	17.3	16.8	19.2	19.2	8.8	19.2	24.1

5.2 Pryout failure of the most unfavourable anchor

$$V_{Rd.cp} = N_{Rd.c} \cdot k$$

k-factor

Anchor type	FH II 12 M6 I - FH II 15 M12 I
k	2.0

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5.3 Concrete edge failure of the most unfavourable anchor

$$V_{Rd,c} = V^o_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary. if the following condition is met:

- $c < \max(10\ h_{ef}\ ;\ 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

edge distance	$V^0_{Rd,c}$ [kN]							
	FH II 12 M6 I		FH II 12 M8 I		FH II 15 M10 I		FH II 15 M12 I	
[mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
50		3.6		3.6				
55		4.1		4.1				
60	6.4	4.5	6.4	4.5		4.9		4.9
65	7.1	5.0	7.1	5.0		5.4		5.4
70	7.9	5.6	7.9	5.6	8.4	5.9	8.4	5.9
75	8.6	6.1	8.6	6.1	9.2	6.5	9.2	6.5
80	9.4	6.7	9.4	6.7	10.0	7.1	10.0	7.1
85	10.2	7.2	10.2	7.2	10.8	7.7	10.8	7.7
90	11.0	7.8	11.0	7.8	11.7	8.3	11.7	8.3
95	11.8	8.4	11.8	8.4	12.5	8.9	12.5	8.9
100	12.7	9.0	12.7	9.0	13.4	9.5	13.4	9.5
120	16.2	11.5	16.2	11.5	17.1	12.1	17.1	12.1
130	18.1	12.8	18.1	12.8	19.1	13.5	19.1	13.5
135	19.1	13.5	19.1	13.5	20.1	14.2	20.1	14.2
140	20.0	14.2	20.0	14.2	21.1	14.9	21.1	14.9
160	24.1	17.0	24.1	17.0	25.2	17.9	25.2	17.9
180	28.3	20.0	28.3	20.0	29.6	21.0	29.6	21.0
200	32.7	23.2	32.7	23.2	34.2	24.2	34.2	24.2
250	44.6	31.6	44.6	31.6	46.5	32.9	46.5	32.9
300	57.6	40.8	57.6	40.8	59.8	42.4	59.8	42.4
350	71.5	50.7	71.5	50.7	74.1	52.5	74.1	52.5
400	86.3	61.2	86.3	61.2	89.3	63.3	89.3	63.3
450	102.0	72.2	102.0	72.2	105.4	74.6	105.4	74.6
500	118.4	83.8	118.4	83.8	122.2	86.6	122.2	86.6
550	135.5	96.0	135.5	96.0	139.8	99.0	139.8	99.0
600	153.4	108.6	153.4	108.6	158.0	111.9	158.0	111.9
650	171.9	121.8	171.9	121.8	177.0	125.3	177.0	125.3
700	191.1	135.3	191.1	135.3	196.6	139.2	196.6	139.2
750					216.8	153.5	216.8	153.5
800					237.6	168.3	237.6	168.3
850					259.0	183.4	259.0	183.4
900					280.9	199.0	280.9	199.0
950					303.4	214.9	303.4	214.9

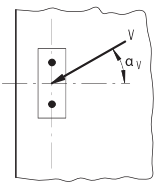
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			**C 12/15**	**C 16/20**	**C 20/25**	**C 25/30**	**C 30/37**	**C 35/45**	**C 40/50**	**C 45/55**	**C 50/60**
Cylinder compressive strength	$f_{ck.cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck.cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b.N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha.V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

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5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1.V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2.V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

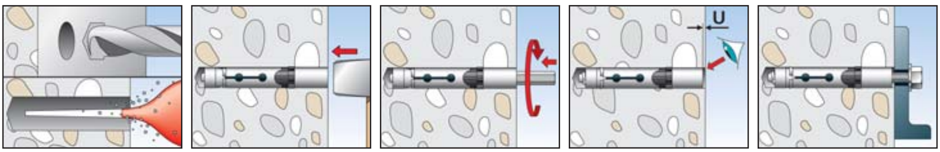
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd}; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd}; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details



fischer High Performance anchor FH II-I

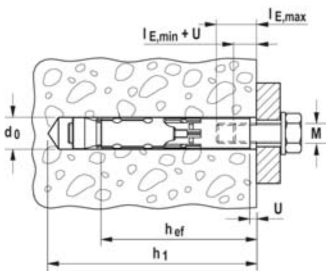
Anchor design according to fischer specification

8. Anchor characteristics

Anchor type			FH II 12 M6 I	FH II 12 M8 I	FH II 15 M10 I	FH II 15 M12 I
diameter of thread	M		6	8	10	12
nominal drill hole diameter	d_0	[mm]	12	12	15	15
drill depth	h_1	[mm]	85	85	95	95
effective anchorage depth	h_{ef}	[mm]	60	60	70	70
clearance-hole in fixture to be attached	d_f	[mm]	7	9	12	14
wrench size	SW	[mm]	10	13	17	19
required installation torque of the anchor [1]	T_{inst}	[mm]	15	15	25	25
maximum installation torque on the fixture	T_{max}	[mm]	3	8	15	20
required gap after torquing [1]	U	[mm]	3 - 5			
minimum screw in length	$l_s \geq$	[mm]	11+U	13+U	10+U	12+U
maximum screw in length	$l_s \leq$	[mm]	20+U			
min. thickness of concrete member	h_{min}	[mm]	125	125	150	150
non-cracked concrete [2]						
minimum spacing	s_{min}	[mm]	60	60	70	70
for required edge distances	for c	[mm]	100	100	100	100
minimum edge distances	c_{min}	[mm]	60	60	70	70
for required spacing	for s	[mm]	100	100	140	140
cracked concrete [2]						
minimum spacing	s_{min}	[mm]	50	50	60	60
for required edge distances	for c	[mm]	80	80	120	120
minimum edge distances	c_{min}	[mm]	50	50	60	60
for required spacing	for s	[mm]	80	80	120	120

[1] Only one of both requirements has to be fullfilled

[2] Intermediate values by linear interpolation.



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9. Mechanical characteristics

Anchor type			**FH II 12 M6 I**						**FH II 18 M12 I**					
			gvz 5.8	**gvz 6.8**	**gvz 8.8**	**A4-50**	**A4-70**	**A4-80**	**gvz 5.8**	**gvz 6.8**	**gvz 8.8**	**A4-50**	**A4-70**	**A4-80**
stressed cross sectional area screw	A_s	[mm²]	20.1						36.6					
resisting moment screw	W	[mm³]	12.7						31.2					
design value of bending moment	$M^0_{Rd,s}$	[N/m]	6.1	7.2	9.6	3.3	7.0	9.0	15.2	18.4	24.0	7.9	16.6	22.5
yield strength screw	f_{yk}	[N/mm²]	400	480	640	210	450	600	400	480	640	210	450	600
tensile strength screw	f_{uk}	[N/mm²]	500	600	800	500	700	800	500	600	800	500	700	800

Anchor type			**FH II 15 M10 I**						**FH II 15 M12 I**					
			gvz 5.8	**gvz 6.8**	**gvz 8.8**	**A4-50**	**A4-70**	**A4-80**	**gvz 5.8**	**gvz 6.8**	**gvz 8.8**	**A4-50**	**A4-70**	**A4-80**
stressed cross sectional area screw	A_s	[mm²]	58						84.3					
resisting moment screw	W	[mm³]	62.3						109.1					
design value of bending moment	$M^0_{Rd,s}$	[N/m]	29.6	35.2	48.0	14.5	33.3	45.1	52.0	62.4	84.0	27.3	58.9	78.9
yield strength screw	f_{yk}	[N/mm²]	400	480	640	210	450	600	400	480	640	210	450	600
tensile strength screw	f_{uk}	[N/mm²]	500	600	800	500	700	800	500	600	800	500	700	800

Notes

4

fischer Zykon anchor FZA

Anchor design according to fischer specification

1. Types

FZA – Bolt anchor (gvz)

FZA – Bolt anchor (A4)

FZA – Bolt anchor (C)

ETA-98/004
ETAG 001-3
Option 1 for cracked concrete *)

Fire resistance classification
R 120
Anchor types see test report

FM APPROVED
from thread M 10

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

4

Features and Advantages

- European Technical Approval option 1*) for cracked an non-cracked concrete.
- Independent controlled and confirmed product characteristics (Approval) gives the required safety guarantees.
- Expansion free fixing allows small spacing and edge distances.
- Depth marking (green ring) enable visual control and ensures correct function.
- Fire resistance classifications (F 120) according to test report independently proved gives the safety case of fire.
- Formlocking fit in the undercut enables high loads at shallow anchorage depth.

*) The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Anchor:
- Carbon steel, zinc plated (5 µm) and passivated (gvz)
- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
- Highly corrosion-resistant steel of the corrosion resistance class IV, e. g. 1.4529.

2. Ultimate resistance of single anchors with large spacing and large edge distance

Mean values

Anchor type				FZA 10x40 M 6			FZA 12x40 M 8			FZA 14x40 M 10			FZA 12x50 M 8			FZA 14x60 M 10			FZA 18x80 M 12			FZA 22x100 M 16			FZA 22x125 M 16		
				gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete																											
tension	C 20/25	N_u	[kN]	16.1	14.1		17.1			17.1			23.9			31.4			48.3			67.5			94.3		
	C 50/60	N_u	[kN]	16.1	14.1		26.4			26.4			29.3	25.6		46.4	40.6		67.4	59.0		104.6			125.6	110.0	
shear	≧ C 20/25	V_u	[kN]	9.6	8.4		17.6	15.4		27.8	24.4		17.6	15.4		27.8	24.4		40.5	35.4		75.4	65.9		75.4	65.9	
cracked concrete																											
tension	C 20/25	N_u	[kN]	12.0			12.0			12.0			16.7			22.0			33.8			47.2			66.0		
	C 50/60	N_u	[kN]	16.1	14.1		18.5			18.5			25.9	25.6		34.1			52.3			73.1			102.2		
shear	C 20/25	V_u	[kN]	9.6	8.4		15.5	15.4		15.5			17.6	15.4		27.8	24.4		40.5	35.4		75.4	65.9		75.4	65.9	

fischer innovative solutions

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance

Anchor type			FZA 10x40 M 6			FZA 12x40 M 8			FZA 14x40 M 10			FZA 12x50 M 8			FZA 14x60 M 10			FZA 18x80 M 12			FZA 22x100 M 16			FZA 22x125 M 16		
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete																										
tension	C 20/25 N_{Rk}	[kN]	14.0			14.0			14.0			19.6			25.8			39.7			55.4			77.5		
	C 50/60 N_{Rk}	[kN]	16.1	14.1		21.7			21.7			29.3	25.6		39.9			61.5	59.0		85.9			120.0	110.0	
shear	C 20/25 V_{Rk}	[kN]	8.0	7.0		14.7	12.8		18.2			14.7	12.8		23.2	20.3		33.8	29.5		62.8	55.0		62.8	55.0	
	≧ C 40/50 V_{Rk}	[kN]	8.0	7.0		14.7	12.8		23.2	20.3		14.7	12.8		23.2	20.3		33.8	29.5		62.8	55.0		62.8	55.0	
cracked concrete																										
tension	C 20/25 N_{Rk}	[kN]	9.1			9.1			9.1			12.7			16.7			25.8			36.0			50.3		
	C 50/60 N_{Rk}	[kN]	14.1			14.1			14.1			19.7			25.9			39.9			55.8			77.9		
shear	C 20/25 V_{Rk}	[kN]	8.0	7.0		11.8			11.8			14.7	12.8		23.2	20.3		33.8	29.5		62.8	55.0		62.8	55.0	
	C 50/60 V_{Rk}	[kN]	8.0	7.0		14.7	12.8		18.3			14.7	12.8		23.2	20.3		33.8	29.5		62.8	55.0		62.8	55.0	

3.2 Design resistance

Anchor type			FZA 10x40 M 6			FZA 12x40 M 8			FZA 14x40 M 10			FZA 12x50 M 8			FZA 14x60 M 10			FZA 18x80 M 12			FZA 22x100 M 16			FZA 22x125 M 16		
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete																										
tension	C 20/25 N_{Rd}	[kN]	9.4	7.5	9.4	9.4			9.4			13.1			17.2			26.4			37.0			51.7		
	C 50/60 N_{Rd}	[kN]	10.7	7.5	9.4	14.5	13.7	14.5	14.5			19.5	13.7	17.1	26.6	21.7	26.6	41.0	31.6	39.3	57.3			80.0	58.8	73.3
shear	C 20/25 V_{Rd}	[kN]	6.4	4.5	5.6	11.8	8.2	10.2	12.2			11.8	8.2	10.2	18.6	13.0	16.2	27.0	18.9	23.6	50.2	35.3	44.0	50.2	35.3	44.0
	C 40/50 V_{Rd}	[kN]	6.4	4.5	5.6	11.8	8.2	10.2	18.6	13.0	16.2	11.8	8.2	10.2	18.6	13.0	16.2	27.0	18.9	23.6	50.2	35.3	44.0	50.2	35.3	44.0
cracked concrete																										
tension	C 20/25 N_{Rd}	[kN]	6.1			6.1			6.1			8.5			11.2			17.2			24.0			33.5		
	C 50/60 N_{Rd}	[kN]	9.4	7.5	9.4	9.4			9.4			13.1			17.3			26.6			37.2			52.0		
shear	C 20/25 V_{Rd}	[kN]	6.4	4.5	5.6	7.9			7.9			11.0	8.2	10.2	18.6	13.0	16.2	27.0	18.9	23.6	48.0	35.3	44.0	50.2	35.3	44.0
	C 50/60 V_{Rd}	[kN]	6.4	4.5	5.6	11.8	8.2	10.2	12.2			11.8	8.2	10.2	18.6	13.0	16.2	27.0	18.9	23.6	50.2	35.3	44.0	50.2	35.3	44.0

3.3 Recommended resistance [1)]

Anchor type			FZA 10x40 M 6			FZA 12x40 M 8			FZA 14x40 M 10			FZA 12x50 M 8			FZA 14x60 M 10			FZA 18x80 M 12			FZA 22x100 M 16			FZA 22x125 M 16		
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete																										
tension	C 20/25 N_R	[kN]	6.7	5.4	6.7	6.7			6.7			9.3			12.3			18.9			26.4			36.9		
	C 50/60 N_R	[kN]	7.7	5.4	6.7	10.3	9.8	10.3	10.3			14.0	9.8	12.2	19.0	15.5	19.0	19.3	22.5	28.1	40.9			57.2	42.0	52.4
shear	C 20/25 V_R	[kN]	4.6	3.2	4.0	7.2	5.9	7.2	7.2			8.4	5.9	7.3	13.3	9.3	11.6	19.3	13.5	16.9	35.9	25.2	31.4	35.9	25.2	31.4
	C 40/50 V_R	[kN]	4.6	3.2	4.0	8.4	5.9	7.3	11.2	9.3	11.2	8.4	5.9	7.3	13.3	9.3	11.6	19.3	13.5	16.9	35.9	25.2	31.4	35.9	25.2	31.4
cracked concrete																										
tension	C 20/25 N_R	[kN]	4.3			4.3			4.3			6.1			8.0			12.3			17.1			24.0		
	C 50/60 N_R	[kN]	6.7	5.4	6.7	6.7			6.7			9.4			12.3			19.0			26.6			37.1		
shear	C 20/25 V_R	[kN]	4.6	3.2	4.0	5.6			5.6			7.9	5.9	7.3	13.3	9.3	11.6	19.3	13.5	16.9	34.3	25.2	31.4	35.9	25.2	31.4
	≧ C 45/55 V_R	[kN]	4.6	3.2	4.0	8.4	5.9	7.3	8.7			8.4	5.9	7.3	13.3	9.3	11.6	19.3	13.5	16.9	35.9	25.2	31.4	35.9	25.2	31.4

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

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Pull-out/pull-through failure: *Failure mode is not decisive*

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: *Failure mode is not decisive*

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FZA 10x40 M 6			FZA 12x40 M 8			FZA 14x40 M 10			FZA 12x50 M 8			FZA 14x60 M 10			FZA 18x80 M 12			FZA 22x100 M 16			FZA 22x125 M 16		
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
design resistance	$N_{Rd,s}$	[kN]	10.7	7.5	9.4	19.5	13.7	17.1	30.9	21.7	27.1	19.5	13.7	17.1	30.9	21.7	27.1	44.9	31.6	39.3	84.0	58.8	73.3	84.0	58.8	73.3

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4.2 Pull-out/pull-through failure of the highest loaded anchor

Failure mode is not decisive and therefore may be neglected

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: *Failure mode is not decisive*

Design resistance of single anchor

Anchor type			FZA 10x40 M 6	FZA 12x40 M 8	FZA 14x40 M 10	FZA 12x50 M 8	FZA 14x60 M 10	FZA 18x80 M 12	FZA 22x100 M 16	FZA 22x125 M 16
eff. anchorage depth	h_{ef}	[mm]	40	40	40	50	60	80	100	125
non-cracked concrete										
design resistance	$N^0_{Rd,c}$	[kN]	9.4	9.4	9.4	13.1	17.2	26.4	37.0	51.7
cracked concrete										
design resistance	$N^0_{Rd,c}$	[kN]	6.1	6.1	6.1	8,5	11.2	17.2	24.0	33.5

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic edge distance and spacing for design

Anchor type		FZA 10x40 M 6	FZA 12x40 M 8	FZA 14x40 M 10	FZA 12x50 M 8	FZA 14x60 M 10	FZA 18x80 M 12	FZA 22x100 M 16	FZA 22x125 M 16
h_{ef}		**40**	**40**	**40**	**50**	**60**	**80**	**100**	**125**
$s_{cr,N}$	[mm]	120	120	120	150	180	240	300	375
$c_{cr,N}$	[mm]	60	60	60	75	90	120	150	188

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Failure mode is not decisive and therefore may be neglected

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = N_{Rd,c} \cdot k$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type	FZA 10x40 M 6			FZA 12x40 M 8			FZA 14x40 M 10			FZA 12x50 M 8			FZA 14x60 M 10			FZA 18x80 M 12			FZA 22x100 M 16			FZA 22x125 M 16		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
design resistance $V_{Rd,s}$ [kN]	6.4	4.5	5.6	11.8	8.2	10.2	18.6	13.0	16.2	11.8	8.2	10.2	18.6	13.0	16.2	27.0	18.9	23.6	50.2	35.3	44.0	50.2	35.3	44.0

5.2 Pryout failure for the most unfavourable anchor

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

k-factor

Anchor type	FZA 10x40 M 6	FZA 12x40 M 8	FZA 14x40 M 10	FZA 12x50 M 8	FZA 14x60 M 10	FZA 18x80 M 12	FZA 22x100 M 16	FZA 22x125 M 16
k	1.3	1.3	1.3	1.3	2.0	2.0	2.0	2.0

5.3 Concrete edge failure of the most unfavourable anchor

$$V_{Rd,c} = V^{o}_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_{m}$$

Proof of concrete edge failure is only necessary, if the following condition is met:

- $c < \max(10\,h_{ef}\,;\,60\,d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

edge distance [mm]	$V^0_{Rd,c}$ [kN]							
	FZA 10x40 M6		FZA 12x40 M8		FZA 14x40 M10		FZA 12x50 M8	
	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
35	2.8	2.0						
40	3.4	2.4	3.5	2.5				
45	3.9	2.8	4.1	2.9			4.2	3.0
50	4.5	3.2	4.7	3.3			4.9	3.4
55	5.2	3.7	5.3	3.8			5.5	3.9
60	5.8	4.1	6.0	4.2			6.2	4.4
65	6.5	4.6	6.6	4.7			6.9	4.9
70	7.2	5.1	7.3	5.2	7.5	5.3	7.6	5.4
75	7.9	5.6	8.0	5.7	8.2	5.8	8.3	5.9
80	8.6	6.1	8.8	6.2	8.9	6.3	9.1	6.4
85	9.3	6.6	9.5	6.8	9.7	6.9	9.9	7.0
90	10.1	7.2	10.3	7.3	10.5	7.4	10.7	7.6
95	10.9	7.7	11.1	7.9	11.3	8.0	11.5	8.1
100	11.7	8.3	11.9	8.4	12.1	8.6	12.3	8.7
120	15.0	10.6	15.3	10.9	15.6	11.0	15.8	11.2
125	15.9	11.3	16.2	11.5	16.5	11.7	16.7	11.8
130	16.8	11.9	17.1	12.1	17.4	12.3	17.6	12.5
135	17.7	12.5	18.0	12.8	18.3	13.0	18.6	13.2
140	18.6	13.2	19.0	13.4	19.3	13.6	19.5	13.8
160	22.5	15.9	22.8	16.2	23.2	16.4	23.5	16.6
180	26.5	18.8	26.9	19.1	27.3	19.3	27.7	19.6
200	30.7	21.8	31.2	22.1	31.6	22.4	32.0	22.7
250	42.1	29.8	42.7	30.2	43.2	30.6	43.7	31.0
300	54.5	38.6	55.3	39.1	55.9	39.6	56.5	40.0
350	67.9	48.1	68.8	48.7	69.5	49.2	70.2	49.7
400	82.1	58.2	83.1	58.9	84.0	59.5	84.8	60.1
450	97.2	68.8	98.3	69.7	99.3	70.4	100.3	71.0
500	113.0	80.0	114.3	81.0	115.4	81.8	116.5	82.5
550	129.6	91.8	131.0	92.8	132.3	93.7	133.4	94.5
600	146.8	104.0	148.4	105.1	149.8	106.1	151.1	107.0
650			166.5	117.9	168.0	119.0	169.4	120.0
700			185.2	131.2	186.8	132.3	188.3	133.4
750			204.5	144.8	206.3	146.1	207.9	147.3
800					226.3	160.3		
850					246.9	174.9		
900								
950								
1000								
1100								
1200								
1300								
1400								

continued next page

fischer Zykon anchor FZA

Anchor design according to fischer specification

edge distance [mm]	$V^0_{Rd,c}$ [kN]							
	FZA 14x60 M10		FZA 18x80 M12		FZA 22x100 M16		FZA 22x125 M16	
	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
35								
40								
45								
50								
55	5.9	4.2						
60	6.6	4.7						
65	7.3	5.2						
70	8.0	5.7	8.9	6.3				
75	8.8	6.2	9.7	6.9				
80	9.6	6.8	10.6	7.5				
85	10.4	7.4	11.4	8.1				
90	11.2	8.0	12.3	8.7				
95	12.1	8.6	13.2	9.4				
100	12.9	9.2	14.1	10.0	15.3	10.8		
120	16.5	11.7	18.0	12.7	19.4	13.7		
125	17.5	12.4	19.0	13.4	20.4	14.5	21.4	15.2
130	18.4	13.1	20.0	14.2	21.5	15.2	22.5	16.0
135	19.4	13.7	21.0	14.9	22.6	16.0	23.6	16.7
140	20.4	14.4	22.1	15.6	23.7	16.8	24.8	17.5
160	24.5	17.3	26.4	18.7	28.2	20.0	29.4	20.9
180	28.8	20.4	30.9	21.9	32.9	23.3	34.3	24.3
200	33.3	23.6	35.6	25.2	37.9	26.8	39.4	27.9
250	45.3	32.1	48.2	34.2	51.0	36.2	53.0	37.5
300	58.4	41.4	61.9	43.9	65.3	46.3	67.6	47.9
350	72.5	51.3	76.6	54.3	80.5	57.0	83.2	58.9
400	87.4	61.9	92.2	65.3	96.7	68.5	99.7	70.6
450	103.2	73.1	108.6	76.9	113.6	80.5	117.0	82.9
500	119.7	84.8	125.8	89.1	131.4	93.1	135.2	95.8
550	137.0	97.1	143.7	101.8	149.9	106.2	154.1	109.1
600	155.0	109.8	162.4	115.0	169.2	119.8	173.7	123.0
650	173.7	123.0	181.7	128.7	189.1	134.0	194.0	137.4
700	193.0	136.7	201.7	142.9	209.7	148.5	215.0	152.3
750	213.0	150.8	222.3	157.5	230.9	163.6	236.6	167.6
800	233.5	165.4	243.5	172.5	252.7	179.0	258.8	183.3
850	254.6	180.4	265.3	187.9	275.1	194.9	281.6	199.5
900			287.7	203.8	298.1	211.2	305.0	216.0
950			310.6	220.0	321.7	227.9	328.9	233.0
1000			334.0	236.6	345.8	244.9	353.4	250.3
1100			382.5	270.9	395.5	280.1	403.9	286.1
1200					447.2	316.8	456.5	323.3
1300					500.8	354.8	510.9	361.9
1400					556.3	394.1	567.2	401.8

4

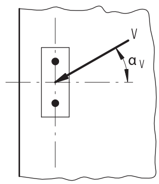
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck.cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck.cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b.V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha.V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1.V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2.V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h.V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd.s}$; $N_{Rd.p}$; $N_{Rd.c}$; $N_{Rd.sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd.s}$; $V_{Rd.cp}$; $V_{Rd.c}$

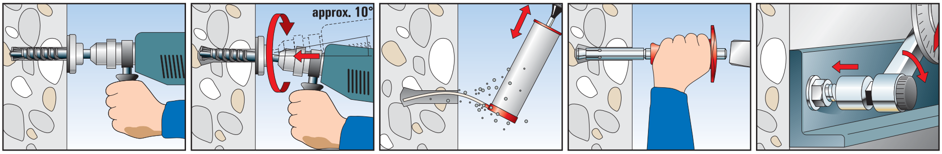
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd}; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd}; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details



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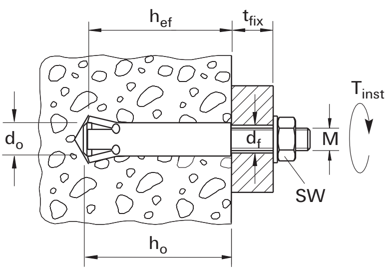
8. Anchor installation data

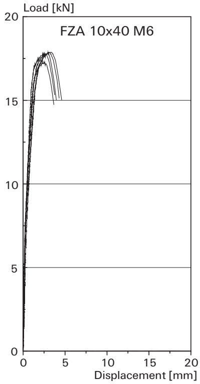
Anchor type			FZA 10x40 M 6	FZA 12x40 M 8	FZA 14x40 M 10	FZA 12x50 M 8	FZA 14x60 M 10	FZA 18x80 M 12	FZA 22x100 M 16	FZA 22x125 M 16
diameter of thread			M 6	M 8	M 10	M 8	M 10	M 12	M 16	M 16
nominal drill hole diameter	d_0	[mm]	10	12	14	12	14	18	22	22
drill depth	h_0	[mm]	43	43	43	54	63	83	103	127
effective anchorage depth	h_{ef}	[mm]	40	40	40	50	60	80	100	125
clearance-hole in fixture to be attached	d_f	[mm]	≦ 7	≦ 9	≦ 12	≦ 9	≦ 12	≦ 14	≦ 18	≦ 18
wrench size	SW	[mm]	10	13	17	13	17	19	24	24
required torque	T_{inst}	[Nm]	8.5	20	40	20	40	60	100	100
minimum thickness of concrete member	h_{min}	[mm]	100	100	100	110	130	160	200	250
minimum spacing	s_{min}	[mm]	40	40	70	50	60	80	100	125
minimum edge distances	c_{min}	[mm]	35	40	70	45	55	70	100	125

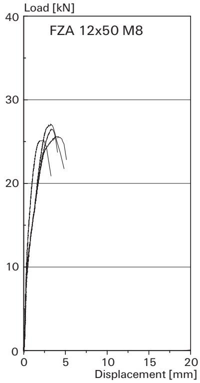


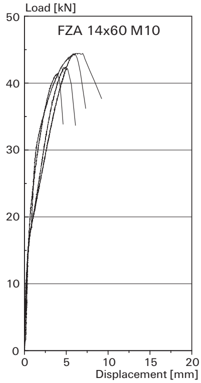
9. Mechanical anchor material characteristics

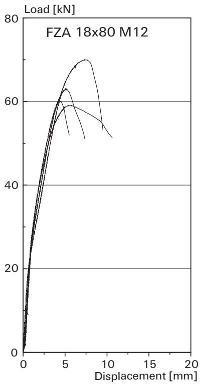
Anchor type			FZA 10x40 M 6			FZA 12x40 M 8			FZA 14x40 M 10			FZA 12x50 M 8			FZA 14x60 M 10			FZA 18x80 M 12			FZA 22x100 M 16			FZA 22x125 M 16		
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
stressed cross sectional area cone bolt	A_S	[mm²]	20.1			36.6			58.0			36.6			58.0			84.3			157			157		
resisting moment cone bolt	W	[mm³]	12.7			31.2			62.3			31.2			62.3			109			278			278		
design value of bending moment	$M^0_{Rd,s}$	[Nm]	9.8	6.9	8.6	24.0	16.8	21.0	47.8	33.5	41.8	24.0	16.8	21.0	47.8	33.5	41.8	84.0	58.7	73.3	212.8	148.7	185.6	212.8	148.7	185.6
yield strength cone bolt	f_{yk}	[N/mm²]	640	450	560	640	450	560	640	450	560	640	450	560	640	450	560	640	450	560	640	450	560	640	450	560
tensile strength cone bolt	f_{uk}	[N/mm²]	800	700		800	700		800	700		800	700		800	700		800	700		800	700		800	700	

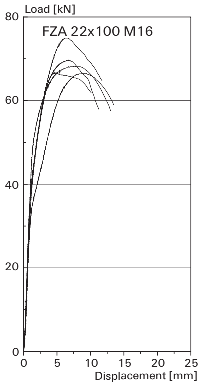
10. Load displacement curves for tension in non-cracked concrete ($f_{ck,cube\,(200)}$ = 30 N/mm²)

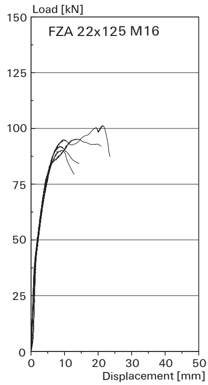












Notes

fischer Zykon through anchor FZA-D

Anchor design according to fischer specification

1. Types

FZA-D – Through anchor (gvz)

FZA-D – Through anchor (A4)

FZA-D – Through anchor (C)

ETA-98/004
ETAG 001-3
Option 1 for cracked concrete *)

Fire resistance classification
R 120
Anchor types see test report

FM APPROVED
from thread M 10

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 1*) for cracked an non-cracked concrete.
- Independent controlled and confirmed product characteristics (Approval) gives the required safety guarantees.
- Expansion free fixing allows small spacing and edge distances.
- Depth marking (green ring) enable visual control and ensures correct function.
- Fire resistance classifications (F 120) according to test report independently proved gives the safety case of fire.
- Formlocking fit in the undercut enables high loads at shallow anchorage depth.

*) The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Anchor:
- Carbon steel, zinc plated (5 µm) and passivated (gvz)
- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
- Highly corrosion-resistant steel of the corrosion resistance class IV, e. g. 1.4529.

2. Ultimate resistance of single anchors with large spacing and large edge distance

Mean values

Anchor type				FZA 12x50 M 8 D		FZA 12x60 M 8 D		FZA 12x80 M 8 D		FZA 14x80 M 10 D		FZA 14x100 M 10 D		FZA 18x100 M 12 D		FZA 18x130 M 12 D		FZA 22x125 M 16 D	
				gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4	gvz	A4 / C	gvz	A4 / C	gvz	A4
non-cracked concrete																			
tension	C 20/25	N_u	[kN]	17.1		23.9		23.9		31.4		31.4		48.3		48.3		67.5	
	C 50/60	N_u	[kN]	26.4		29.3	25.6	29.3	25.6	46.4	40.6	46.4	40.6	67.4	59.0	67.4	59.0	104.6	
shear	≥ C 20/25	V_u	[kN]	23.8	25.4	23.8	25.4	23.8	25.4	33.6	34.5	33.6	34.5	53.1	56.2	53.1	56.2	85.3	85.5
cracked concrete																			
tension	C 20/25	N_u	[kN]	12.0		16.7		16.7		22.0		22.0		33.8		33.8		47.2	
	C 50/60	N_u	[kN]	18.5		25.9	25.6	25.9	25.6	34.1		34.1		52.3		52.3		73.1	
shear	C 20/25	V_u	[kN]	15.5		21.7		21.7		33.6	34.5	33.6	34.5	53.1	56.2	53.1	56.2	85.3	85.5

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance

Anchor type			FZA 12x50 M 8 D			FZA 12x60 M 8 D			FZA 12x80 M 8 D			FZA 14x80 M 10 D			FZA 14x100 M 10 D		FZA 18x100 M 12 D			FZA 18x130 M 12 D			FZA 22x125 M 16 D	
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	gvz	A4	C	gvz	A4	C	gvz	A4
non-cracked concrete																								
tension	C 20/25 N_{Rk}	[kN]	14.0			19.6			19.6			25.8			25.8		39.7			39.7			55.4	
	C 50/60 N_{Rk}	[kN]	21.7			29.3	25.6		29.3	25.6		39.9			39.9		61.5	59.0		61.5	59.0		85.9	
shear	C 20/25 V_{Rk}	[kN]	18.2	17.8		21.3	17.8		21.3	17.8		29.8	25.4		29.8	25.4	46.3	38.7		46.3	38.7		75.3	64.1
	≧ C 30/37 V_{Rk}	[kN]	21.3	17.8		21.3	17.8		21.3	17.8		29.8	25.4		29.8	25.4	33.8	38.7		33.8	38.7		75.3	64.1
cracked concrete																								
tension	C 20/25 N_{Rk}	[kN]	9.1			12.7			12.7			16.7			16.7		25.8			25.8			36.0	
	C 50/60 N_{Rk}	[kN]	14.1			19.7			19.7			25.9			25.9		39.9			39.9			55.8	
shear	C 20/25 V_{Rk}	[kN]	11.8			16.5			16.5			29.8	25.4		29.8	25.4	46.3	38.7		46.3	38.7		72.0	64.1
	C 50/60 V_{Rk}	[kN]	18.3	17.8		21.3	17.8		21.3	17.8		29.8	25.4		29.8	25.4	46.3	38.7		46.3	38.7		72.0	64.1

3.2 Design resistance

Anchor type			FZA 12x50 M 8 D			FZA 12x60 M 8 D			FZA 12x80 M 8 D			FZA 14x80 M 10 D			FZA 14x100 M 10 D		FZA 18x100 M 12 D			FZA 18x130 M 12 D			FZA 22x125 M 16 D	
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	gvz	A4	C	gvz	A4	C	gvz	A4
non-cracked concrete																								
tension	C 20/25 N_{Rd}	[kN]	9.4			13.1			13.1			17.2			17.2		26.4			26.4			37.0	
	C 50/60 N_{Rd}	[kN]	14.5	13.7	14.5	19.5	13.7	17.1	19.5	13.7	17.1	26.6	21.7	26.6	26.6	21.7	41.0	31.6	39.3	41.0	31.6	39.3	57.3	
shear	C 20/25 V_{Rd}	[kN]	12.2	11.4	12.2	17.0	11.4	14.2	17.0	11.4	14.2	23.8	16.3	20.3	23.8	16.3	37.0	24.8	31.0	37.0	24.8	31.0	60.2	41.1
	C 30/37 V_{Rd}	[kN]	17.0	11.4	14.2	17.0	11.4	14.2	17.0	11.4	14.2	23.8	16.3	20.3	23.8	16.3	37.0	24.8	31.0	37.0	24.8	31.0	60.2	41.1
cracked concrete																								
tension	C 20/25 N_{Rd}	[kN]	6.1			8.5			8.5			11.2			11.2		17.2			17.2			24.0	
	C 50/60 N_{Rd}	[kN]	9.4			13.1			13.1			17.3			17.3		26.6			26.6			37.2	
shear	C 20/25 V_{Rd}	[kN]	7.9			11.0			11.0			22.3	16.3	20.3	22.3	16.3	34.3	24.8	31.0	34.3	24.8	31.0	60.2	41.1
	C 50/60 V_{Rd}	[kN]	10.2			14.2	11.4	14.2	14.2	11.4	14.2	23.8	16.3	20.3	23.8	16.3	37.0	24.8	31.0	37.0	24.8	31.0	60.2	41.1

3.3 Recommended resistance [1)]

Anchor type			FZA 12x50 M 8 D			FZA 12x60 M 8 D			FZA 12x80 M 8 D			FZA 14x80 M 10 D			FZA 14x100 M 10 D		FZA 18x100 M 12 D			FZA 18x130 M 12 D			FZA 22x125 M 16 D	
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	gvz	A4	C	gvz	A4	C	gvz	A4
non-cracked concrete																								
tension	C 20/25 N_R	[kN]	6.7			9.3			9.3			12.3			12.3		18.9			18.9			26.4	
	C 50/60 N_R	[kN]	10.3	9.8	10.3	14.0	9.8	12.2	14.0	9.8	12.2	19.0	15.5	19.0	19.0	15.5	29.3	22.5	28.1	29.3	22.5	28.1	40.9	
shear	C 20/25 V_R	[kN]	8.7	8.2	8.7	12.1	8.2	10.2	12.1	8.2	10.2	17.0	11.6	14.5	17.0	11.6	26.5	17.7	22.1	26.5	17.7	22.1	43.0	29.3
	C 30/37 V_R	[kN]	12.2	8.2	10.2	12.2	8.2	10.2	12.2	8.2	10.2	17.0	11.6	14.5	17.0	11.6	26.5	17.7	22.1	26.5	17.7	22.1	43.0	29.3
cracked concrete																								
tension	C 20/25 N_R	[kN]	4.3			6.1			6.1			8.0			8.0		12.3			12.3			17.1	
	C 50/60 N_R	[kN]	6.7			9.4			9.4			12.3			12.3		19.0			19.0			26.6	
shear	C 20/25 V_R	[kN]	5.6			7.9			7.9			15.9	11.6	14.5	15.9	11.6	24.5	17.7	22.1	24.5	17.7	22.1	34.3	29.3
	≧ C 50/60 V_R	[kN]	10.2	8.2	10.2	10.2	8.2	10.2	10.2	8.2	10.2	17.0	11.6	14.5	17.0	11.6	26.5	17.7	22.1	26.5	17.7	22.1	43.0	29.3

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

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Pull-out / pull-through failure: *Failure mode is not decisive*

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: *Failure mode is not decisive*

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FZA 12x50 M 8 D			FZA 12x60 M 8 D			FZA 12x80 M 8 D			FZA 14x80 M 10 D			FZA 14x100 M 10 D		FZA 18x100 M 12 D			FZA 18x130 M 12 D			FZA 22x125 M 16 D	
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	gvz	A4	C	gvz	A4	C	gvz	A4
design resistance	$N_{Rd,s}$	[kN]	19.5	13.7	17.1	19.5	13.7	17.1	19.5	13.7	17.1	30.9	21.7	27.1	30.9	21.7	44.9	31.6	39.3	44.9	31.6	39.3	84.0	58.8

4

4.2 Pull-out/pull-through failure of the highest loaded anchor

Failure mode is not decisive and therefore may be neglected

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: *Failure mode is not decisive*

Design resistance of single anchor

Anchor type			FZA 12x50 M 8 D	FZA 12x60 M 8 D	FZA 12x80 M 8 D	FZA 14x80 M 10 D	FZA 14x100 M 10 D	FZA 18x100 M 12 D	FZA 18x130 M 12 D	FZA 22x125 M 16 D
eff. anchorage depth	h_{ef}	[mm]	40	50	50	60	60	80	80	100
non-cracked concrete										
design resistance	$N^0_{Rd,c}$	[kN]	9.4	13.1	13.1	17.2	17.2	26.4	26.4	37.0
cracked concrete										
design resistance	$N^0_{Rd,c}$	[kN]	6.1	8.5	8.5	11.2	11.2	17.2	17.2	24.0

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic edge distance and spacing for design

Anchor type		FZA 12x50 M 8 D	FZA 12x60 M 8 D	FZA 12x80 M 8 D	FZA 14x80 M 10 D	FZA 14x100 M 10 D	FZA 18x100 M 12 D	FZA 18x130 M 12 D	FZA 22x125 M 16 D
h_{ef}		40	50	50	60	60	80	80	100
$s_{cr,N}$	[mm]	120	150	150	180	180	240	240	300
$c_{cr,N}$	[mm]	60	75	75	90	90	120	120	150

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Failure mode is not decisive and therefore may be neglected

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = N_{Rd,c} \cdot k$

Concrete edge failure: $V_{Rd,c} = V^{0}_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_{m}$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type			FZA 12x50 M 8 D			FZA 12x60 M 8 D			FZA 12x80 M 8 D			FZA 14x80 M 10 D			FZA 14x100 M 10 D		FZA 18x100 M 12 D			FZA 18x130 M 12 D			FZA 22x125 M 16 D	
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	gvz	A4	C	gvz	A4	C	gvz	A4
design resistance	$V_{Rd,s}$	[kN]	17.0	11.4	14.2	17.0	11.4	14.2	17.0	11.4	14.2	23.8	16.3	20.3	23.8	16.3	37.0	24.8	31.0	37.0	24.8	31.0	60.2	41.1

5.2 Pryout failure for the most unfavourable anchor

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

k-factor

Anchor type	FZA 12x50 M 8 D	FZA 12x60 M 8 D	FZA 12x80 M 8 D	FZA 14x80 M 10 D	FZA 14x100 M 10 D	FZA 18x100 M 12 D	FZA 18x130 M 12 D	FZA 22x125 M 16 D
k	1.3	1.3	1.3	2.0	2.0	2.0	2.0	2.0

5.3 Concrete edge failure of the most unfavourable anchor

$$V_{Rd,c} = V^{o}_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_{m}$$

Proof of concrete edge failure is only necessary, if the following condition is met:

- $c < \max(10\ h_{ef}\ ;\ 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

edge distance [mm]	$V^{0}_{Rd,c}$ [kN] FZA 12x50 M 8 D non-cracked concrete	FZA 12x50 M 8 D cracked concrete	FZA 12x60 M 8 D non-cracked concrete	FZA 12x60 M 8 D cracked concrete	FZA 12x80 M 8 D non-cracked concrete	FZA 12x80 M 8 D cracked concrete	FZA 14x80 M 10 D non-cracked concrete	FZA 14x80 M 10 D cracked concrete	FZA 14x100 M 10 D non-cracked concrete	FZA 14x100 M 10 D cracked concrete	FZA 18x100 M 12 D non-cracked concrete	FZA 18x100 M 12 D cracked concrete	FZA 18x130 M 12 D non-cracked concrete	FZA 18x130 M 12 D cracked concrete	FZA 22x125 M 16 D non-cracked concrete	FZA 22x125 M 16 D cracked concrete
40	3.6	2.6														
45	4.2	3.0	4.4	3.1	4.7	3.3										
50	4.9	3.4	5.1	3.6	5.4	3.8										
55	5.5	3.9	5.7	4.1	6.1	4.3	6.3	4.4	6.6	4.7						
60	6.2	4.4	6.4	4.5	6.8	4.8	7.0	5.0	7.4	5.2						
65	6.9	4.9	7.1	5.0	7.5	5.3	7.8	5.5	8.2	5.8						
70	7.6	5.4	7.9	5.6	8.3	5.9	8.5	6.0	9.0	6.4	9.4	6.7	10.1	7.1		
75	8.3	5.9	8.6	6.1	9.1	6.4	9.3	6.6	9.8	6.9	10.3	7.3	11.0	7.8		
80	9.1	6.4	9.4	6.7	9.9	7.0	10.2	7.2	10.6	7.5	11.1	7.9	11.9	8.4		
85	9.9	7.0	10.2	7.2	10.7	7.6	11.0	7.8	11.5	8.2	12.0	8.5	12.8	9.1		
90	10.7	7.6	11.0	7.8	11.6	8.2	11.8	8.4	12.4	8.8	12.9	9.2	13.8	9.7		
95	11.5	8.1	11.8	8.4	12.4	8.8	12.7	9.0	13.3	9.4	13.9	9.8	14.7	10.4		
100	12.3	8.7	12.7	9.0	13.3	9.4	13.6	9.6	14.2	10.1	14.8	10.5	15.7	11.1	16.1	11.4
120	15.8	11.2	16.2	11.5	17.0	12.0	17.3	12.3	18.1	12.8	18.8	13.3	19.8	14.0	20.3	14.4
125	16.7	11.8	17.2	12.2	17.9	12.7	18.3	13.0	19.1	13.5	19.8	14.0	20.9	14.8	21.4	15.2
130	17.6	12.5	18.1	12.8	18.9	13.4	19.3	13.7	20.1	14.2	20.8	14.8	22.0	15.6	22.5	16.0
135	18.6	13.2	19.1	13.5	19.9	14.1	20.3	14.4	21.1	14.9	21.9	15.5	23.1	16.3	23.6	16.7
140	19.5	13.8	20.0	14.2	20.9	14.8	21.3	15.1	22.1	15.7	23.0	16.3	24.2	17.1	24.8	17.5
160	23.5	16.6	24.1	17.0	25.1	17.7	25.5	18.1	26.5	18.7	27.4	19.4	28.8	20.4	29.4	20.9
180	27.7	19.6	28.3	20.0	29.4	20.8	30.0	21.2	31.0	22.0	32.0	22.7	33.6	23.8	34.3	24.3
200	32.0	22.7	32.7	23.2	34.0	24.1	34.6	24.5	35.7	25.3	36.9	26.1	38.6	27.3	39.4	27.9
250	43.7	31.0	44.6	31.6	46.2	32.7	47.0	33.3	48.4	34.3	49.8	35.3	51.9	36.8	53.0	37.5
300	56.5	40.0	57.6	40.8	59.5	42.1	60.4	42.8	62.1	44.0	63.9	45.2	66.3	47.0	67.6	47.9
350	70.2	49.7	71.5	50.7	73.7	52.2	74.8	53.0	76.8	54.4	78.8	55.8	81.7	57.9	83.2	58.9
400	84.8	60.1	86.3	61.2	88.9	63.0	90.1	63.8	92.4	65.5	94.7	67.1	98.0	69.5	99.7	70.6
450	100.3	71.0	102.0	72.2	104.9	74.3	106.2	75.3	108.9	77.1	111.5	79.0	115.2	81.6	117.0	82.9
500	116.5	82.5	118.4	83.8	121.6	86.1	123.2	87.2	126.1	89.3	129.0	91.4	133.1	94.3	135.2	95.8
550	133.4	94.5	135.5	96.0	139.1	98.5	140.8	99.8	144.0	102.0	147.3	104.3	151.8	107.5	154.1	109.1
600	151.1	107.0	153.4	108.6	157.3	111.4	159.2	112.8	162.7	115.3	166.2	117.8	171.2	121.3	173.7	123.0
650	169.4	120.0	171.9	121.8	176.2	124.8	178.2	126.3	182.1	129.0	185.9	131.7	191.3	135.5	194.0	137.4
700	188.3	133.4	191.1	135.3	195.7	138.6	197.9	140.2	202.1	143.1	206.2	146.1	212.1	150.2	215.0	152.3
750	207.9	147.3	210.8	149.4	215.9	152.9	218.2	154.6	222.7	157.8	227.2	160.9	233.5	165.4	236.6	167.6
800							239.2	169.4	243.9	172.8	248.7	176.2	255.4	180.9	258.8	183.3
850							260.7	184.6	265.8	188.3	270.9	191.9	278.0	196.9	281.6	199.5
900											293.6	208.0	301.2	213.3	305.0	216.0
950											316.9	224.4	324.9	230.1	328.9	233.0
1000											340.7	241.3	349.1	247.3	353.4	250.3
1100											389.8	276.1	399.2	282.8	403.9	286.1
1200															456.5	323.3
1300															510.9	361.9
1400															567.2	401.8

fischer Zykon through anchor FZA-D

Anchor design according to fischer specification

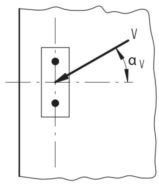
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

fischer Zykon through anchor FZA-D

Anchor design according to fischer specification

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

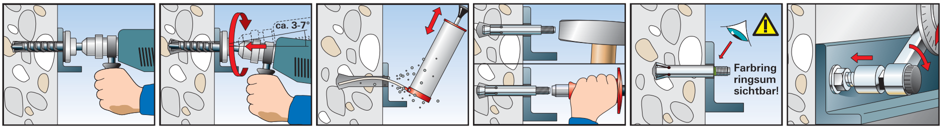
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = **tension/shear component of the design load acting on the most unfavourable single anchor**

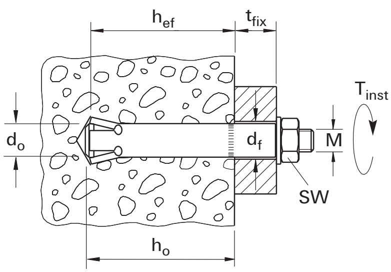
N_{Rd} ; V_{Rd} = **tension/shear design resistance including safety factors of the most unfavourable single anchor**

7. Installation details



8. Anchor installation data

Anchor type			FZA 12x50 M 8 D	FZA 12x60 M 8 D	FZA 12x80 M 8 D	FZA 14x80 M 10 D	FZA 14x100 M 10 D	FZA 18x100 M 12 D	FZA 18x130 M 12 D	FZA 22x125 M 16 D
diameter of thread			M 8	M 8	M 8	M 10	M 10	M 12	M 12	M 16
nominal drill hole diameter	d_0	[mm]	12	12	12	14	14	18	18	22
drill depth	h_0	[mm]	43	53	53	63	63	83	83	105
effective anchorage depth	h_{ef}	[mm]	40	50	50	60	60	80	80	100
clearance-hole in fixture to be attached	d_f	[mm]	≤ 14	≤ 14	≤ 14	≤ 16	≤ 16	≤ 20	≤ 20	≤ 24
wrench size	SW	[mm]	13	13	13	17	17	19	19	24
required torque	T_{inst}	[Nm]	20	20	20	40	40	60	60	100
minimum thickness of concrete member	h_{min}	[mm]	100	110	110	130	130	160	160	200
minimum spacing	s_{min}	[mm]	40	50	50	60	60	80	80	100
minimum edge distances	c_{min}	[mm]	35	45	45	55	55	70	70	100



fischer Zykon through anchor FZA-D

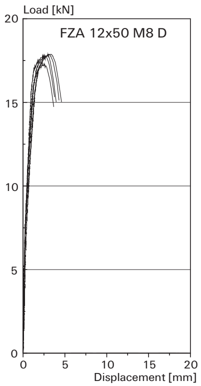
Anchor design according to fischer specification

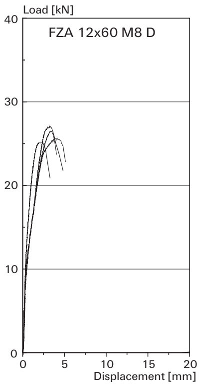
9. Mechanical characteristics

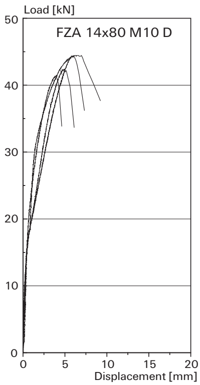
Anchor type			FZA 12x50 M 8 D			FZA 12x60 M 8 D			FZA 12x80 M 8 D			FZA 14x80 M 10 D		
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
stressed cross sectional area cone bolt	A_S	[mm²]	36.6			36.6			36.6			58.0		
resisting moment cone bolt	W	[mm³]	31.2			31.2			31.2			62.3		
design value of bending moment	$M^0_{Rd,s}$		24.0	16.8	21.0	24.0	16.8	21.0	24.0	16.8	21.0	47.8	33.5	41.8
yield strength cone bolt	f_{yk}	[N/mm²]	640	450	560	640	450	560	640	450	560	640	450	560
tensile strength cone bolt	f_{uk}	[N/mm²]	800	700		800	700		800	700		800	700	

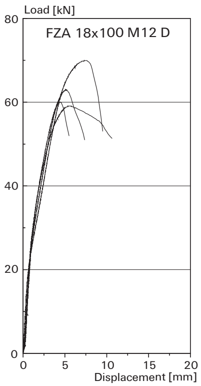
Anchor type			FZA 14x100 M 10 D			FZA 18x100 M 12 D			FZA 18x130 M 12 D			FZA 22x125 M 16 D		
			gvz	A4		gvz	A4	C	gvz	A4	C	gvz	A4	
stressed cross sectional area cone bolt	A_S	[mm²]	58.0			84.3			84.3			157		
resisting moment cone bolt	W	[mm³]	62.3			109			109			278		
design value of bending moment	$M^0_{Rd,s}$		47.8	33.5	41.8	84.0	58.7	73.3	84.0	58.7	73.3	212.8	148.7	185.6
yield strength cone bolt	f_{yk}	[N/mm²]	640	450		640	450	560	640	450	560	640	450	
tensile strength cone bolt	f_{uk}	[N/mm²]	800	700		800	700		800	700		800	700	

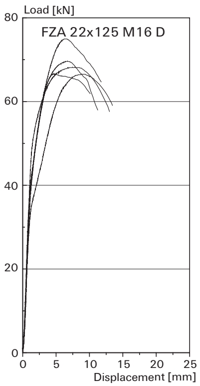
10. Load displacement curves for tension in non-cracked concrete ($f_{ck,cube\,(200)}$ = 30 N/mm²)











4

fischer Zykon internally-threaded anchor FZA-I

Anchor design according to fischer specification

1. Types

FZA-I – Internally-threaded anchor (gvz)

FZA-I – Internally-threaded anchor (A4)

ETA-98/004
ETAG 001-3
Option 1 for cracked concrete *)

Fire resistance classification R 120
Anchor types see test report

FM APPROVED from thread M 10

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 1 for cracked an non-cracked concrete.
- Independent controlled and confirmed product characteristics (Approval) gives the required safety guarantees.
- Expansion free fixing allows small spacing and edge distances.
- Depth marking enable visual control and ensures correct function.
- Fire resistance classifications (F 120) according to test report independently proved gives the safety case of fire.
- Formlocking fit in the undercut enables high loads at shallow anchorage depth.

The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Anchor:
- Carbon steel, zinc plated (5 µm) and passivated (gvz)
- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316

2. Ultimate resistance of single anchors with large spacing and large edge distance

Mean values

Anchor type	FZA 12x40 M 6 I		FZA 12x50 M 6 I	FZA 14x60 M 8 I		FZA 18x80 M 10 I		FZA 22x100 M 12 I		FZA 22x125 M 12 I	
	gvz [1]	A4 [2]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]
non-cracked concrete											
tension ≥ C 20/25 N_u [kN]	17.2	13.4	13.4	23.0	18.0	26.9	22.7	63.0	53.2	63.0	53.2
shear ≥ C 20/25 V_u [kN]	9.6	8.4	8.4	17.6	15.4	27.8	24.4	40.5	35.4	40.5	35.4
cracked concrete											
tension C 20/25 N_u [kN]	12.0		12.0	23.0	18.0	26.9	22.7	47.2		63.0	53.2
tension C 50/60 N_u [kN]	17.2	13.4	13.4	23.0	18.0	26.9	22.7	63.0	53.2	63.0	53.2
shear ≥ C 20/25 V_u [kN]	9.6	8.4	8.4	17.6	15.4	27.8	24.4	40.5	35.4	40.5	35.4

1) The values apply to screws with a strength class 8.8
2) The values apply to screws with a strength class A4 - 70

fischer innovative solutions

fischer Zykon internally-threaded anchor FZA-I

Anchor design according to fischer specification

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance

Anchor type		FZA 12x40 M 6 I		FZA 12x50 M 6 I	FZA 14x60 M 8 I		FZA 18x80 M 10 I		FZA 22x100 M 12 I		FZA 22x125 M 12 I	
		gvz [1]	A4 [2]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]
non-cracked concrete												
tension	C 20/25 N_{Rk} [kN]	14.0	13.5	13.5	22.9	17.9	26.9	22.7	55.4	53.1	63.0	53.1
	≥ C 40/50 N_{Rk} [kN]	17.2	13.5	13.5	22.9	17.9	26.9	22.7	63.0	53.1	63.0	53.1
shear	≥ C 20/25 V_{Rk} [kN]	8.6	6.7	6.7	11.4	9.0	13.4	11.3	31.5	26.6	31.5	26.6
cracked concrete												
tension	C 20/25 N_{Rk} [kN]	9.1		12.7	16.7		25.8	22.7	36.0		50.3	
	C 50/60 N_{Rk} [kN]	14.1	13.5	13.5	22.9	17.9	26.9	22.7	55.8	53.1	63.0	53.1
shear	≥ C 20/25 V_{Rk} [kN]	8.6	6.7	6.7	11.4	9.0	13.4	11.3	31.5	26.6	31.5	26.6

1) The values apply to screws with a strength class 8.8

2) The values apply to screws with a strength class A4 - 70

3.2 Design resistance

Anchor type		FZA 12x40 M 6 I		FZA 12x50 M 6 I	FZA 14x60 M 8 I		FZA 18x80 M 10 I		FZA 22x100 M 12 I		FZA 22x125 M 12 I	
		gvz [1]	A4 [2]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]
non-cracked concrete												
tension	C 20/25 N_{Rd} [kN]	9.4	7.5	7.5	13.1	9.9	13.5	12.6	31.5	29.5	31.5	29.5
	≥ C 40/50 N_{Rd} [kN]	9.8	7.5	7.5	13.1	9.9	13.5	12.6	31.5	29.5	31.5	29.5
shear	≥ C 20/25 V_{Rd} [kN]	5.7	4.5	4.5	7.6	6.0	7.9	7.5	18.5	17.7	18.5	17.7
cracked concrete												
tension	C 20/25 N_{Rd} [kN]	6.1		7.5	11.2	9.9	13.5	12.6	24.0		31.5	29.5
	C 50/60 N_{Rd} [kN]	9.4	7.5	7.5	13.1	9.9	13.5	12.6	31.5	29.5	31.5	29.5
shear	≥ C 20/25 V_{Rd} [kN]	5.7	4.5	4.5	7.6	6.0	7.9	7.5	18.5	17.7	18.5	17.7

1) The values apply to screws with a strength class 8.8

2) The values apply to screws with a strength class A4 - 70

3.3 Recommended resistance [3]

Anchor type		FZA 12x40 M 6 I		FZA 12x50 M 6 I	FZA 14x60 M 8 I		FZA 18x80 M 10 I		FZA 22x100 M 12 I		FZA 22x125 M 12 I	
		gvz [1]	A4 [2]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]
non-cracked concrete												
tension	C 20/25 N_R [kN]	6.7	5.4	5.4	9.3	7.1	9.6	9.0	22.5	21.1	22.5	21.1
	≥ C 40/50 N_R [kN]	7.0	5.4	5.4	9.3	7.1	9.6	9.0	22.5	12.1	22.5	21.1
shear	≥ C 20/25 V_R [kN]	4.1	3.2	3.2	5.4	4.3	5.6	5.4	13.2	12.7	13.2	12.7
cracked concrete												
tension	C 20/25 N_R [kN]	4.3		5.4	8.0	7.1	9.6	9.0	17.1		22.5	21.1
	C 50/60 N_R [kN]	6.7	5.4	5.4	9.3	7.1	9.6	9.0	22.5	21.1	22.5	21.1
shear	≥ C 20/25 V_R [kN]	4.1	3.2	3.2	5.4	4.3	5.6	5.4	13.2	12.7	13.2	12.7

1) The values apply to screws with a strength class 8.8

2) The values apply to screws with a strength class A4 - 70

3) Material safety factors γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on the failure mode of the anchor.

4

fischer Zykon internally-threaded anchor FZA-I

Anchor design according to fischer specification

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Pull-out / pull-through failure: *Failure mode is not decisive*

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: *Failure mode is not decisive*

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FZA 12x40 M 6 I		FZA 12x50 M 6 I	FZA 14x60 M 8 I		FZA 18x80 M 10 I		FZA 22x100 M 12 I		FZA 22x125 M 12 I	
			gvz [1]	A4 [2]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]
design resistance	$N_{Rd,s}$	[kN]	9.8	7.5	7.5	13.1	9.9	13.5	12.6	31.5	29.5	31.5	29.5

[1] The values apply to screws with a strength class 8.8

[2] The values apply to screws with a strength class A4 - 70

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4.2 Pull-out/pull-through failure of the highest loaded anchor

Failure mode is not decisive and therefore may be neglected

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: *Failure mode is not decisive*

Design resistance of single anchor

Anchor type			FZA 12x40 M 6 I	FZA 12x50 M 6 I	FZA 14x60 M 8 I	FZA 18x80 M 10 I	FZA 22x100 M 12 I	FZA 22x125 M 12 I
eff. anchorage depth	h_{ef}	[mm]	40	50	60	80	100	125
non-cracked concrete								
design resistance	$N^0_{Rd,c}$	[kN]	9.4	13.1	17.2	26.4	37.0	51.7
cracked concrete								
design resistance	$N^0_{Rd,c}$	[kN]	6.1	8.5	11.2	17.2	24.0	33.5

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic edge distance and spacing for design

Anchor type		FZA 12x40 M 6 I	FZA 12x50 M 6 I	FZA 14x60 M 8 I	FZA 18x80 M 10 I	FZA 22x100 M 12 I	FZA 22x125 M 12 I
h_{ef}		40	50	60	80	100	125
$s_{cr,N}$	[mm]	120	150	180	240	300	375
$c_{cr,N}$	[mm]	60	75	90	120	150	188

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4

4.3.3 Concrete splitting failure

Failure mode is not decisive and therefore may be neglected

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = N_{Rd,c} \cdot k$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type		FZA 12x40 M 6 I		FZA 12x50 M 6 I	FZA 14x60 M 8 I		FZA 18x80 M 10 I		FZA 22x100 M 12 I		FZA 22x125 M 12 I	
		gvz [1]	A4 [2]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]	gvz [1]	A4 [2]
design resistance $V_{Rd,s}$	[kN]	5.7	4.5	4.5	7.6	6.0	7.9	7.5	18.5	17.7	18.5	17.7

[1] The values apply to screws with a strength class 8.8

[2] The values apply to screws with a strength class A4 - 70

5.2 Pryout failure for the most unfavourable anchor

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

k-factor

Anchor type	FZA 12x40 M 6 I	FZA 12x50 M 6 I	FZA 14x60 M 8 I	FZA 18x80 M 10 I	FZA 22x100 M 12 I	FZA 22x125 M 12 I
k	1.3	1.3	2.0	2.0	2.0	2.0

fischer Zykon internally-threaded anchor FZA-I

Anchor design according to fischer specification

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary, if the following condition is met:

- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

edge distance [mm]	$V^0_{Rd,c}$ [kN]											
	FZA 12x40 M 6 I		FZA 12x50 M 6 I		FZA 14x60 M 8 I		FZA 18x80 M 10 I		FZA 22x100 M 12 I		FZA 22x125 M 12 I	
	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
35	2.9	2.1										
40	3.5	2.5										
45	4.1	2.9	4.2	3.0								
50	4.7	3.3	4.9	3.4								
55	5.3	3.8	5.5	3.9	5.9	4.2						
60	6.0	4.2	6.2	4.4	6.6	4.7						
65	6.6	4.7	6.9	4.9	7.3	5.2						
70	7.3	5.2	7.6	5.4	8.0	5.7	8.9	6.3				
75	8.0	5.7	8.3	5.9	8.8	6.2	9.7	6.9				
80	8.8	6.2	9.1	6.4	9.6	6.8	10.6	7.5				
85	9.5	6.8	9.9	7.0	10.4	7.4	11.4	8.1				
90	10.3	7.3	10.7	7.6	11.2	8.0	12.3	8.7				
95	11.1	7.9	11.5	8.1	12.1	8.6	13.2	9.4				
100	11.9	8.4	12.3	8.7	12.9	9.2	14.1	10.0	15.3	10.8		
120	15.3	10.9	15.8	11.2	16.5	11.7	18.0	12.7	19.4	13.7		
125	16.2	11.5	16.7	11.8	17.5	12.4	19.0	13.4	20.4	14.5	21.4	15.2
130	17.1	12.1	17.6	12.5	18.4	13.1	20.0	14.2	21.5	15.2	22.5	16.0
135	18.0	12.8	18.6	13.2	19.4	13.7	21.0	14.9	22.6	16.0	23.6	16.7
140	19.0	13.4	19.5	13.8	20.4	14.4	22.1	15.6	23.7	16.8	24.8	17.5
160	22.8	16.2	23.5	16.6	24.5	17.3	26.4	18.7	28.2	20.0	29.4	20.9
180	26.9	19.1	27.7	19.6	28.8	20.4	30.9	21.9	32.9	23.3	34.3	24.3
200	31.2	22.1	32.0	22.7	33.3	23.6	35.6	25.2	37.9	26.8	39.4	27.9
250	42.7	30.2	43.7	31.0	45.3	32.1	48.2	34.2	51.0	36.2	53.0	37.5
300	55.3	39.1	56.5	40.0	58.4	41.4	61.9	43.9	65.3	46.3	67.6	47.9
350	68.8	48.7	70.2	49.7	72.5	51.3	76.6	54.3	80.5	57.0	83.2	58.9
400	83.1	58.9	84.8	60.1	87.4	61.9	92.2	65.3	96.7	68.5	99.7	70.6
450	98.3	69.7	100.3	71.0	103.2	73.1	108.6	76.9	113.6	80.5	117.0	82.9
500	114.3	81.0	116.5	82.5	119.7	84.8	125.8	89.1	131.4	93.1	135.2	95.8
550	131.0	92.8	133.4	94.5	137.0	97.1	143.7	101.8	149.9	106.2	154.1	109.1
600	148.4	105.1	151.1	107.0	155.0	109.8	162.4	115.0	169.2	119.8	173.7	123.0
650	166.5	117.9	169.4	120.0	173.7	123.0	181.7	128.7	189.1	134.0	194.0	137.4
700	185.2	131.2	188.3	133.4	193.0	136.7	201.7	142.9	209.7	148.5	215.0	152.3
750	204.5	144.8	207.9	147.3	213.0	150.8	222.3	157.5	230.9	163.6	236.6	167.6
800					233.5	165.4	243.5	172.5	252.7	179.0	258.8	183.3
850					254.6	180.4	265.3	187.9	275.1	194.9	281.6	199.5
900							287.7	203.8	298.1	211.2	305.0	216.0
950							310.6	220.0	321.7	227.9	328.9	233.0
1000							334.0	236.6	345.8	244.9	353.4	250.3
1100							382.5	270.9	395.5	280.1	403.9	286.1
1200									447.2	316.8	456.5	323.3
1300									500.8	354.8	510.9	361.9

fischer Zykon internally-threaded anchor FZA-I

Anchor design according to fischer specification

5.3.1 Influence of concrete strength for shear

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

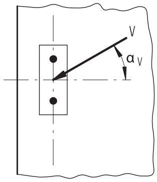
Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm^2]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm^2]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$

	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.



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5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

fischer Zykon internally-threaded anchor FZA-I

Anchor design according to fischer specification

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

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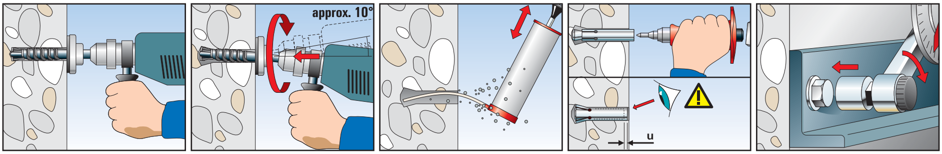
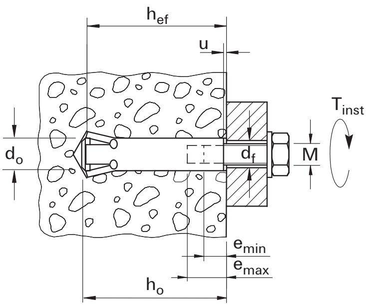
7. Installation details



8. Anchor installation data

Anchor type			FZA 12x40 M 6 I gvz	FZA 12x40 M 6 I A4	FZA 12x50 M 6 I A4	FZA 14x60 M 8 I gvz	FZA 14x60 M 8 I A4	FZA 18x80 M 10 I gvz	FZA 18x80 M 10 I A4	FZA 22x100 M 12 I gvz	FZA 22x100 M 12 I A4	FZA 22x125 M 12 I gvz	FZA 22x125 M 12 I A4
diameter of thread			M 6		M 6	M 8		M 10		M 12		M 12	
nominal drill hole diameter	d_0	[mm]	12		12	14		18		22		22	
drill depth	h_0	[mm]	43		53	63		83		103		127	
effective anchorage depth	h_{ef}	[mm]	40		50	60		80		100		125	
clearance-hole in fixture to be attached	d_f	[mm]	≦ 7		≦ 7	≦ 9		≦ 12		≦ 14		≦ 14	
screw penetration depth	e_{min} / e_{max}	[mm]	8 / 13		8 / 13	11 / 17		13 / 21		15 / 25		15 / 25	
required torque	T_{inst}	[Nm]	8.5		8.5	15		30		60		60	
gap	u	[mm]	0 - 4.0		0 - 4.0	0 - 4.0		0 - 4.5		0 - 4.5		0 - 4.5	
minimum thickness of concrete member	h_{min}	[mm]	100		110	130		160		200		250	
minimum spacing	s_{min}	[mm]	40		50	60		80		100		125	
minimum edge distances	c_{min}	[mm]	35		45	55		70		100		125	

1) Intermediate values by linear interpolation.



fischer Zykon internally-threaded anchor FZA-I

Anchor design according to fischer specification

9. Mechanical anchor material characteristics

Anchor type			FZA 12x40 M 6 I		FZA 12x50 M 6 I		FZA 14x60 M 8 I		FZA 18x80 M 10 I		FZA 22x100 M 12 I		FZA 22x125 M 12 I	
			gvz	A4	A4		gvz	A4	gvz	A4	gvz	A4	gvz	A4
stressed cross sectional area cone bolt	A_s	[mm²]	24.9		24.9		33.3		42.1		98.5		98.5	
stressed cross sectional area screw	A_s	[mm²]	20.1		20.1		36.6		58.0		84.3		84.3	
resisting moment cone bolt	W	[mm³]	37.5		37.5		65.6		103		297		297	
resisting moment screw	W	[mm³]	12.7		12.7		31.2		62.3		109		109	
design value of bending moment	$M^0_{Rd,s}$	[Nm]	9.8	6.9	9.8	6.9	24.0	16.8	47.8	33.5	84.0	58.7	84.0	58.7
yield strength cone bolt	f_{yk}	[N/mm²]	470	355	355		470	355	375	355	375	355	375	355
tensile strength cone bolt	f_{uk}	[N/mm²]	690	540	540		690	540	640	540	640	540	640	540

fischer Zykon hammerset anchor FZEA II

Anchor design according to fischer specification

1. Types

FZEA II – Zykon hammerset anchor (gvz)

FZEA II – Zykon hammerset anchor (A4)

FZEA II – Zykon hammerset anchor (C)

ETA-06/0271
ETAG 001-3
Option 1 for cracked concrete *)

Fire resistance classification
R 120
Anchor types see test report

FM APPROVED
from thread M 10

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

4

Features and Advantages

- European Technical Approval option 1*) for cracked and non-cracked concrete.
- The drill bit FZUB enable drilling and undercutting in one working process.
- Setting tool FZED leaves 4 imprints for a visual control of a proper setting.
- Expansion free fixing allows small spacing and edge distances.
- Shallow anchorage depth avoid reinforcement-hits.
- Various steel types allows economic fixing for different applications.
- Internal thread enable high flexibility by using threaded rods or screws.
- No installation torque necessary.

*) The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Anchor:
- Carbon steel, zinc plated (5 µm) and passivated (gvz)
- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
- Highly corrosion-resistant steel of the corrosion resistance class IV, e. g. 1.4529.

2. Ultimate loads of single anchors with large spacing and large edge distance

Mean values

Anchor type			FZEA II 10x40 M8			FZEA II 12x40 M10			FZEA II 14x40 M12		
			gvz 5.6	A4-50	C-50	gvz 5.6	A4-50	C-50	gvz 5.6	A4-50	C-50
non-cracked concrete											
tension	C 20/25	N_u [kN]	10.1	12.8		13.0			13.0		
	C 50/60	N_u [kN]	10.1	12.8		17.9	20.2		20.2		
shear	≥ C 20/25	V_u [kN]	22.2			22.2			22.2		
cracked concrete											
tension	C 20/25	N_u [kN]	8.5			9.0			9.1		
	C 50/60	N_u [kN]	10.1	12.8		14.0			14.1		
shear	≥ C 20/25	V_u [kN]	8.7	10.5		14.3	15.8		20.1	21.6	

fischer Zykon hammerset anchor FZEA II

Anchor design according to fischer specification

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance

Anchor type	FZEA II 10x40 M8			FZEA II 12x40 M10			FZEA II 14x40 M12		
	gvz 5.6	A4-50	C-50	gvz 5.6	A4-50	C-50	gvz 5.6	A4-50	C-50
non-cracked concrete									
tension C 20/25 N_{Rk} [kN]	9.0			9.0			9.0		
C 50/60 N_{Rk} [kN]	9.6	12.2		14.0			14.0		
shear ≧ C 20/25 V_{Rk} [kN]	8.3	10.0		13.6	15.0		16.6		
cracked concrete									
tension C 20/25 N_{Rk} [kN]	4.0			7.5			9.0		
C 50/60 N_{Rk} [kN]	6.2			11.6			14.0		
shear ≧ C 20/25 V_{Rk} [kN]	8.3	10.0		11.8			11.8		

3.2 Design resistance

Anchor type	FZEA II 10x40 M8			FZEA II 12x40 M10			FZEA II 14x40 M12		
	gvz 5.6	A4-50	C-50	gvz 5.6	A4-50	C-50	gvz 5.6	A4-50	C-50
non-cracked concrete									
tension C 20/25 N_{Rd} [kN]	5.0			5.0			5.0		
C 50/60 N_{Rd} [kN]	6.4	5.5		7.8			7.8		
shear ≧ C 20/25 V_{Rd} [kN]	5.2	3.8		8.5	5.8		11.1	7.9	
cracked concrete									
tension C 20/25 N_{Rd} [kN]	2.2			4.2			5.0		
C 50/60 N_{Rd} [kN]	3.4			6.5			7.8		
shear ≧ C 20/25 V_{Rd} [kN]	5.2	3.8		7.9	5.8		7.9		

3.3 Recommended resistance [3)]

Anchor type	FZEA II 10x40 M8			FZEA II 12x40 M10			FZEA II 14x40 M12		
	gvz 5.6	A4-50	C-50	gvz 5.6	A4-50	C-50	gvz 5.6	A4-50	C-50
non-cracked concrete									
tension C 20/25 N_R [kN]	3,6			3,6			3,6		
C 50/60 N_R [kN]	4,6	4,0		5,5			5,5		
shear ≧ C 20/25 V_R [kN]	3,7	2,7		6,1	4,1		7,9	5,7	
cracked concrete									
tension C 20/25 N_R [kN]	1,6			3,0			3,6		
C 50/60 N_R [kN]	2,5			4,6			5,5		
shear ≧ C 20/25 V_R [kN]	3,7	2,7		5,6	4,1		5,6		

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Pull-out / pull-through failure: $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FZEA II 10x40 M8			FZEA II 12x40 M10			FZEA II 14x40 M12		
			gvz	A4	C	gvz	A4	C	gvz	A4	C
design resistance	$N_{Rd,s}$	[kN]	6.4[1]	5.5[2]	8.1	11.3[1]	9.8[2]	14.4	13.1[1]	11.4[2]	16.7
	$N_{Rd,s}$	[kN]	6.4[3]	8.1[4]		11.3[3]	14.4[4]		13.1[3]	16.7[4]	

[1] The values apply to screws with a strength class 5.6

[2] The values apply to screws with a strength class A4 - 50 or f_{uk} = 500 N/mm² respectively

[3] The values apply to screws with a strength class 8.8

[4] The values apply to screws with a strength class A4 - 70 or f_{uk} = 700 N/mm² respectively

4.2 Pull-out/pull-through failure of the highest loaded anchor

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

Design resistance of single anchor

Anchor type			FZEA II 10x40 M8	FZEA II 12x40 M10	FZEA II 14x40 M12
non-cracked concrete					
design resistance	$N^0_{Rd,p}$	[kN]	8.7	8.7	8.7
cracked concrete					
design resistance	$N^0_{Rd,p}$	[kN]	5.7	6.0	6.1

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type			FZEA II 10x40 M8	FZEA II 12x40 M10	FZEA II 14x40 M12
eff. anchorage depth	h_{ef}	[mm]	40	40	40
non-cracked concrete					
design resistance	$N^0_{Rd,c}$	[kN]	9.4	9.4	9.4
cracked concrete					
design resistance	$N^0_{Rd,c}$	[kN]	6.1	6.1	6.1

fischer Zykon hammerset anchor FZEA II

Anchor design according to fischer specification

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic edge distance and spacing for design

Anchor type		FZEA II 10x40 M8	FZEA II 12x40 M10	FZEA II 14x40 M12
h_{ef}		40	40	40
$s_{cr,N}$	[mm]	120	120	120
$c_{cr,N}$	[mm]	60	60	60

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic edge distance and spacing for design

Anchor type			FZEA II 10x40 M8	FZEA II 12x40 M10	FZEA II 14x40 M12
	h_{ef}		40	40	40
	$s_{cr,sp}$	[mm]	170	170	170
	$c_{cr,sp}$	[mm]	85	85	85
	h_{min}	[mm]	80	80	80

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / concrete splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = N_{Rd,c} \cdot k$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type			FZEA II 10x40 M8			FZEA II 12x40 M10			FZEA II 14x40 M12		
			gvz	A4	C	gvz	A4	C	gvz	A4	C
design resistance	$V_{Rd,s}$	[kN]	5.2[1]	3.8[2]	8.0	8.5[1]	5.8[2]	12.0	11.9[1]	7.9[2]	16.5
	$V_{Rd,s}$	[kN]	6.6[3]	8.0[4]		10.9[3]	12.0[4]		15.3[3]	16.5[4]	

[1] The values apply to screws with a strength class 5.6
[2] The values apply to screws with a strength class A4 - 50 or f_{uk} = 500 N/mm² respectively
[3] The values apply to screws with a strength class 8.8
[4] The values apply to screws with a strength class A4 - 70 or f_{uk} = 700 N/mm² respectively

5.2 Pryout failure for the most unfavourable anchor

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

k-factor

Anchor type	FZEA II 10x40 M8	FZEA II 12x40 M10	FZEA II 14x40 M12
k	1.3	1.3	1.3

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary, if the following condition is met:

- $c < \max(10\ h_{ef}\ ;\ 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

edge distance [mm]	$V^0_{Rd,c}$ [kN]					
	FZEA II 10x40 M8		FZEA II 12x40 M10		FZEA II 14x40 M12	
	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
40	3.4	2.4				
45	3.9	2.8	4.1	2.9		
50	4.5	3.2	4.7	3.3	4.8	3.4
55	5.2	3.7	5.3	3.8	5.4	3.8
60	5.8	4.1	6.0	4.2	6.1	4.3
65	6.5	4.6	6.6	4.7	6.8	4.8
70	7.2	5.1	7.3	5.2	7.5	5.3
75	7.9	5.6	8.0	5.7	8.2	5.8
80	8.6	6.1	8.8	6.2	8.9	6.3
85	9.3	6.6	9.5	6.8	9.7	6.9
90	10.1	7.2	10.3	7.3	10.5	7.4
95	10.9	7.7	11.1	7.9	11.3	8.0
100	11.7	8.3	11.9	8.4	12.1	8.6
120	15.0	10.6	15.3	10.9	15.6	11.0
130	16.8	11.9	17.1	12.1	17.4	12.3
135	17.7	12.5	18.0	12.8	18.3	13.0
140	18.6	13.2	19.0	13.4	19.3	13.6
160	22.5	15.9	22.8	16.2	23.2	16.4
180	26.5	18.8	26.9	19.1	27.3	19.3
200	30.7	21.8	31.2	22.1	31.6	22.4
250	42.1	29.8	42.7	30.2	43.2	30.6
300	54.5	38.6	55.3	39.1	55.9	39.6
350	67.9	48.1	68.8	48.7	69.5	49.2
400	82.1	58.2	83.1	58.9	84.0	59.5
450	97.2	68.8	98.3	69.7	99.3	70.4
500	113.0	80.0	114.3	81.0	115.4	81.8
550	129.6	91.8	131.0	92.8	132.3	93.7
600	146.8	104.0	148.4	105.1	149.8	106.1
650			166.5	117.9	168.0	119.0
700			185.2	131.2	186.8	132.3
750			204.5	144.8	206.3	146.1
800					226.3	160.3
850					246.9	174.9
850						

5.3.1 Influence of concrete strength for shear

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

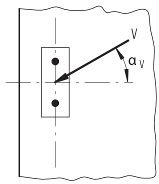
Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$

	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.



5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

fischer Zykon hammerset anchor FZEA II

Anchor design according to fischer specification

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

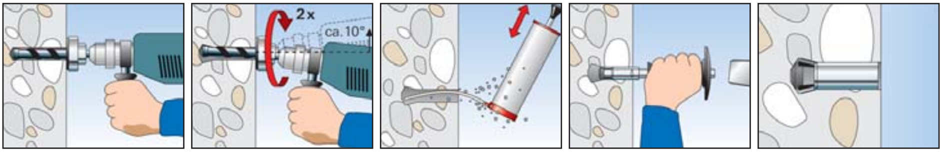
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

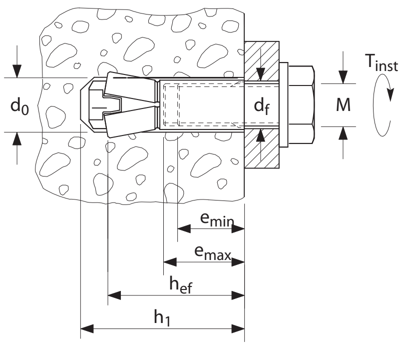
N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details



8. Anchor installation data

Anchor type			FZEA II 10x40 M8			FZEA II 12x40 M10			FZEA II 14x40 M12		
			gvz	A4	C	gvz	A4	C	gvz	A4	C
diameter of thread	M		M 8			M 10			M 12		
nominal drill hole diameter	d_0	[mm]	10			12			14		
drill depth	h_1	[mm]	43			43			43		
effective anchorage depth	h_{ef}	[mm]	40			40			40		
clearance-hole in fixture to be attached	d_f	[mm]	≦ 9			≦ 12			≦ 14		
screw penetration depth	e_{min} / e_{max}	[mm]	11 / 17			13 / 19			15 / 21		
required torque	T_{inst}	[Nm]	≦ 10	≦ 15		≦ 15	≦ 20		≦ 20	≦ 40	
minimum thickness of concrete member	h_{min}	[mm]	80			80			80		
minimum spacing	s_{min}	[mm]	40			45			50		
minimum edge distances	c_{min}	[mm]	40			45			50		

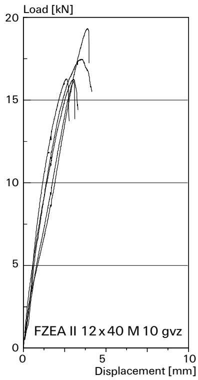


9. Mechanical characteristics

Anchor type			FZEA II 10x40 M8			FZEA II 12x40 M10			FZEA II 14x40 M12		
			gvz	A4	C	gvz	A4	C	gvz	A4	C
stressed cross sectional area sleeve	A_S	[mm²]	18.8*)			33.3*)			38.6*)		
stressed cross sectional area screw	A_S	[mm²]	36.6			58.0			84.3		
resisting moment sleeve	W	[mm³]	52.1*)			82.5*)			130.7*)		
resisting moment screw	W	[mm³]	31.2			62.3			109.2		
design value of bending moment	$M^0_{Rd,s}$	[Nm]	10.7 1)	7.6 2)	15.2	16.4 1)	11.6 2)	23.2	22.1 1)	15.6 2)	31.2
design value of bending moment	$M^0_{Rd,s}$	[Nm]	12.0 3)	15.2 4)		18.4 3)	23.2 4)		24.8 3)	31.2 4)	
yield strength sleeve	f_{yk}	[N/mm²]	410	520		410	520		410	520	
tensile strength sleeve	f_{uk}	[N/mm²]	510	650		510	650		510	650	

1) The values apply to screws with a strength class 5.6
2) The values apply to screws with a strength class A4 - 50 or f_{uk} = 500 N/mm² respectively
3) The values apply to screws with a strength class 8.8
4) The values apply to screws with a strength class A4 - 70 or f_{uk} = 700 N/mm² respectively
*) Begin of expansion segment

10. Load displacement curves for tension in non-cracked concrete ($f_{ck,cube\,(200)}$ = 30 N/mm²)



Notes

4

fischer Heavy-duty anchor TA M

Anchor design according to fischer specification

1. Types

TA M – with internal thread (gvz)

TA M-S – with screw (gvz)

TA M-T– for push-through installation (gvz)

ETA-04/0003
ETAG 001-2
Option 7 for non-cracked concrete *)

Fire resistance classification
R 120
Anchor types see test report

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 7*).
- Approved for non-cracked concrete.
- Suitabel for all bolts or studs with metric thread.
- Independent controlled and confirmed product characteristics (Approval) give the required safety guarantees.
- Three-part expansion sleeve ensures uniformed load distribution which allows small spacing and edge distances.
- Suitable for C12/15 and dense natural stone enables flexible using in different substrates.
- With the ETA approval (option 7) and the fire resistance classification F 120 the TA M opens up different possibilities for safety relevant fixings in non-cracked concrete.
- TA M with internal thread enable high flexibility by using threaded rods or screws.

*) The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Anchor: Carbon steel, zinc plated (5 µm) and passivated (gvz)

2. Ultimate loads of single anchors with large spacing and large edge distance

Mean values

Anchor type				TA M 6 gvz 1)	TA M 8 gvz 1)	TA M 10 gvz 1)	TA M 12 gvz 1)
non-cracked concrete							
tension	C 20/25	N_u	[kN]	11.0	16.3	25.0	32.1
	C 50/60	N_u	[kN]	16.1	25.3	38.7	49.7
shear	≥ C 20/25	V_u	[kN]	6.9	14.6	21.4	32.9

1) The values apply to screws with a strength class 8.8

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance

Anchor type				TA M 6 gvz [1]	TA M 8 gvz [1]	TA M 10 gvz [1]	TA M 12 gvz [1]
non-cracked concrete							
tension	C 20/25	N_{Rk}	[kN]	8.9	13.6	20.0	27.0
	C 50/60	N_{Rk}	[kN]	13.8	21.1	31.0	41.8
shear	≧ C 20/25	V_{Rk}	[kN]	5.8	11.7	19.2	29.8

[1] The values apply to screws with a strength class 8.8

3.2 Design resistance

Anchor type				TA M 6 gvz [1]	TA M 8 gvz [1]	TA M 10 gvz [1]	TA M 12 gvz [1]
non-cracked concrete							
tension	C 20/25	N_{Rd}	[kN]	5.9	9.1	13.3	18.0
	C 50/60	N_{Rd}	9.2	9.2	14.0	20.7	27.9
shear	≧ C 20/25	V_{Rd}	[kN]	4.6	9.4	15.4	23.8

[1] The values apply to screws with a strength class 8.8

4

3.3 Recommended resistance [2]

Anchor type				TA M 6 gvz [1]	TA M 8 gvz [1]	TA M 10 gvz [1]	TA M 12 gvz [1]
non-cracked concrete							
tension	C 20/25	N_R	[kN]	4.2	6.5	9.5	12.9
	C 50/60	N_R	[kN]	6.6	10.0	14.8	19.9
shear	≧ C 20/25	V_R	[kN]	3.3	6.7	11.0	17.0

[1] The values apply to screws with a strength class 8.8
[2] Material safety factors γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on the failure mode of the anchor.

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Pull-out/pull-through failure: $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			TA M 6 gvz [1]	TA M 8 gvz [1]	TA M 10 gvz [1]	TA M 12 gvz [1]
design resistance	$N_{Rd,s}$	[kN]	10.7	19.5	30.9	44.9

[1] The values apply to screws with a strength class 8.8

4.2 Pull-out/pull-through failure of the highest loaded anchor

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

Design resistance of single anchor

Anchor type			TA M 6 gvz [1]	TA M 8 gvz [1]	TA M 10 gvz [1]	TA M 12 gvz [1]
non-cracked concrete						
design resistance	$N^0_{Rd,p}$	[kN]	5.9	9.1	13.3	18.0

[1] The values apply to screws with a strength class 8.8

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0{}_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0{}_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\, c_{cr,sp}$

4

Design resistance of single anchor

Anchor type			TA M 6 gvz [1]	TA M 8 gvz [1]	TA M 10 gvz [1]	TA M 12 gvz [1]
eff. anchorage depth	h_{ef}	[mm]	40	45	55	70
non-cracked concrete						
design resistance	$N^0_{Rd,c}$	[kN]	8.5	10.1	13.7	19.7

[1] The values apply to screws with a strength class 8.8

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic edge distance and spacing for design

Anchor type		TA M 6	TA M 8	TA M 10	TA M 12
h_{ef}		40	45	55	70
$s_{cr,N}$	[mm]	120	135	220	210
$c_{cr,N}$	[mm]	60	68	110	105

fischer Heavy-duty anchor TA M

Anchor design according to fischer specification

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr.N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr.N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1.A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1.B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic edge distance and spacing for design

Anchor type			TA M 6	TA M 8	TA M 10	TA M 12
h_{ef}			40	45	55	70
	$s_{cr.\,sp}$	[mm]	120	180	330	420
	$c_{cr.\,sp}$	[mm]	60	90	165	210
	h_{min}	[mm]	100	100	110	140

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr.sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s.sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / concrete splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr.sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1.sp.A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1.sp.B}$ $f_{c2.sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = N_{Rd,c} \cdot k$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

4

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type	TA M 6 gvz [1)]	TA M 8 gvz [1)]	TA M 10 gvz [1)]	TA M 12 gvz [1)]
design resistance $V_{Rd.s}$ [kN]	4.6	9.4	15.4	23.8

[1)] The values apply to screws with a strength class 8.8

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd.cp} = N_{Rd.c} \cdot k$$

k-factor

Anchor type	TA M 6	TA M 8	TA M 10	TA M 12
k	1.1	1.8	1.8	2.0

5.3 Concrete edge failure of the most unfavourable anchor

$$V_{Rd,c} = V^o_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary, if the following condition is met:

- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

edge distance [mm]	$V^0_{Rd,c}$ [kN]			
	TA M 6 non-cracked concrete	TA M 8 non-cracked concrete	TA M 10 non-cracked concrete	TA M 12 non-cracked concrete
50	4.5			
55	5.2			
60	5.8	6.1		
65	6.5	6.8		
70	7.2	7.5	8.0	
75	7.9	8.2	8.8	
80	8.6	8.9	9.5	
85	9.3	9.7	10.3	
90	10.1	10.5	11.2	
95	10.9	11.3	12.0	
100	11.7	12.1	12.9	
120	15.0	15.6	16.5	17.5
125	15.9	16.5	17.4	18.5
130	16.8	17.4	18.3	19.5
135	17.7	18.3	19.3	20.5
140	18.6	19.3	20.3	21.6
160	22.5	23.2	24.4	25.8
180	26.5	27.3	28.6	30.2
200	30.7	31.6	33.1	34.9
250	42.1	43.2	45.1	47.4
300	54.5	55.9	58.2	60.9
350	67.9	69.5	72.2	75.4
400	82.1	84.0	87.1	90.8
450	97.2	99.3	102.8	107.0
500	113.0	115.4	119.4	124.0
550	129.6	132.3	136.6	141.8
600	146.8	149.8	154.6	160.2
650		168.0	173.2	179.4
700		186.8	192.5	199.1
750			212.4	219.6
800			232.9	240.6
850			254.0	262.2
900			275.6	284.3
950				307.1
1000				330.3
1100				378.4

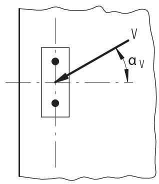
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck.cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck.cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b.V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha.V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1.V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2.V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h.V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

Anchor design according to fischer specification

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = lowest value of $N_{Rd.s}$; $N_{Rd.p}$; $N_{Rd.c}$; $N_{Rd.sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd.s}$; $V_{Rd.cp}$; $V_{Rd.c}$

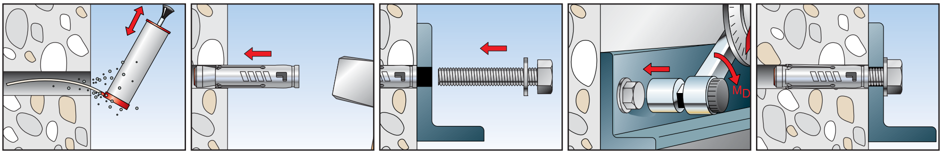
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd}; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd}; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details



4

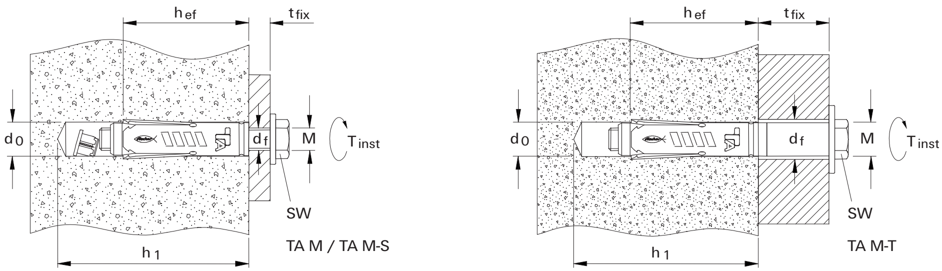
fischer Heavy-duty anchor TA M

Anchor design according to fischer specification

8. Anchor installation data

Anchor type			TA M 6 gvz	TA M 8 gvz	TA M 10 gvz	TA M 12 gvz
diameter of thread			M 6	M 8	M 10	M 12
nominal drill hole diameter	d_0	[mm]	10	12	15	18
drill depth type TA M; TA M-S	h_1	[mm]	65	70	90	105
drill depth type TA M-T	h_1	[mm]	60	65	80	95
effective anchorage depth	h_{ef}	[mm]	40	45	55	70
clearance-hole in fixture to be attached type TA M; TA M-S	d_f	[mm]	≦ 7	≦ 9	≦ 12	≦ 14
clearance-hole in fixture to be attached type TA M-T	d_f	[mm]	≦ 12	≦ 14	≦ 18	≦ 20
drill hole depth for through fixing type TA M-T	t_d	[mm]	$t_d = h_1 + t_{fix}$			
wrench size type S; T	SW	[mm]	10	13	17	19
installation torque	T_{inst}	[Nm]	10	20	40	75
min. thickness of concrete member	h_{min}	[mm]	100	100	110	140
minimum spacing	s_{min}	[mm]	80	90	110	160
minimum edge distances	c_{min}	[mm]	50	60	70	120

4



9. Mechanical anchor material characteristics

Anchor type			TA M 6 gvz	TA M 8 gvz	TA M 10 gvz	TA M 12 gvz
stressed cross sectional area screw	A_s	[mm²]	20.1	36.6	58.0	84.3
resisting moment screw	W	[mm³]	12.7	31.2	62.3	109
design value of bending moment, larger embedment depth	$M^0_{Rd,s}$	[Nm]	9.6	24.0	48.0	84.0
yield strength screw	f_{yk}	[N/mm²]	640	640	640	640
tensile strength screw	f_{uk}	[N/mm²]	800	800	800	800

Notes

fischer Hammerset anchor EA II

Anchor design according to fischer specification

1. Types

EA II – Hammerset anchor (gvz)

EA II – Hammerset anchor (A4)

ETA-07/0142
ETAG 001-6
Multiple use for non-structural applications in concrete

ETA-07/0135
ETAG 001-4
Option 7 for non-cracked concrete *)

FM APPROVED
from thread M 10

Fire resistance classification
R 120
Anchor types see test report

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

4

Features and Advantages

- European Technical Approval option 7*) for non-cracked concrete.
- European Technical Approval for redundant / multiple fixings in cracked concrete.
- All screws and threaded bolts with metric thread are able to be used.
- The moulded rim closes the annular gap between dowel and the wall of the drillhole, so the fixing point looks better.
- The EA II offers you an universal fixing solution with the ETA approval (option 7), the approval for redundant / multiple fixings in cracked conccrete, the FM approval.
- All screws and threaded bolts with metric threads are able to be used.
- The moulded rim closes the annular gap between dowel and the wall of the drillhole, so the fixing points looks better.
- With small anchorage and drilling depth (32 mm at M6 up to 85 mm at M20) it can be used to execute very economic fixing points.
- Dismounting the screw or threaded bolt / rod the anchor is surface flush.

*) The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Hammerset anchor:
- Carbon steel. zinc plated (5 µm) and passivated (gvz)
- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316

2. Ultimate loads of single anchors with large spacing and edge distance

Mean values

Anchor type				EA II M6		EA II M8		EA II M8x40		EA II M10x30		EA II M10		EA II M12		EA II M16		EA II M20	
				gvz[1]	A4[2]	gvz[1]	A4[2]	gvz[1]	A4[2]	gvz[1]	A4[2]	gvz[1]	A4[2]	gvz[1]	A4[2]	gvz[1]	A4[2]	gvz[1]	A4[2]
non-cracked concrete																			
tension	C 20/25	N_u	[kN]	10.1	11.1	11.1	11.1	17.1	17.1	11.1	11.1	17.1	17.1	23.9	23.9	35.4	35.4	48.3	48.3
shear	≥ C 20/25	V_u	[kN]	5.0	7.7	8.6	9.8	8.6	9.8	10.9	12.4	10.9	12.5	19.8	22.6	32.4	36.9	51.4	58.6

1) The values apply to screws with a strength class 5.8
2) The values apply to screws with a strength class A4 - 70

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance

Anchor type			EA II M6*		EA II M8*		EA II M8x40		EA II M10x30*		EA II M10		EA II M12		EA II M16		EA II M20	
			gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)
non-cracked concrete																		
tension	C 20/25	N_{Rk} [kN]	8.3		8.3		12.8		8.3		12.8		17.8		26.4		36.1	
	≧ C 50/60	N_{Rk} [kN]	10.1	12.8	12.8		17.2	19.6	12.8		19.8		27.6		40.9		55.9	
shear	≧ C 20/25	V_{Rk} [kN]	5.0	7.0	8.3		8.6	9.8	8.3		10.9	12.4	17.8		32.0	37.0	51.0	59.0
	≧ C 50/60	V_{Rk} [kN]	5.0	7.0	8.6	9.8	8.6	9.8	10.9	12.4	10.9	12.4	19.8	22.6	32.0	37.0	51.0	59.0

* Use restricted to anchoring of structural components which are statically indeterminate.

1) The values apply to screws with a strength class 5.8

2) The values apply to screws with a strength class A4 - 70

3.2 Design resistance

Anchor type			EA II M6*		EA II M8*		EA II M8x40		EA II M10x30*		EA II M10		EA II M12		EA II M16		EA II M20	
			gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)
non-cracked concrete																		
tension	C 20/25	N_{Rd} [kN]	5.5		5.5		8.5		5.5		8.5		11.9		17.6		24.0	
	≧ C 50/60	N_{Rd} [kN]	6.7	7.5	8.6		11.5	13.1	8.6		13.2		18.4		27.3		37.3	
shear	≧ C 20/25	V_{Rd} [kN]	4.0	4.5	5.5		6.9	7.8	5.5		8.5		11.9		25.6	29.6	40.8	47.2
	≧ C 50/60	V_{Rd} [kN]	4.0	4.5	6.9	7.8	6.9	7.8	8.6		8.7	9.9	15.8	18.1	25.6	29.6	40.8	47.2

* Use restricted to anchoring of structural components which are statically indeterminate.

1) The values apply to screws with a strength class 5.8

2) The values apply to screws with a strength class A4 - 70

3.3 Recommended resistance 3)

Anchor type			EA II M6*		EA II M8*		EA II M8x40		EA II M10x30*		EA II M10		EA II M12		EA II M16		EA II M20	
			gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)	gvz 1)	A4 2)
non-cracked concrete																		
tension	C 20/25	N_R [kN]	3.9		3.9		6.1		3.9		6.1		8.5		12.6		17.2	
	≧ C 50/60	N_R [kN]	4.8	5.4	6.1		8.2	9.3	6.1		9.4		13.2		19.5		26.6	
shear	≧ C 20/25	V_R [kN]	2.9	3.2	3.9		4.9	5.6	3.9		6.1		8.5		18.3	21.1	29.1	33.7
	≧ C 50/60	V_R [kN]	2.9	3.2	4.9	5.6	4.9	5.6	6.1		6.2	7.1	11.3	12.9	18.3	21.1	29.1	33.7

* Use restricted to anchoring of structural components which are statically indeterminate.

1) The values apply to screws with a strength class 5.8

2) The values apply to screws with a strength class A4 - 70

3) Material safety factors γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on failure mode of the anchor.

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Pull-out / pull-through failure: *Failure mode is not decisive*

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			**EA II M6***					**EA II M8***					**EA II M8x40**					**EA II M10x30***				
			gvz				**A4**	**gvz**				**A4**	**gvz**				**A4**	**gvz**				**A4**
screw strength class			4.6	5.6	5.8	8.8	A4-70	4.6	5.6	5.8	8.8	A4-70	4.6	5.6	5.8	8.8	A4-70	4.6	5.6	5.8	8.8	A4-70
design resistance	$N_{Rd,s}$	[kN]	4.0	5.1	6.7	9.0	7.5	7.3	9.2	11.5	11.5	13.1	7.3	9.2	11.5	11.5	13.1	11.6	14.5	14.5	14.5	16.6
Anchor type			**EA II M10**					**EA II M12**					**EA II M16**					**EA II M20**				
			gvz				**A4**	**gvz**				**A4**	**gvz**				**A4**	**gvz**				**A4**
screw strength class			4.6	5.6	5.8	8.8	A4-70	4.6	5.6	5.8	8.8	A4-70	4.6	5.6	5.8	8.8	A4-70	4.6	5.6	5.8	8.8	A4-70
design resistance	$N_{Rd,s}$	[kN]	11.6	14.5	14.5	14.5	16.6	16.9	21.1	26.4	26.4	30.1	31.4	39.2	43.1	43.1	49.2	49.0	61.2	68.5	68.5	78.1

* Use restricted to anchoring of structural components which are statically indeterminate.

4.2 Pull-out/pull-through failure of the highest loaded anchor

Failure mode is not decisive and therefore may be neglected

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:

- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1{,}2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type			**EA II M6***	**EA II M8***	**EA II M8x40**	**EA II M10x30***	**EA II M10**	**EA II M12**	**EA II M16**	**EA II M20**
eff. anchorage depth	h_{ef}	[mm]	30	30	40	30	40	50	65	80
non-cracked concrete										
design resistance	$N^0_{Rd,c}$	[kN]	5.5	5.5	8.5	5.5	8.5	11.9	17.6	24.0

* Use restricted to anchoring of structural components which are statically indeterminate.

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic edge distance and spacing for design

Anchor type		EA II M6*	EA II M8*	EA II M8x40	EA II M10x30*	EA II M10	EA II M12	EA II M16	EA II M20
h_{ef}		30	30	40	30	40	50	65	80
$s_{cr,N}$	[mm]	90	90	120	90	120	150	195	240
$c_{cr,N}$	[mm]	45	45	60	45	60	75	98	120

* Use restricted to anchoring of structural components which are statically indeterminate.

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic edge distance and spacing for design

Anchor type		EA II M6*	EA II M8*	EA II M8x40	EA II M10x30*	EA II M10	EA II M12	EA II M16	EA II M20
h_{ef}		30	30	40	30	40	50	65	80
$s_{cr,sp}$	[mm]	210	210	280	210	320	350	455	560
$c_{cr,sp}$	[mm]	105	105	140	105	160	175	228	280
h_{min}	[mm]	100	100	100	120	120	120	160	200

* Use restricted to anchoring of structural components which are statically indeterminate.

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4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / concrete splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = N_{Rd,c} \cdot k$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type	EA II M6*					EA II M8*					EA II M8x40					EA II M10x30*				
	gvz				A4	gvz				A4	gvz				A4	gvz				A4
screw strength class	4.6	5.6	5.8	8.8	A4-70	4.6	5.6	5.8	8.8	A4-70	4.6	5.6	5.8	8.8	A4-70	4.6	5.6	5.8	8.8	A4-70
design resistance $V_{Rd,s}$ [kN]	2.4	3.0	4.0	5.4	4.5	4.4	5.5	6.9	6.9	7.8	4.4	5.5	6.9	6.9	7.8	6.9	8.7	8.7	8.7	9.9
Anchor type	**EA II M10**					**EA II M12**					**EA II M16**					**EA II M20**				
	gvz				A4	gvz				A4	gvz				A4	gvz				A4
screw strength class	4.6	5.6	5.8	8.8	A4-70	4.6	5.6	5.8	8.8	A4-70	4.6	5.6	5.8	8.8	A4-70	4.6	5.6	5.8	8.8	A4-70
design resistance $V_{Rd,s}$ [kN]	6.9	8.7	8.7	8.7	9.9	10.1	12.6	15.8	15.8	18.1	18.6	23.4	25.6	25.6	29.6	29.3	36.5	40.8	40.8	47.2

* Use restricted to anchoring of structural components which are statically indeterminate.

5.2 Pryout failure for the most unfavourable anchor

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

k-factor

Anchor type	EA II M6*	EA II M8*	EA II M8x40	EA II M10x30*	EA II M10	EA II M12	EA II M16	EA II M20
k	1.0	1.0	1.0	1.0	1.0	1.0	2.0	2.0

* Use restricted to anchoring of structural components which are statically indeterminate.

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd.c} = V^0_{Rd.c} \cdot f_{b.V} \cdot f_{\alpha.V} \cdot f_{s1.V} \cdot f_{s2.V} \cdot f_{c2.V} \cdot f_{h.V} \cdot f_m$$

Proof of concrete edge failure is only necessary. if the following condition is met:

- $c < \max(10\ h_{ef}\ ;\ 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

edge distance [mm]	$V^0_{Rd,c}$ [kN]							
	EA II M6 non-cracked concrete	EA II M8 non-cracked concrete	EA II M8x40 non-cracked concrete	EA II M10x30 non-cracked concrete	EA II M10 non-cracked concrete	EA II M12 non-cracked concrete	EA II M16 non-cracked concrete	EA II M20 non-cracked concrete
115	13.4							
120	14.2							
125	15.1							
130	15.9							
135	16.8							
140	17.7	18.0	18.6	18.3				
150	19.5	19.9	20.5	20.2				
160	21.4	21.7	22.5	22.1	22.8			
170	23.3	23.7	24.4	24.0	24.9			
180	25.2	25.7	26.5	26.1	26.9			
190	27.3	27.7	28.6	28.1	29.0			
200	29.3	29.8	30.7	30.2	31.2	32.7		
210	31.4	32.0	32.9	32.4	33.4	35.0		
220	33.6	34.1	35.1	34.6	35.7	37.3		
230	35.8	36.4	37.4	36.9	38.0	39.7		
240	38.0	38.6	39.7	39.1	40.3	42.1	44.8	
250	40.3	40.9	42.1	41.5	42.7	44.6	47.4	
260	42.6	43.3	44.5	43.9	45.1	47.1	50.0	
270	45.0	45.7	46.9	46.3	47.6	49.7	52.7	
280	47.4	48.1	49.4	48.7	50.1	52.3	55.4	58.3
300	52.3	53.1	54.5	53.8	55.3	57.6	60.9	64.1
300	52.3	53.1	54.5	53.8	55.3	57.6	60.9	64.1
350	65.3	66.2	67.9	67.0	68.8	71.5	75.4	79.1
400	79.2	80.2	82.1	81.1	83.1	86.3	90.8	95.1
450	93.8	95.0	97.2	96.0	98.3	101.9	107.1	111.8
500	109.2	110.6	113.0	111.7	114.3	118.3	124.1	129.4
600		143.8	146.8	145.2	148.4	153.3	160.3	166.8
700				181.4	185.2	191.0	199.3	206.9
800						231.1	240.7	249.5
900						273.6	284.5	294.5
1000							330.5	341.7
1100							378.6	391.0
1200							428.6	442.3
1300								495.5
1400								550.5
1500								607.3

5.3.1 Influence of concrete strength for shear

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

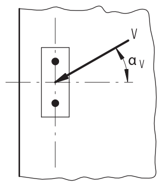
Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$

	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.



5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

fischer Hammerset anchor EA II

Anchor design according to fischer specification

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd.s}; N_{Rd.p}; N_{Rd.c}; N_{Rd.sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd.s}; V_{Rd.cp}; V_{Rd.c}$

6.3 Combined tension and shear load:

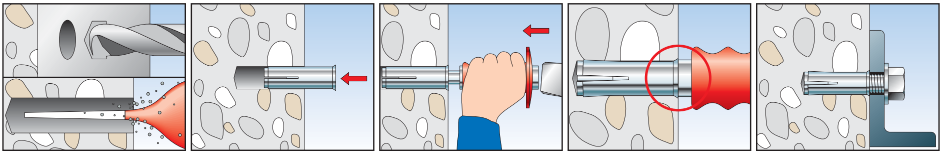
$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

$N_{Sd}; V_{Sd}$ = **tension/shear component of the design load acting on the most unfavourable single anchor**

$N_{Rd}; V_{Rd}$ = **tension/shear design resistance including safety factors of the most unfavourable single anchor**

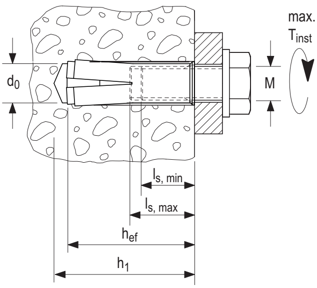
4

7. Installation details



8. Anchor installation data

Anchor type			EA II M6	EA II M8	EA II M8x40	EA II M10x30	EA II M10	EA II M12	EA II M16	EA II M20
			gvz | A4	gvz | A4	gvz | A4	gvz | A4	gvz | A4	gvz | A4	gvz | A4	gvz | A4
diameter of thread			M 6	M 8	M 8	M 10	M 10	M 12	M 16	M 20
nominal drill hole diameter	d_0	[mm]	8	10	10	12	12	15	20	25
drill depth	h_1	[mm]	≧ 32	≧ 33	≧ 43	≧ 33	≧ 43	≧ 54	≧ 70	≧ 85
effective anchorage depth	h_{ef}	[mm]	30	30	40	30	40	50	65	80
clearance-hole in fixture to be attached	d_f	[mm]	≦ 7	≦ 9	≦ 9	≦ 12	≦ 12	≦ 14	≦ 18	≦ 22
screw penetration depth	$l_{s,min} / l_{s,max}$	[mm]	≧ 6 / ≦ 13	≧ 8 / ≦ 13	≧ 8 / ≦ 13	≧ 10 / ≦ 13	≧ 10 / ≦ 17	≧ 12 / ≦ 22	≧ 16 / ≦ 28	≧ 20 / ≦ 34
required torque	max. T_{inst}	[Nm]	4	8	8	15	15	35	60	120
minimum thickness of concrete member	h_{min}	[mm]	100	100	100	120	120	120	160	200
minimum spacing	s_{min}	[mm]	65	95	95	85	95	145	180	190
minimum edge distances	c_{min}	[mm]	115	140	140	140	160	200	240	280



9. Mechanical characteristics

Anchor type			EA II M6		EA II M8		EA II M8x40		EA II M10x30		EA II M10		EA II M12		EA II M16		EA II M20	
			gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	A4
stressed cross sectional area sleeve	A_S	[mm²]	23.7		30.1		30.1		38.3		38.3		69.4		113.6		180.3	
stressed cross sectional area screw	A_S	[mm²]	20.1		36.6		36.6		58.0		58.0		84.3		156.7		244.8	
resisting moment sleeve *	W	[mm³]	40.3		70.6		70.6		115.9		115.9		242.0		527.6		1044.9	
resisting moment screw	W	[mm³]	12.7		31.2		31.2		62.3		62.3		109.1		176.6		540.3	
design value of bending moment [1]	$M^0_{Rd,s}$	[Nm]	6.1		15.2		15.2		29.6		29.6		52.8		132.8		259.2	
design value of bending moment [2]	$M^0_{Rd,s}$	[Nm]	7.1		16.7		16.7		33.3		33.3		59.0		148.7		291.0	
yield strength sleeve	f_{yk}	[N/mm²]	455	520	455	520	455	520	455	520	455	520	455	520	455	520	455	520
tensile strength sleeve	f_{uk}	[N/mm²]	570	650	570	650	570	650	570	650	570	650	570	650	570	650	570	650

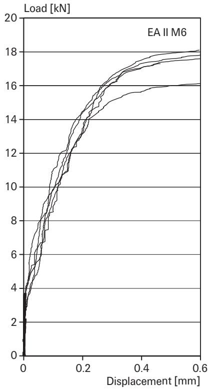
* Begin of expansion element

[1] The values apply to screws with a strength class 5.8

[2] The values apply to screws with a strength class A4-70

4

10. Load displacement curves for tension in non-cracked concrete ($f_{ck.cube\,(200)}$ = 30 N/mm²)



Notes

fischer Highbond anchor FHB II

Anchor design according to fischer specification

1. Types

FHB II-A S (gvz, A4 and C)

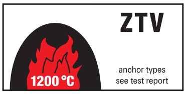
FHB II-A L (gvz, A4 and C)

FHB II - Resin capsule

FHB II-PF Quick Version - Resin capsule

FIS HB 345 S - Injection mortar
+ static mixer FIS S

FIS HB 150 C - Injection mortar



Features and Advantages

- European Technical Approval option 1*) for cracked and non-cracked concrete.
- Fire resistance classifications according to test report independently proved gives the safety in case of fire.
- Expansion stress free anchoring guarantees a safe use with small spacing and edge distances.
- Push-through installation enables mounting without special accessories and therefore safes time and money.
- Variable embedment depth enables the application in all kind of building structures.
- The quick curing resin in the capsule (FHB II-PF) saves curing time. e.g. 2 min > 20 °C
- The FHB II anchor rod can be used with mortar or resin capsule and gives high flexibility.
- With capsule approved for under water applications.

*) The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Anchor bolt:	- Carbon steel, zinc plated (5 µm) and passivated (gvz)
	- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
	- Highly corrosion-resistant steel of the corrosion resistance class IV, e.g. 1.4529
Injection mortar:	- Vinylester resin (styrene-free). quartz sand and hardener
Resin capsule:	- Vinylester resin (styrene-free). quartz sand and hardener

2. Ultimate resistances of single anchors with large spacing and large edge distance[1) 2)]

Mean values

Anchor type	FHB II A L M8x60			FHB II A S M10x60			FHB II A S M10x75			FHB II A L M10x95		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+80 °C / +50 °C) [3)]												
tension C 20/25 N_u [kN]	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	23.0	36.1	36.1	36.1
shear ≧ C 20/25 V_u [kN]	15.8	22.5	21.6	22.4	28.2	31.7	22.4	28.2	31.7	26.1	34.5	35.6
cracked concrete temperature range (+80 °C / +50 °C) [3)]												
tension C 20/25 N_u [kN]	20.9	20.9	20.9	22.3	22.3	22.3	23.0	23.0	23.0	36.1	36.1	36.1
shear ≧ C 20/25 V_u [kN]	15.8	22.5	21.6	22.4	28.2	31.7	22.4	28.2	31.7	26.1	34.5	35.6

Anchor type	FHB II A S M12x75			FHB II A L M12x100			FHB II A L M12x120			FHB II A S M16x95		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+80 °C / +50 °C) [3)]												
tension C 20/25 N_u [kN]	36.1	36.1	36.1	52.3	52.3	52.3	52.3	52.3	52.3	62.2	62.2	62.2
shear ≧ C 20/25 V_u [kN]	32.6	41.1	46.0	44.5	51.4	51.3	44.5	51.4	51.3	64.8	81.9	88.9
cracked concrete temperature range (+80 °C / +50 °C) [3)]												
tension C 20/25 N_u [kN]	31.2	31.2	31.2	48.0	48.0	48.0	50.7	50.7	50.7	44.4	44.4	44.4
shear ≧ C 20/25 V_u [kN]	32.6	41.1	46.0	44.5	51.4	51.3	44.5	51.4	51.3	64.8	81.9	88.9

Anchor type	FHB II A L M16x125			FHB II A L M16x145			FHB II A L M16x160			FHB II A S M20x170		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+80 °C / +50 °C) [3)]												
tension C 20/25 N_u [kN]	93.9	93.9	93.9	101.4	101.4	101.4	101.4	101.4	101.4	134.9	134.9	134.9
shear ≧ C 20/25 V_u [kN]	76.4	93.7	96.3	76.4	93.7	96.3	76.4	93.7	96.3	122.1	140.1	155.8
cracked concrete temperature range (+80 °C / +50 °C) [3)]												
tension C 20/25 N_u [kN]	67.1	67.1	67.1	83.8	83.8	83.8	97.1	97.1	97.1	106.4	106.4	106.4
shear ≧ C 20/25 V_u [kN]	76.4	93.7	96.3	76.4	93.7	96.3	76.4	93.7	96.3	122.1	140.1	155.8

Anchor type	FHB II A L M20x210			FHB II A S M24x170			FHB II A L M24x210		
	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+80 °C / +50 °C) [3)]									
tension C 20/25 N_u [kN]	144.5	144.5	144.5	134.9	134.9	134.9	144.5	144.5	144.5
shear ≧ C 20/25 V_u [kN]	122.1	140.1	155.8	136.4	159.2	184.5	136.4	159.2	184.5
cracked concrete temperature range (+80 °C / +50 °C) [3)]									
tension C 20/25 N_u [kN]	144.5	144.5	144.5	106.4	106.4	106.4	144.5	144.5	144.5
shear ≧ C 20/25 V_u [kN]	122.1	140.1	155.8	136.4	159.2	184.5	136.4	159.2	184.5

1) The loads apply to fischer FHB II anchor bolts and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ + 80 °C and long term temperature T ≦ + 50 °C (see also "Installation details, section 7").

2) Values for injection mortar

3) (short term temperature / long term temperature)

fischer Highbond anchor FHB II

Anchor design according to fischer specification

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance [1) 2)]

Anchor type	FHB II A L M8x60			FHB II A S M10x60			FHB II A S M10x75			FHB II A L M10x95			FHB II A S M12x75			FHB II A L M12x100			FHB II A L M12x120			FHB II A S M16x95		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+80 °C / +50 °C) [3)]																								
tension																								
C 20/25 N_{Rk} [kN]	25.1			25.1			25.1			34.4			34.4			49.8			49.8			51.4		
shear																								
≧ C 20/25 V_{Rk} [kN]	13.7	15.2		19.7	24.1		19.7	24.1		20.8	23.2		27.3	33.7		30.3	33.7		30.3	33.7		50.8	62.7	
cracked concrete temperature range (+80 °C / +50 °C) [3)]																								
tension																								
C 20/25 N_{Rk} [kN]	16.7			16.7			23.4			33.3			23.4			36.0			47.3			33.3		
shear																								
≧ C 20/25 V_{Rk} [kN]	13.7	15.2		19.7	24.1		19.7	24.1		20.8	23.2		27.3	33.7		30.3	33.7		30.3	33.7		50.8	66.7	

4

Anchor type	FHB II A L M16x125			FHB II A L M16x145			FHB II A L M16x160			FHB II A S M20x170			FHB II A L M20x210			FHB II A S M24x170			FHB II A L M24x210		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+80 °C / +50 °C) [3)]																					
tension																					
C 20/25 N_{Rk} [kN]	77.6			96.6			96.6			123.1			137.6			123.1			137.6		
shear																					
≧ C 20/25 V_{Rk} [kN]	56.3	62.7		56.3	62.7		56.3	62.7		80.3	97.9		87.9	97.9		114.2	124.5	141.0	126.9	141.0	
cracked concrete temperature range (+80 °C / +50 °C) [3)]																					
tension																					
C 20/25 N_{Rk} [kN]	50.3			62.9			72.9			79.8			109.6			79.8			109.6		
shear																					
≧ C 20/25 V_{Rk} [kN]	56.3	62.7		56.3	62.7		56.3	62.7		80.3	97.9		87.9	97.9		114.2	124.5	159.6	126.9	141.0	

1) The loads apply to fischer FHB II anchor bolts and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ + 80 °C and long term temperature T ≦ + 50 °C (see also "Installation details, section 7").

2) Values for injection mortar

3) (short term temperature / long term temperature)

fischer Highbond anchor FHB II

Anchor design according to fischer specification

3.2 Design resistance [1] [2]

Anchor type	FHB II A L M8x60			FHB II A S M10x60			FHB II A S M10x75			FHB II A L M10x95			FHB II A S M12x75			FHB II A L M12x100			FHB II A L M12x120			FHB II A S M16x95		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete																								
temperature range (+80 °C / +50 °C) [3]																								
tension																								
C 20/25 N_{Rd} [kN]	16.7			16.7			16.7			22.9			22.9			33.2			33.2			34.4		
shear																								
≧ C 20/25 V_{Rd} [kN]	11.0	12.2		15.8	19.3		15.8	19.3		16.6	18.6		21.8	27.0		24.2	27.0		24.2	27.0		40.6	50.2	
cracked concrete																								
temperature range (+80 °C / +50 °C) [3]																								
tension																								
C 20/25 N_{Rd} [kN]	11.2			11.2			15.6			22.2			15.6			24.0			31.5			22.2		
shear																								
≧ C 20/25 V_{Rd} [kN]	11.0	12.2		15.8	19.3		15.8	19.3		16.6	18.6		21.8	27.0		24.2	27.0		24.2	27.0		40.6	44.4	

Anchor type	FHB II A L M16x125			FHB II A L M16x145			FHB II A L M16x160			FHB II A S M20x170			FHB II A L M20x210			FHB II A S M24x170			FHB II A L M24x210		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete																					
temperature range (+80 °C / +50 °C) [3]																					
tension																					
C 20/25 N_{Rd} [kN]	51.8			64.4			64.4			82.1			91.7			82.1			91.7		
shear																					
≧ C 20/25 V_{Rd} [kN]	45.0	50.2		45.0	50.2		45.0	50.2		64.2	78.3		70.3	78.3		91.4	99.6	112.8	101.5	112.8	
cracked concrete																					
temperature range (+80 °C / +50 °C) [3]																					
tension																					
C 20/25 N_{Rd} [kN]	33.5			41.9			48.6			53.2			73.0			53.2			73.0		
shear																					
≧ C 20/25 V_{Rd} [kN]	45.0	50.2		45.0	50.2		45.0	50.2		64.2	78.3		70.3	78.3		91.4	99.6	106.4	101.5	112.8	

[1] The loads apply to fischer FHB II anchor bolts and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ + 80 °C and long term temperature T ≦ + 50 °C (see also "Installation details, section 7").

[2] Values for injection mortar

[3] (short term temperature / long term temperature)

3.3 Recommended resistance [1) 2) 3)]

Anchor type	FHB II A L M8x60			FHB II A S M10x60			FHB II A S M10x75			FHB II A L M10x95			FHB II A S M12x75			FHB II A L M12x100			FHB II A L M12x120			FHB II A S M16x95		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+80 °C / +50 °C) [4)]																								
tension																								
C 20/25 N_R [kN]	12.0			12.0			12.0			16.4			16.4			23.7			23.7			24.4		
shear																								
≧ C 20/25 V_R [kN]	7.8	8.7		11.3	13.8		11.3	13.8		11.9	13.3		15.6	19.3		17.3	19.3		17.3	19.3		29.0	35.8	
cracked concrete temperature range (+80 °C / +50 °C) [4)]																								
tension																								
C 20/25 N_R [kN]	8.0			8.0			11.1			15.9			11.1			17.1			22.5			15.9		
shear																								
≧ C 20/25 V_R [kN]	7.8	8.7		11.3	13.8		11.3	13.8		11.9	13.3		15.6	19.3		17.3	19.3		17.3	19.3		29.0	31.7	

Anchor type	FHB II A L M16x125			FHB II A L M16x145			FHB II A L M16x160			FHB II A S M20x170			FHB II A L M20x210			FHB II A S M24x170			FHB II A L M24x210		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+80 °C / +50 °C) [4)]																					
tension																					
C 20/25 N_R [kN]	37.0			46.0			46.0			58.6			65.5			58.6			65.5		
shear																					
≧ C 20/25 V_R [kN]	32.2	35.8		32.2	35.8		32.2	35.8		45.9	55.9		50.2	55.9		65.3	71.1	80.6	72.5	80.6	
cracked concrete temperature range (+80 °C / +50 °C) [4)]																					
tension																					
C 20/25 N_R [kN]	24.0			29.9			34.7			38.0			52.2			38.0			52.2		
shear																					
≧ C 20/25 V_R [kN]	32.2	35.8		32.2	35.8		32.2	35.8		45.9	55.9		50.2	55.9		65.3	71.1	76.0	72.5	80.6	

1) The loads apply to fischer FHB II anchor bolts and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ + 80 °C and long term temperature T ≦ + 50 °C (see also "Installation details, section 7").

2) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on failure mode of the anchor.

3) Values for injection mortar

4) (short term temperature / long term temperature)

fischer Highbond anchor FHB II

Anchor design according to fischer specification

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Pull-out / pull-through failure: $N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N}$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1.A} \cdot f_{c1.B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type	FHB II A L M8x60	FHB II A S M10x60	FHB II A S M10x75	FHB II A L M10x95	FHB II A S M12x75	FHB II A L M12x100	FHB II A L M12x120	FHB II A S M16x95
Design resistance $N_{Rd,s}$ [kN]	16.7	16.7	16.7	22.9	22.9	33.2	33.2	41.1

Anchor type	FHB II A L M16x125	FHB II A L M16x145	FHB II A L M16x160	FHB II A S M20x170	FHB II A L M20x210	FHB II A S M24x170	FHB II A L M24x210
Design resistance $N_{Rd,s}$ [kN]	64.4	64.4	64.4	85.7	91.7	85.7	91.7

4.2 Pull-out/pull-through failure of the highest loaded anchor

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

Design resistance of single anchor

Anchor type	FHB II A L M8x60 Injek.	FHB II A L M8x60 Patro.	FHB II A S M10x60 Injek.	FHB II A S M10x60 Patro.	FHB II A S M10x75	FHB II A L M10x95	FHB II A S M12x75	FHB II A L M12x100	FHB II A L M12x120
non-cracked concrete									
temperature range (+80 °C / +50 °C) [1]									
$N^0_{Rd,p}$ [kN]	17.2	14.3	17.2	14.3	24.1	34.3	24.1	37.0	48.7
cracked concrete									
temperature range (+80 °C / +50 °C) [1]									
$N^0_{Rd,p}$ [kN]	11.2	9.3	11.2	9.3	15.6	22.2	15.6	24.0	31.5

Anchor type	FHB II A S M16x95	FHB II A L M16x125	FHB II A L M16x145	FHB II A L M16x160	FHB II A S M20x170	FHB II A L M20x210	FHB II A S M24x170	FHB II A L M24x210
non-cracked concrete								
temperature range (+80 °C / +50 °C) [1]								
$N^0_{Rd,p}$ [kN]	34.3	51.8	64.7	75.0	82.1	112.7	82.1	112.7
cracked concrete								
temperature range (+80 °C / +50 °C) [1]								
$N^0_{Rd,p}$ [kN]	22.2	33.5	41.9	48.6	53.2	73.0	53.2	73.0

[1] (short term temperature / long term temperature)

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4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type	FHB II A L M8x60	FHB II A S M10x60	FHB II A S M10x75	FHB II A L M10x95	FHB II A S M12x75	FHB II A L M12x100	FHB II A L M12x120	FHB II A S M16x95
non-cracked concrete temperature range (+80 °C / +50 °C)								
Design resistance $N^0_{Rd,c}$ [kN]	17.2	17.2	24.1	34.3	24.1	37.0	48.7	34.3
cracked concrete temperature range (+80 °C / +50 °C)								
Design resistance $N^0_{Rd,c}$ [kN]	11.2	11.2	15.6	22.2	15.6	24.0	31.5	22.2

Anchor type	FHB II A L M16x125	FHB II A L M16x145	FHB II A L M16x160	FHB II A S M20x170	FHB II A L M20x210	FHB II A S M24x170	FHB II A L M24x210
non-cracked concrete temperature range (+80 °C / +50 °C)							
Design resistance $N^0_{Rd,c}$ [kN]	51.8	64.7	75.0	82.1	112.7	82.1	112.7
cracked concrete temperature range (+80 °C / +50 °C)							
Design resistance $N^0_{Rd,c}$ [kN]	33.5	41.9	48.6	53.2	73.0	53.2	73.0

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type	FHB II A L M8x60	FHB II A S M10x60	FHB II A S M10x75	FHB II A L M10x95	FHB II A S M12x75	FHB II A L M12x100	FHB II A L M12x120	FHB II A S M16x95
$s_{cr,N}$ [mm]	180	180	225	285	225	300	360	285
$c_{cr,N}$ [mm]	90	90	113	143	113	150	180	143

Anchor type	FHB II A L M16x125	FHB II A L M16x145	FHB II A L M16x160	FHB II A S M20x170	FHB II A L M20x210	FHB II A S M24x170	FHB II A L M24x210
$s_{cr,N}$ [mm]	375	435	480	510	630	510	630
$c_{cr,N}$ [mm]	188	218	240	255	315	255	315

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type eff. anchorage depth h_{ef} [mm]		FHB II A L M8x60	FHB II A S M10x60	FHB II A S M10x75	FHB II A L M10x95	FHB II A S M12x75	FHB II A L M12x100	FHB II A L M12x120	FHB II A S M16x95
$s_{cr,sp}$	[mm]	300	300	300	480	300	380	600	340
$c_{cr,sp}$	[mm]	150	150	150	240	150	190	300	170
h_{min}	[mm]	100	100	120	140	120	140	170	150

Anchor type eff. anchorage depth h_{ef} [mm]		FHB II A L M16x125	FHB II A L M16x145	FHB II A L M16x160	FHB II A S M20x170	FHB II A L M20x210	FHB II A S M24x170	FHB II A L M24x210
$s_{cr,sp}$	[mm]	375	500	580	510	630	510	630
$c_{cr,sp}$	[mm]	188	250	290	255	315	255	315
h_{min}	[mm]	170	190	220	240	280	240	280

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = N_{Rd,c} \cdot k$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

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5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type	FHB II A L M8x60		FHB II A S M10x60		FHB II A S M10x75		FHB II A L M10x95		FHB II A S M12x75		FHB II A L M12x100		FHB II A L M12x120		FHB II A S M16x95	
	gvz	A4/C	gvz	A4/C	gvz	A4/C	gvz	A4/C	gvz	A4/C	gvz	A4/C	gvz	A4/C	gvz	A4/C
Design resistance $V_{Rd,s}$ [kN]	11.0	12.2	15.8	19.3	15.8	19.3	16.6	18.6	21.8	27.0	24.2	27.0	24.2	27.0	40.6	50.2

Anchor type	FHB II A L M16x125		FHB II A L M16x145		FHB II A L M16x160		FHB II A S M20x170		FHB II A L M20x210		FHB II A S M24x170			FHB II A L M24x210	
	gvz	A4/C	gvz	A4/C	gvz	A4/C	gvz	A4/C	gvz	A4/C	gvz	A4	C	gvz	A4/C
Design resistance $V_{Rd,s}$ [kN]	45.0	50.2	45.0	50.2	45.0	50.2	64.2	78.3	70.3	78.3	91.4	99.6	112.8	101.5	112.8

5.2 Pryout failure for the most unfavourable anchor

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

k-factor

Anchor type	FHB II M8 to FHB II M24
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- $c < \max(10\ h_{ef}\ ;\ 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]									
	FHB II A L M8x60		FHB II A S M10x60		FHB II A S M10x75		FHB II A L M10x95		FHB II A S M12x75	
Edge Distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
40	3.5	2.5	3.7	2.6	3.8	2.7	4.1	2.9	4.0	2.8
45	4.1	2.9	4.3	3.0	4.5	3.2	4.7	3.3	4.6	3.3
50	4.7	3.3	4.9	3.5	5.1	3.6	5.4	3.8	5.3	3.8
55	5.4	3.8	5.6	3.9	5.8	4.1	6.1	4.3	6.0	4.2
60	6.0	4.3	6.2	4.4	6.5	4.6	6.8	4.8	6.7	4.8
65	6.7	4.7	6.9	4.9	7.2	5.1	7.6	5.4	7.4	5.3
70	7.4	5.2	7.7	5.4	8.0	5.6	8.3	5.9	8.2	5.8
75	8.1	5.8	8.4	5.9	8.7	6.2	9.1	6.5	9.0	6.4
80	8.9	6.3	9.2	6.5	9.5	6.7	9.9	7.0	9.8	6.9
85	9.6	6.8	9.9	7.0	10.3	7.3	10.8	7.6	10.6	7.5
90	10.4	7.4	10.7	7.6	11.1	7.9	11.6	8.2	11.4	8.1
95	11.2	7.9	11.5	8.2	12.0	8.5	12.5	8.8	12.3	8.7
100	12.0	8.5	12.4	8.8	12.8	9.1	13.3	9.5	13.2	9.3
120	15.5	10.9	15.9	11.2	16.4	11.6	17.0	12.1	16.8	11.9
130	17.3	12.2	17.7	12.5	18.3	13.0	19.0	13.4	18.7	13.3
135	18.2	12.9	18.7	13.2	19.3	13.6	20.0	14.1	19.7	14.0
140	19.1	13.6	19.6	13.9	20.2	14.3	21.0	14.8	20.7	14.7
160	23.0	16.3	23.6	16.7	24.3	17.2	25.1	17.8	24.8	17.6
180	27.1	19.2	27.8	19.7	28.6	20.2	29.5	20.9	29.2	20.7
200	31.4	22.3	32.1	22.8	33.0	23.4	34.1	24.1	33.7	23.9
250	43.0	30.5	43.9	31.1	45.0	31.9	46.3	32.8	45.8	32.5
300	55.6	39.4	56.7	40.2	58.0	41.1	59.6	42.2	59.1	41.8
350	69.2	49.0	70.5	49.9	72.0	51.0	73.9	52.3	73.2	51.9
400	83.7	59.3	85.1	60.3	86.9	61.6	89.0	63.1	88.3	62.5
450	98.9	70.1	100.6	71.2	102.6	72.7	105.0	74.4	104.2	73.8
500	115.0	81.4	116.8	82.7	119.1	84.4	121.8	86.3	120.9	85.6
550	131.8	93.3	133.8	94.8	136.4	96.6	139.3	98.7	138.3	97.9
600	149.2	105.7	151.5	107.3	154.3	109.3	157.5	111.6	156.4	110.8
650					172.9	122.5	176.4	125.0	175.2	124.1
700					192.1	136.1	195.9	138.8	194.6	137.9
750					212.0	150.2	216.1	153.1	214.7	152.1
800							236.9	167.8		
850							258.2	182.9		
900							280.1	198.4		
950							302.6	214.3		

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fischer Highbond anchor FHB II

Anchor design according to fischer specification

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]									
	FHB II A L M12x100		FHB II A L M12x120		FHB II A S M16x95		FHB II A L M16x125		FHB II A L M16x145	
Edge Distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
50	5.7	4.0	6.0	4.2	6.0	4.2				
55	6.4	4.5	6.7	4.7	6.7	4.7	7.2	5.1		
60	7.2	5.1	7.5	5.3	7.5	5.3	8.0	5.7	8.4	5.9
65	7.9	5.6	8.3	5.9	8.3	5.9	8.9	6.3	9.2	6.5
70	8.7	6.2	9.1	6.4	9.1	6.4	9.7	6.9	10.1	7.2
75	9.5	6.7	9.9	7.0	9.9	7.0	10.6	7.5	11.0	7.8
80	10.4	7.3	10.8	7.6	10.8	7.6	11.5	8.1	11.9	8.4
85	11.2	7.9	11.6	8.2	11.6	8.2	12.4	8.8	12.9	9.1
90	12.1	8.6	12.5	8.9	12.5	8.9	13.3	9.4	13.8	9.8
95	13.0	9.2	13.4	9.5	13.4	9.5	14.3	10.1	14.8	10.5
100	13.9	9.8	14.4	10.2	14.4	10.2	15.2	10.8	15.8	11.2
120	17.6	12.5	18.2	12.9	18.2	12.9	19.3	13.7	19.9	14.1
130	19.6	13.9	20.3	14.4	20.3	14.4	21.4	15.1	22.0	15.6
135	20.6	14.6	21.3	15.1	21.3	15.1	22.5	15.9	23.1	16.4
140	21.7	15.3	22.4	15.8	22.4	15.8	23.5	16.7	24.3	17.2
160	25.9	18.4	26.7	18.9	26.7	18.9	28.1	19.9	28.9	20.4
180	30.4	21.5	31.3	22.1	31.3	22.2	32.8	23.2	33.7	23.9
200	35.1	24.8	36.0	25.5	36.1	25.5	37.7	26.7	38.7	27.4
250	47.6	33.7	48.8	34.5	48.8	34.6	50.8	36.0	52.1	36.9
300	61.1	43.3	62.6	44.3	62.6	44.3	65.0	46.1	66.5	47.1
350	75.6	53.6	77.3	54.8	77.4	54.8	80.2	56.8	81.9	58.0
400	91.1	64.5	93.0	65.9	93.1	65.9	96.3	68.2	98.2	69.6
450	107.3	76.0	109.5	77.6	109.6	77.6	113.2	80.2	115.4	81.7
500	124.4	88.1	126.8	89.8	126.9	89.9	130.9	92.8	133.3	94.5
550	142.1	100.7	144.8	102.6	144.9	102.7	149.4	105.8	152.1	107.7
600	160.6	113.8	163.6	115.9	163.7	115.9	168.6	119.4	171.5	121.5
650	179.8	127.4	183.0	129.6	183.1	129.7	188.5	133.5	191.6	135.7
700	199.6	141.4	203.1	143.8	203.2	144.0	209.0	148.0	212.4	150.4
750	220.1	155.9	223.8	158.5	224.0	158.6	230.1	163.0	233.7	165.6
800	241.1	170.8	245.1	173.6	245.3	173.7	251.9	178.4	255.8	181.2
850	262.7	186.1	267.0	189.1	267.2	189.3	274.2	194.3	278.4	197.2
900	284.9	201.8	289.4	205.0	289.7	205.2	297.2	210.5	301.5	213.6
950	307.7	217.9	312.4	221.3	312.7	221.5	320.6	227.1	325.3	230.4
1000	331.0	234.4	336.0	238.0			344.6	244.1	349.5	247.6
1100			384.6	272.5			394.2	279.2	399.6	283.1
1200			435.3	308.3			445.8	315.8	451.7	320.0
1300							499.3	353.7	505.7	358.2
1400									561.6	397.8
1500									619.2	438.6
1400									561.6	397.8
1500									619.2	438.6

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fischer Highbond anchor FHB II

Anchor design according to fischer specification

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]									
	FHB II A L M16x160		FHB II A S M20x170		FHB II A L M20x210		FHB II A S M24x170		FHB II A L M24x210	
Edge Distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
70	10.4	7.4								
75	11.3	8.0								
80	12.2	8.7	13.1	9.3			13.6	9.6		
85	13.2	9.3	14.1	10.0			14.6	10.4		
90	14.2	10.0	15.1	10.7	16.0	11.4	15.7	11.1	16.7	11.9
95	15.1	10.7	16.1	11.4	17.1	12.1	16.7	11.9	17.8	12.6
100	16.2	11.4	17.2	12.2	18.2	12.9	17.8	12.6	19.0	13.4
120	20.3	14.4	21.5	15.2	22.7	16.1	22.3	15.8	23.6	16.7
130	22.5	16.0	23.8	16.8	25.1	17.8	24.6	17.4	26.0	18.4
135	23.6	16.7	24.9	17.7	26.3	18.6	25.8	18.3	27.2	19.3
140	24.8	17.5	26.1	18.5	27.5	19.5	27.0	19.1	28.5	20.2
160	29.4	20.8	30.9	21.9	32.5	23.0	31.9	22.6	33.6	23.8
180	34.3	24.3	36.0	25.5	37.7	26.7	37.1	26.3	38.9	27.6
200	39.4	27.9	41.2	29.2	43.1	30.5	42.4	30.1	44.5	31.5
250	52.9	37.5	55.2	39.1	57.5	40.7	56.7	40.1	59.1	41.9
300	67.5	47.8	70.2	49.7	72.9	51.6	72.0	51.0	74.9	53.0
350	83.1	58.9	86.2	61.1	89.3	63.3	88.3	62.5	91.6	64.9
400	99.6	70.5	103.2	73.1	106.7	75.6	105.5	74.7	109.3	77.4
450	116.9	82.8	120.9	85.7	124.8	88.4	123.6	87.5	127.8	90.5
500	135.0	95.6	139.5	98.8	143.8	101.9	142.4	100.9	147.1	104.2
550	153.9	109.0	158.8	112.5	163.6	115.9	162.0	114.8	167.1	118.4
600	173.5	122.9	178.9	126.7	184.0	130.4	182.4	129.2	187.9	133.1
650	193.8	137.2	199.6	141.4	205.2	145.3	203.4	144.1	209.4	148.3
700	214.7	152.1	221.0	156.5	227.0	160.8	225.1	159.4	231.5	164.0
750	236.3	167.4	243.0	172.1	249.5	176.7	247.4	175.3	254.3	180.1
800	258.4	183.1	265.7	188.2	272.5	193.0	270.4	191.5	277.7	196.7
850	281.2	199.2	288.9	204.6	296.2	209.8	293.9	208.2	301.7	213.7
900	304.6	215.7	312.7	221.5	320.4	227.0	318.0	225.3	326.3	231.1
950	328.5	232.7	337.1	238.8	345.3	244.6	342.7	242.8	351.4	248.9
1000	352.9	250.0	362.0	256.4	370.6	262.5	367.9	260.6	377.1	267.1
1100	403.3	285.7	413.4	292.8	422.9	299.5	420.0	297.5	430.1	304.6
1200	455.8	322.9	466.9	330.7	477.2	338.0	474.0	335.8	485.1	343.6
1300	510.2	361.4	522.2	369.9	533.4	377.8	530.0	375.4	542.0	383.9
1400	566.4	401.2	579.4	410.4	591.5	419.0	587.9	416.4	600.8	425.5
1500	624.4	442.3	638.4	452.2	651.4	461.4	647.5	458.6	661.3	468.5
1600	684.1	484.5	699.1	495.2	713.0	505.0	708.9	502.1	723.7	512.6
1700			761.4	539.4	776.2	549.8	771.9	546.7	787.6	557.9
1800					841.1	595.8			853.2	604.4
1900					907.6	642.9			920.4	652.0
2000					975.5	691.0			989.1	700.6
2100					1045.0	740.2			1059.3	750.3

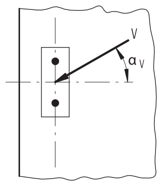
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle α ≧ 90° the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

fischer Highbond anchor FHB II

Anchor design according to fischer specification

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

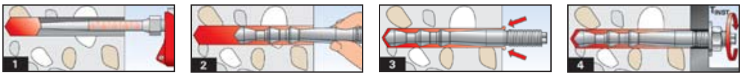
N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details

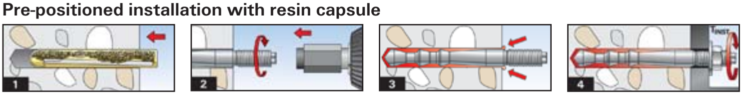
Drill a hole

Preparation injection mortar

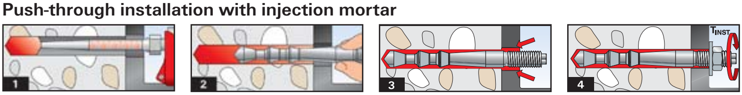
Pre-positioned installation with injection mortar



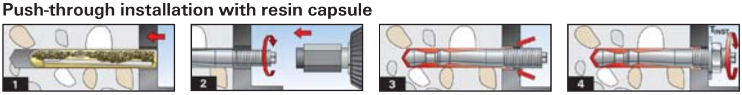
Pre-positioned installation with resin capsule



Push-through installation with injection mortar



Push-through installation with resin capsule



fischer Highbond anchor FHB II

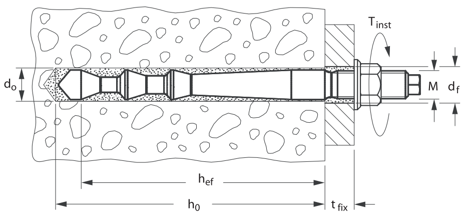
Anchor design according to fischer specification

8. Anchor characteristics

Anchor type			FHB II A L M8x60	FHB II A S M10x60	FHB II A S M10x75	FHB II A L M10x95	FHB II A S M12x75	FHB II A L M12x100	FHB II A L M12x120	FHB II A S M16x95
diameter of thread			M 8	M 10	M 10	M 10	M 12	M 12	M 12	M 16
nominal drill hole diameter	d_0	[mm]	10	10	10	12	12	14	14	16
drill depth	h_0	[mm]	75	75	90	110	90	115	135	110
effective anchorage depth	h_{ef}	[mm]	60	60	75	95	75	100	120	95
clearance-hole in fixture to be attached pre-positioned installation	d_f	[mm]	≦ 9	≦ 12	≦ 12	≦ 12	≦ 14	≦ 14	≦ 14	≦ 18
clearance-hole in fixture to be attached push-through installation [1]	d_f	[mm]	≦ 11	≦ 12	≦ 12	≦ 14	≦ 14	≦ 16	≦ 16	≦ 18
wrench size	SW	[mm]	13	17	17	17	19	19	19	24
required torque	T_{inst}	[Nm]	15	15	15	20	30	40	40	50
minimum thickness of concrete member	h_{min}	[mm]	100	100	120	140	120	140	170	150
minimum spacing	s_{min}	[mm]	40	40	40	40	40	50	50	50
minimum edge distances	c_{min}	[mm]	40	40	40	40	40	50	50	50
mortar filling quantity		[scale units]	3	3	4	5	4	7	7	8

Anchor type			FHB II A L M16x125	FHB II A L M16x145	FHB II A L M16x160	FHB II A S M20x170	FHB II A L M20x210	FHB II A S M24x170	FHB II A L M24x210
diameter of thread			M 16	M 16	M 16	M 20	M 20	M 24	M 24
nominal drill hole diameter	d_0	[mm]	18	18	18	25	25	25	25
drill depth	h_0	[mm]	140	160	175	190	235	190	235
effective anchorage depth	h_{ef}	[mm]	125	145	160	170	210	170	210
clearance-hole in fixture to be attached pre-positioned installation	d_f	[mm]	≦ 18	≦ 18	≦ 18	≦ 22	≦ 22	≦ 26	≦ 26
clearance-hole in fixture to be attached push-through installation [1]	d_f	[mm]	≦ 20	≦ 20	≦ 20	≦ 26	≦ 26	≦ 26	≦ 26
wrench size	SW	[mm]	24	24	24	30	30	36	36
required torque	T_{inst}	[Nm]	60	60	60	100	100	100	100
minimum thickness of concrete member	h_{min}	[mm]	170	190	220	240	280	240	280
minimum spacing	s_{min}	[mm]	55	60	70	80	90	80	90
minimum edge distances	c_{min}	[mm]	55	60	70	80	90	80	90
mortar filling quantity		[scale units]	11	13	13	26	33	26	33

[1] Hole clearance in base plate has to be filled with excess mortar



fischer
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8.1 Gelling and curing times for installation with cartridges

Temperature at anchoring base	Max. processing time	Temperature at anchoring base	Curing time
		- 5 °C	360 min.
		± 0 °C	180 min.
+ 5 °C	15 min.	+ 5 °C	90 min.
+ 20 °C	6 min.	+ 20 °C	35 min.
+ 30 °C	4 min.	+ 30 °C	20 min.
+ 40 °C	2 min.	≧ + 40 °C	12 min.

The above times apply for dry concrete from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least + 5 °C. In wet concrete curing time has to be doubled. For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.

8.2 Gelling and curing times for installation with capsules

Temperature at anchoring base	Curing time	
	FHB II-P	FHB II-PF
- 5 °C	240 min.	8 min.
± 0 °C	45 min.	6 min.
+ 10 °C	20 min.	4 min.
≧ 20 °C	10 min.	2 min.

The above times apply for dry concrete. In wet concrete the curing time has to be doubled.

4

9. Mechanical characteristics

Anchor type			FHB II A L M8x60	FHB II A S M10x60	FHB II A S M10x75	FHB II A L M10x95	FHB II A S M12x75	FHB II A L M12x100	FHB II A L M12x120	FHB II A S M16x95
			gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C
stressed cross sectional area anchor rod	A_S	[mm²]	37	58	58	58	84	84	84	157
section modolus	W	[mm³]	31	62	62	62	109	109	109	277
design value of bending moment	$M^0_{Rd,s}$	[Nm]	24.8	49.6	49.6	48.0	84.0	84.0	84.0	212.8
yield strength anchor rod	f_{yk}	[N/mm²]	640	640	640	640	640	640	640	640
tensile strength anchor rod	f_{uk}	[N/mm²]	800	800	800	800	800	800	800	800

Anchor type			FHB II A L M16x125	FHB II A L M16x145	FHB II A L M16x160	FHB II A S M20x170	FHB II A L M20x210	FHB II A S M24x170	FHB II A L M24x210
			gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C
stressed cross sectional area anchor rod	A_S	[mm²]	157	157	157	245	245	353	245
section modolus	W	[mm³]	277	277	277	541	541	934	541
design value of bending moment	$M^0_{Rd,s}$	[Nm]	212.8	212.8	212.8	415.2	415.2	716.8	716.8
yield strength anchor rod	f_{yk}	[N/mm²]	640	640	640	640	640	640	640
tensile strength anchor rod	f_{uk}	[N/mm²]	800	800	800	800	800	800	800

fischer Powerbond-System FPB

Anchor design according to fischer specification

1. Types

FIS A M10 - M16 - threaded rod (gvz, A4 and C)

RG M10 - M16 - threaded rod (gvz, A4 and C)

Powersleeve FIS PS

Injection mortar FIS PM

4

ETA
ETA-12/0160
ETAG 001-5
Option 1 for cracked concrete
*)

Fire resistance classification
R 120
Anchor types see test report

CALCULATION WITH
CC
COMPUFIX
CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 1*) for cracked concrete.
- Fire resistance classifications according to test report independently proved gives the safety in case of fire.
- The variability in the anchorage depth and building component thickness enables optimal dimensioning for economic anchorage.
- Approved in hammer- and diamond-drilled drill holes for maximum safety in planning and processing.
- With just three power sleeve dimensions and the fischer FIS A threaded rods, an entire M10/M12/M16 assortment can be covered with the lowest inventory cost.
- Savings in assembly time through the special mortar which is permitted for water-filled drill holes.
- Powerbond is suitable for pre-positioned and push-through installation.
- The mortar fully bonds the sleeve and threaded rod with the drill hole wall and seals the drill hole.

*) The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Threaded rod :
- Carbon steel grade 5.8 and 8.8 zinc plated (5 µm) and passivated (gvz)
- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
- Highly corrosion-resistant steel of the corrosion resistance class IV, e.g. 1.4529

Power sleeve :
- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316

Injection mortar:
- Vinylester resin (styrene-free), hydraulic additives, quartz sand and hardener

2. Ultimate resistances of single anchors with large spacing and large edge distance[1)]

Mean values [1)]

Anchor type				Powerbond M10								Powerbond M12							
				gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}			[mm]	90								110							
non-cracked concrete temperature range (+ 50 °C / + 24 °C) [2)]																			
tension static	C 20/25	N_u	[kN]	30.5	49.4	30.5	43.1	49.4	30.5	43.1	49.4	45.2	70.9	45.2	62.0	70.9	45.2	62.0	70.9
	C 50/60	N_u	[kN]	30.5	49.4	30.5	43.1	49.4	30.5	43.1	49.4	45.2	71.4	45.2	62.0	71.4	45.2	62.0	71.4
shear static	≧ C 20/25	V_u	[kN]	18.3	29.6	18.3	25.8	29.6	18.3	25.8	29.6	27.1	42.8	27.1	37.2	42.8	27.1	37.2	42.8
cracked concrete temperature range (+ 50 °C / + 24 °C) [2)]																			
tension static	C 20/25	N_u	[kN]	30.5	40.9	30.5	40.9	40.9	30.5	40.9	40.9	45.2	55.3	45.2	55.3	55.3	45.2	55.3	55.3
	C 50/60	N_u	[kN]	30.5	49.4	30.5	43.1	49.4	30.5	43.1	49.4	45.2	71.4	45.2	62.0	71.4	45.2	62.0	71.4
shear static	≧ C 20/25	V_u	[kN]	18.3	29.6	18.3	25.8	29.6	18.3	25.8	29.6	27.1	42.8	27.1	37.2	42.8	27.1	37.2	42.8

Anchor type				Powerbond M16							
				gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}			[mm]	125							
non-cracked concrete temperature range (+ 50 °C / + 24 °C) [2)]											
tension static	C 20/25	N_u	[kN]	83.0	94.3	83.0	94.3	94.3	83.0	94.3	94.3
	C 50/60	N_u	[kN]	83.0	127.4	83.0	115.5	127.4	83.0	115.5	127.4
shear static	≧ C 20/25	V_u	[kN]	49.8	79.4	49.8	69.3	79.4	49.8	69.3	79.4
cracked concrete temperature range (+ 50 °C / + 24 °C) [2)]											
tension static	C 20/25	N_u	[kN]	67.0	67.0	67.0	67.0	67.0	67.0	67.0	67.0
	C 50/60	N_u	[kN]	83.0	103.8	83.0	103.8	103.8	83.0	103.8	103.8
shear static	≧ C 20/25	V_u	[kN]	49.8	79.4	49.8	69.3	79.4	49.8	69.3	79.4

1) The loads apply to fischer threaded rods and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance [1)]

Anchor type	Powerbond M10								Powerbond M12							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	90								110							
non-cracked concrete																
temperature range (+ 50 °C / + 24 °C) [2)]																
tension static C 20/25 N_{Rk} [kN]	29.0	36.8	29.0	36.8	36.8	29.0	36.8	36.8	43.0	53.9	43.0	53.9	53.9	43.0	53.9	53.9
C 50/60 N_{Rk} [kN]	29.0	47.0	29.0	41.0	47.0	29.0	41.0	47.0	43.0	68.0	43.0	59.0	68.0	43.0	59.0	68.0
shear static ≧ C 20/25 V_{Rk} [kN]	15.0	23.0	15.0	20.0	23.0	15.0	20.0	23.0	21.0	34.0	21.0	30.0	34.0	21.0	30.0	34.0
cracked concrete																
temperature range (+ 50 °C / + 24 °C) [2)]																
tension static C 20/25 N_{Rk} [kN]	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.3	41.5	41.5	41.5	41.5	41.5	41.5	41.5	41.5
C 50/60 N_{Rk} [kN]	29.0	36.8	29.0	36.8	36.8	29.0	36.8	36.8	43.0	53.9	43.0	53.9	53.9	43.0	53.9	53.9
shear static ≧ C 20/25 V_{Rk} [kN]	15.0	23.0	15.0	20.0	23.0	15.0	20.0	23.0	21.0	34.0	21.0	30.0	34.0	21.0	30.0	34.0

Anchor type	Powerbond M16							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	125							
non-cracked concrete								
temperature range (+ 50 °C / + 24 °C) [2)]								
tension static C 20/25 N_{Rk} [kN]	70.6	70.6	70.6	70.6	70.6	70.6	70.6	70.6
C 50/60 N_{Rk} [kN]	79.0	106.2	79.0	106.2	106.2	79.0	106.2	106.2
shear static ≧ C 20/25 V_{Rk} [kN]	39.0	63.0	39.0	55.0	63.0	39.0	55.0	63.0
cracked concrete								
temperature range (+ 50 °C / + 24 °C) [2)]								
tension static C 20/25 N_{Rk} [kN]	50.3	50.3	50.3	50.3	50.3	50.3	50.3	50.3
C 50/60 N_{Rk} [kN]	77.9	77.9	77.9	77.9	77.9	77.9	77.9	77.9
shear static ≧ C 20/25 V_{Rk} [kN]	39.0	63.0	39.0	55.0	63.0	39.0	55.0	63.0

1) The loads apply to fischer threaded rods and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)

fischer Powerbond-System FPB

Anchor design according to fischer specification

3.2 Design resistance [1)]

Anchor type	Powerbond M10								Powerbond M12							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	90								110							
non-cracked concrete																
temperature range (+ 50 °C / + 24 °C) [2)]																
tension static C 20/25 N_{Rd} [kN]	19.3	24.5	10.1	21.9	24.5	10.1	24.5	24.5	28.7	35.9	15.0	31.6	35.9	15.0	35.9	35.9
C 50/60 N_{Rd} [kN]	19.3	31.3	10.1	21.9	31.3	10.1	27.3	29.4	28.7	45.3	15.0	31.6	45.3	15.0	39.3	42.5
shear static ≧ C 20/25 V_{Rd} [kN]	12.0	18.4	6.3	12.8	18.4	6.3	16.0	17.3	16.8	27.2	8.8	19.2	27.2	8.8	24.0	25.6
cracked concrete																
temperature range (+ 50 °C / + 24 °C) [2)]																
tension static C 20/25 N_{Rd} [kN]	18.8	18.8	10.1	18.8	18.8	10.1	18.8	18.8	27.6	27.6	15.0	27.6	27.6	15.0	27.6	27.6
C 50/60 N_{Rd} [kN]	19.3	24.5	10.1	21.9	24.5	10.1	24.5	24.5	28.7	35.9	15.0	31.6	35.9	15.0	35.9	35.9
shear static ≧ C 20/25 V_{Rd} [kN]	12.0	18.4	6.3	12.8	18.4	6.3	16.0	17.3	16.8	27.2	8.8	19.2	27.2	8.8	24.0	25.6

Anchor type	Powerbond M16							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	125							
non-cracked concrete								
temperature range (+ 50 °C / + 24 °C) [2)]								
tension static C 20/25 N_{Rd} [kN]	47.1	47.1	27.6	47.1	47.1	27.6	47.1	47.1
C 50/60 N_{Rd} [kN]	52.7	70.8	27.6	58.8	70.8	27.6	70.8	70.8
shear static ≧ C 20/25 V_{Rd} [kN]	31.2	50.4	16.4	35.3	50.4	16.4	44.0	47.4
cracked concrete								
temperature range (+ 50 °C / + 24 °C) [2)]								
tension static C 20/25 N_{Rd} [kN]	33.5	33.5	27.6	33.5	33.5	27.6	33.5	33.5
C 50/60 N_{Rd} [kN]	52.0	52.0	27.6	52.0	52.0	27.6	52.0	52.0
shear static ≧ C 20/25 V_{Rd} [kN]	31.2	50.4	16.4	35.3	50.4	16.4	44.0	47.4

1) The loads apply to fischer threaded rods and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)

3.3 Allowable resistance [1) 3)]

Anchor type	Powerbond M10								Powerbond M12							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	90								110							
non-cracked concrete																
temperature range (+ 50 °C / + 24 °C) [2)]																
tension static C 20/25 N_R [kN]	13.8	17.5	7.2	15.7	17.5	7.2	17.5	17.5	20.5	25.7	10.7	22.5	25.7	10.7	25.7	25.7
C 50/60 N_R [kN]	13.8	22.4	7.2	15.7	22.4	7.2	19.5	21.0	20.5	32.4	10.7	22.5	32.4	10.7	28.1	30.4
shear static ≧ C 20/25 V_R [kN]	8.6	13.1	4.5	9.2	13.1	4.5	11.4	12.4	12.0	19.4	6.3	13.7	19.4	6.3	17.1	18.3
cracked concrete																
temperature range (+ 50 °C / + 24 °C) [2)]																
tension static C 20/25 N_R [kN]	13.5	13.5	7.2	13.5	13.5	7.2	13.5	13.5	19.7	19.7	10.7	19.7	19.7	10.7	19.7	19.7
C 50/60 N_R [kN]	13.8	17.5	7.2	15.7	17.5	7.2	17.5	17.5	20.5	25.7	10.7	22.5	25.7	10.7	25.7	25.7
shear static ≧ C 20/25 V_R [kN]	8.6	13.1	4.5	9.2	13.1	4.5	11.4	12.4	12.0	19.4	6.3	13.7	19.4	6.3	17.1	18.3

Anchor type	Powerbond M16							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	125							
non-cracked concrete								
temperature range (+ 50 °C / + 24 °C) [2)]								
tension static C 20/25 N_R [kN]	33.6	33.6	19.7	33.6	33.6	19.7	33.6	33.6
C 50/60 N_R [kN]	37.6	50.6	19.7	42.0	50.6	19.7	50.6	50.6
shear static ≧ C 20/25 V_R [kN]	22.3	36.0	11.7	25.2	36.0	11.7	31.4	33.8
cracked concrete								
temperature range (+ 50 °C / + 24 °C) [2)]								
tension static C 20/25 N_R [kN]	24.0	24.0	19.7	24.0	24.0	19.7	24.0	24.0
C 50/60 N_R [kN]	37.1	37.1	19.7	37.1	37.1	19.7	37.1	37.1
shear static ≧ C 20/25 V_R [kN]	22.3	36.0	11.7	25.2	36.0	11.7	31.4	33.8

1) The loads apply to fischer threaded rods and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

3) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on the failure mode of the anchor.

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			Powerbond M10								Powerbond M12							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance	$N_{Rd,s}$	[kN]	19,3	31,3	10,1	21,9	31,3	10,1	27,3	29,4	28,7	45,3	15,0	31,6	45,3	15,0	39,3	42,5

Anchor type			Powerbond M16							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance	$N_{Rd,s}$	[kN]	52,7	84,0	27,6	58,8	84,0	27,6	73,3	78,8

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor [1)]

Anchor type			Powerbond M10			Powerbond M12			Powerbond M16		
eff. anchorage depth	h_{ef}	[mm]	60	90	120	72	110	144	96	125	192
non-cracked concrete											
Design resistance	$N^0_{Rd,p}$	[kN]	16.3	24.5	32.7	23.5	35.9	47.0	41.8	54.5	77.2
cracked concrete											
Design resistance	$N^0_{Rd,p}$	[kN]	12.6	18.8	25.1	18.1	27.6	36.2	32.2	41.9	64.3

1) For underwater installation the resistance values have to be multiplied by 0.83

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	55
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N,p}$	[-]	0.86	0.94	1.00	1.06	1.12	1.19	1.23	1.27	1.30

4.2.2 Characteristic edge distance and spacing for design of combined pull-out and concrete cone failure

Anchor type			Powerbond M10			Powerbond M12			Powerbond M16		
eff. anchorage depth	h_{ef}	[mm]	60	90	120	72	110	144	96	125	192
	$s_{cr,Np}$	[mm]	180	228	228	216	274	274	288	365	351
	$c_{cr,Np}$	[mm]	90	114	114	108	137	137	144	182	175

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\, c_{cr,sp}$

Design resistance of single anchor [1)]

Anchor type		Powerbond M10			Powerbond M12			Powerbond M16		
eff. anchorage depth	h_{ef} [mm]	60	90	120	72	110	144	96	125	192
non-cracked concrete										
Design resistance	$N^0_{Rd,c}$ [kN]	15.6	28.7	44.3	20.6	38.8	58.2	31.7	47.1	89.6
cracked concrete										
Design resistance	$N^0_{Rd,c}$ [kN]	11.2	20.5	31.5	14.7	27.7	41.5	22.6	33.5	63.9

1) For underwater installation the resistance values have to be multiplied by 0.83.

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor [1)]	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure
Characteristic values for design

Anchor type			Powerbond M10			Powerbond M12			Powerbond M16		
eff. anchorage depth	h_{ef}	[mm]	60	90	120	72	110	144	96	125	192
	$s_{cr,N}$	[mm]	180	270	360	216	330	432	288	375	576
	$c_{cr,N}$	[mm]	90	135	180	108	165	216	144	188	288

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0$$

$$f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure
Characteristic values for design

Anchor type			Powerbond M10			Powerbond M12			Powerbond M16		
eff. anchorage depth	h_{ef}	[mm]	60	90	120	72	110	144	96	125	192
	$s_{cr,sp}$	[mm]	210	270	360	266	330	432	374	488	576
	$c_{cr,sp}$	[mm]	105	135	180	133	165	216	187	244	288

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness at splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\,(N_{Rd,p}\,;\,N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type	Powerbond M10								Powerbond M12							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance $V_{Rd,s}$ [kN]	12.0	18.4	6.3	12.8	18.4	6.3	16.0	17.3	16.8	27.2	8.8	19.2	27.2	8.8	24.0	25.6

Anchor type	Powerbond M16							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance $V_{Rd,s}$ [kN]	31.2	50.4	16.4	35.3	50.4	16.4	44.0	47.4

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\,(\,N_{Rd,p}\,;\;N_{Rd,c}\,)$$

k-factor

Anchor type	Powerbond M10 to M16
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]											
	Powerbond M10						Powerbond M12					
h_{ef}	60	60	90	90	120	120	72	72	110	110	144	144
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
50		3.5		3.8		4.0						
55	5.6	3.9	6.0	4.3	6.4	4.6	5.9	4.2	6.6	4.6	7.0	5.0
60	6.2	4.4	6.8	4.8	7.2	5.1	6.7	4.7	7.3	5.2	7.8	5.5
65	6.9	4.9	7.5	5.3	8.0	5.6	7.4	5.2	8.1	5.7	8.7	6.1
70	7.7	5.4	8.3	5.8	8.8	6.2	8.1	5.8	8.9	6.3	9.5	6.7
75	8.4	5.9	9.0	6.4	9.6	6.8	8.9	6.3	9.7	6.9	10.3	7.3
80	9.2	6.5	9.8	7.0	10.4	7.4	9.7	6.9	10.6	7.5	11.2	8.0
85	9.9	7.0	10.7	7.5	11.3	8.0	10.5	7.5	11.4	8.1	12.1	8.6
90	10.7	7.6	11.5	8.1	12.1	8.6	11.4	8.0	12.3	8.7	13.0	9.2
95	11.5	8.2	12.3	8.7	13.0	9.2	12.2	8.6	13.2	9.4	14.0	9.9
100	12.4	8.8	13.2	9.4	13.9	9.9	13.1	9.3	14.1	10.0	14.9	10.6
105	13.2	9.4	14.1	10.0	14.8	10.5	14.0	9.9	15.1	10.7	15.9	11.3
120	15.9	11.2	16.9	12.0	17.7	12.5	16.7	11.8	17.9	12.7	18.9	13.4
125	16.8	11.9	17.8	12.6	18.7	13.2	17.6	12.5	18.9	13.4	19.9	14.1
130	17.7	12.5	18.8	13.3	19.7	14.0	18.6	13.2	20.0	14.1	21.0	14.9
135	18.7	13.2	19.8	14.0	20.7	14.7	19.6	13.9	21.0	14.9	22.0	15.6
140	19.6	13.9	20.8	14.7	21.8	15.4	20.6	14.6	22.0	15.6	23.1	16.4
160	23.6	16.7	24.9	17.7	26.0	18.4	24.7	17.5	26.3	18.6	27.6	19.5
180	27.8	19.7	29.3	20.7	30.5	21.6	29.0	20.5	30.8	21.8	32.2	22.8
200	32.1	22.8	33.8	23.9	35.2	24.9	33.5	23.7	35.6	25.2	37.1	26.3
250	43.9	31.1	46.0	32.6	47.7	33.8	45.6	32.3	48.2	34.1	50.1	35.5
300	56.7	40.2	59.2	42.0	61.3	43.4	58.8	41.6	61.9	43.8	64.1	45.4
350	70.5	49.9	73.4	52.0	75.8	53.7	72.9	51.6	76.5	54.2	79.1	56.1
400	85.1	60.3	88.5	62.7	91.3	64.7	87.9	62.3	92.0	65.2	95.1	67.3
450	100.6	71.2	104.4	74.0	107.6	76.2	103.8	73.5	108.4	76.8	111.8	79.2
500	116.8	82.7	121.2	85.8	124.6	88.3	120.4	85.3	125.6	89.0	129.4	91.6
550	133.8	94.8	138.6	98.2	142.4	100.9	137.8	97.6	143.5	101.7	147.7	104.6
600	151.5	107.3	156.8	111.0	161.0	114.0	155.8	110.4	162.1	114.8	166.7	118.1
650	169.8	120.3	175.6	124.4	180.2	127.6	174.6	123.7	181.4	128.5	186.4	132.0
700			195.1	138.2	200.0	141.7	194.0	137.4	201.4	142.7	206.7	146.4
750			215.1	152.4	220.5	156.2	214.0	151.6	222.0	157.2	227.7	161.3
800			235.8	167.1	241.5	171.1			243.2	172.2	249.3	176.6
850			257.1	182.1	263.2	186.4			264.9	187.7	271.5	192.3
900			279.0	197.6	285.4	202.2			287.3	203.5	294.2	208.4
950			301.3	213.4	308.2	218.3			310.1	219.7	317.5	224.9
1000					331.5	234.8			333.6	236.3	341.3	241.8
1100					379.7	268.9			381.9	270.5	390.5	276.6
1200					429.8	304.5			432.3	306.2	441.7	312.9
1300					481.9	341.3					494.9	350.5
1400											549.8	389.4
1500											606.5	429.6

continued next page

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fischer Powerbond-System FPB

Anchor design according to fischer specification

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]					
	Powerbond M16					
h_{ef}	96	96	125	125	192	192
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
60		5.3		5.7		6.5
65	8.3	5.9	8.9	6.3	10.0	7.1
70	9.1	6.4	9.7	6.9	11.0	7.8
75	9.9	7.0	10.6	7.5	11.9	8.4
80	10.8	7.6	11.5	8.1	12.9	9.1
85	11.7	8.3	12.4	8.8	13.9	9.8
90	12.6	8.9	13.3	9.4	14.9	10.5
95	13.5	9.5	14.3	10.1	15.9	11.2
100	14.4	10.2	15.2	10.8	16.9	12.0
105	15.3	10.9	16.2	11.5	18.0	12.7
120	18.3	13.0	19.3	13.7	21.2	15.0
125	19.3	13.7	20.3	14.4	22.3	15.8
130	20.3	14.4	21.4	15.1	23.5	16.6
135	21.4	15.1	22.5	15.9	24.6	17.4
140	22.4	15.9	23.5	16.7	25.8	18.3
160	26.8	19.0	28.1	19.9	30.6	21.7
180	31.3	22.2	32.8	23.2	35.6	25.2
200	36.1	25.6	37.7	26.7	40.8	28.9
250	48.9	34.6	50.8	36.0	54.6	38.7
300	62.7	44.4	65.0	46.1	69.5	49.2
350	77.5	54.9	80.2	56.8	85.4	60.5
400	93.2	66.0	96.3	68.2	102.2	72.4
450	109.7	77.7	113.2	80.2	119.9	84.9
500	127.0	90.0	130.9	92.8	138.3	98.0
550	145.1	102.8	149.4	105.8	157.5	111.6
600	163.9	116.1	168.6	119.4	177.4	125.7
650	183.3	129.9	188.5	133.5	198.0	140.3
700	203.4	144.1	209.0	148.0	219.3	155.3
750	224.2	158.8	230.1	163.0	241.2	170.9
800	245.5	173.9	251.9	178.4	263.7	186.8
850	267.5	189.4	274.2	194.3	286.8	203.2
900	289.9	205.4	297.2	210.5	310.5	219.9
950	313.0	221.7	320.6	227.1	334.7	237.1
1000	336.6	238.4	344.6	244.1	359.5	254.7
1100			394.2	279.2	410.6	290.9
1200			445.8	315.8	463.8	328.5
1300			499.3	353.7	518.8	367.5
1400					575.8	407.8
1500					634.4	449.4
1600					694.8	492.2
1800					820.6	581.2
2000					952.5	674.7

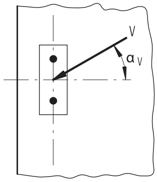
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$f_{\alpha.V}$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angel $\alpha \geqq 90°$ the component of the shear load acting away from the edge can be neglected and the proof can be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1} \right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≥1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≥2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = lowest value of $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

6.3 Combined tension and shear load:

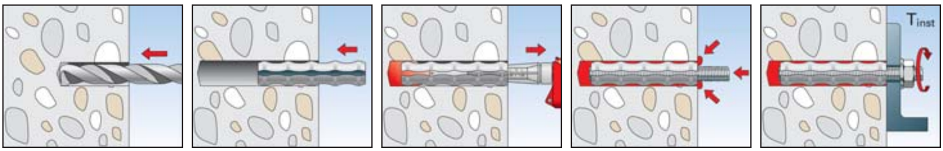
$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd}; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

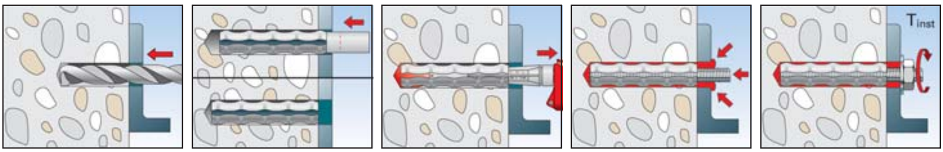
N_{Rd}; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details

Pre-positioned installation:



Push-through installation:

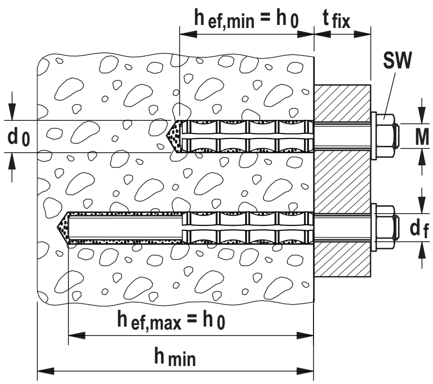


Anchor design according to fischer specification

8. Anchor characteristics

Anchor type		Powerbond M10			Powerbond M12			Powerbond M16		
	h_{ef} [mm]	60	90	120	72	110	144	96	125	192
diameter of thread		M 10			M 12			M 16		
nominal drill hole diameter	d_0 [mm]	14			16			20		
drill depth	h_0 [mm]	60	90	120	72	110	144	96	125	192
clearance-hole in fixture to be attached pre-positioned installation [2]	d_f [mm]	≦ 12			≦ 14			≦ 18		
clearance-hole in fixture to be attached push-through installation [1]		≦ 15			≦ 17			≦ 21		
wrench size	SW [mm]	17			19			24		
maximum torque moment	$T_{inst,\,max}$ [Nm]	20			40			60		
minimum thickness of concrete member	h_{min} [mm]	100	120	150	104	142	176	136	165	232
minimum spacing	s_{min} [mm]	50 (55) [3]			55			60 (65) [3]		
minimum edge distances	c_{min} [mm]	50 (55) [3]			55			60 (65) [3]		
mortar filling quantity	[scale units]	4	6	8	5	8	10	8	10	15

[1] Hole clearance has to be filled with excess mortar.
[2] For larger diameters the clearance has to be filled with excess mortar.
[3] Values in brackets for non-cracked concrete.



9. Gelling and curing times

System temperature				Max. processing time FIS PB
	– 5 °C	to	0 °C	-
>	± 0 °C	to	+ 5 °C	-
>	+ 5 °C	to	+ 20 °C	15 min.
>	+ 20 °C	to	+ 30 °C	6 min.
>	+ 30 °C	to	+ 40 °C	4 min.
>	+ 40 °C			2 min.

Temperature at anchoring base				Curing time [1] FIS PB
	– 5 °C	to	0 °C	360 min.
	± 0 °C	to	+ 5 °C	180 min.
>	5 °C	to	+ 20 °C	90 min.
>	20 °C	to	+ 30 °C	35 min.
>	30 °C	to	+ 40 °C	20 min.
>	40 °C			12 min.

The above times apply from the moment of contact between resin and hardener in the static mixer.
For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.
[1] For wet concrete the curing time must be doubled.

10. Mechanical characteristics of anchor rods FIS A and RGM

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Anchor type			Powerbond M10				Powerbond M12				Powerbond M16			
			gvz		A4-70	C-70	gvz		A4-70	C-70	gvz		A4-70	C-70
property class			**5.8**	**8.8**			**5.8**	**8.8**			**5.8**	**8.8**		
stressed cross sectional area anchor rod	A_s	[mm²]	58.0				84.3				157.0			
section modulus	W	[mm³]	62.3				109.2				277.5			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	29.6	48.0	33.3	41.6	52.8	84.0	59.0	73.6	132.8	212.8	149.7	185.6
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	700	700

fischer Superbond-System FSB

Anchor design according to fischer specification

1. Types

FIS A M8 - M30 - threaded rod (gvz, A4 and C)

RG M8 - M30 - threaded rod (gvz, A4 and C)

Resin capsule RSB

Injection mortar FIS SB

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ETA CE *)
ETA-12/0258
ETAG 001-5
Option 1 for cracked concrete

Fire resistance classification
R 120
Anchor types see test report

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval *) for cracked and non-cracked concrete.
- The injection mortar FIS SB and resin capsule RSB are approved for use in cracked and non-cracked concrete and have the same performance at the same anchorage depth. This gives the installer maximum flexibility.
- Superbond can even be used at extremely high temperatures of up to +150°C. This opens up new fields of application which chemical anchors could not serve until now.
- The resin capsule RSB can be installed in compliance with the approval up to -30°C; installation at up to -15°C is possible with the injection mortar FIS SB.
- The resin capsule RSB is fast curing and enables installation without waiting times.
- The resin capsule RSB is approved for water-filled and diamond drill holes, thus providing more flexibility on the construction site.
- Superbond is a combined injection and capsule system based on a vinyl ester hybrid with silane technology.
- The anchor rod FIS A can only be set with injection mortar FIS SB; the anchor rod RG M with sloping roofs can be optionally set with injection mortar FIS SB or resin capsule RSB.
- Resin and hardener are stored in two separate chambers and are not mixed and activated until extrusion through the static mixer or destruction of the capsule during the setting procedure.
- The mortar bonds the entire surface of the threaded rod with the drill hole wall and seals the drill hole.

*) The conditions of use (e.g. design resistances, characteristic disistance, ...) in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Threaded rod :
- Carbon steel grade 5.8 and 8.8 zinc plated (5 µm) and passivated (gvz)
- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
- Highly corrosion-resistant steel of the corrosion resistance class IV, e.g. 1.4529

Injection mortar:
- Vinylester resin (styrene-free), hydraulic additives, quartz sand and hardener

2. Ultimate resistances of single anchors with large spacing and large edge distance[1]

Mean values

Anchor type				Superbond M8								Superbond M10							
				gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}			[mm]	80								90							
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2]																			
tension static	C 20/25	N_u	[kN]	20.0	31.5	20.0	27.3	31.5	20.0	27.3	31.5	30.5	49.4	30.5	43.1	49.4	30.5	43.1	49.4
	C 50/60	N_u	[kN]	20.0	31.5	20.0	27.3	31.5	20.0	27.3	31.5	30.5	49.4	30.5	43.1	49.4	30.5	43.1	49.4
shear static	≧ C 20/25	V_u	[kN]	12.0	18.9	12.0	16.4	18.9	12.0	16.4	18.9	18.3	29.6	18.3	25.8	29.6	18.3	25.8	29.6
cracked concrete temperature range (+ 40 °C / + 24 °C)[2]																			
tension static	C 20/25	N_u	[kN]	20.0	24.9	20.0	24.9	24.9	20.0	24.9	24.9	30.5	40.9	30.5	40.9	40.9	30.5	40.9	40.9
	C 50/60	N_u	[kN]	20.0	29.0	20.0	27.3	29.0	20.0	27.3	29.0	30.5	48.9	30.5	43.1	48.9	30.5	43.1	48.9
shear static	≧ C 20/25	V_u	[kN]	12.0	18.9	12.0	16.4	18.9	12.0	16.4	18.9	18.3	29.6	18.3	25.8	29.6	18.3	25.8	29.6

Anchor type				Superbond M12								Superbond M16							
				gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}			[mm]	110								125							
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2]																			
tension static	C 20/25	N_u	[kN]	45.2	71.4	45.2	62.0	71.4	45.2	62.0	71.4	83.0	94.3	83.0	94.3	94.3	83.0	94.3	94.3
	C 50/60	N_u	[kN]	45.2	71.4	45.2	62.0	71.4	45.2	62.0	71.4	83.0	132.3	83.0	115.5	132.3	83.0	115.5	132.3
shear static	≧ C 20/25	V_u	[kN]	27.1	42.8	27.1	37.2	42.8	27.1	37.2	42.8	49.8	79.4	49.8	69.3	79.4	49.8	69.3	79.4
cracked concrete temperature range (+ 40 °C / + 24 °C)[2]																			
tension static	C 20/25	N_u	[kN]	45.2	55.3	45.2	55.3	55.3	45.2	55.3	55.3	67.0	67.0	67.0	67.0	67.0	67.0	67.0	67.0
	C 50/60	N_u	[kN]	45.2	71.4	45.2	62.0	71.4	45.2	62.0	71.4	83.0	103.8	83.0	103.8	103.8	83.0	103.8	103.8
shear static	≧ C 20/25	V_u	[kN]	27.1	42.8	27.1	37.2	42.8	27.1	37.2	42.8	49.8	79.4	49.8	69.3	79.4	49.8	69.3	79.4

Anchor type				Superbond M20								Superbond M24							
				gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}			[mm]	170								210							
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2]																			
tension static	C 20/25	N_u	[kN]	129.2	149.6	129.2	149.6	149.6	129.2	149.6	149.6	185.9	205.4	185.9	205.4	205.4	185.9	205.4	205.4
	C 50/60	N_u	[kN]	129.2	205.8	129.2	180.6	205.8	129.2	180.6	205.8	185.9	296.1	185.9	259.4	296.1	185.9	259.4	296.1
shear static	≧ C 20/25	V_u	[kN]	77.5	123.5	77.5	108.4	123.5	77.5	108.4	123.5	111.5	177.7	111.5	155.6	177.7	111.5	155.6	177.7
cracked concrete temperature range (+ 40 °C / + 24 °C)[2]																			
tension static	C 20/25	N_u	[kN]	106.2	106.2	106.2	106.2	106.2	106.2	106.2	106.2	145.8	145.8	145.8	145.8	145.8	145.8	145.8	145.8
	C 50/60	N_u	[kN]	129.2	164.6	129.2	164.6	164.6	129.2	164.6	164.6	185.9	225.9	185.9	225.9	225.9	185.9	225.9	225.9
shear static	≧ C 20/25	V_u	[kN]	77.5	123.5	77.5	108.4	123.5	77.5	108.4	123.5	111.5	177.7	111.5	155.6	177.7	111.5	155.6	177.7

Anchor type				Superbond M27								Superbond M30							
				gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}			[mm]	250								280							
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2]																			
tension static	C 20/25	N_u	[kN]	241.5	266.8	241.5	266.8	266.8	241.5	266.8	266.8	295.1	316.3	295.1	316.3	316.3	295.1	316.3	316.3
	C 50/60	N_u	[kN]	241.5	386.4	241.5	338.1	386.4	241.5	338.1	386.4	295.1	471.5	295.1	412.7	471.5	295.1	412.7	471.5
shear static	≧ C 20/25	V_u	[kN]	144.9	231.8	144.9	202.9	231.8	144.9	202.9	231.8	177.0	282.9	177.0	247.6	282.9	177.0	247.6	282.9
cracked concrete temperature range (+ 40 °C / + 24 °C)[2]																			
tension static	C 20/25	N_u	[kN]	189.4	189.4	189.4	189.4	189.4	189.4	189.4	189.4	224.5	224.5	224.5	224.5	224.5	224.5	224.5	224.5
	C 50/60	N_u	[kN]	241.5	293.5	241.5	293.5	293.5	241.5	293.5	293.5	295.1	347.9	295.1	347.9	347.9	295.1	347.9	347.9
shear static	≧ C 20/25	V_u	[kN]	144.9	231.8	144.9	202.9	231.8	144.9	202.9	231.8	177.0	282.9	177.0	247.6	282.9	177.0	247.6	282.9

1) The loads apply to fischer threaded rods with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

4

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance[1)]

Anchor type	Superbond M8								Superbond M10							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	80								90							
non-cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rk} [kN]	19.0	24.1	19.0	24.1	24.1	19.0	24.1	24.1	29.0	36.8	29.0	36.8	36.8	29.0	36.8	36.8
C 50/60 N_{Rk} [kN]	19.0	26.5	19.0	26.0	26.5	19.0	26.0	26.5	29.0	40.4	29.0	40.4	40.4	29.0	40.4	40.4
shear static ≧ C 20/25 V_{Rk} [kN]	9.0	15.0	9.0	13.0	15.0	9.0	13.0	15.0	15.0	23.0	15.0	20.0	23.0	15.0	20.0	23.0
cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rk} [kN]	13.1	13.1	13.1	13.1	13.1	13.1	13.1	13.1	19.8	19.8	19.8	19.8	19.8	19.8	19.8	19.8
C 50/60 N_{Rk} [kN]	14.4	14.4	14.4	14.4	14.4	14.4	14.4	14.4	21.8	21.8	21.8	21.8	21.8	21.8	21.8	21.8
shear static ≧ C 20/25 V_{Rk} [kN]	9.0	15.0	9.0	13.0	15.0	9.0	13.0	15.0	15.0	23.0	15.0	20.0	23.0	15.0	20.0	23.0

Anchor type	Superbond M12								Superbond M16							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	110								125							
non-cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rk} [kN]	43.0	53.9	43.0	53.9	53.9	43.0	53.9	53.9	70.6	70.6	70.6	70.6	70.6	70.6	70.6	70.6
C 50/60 N_{Rk} [kN]	43.0	59.3	43.0	59.0	59.3	43.0	59.0	59.3	79.0	89.8	79.0	89.8	89.8	79.0	89.8	89.8
shear static ≧ C 20/25 V_{Rk} [kN]	21.0	34.0	21.0	30.0	34.0	21.0	30.0	34.0	39.0	63.0	39.0	55.0	63.0	39.0	55.0	63.0
cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rk} [kN]	31.1	31.1	31.1	31.1	31.1	31.1	31.1	31.1	47.1	47.1	47.1	47.1	47.1	47.1	47.1	47.1
C 50/60 N_{Rk} [kN]	34.2	34.2	34.2	34.2	34.2	34.2	34.2	34.2	51.8	51.8	51.8	51.8	51.8	51.8	51.8	51.8
shear static ≧ C 20/25 V_{Rk} [kN]	21.0	34.0	21.0	30.0	34.0	21.0	30.0	34.0	39.0	63.0	39.0	55.0	63.0	39.0	55.0	63.0

Anchor type	Superbond M20								Superbond M24							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	170								210							
non-cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rk} [kN]	111.9	111.9	111.9	111.9	111.9	111.9	111.9	111.9	153.7	153.7	153.7	153.7	153.7	153.7	153.7	153.7
C 50/60 N_{Rk} [kN]	123.0	152.7	123.0	152.7	152.7	123.0	152.7	152.7	177.0	209.0	177.0	209.0	209.0	177.0	209.0	209.0
shear static ≧ C 20/25 V_{Rk} [kN]	61.0	98.0	61.0	86.0	98.0	61.0	86.0	98.0	89.0	141.0	89.0	124.0	141.0	89.0	124.0	141.0
cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rk} [kN]	79.8	79.8	79.8	79.8	79.8	79.8	79.8	79.8	109.6	109.6	109.6	109.6	109.6	109.6	109.6	109.6
C 50/60 N_{Rk} [kN]	88.1	88.1	88.1	88.1	88.1	88.1	88.1	88.1	130.6	130.6	130.6	130.6	130.6	130.6	130.6	130.6
shear static ≧ C 20/25 V_{Rk} [kN]	61.0	98.0	61.0	86.0	98.0	61.0	86.0	98.0	89.0	141.0	89.0	124.0	141.0	89.0	124.0	141.0

Anchor type	Superbond M27								Superbond M30							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	250								280							
non-cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rk} [kN]	199.6	199.6	199.6	199.6	199.6	199.6	199.6	199.6	236.6	236.6	236.6	236.6	236.6	236.6	236.6	236.6
C 50/60 N_{Rk} [kN]	230.0	233.3	230.0	233.3	233.3	230.0	233.3	233.3	281.0	290.3	281.0	290.3	290.3	281.0	290.3	290.3
shear static ≧ C 20/25 V_{Rk} [kN]	115.0	184.0	115.0	161.0	184.0	115.0	161.0	184.0	141.0	225.0	141.0	197.0	225.0	141.0	197.0	225.0
cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rk} [kN]	142.3	142.3	142.3	142.3	142.3	142.3	142.3	142.3	168.7	168.7	168.7	168.7	168.7	168.7	168.7	168.7
C 50/60 N_{Rk} [kN]	174.9	174.9	174.9	174.9	174.9	174.9	174.9	174.9	217.7	217.7	217.7	217.7	217.7	217.7	217.7	217.7
shear static ≧ C 20/25 V_{Rk} [kN]	115.0	184.0	115.0	161.0	184.0	115.0	161.0	184.0	141.0	225.0	141.0	197.0	225.0	141.0	197.0	225.0

1) The loads apply to fischer threaded rods with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)

fischer Superbond-System FSB

Anchor design according to fischer specification

3.2 Design resistance[1)]

Anchor type	Superbond M8								Superbond M10							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	80								90							
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	12.7	16.1	6.6	13.9	16.1	6.6	16.1	16.1	19.3	24.5	10.1	21.9	24.5	10.1	24.5	24.5
C 50/60 N_{Rd} [kN]	12.7	17.7	6.6	13.9	17.7	6.6	17.3	17.7	19.3	27.0	10.1	21.9	27.0	10.1	27.0	27.0
shear static ≥ C 20/25 V_{Rd} [kN]	7.2	12.0	3.8	8.3	11.3	3.8	10.4	11.3	12.0	18.4	6.3	12.8	17.3	6.3	16.0	17.3
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	8.7	8.7	6.6	8.7	8.7	6.6	8.7	8.7	13.2	13.2	10.1	13.2	13.2	10.1	13.2	13.2
C 50/60 N_{Rd} [kN]	9.6	9.6	6.6	9.6	9.6	6.6	9.6	9.6	14.5	14.5	10.1	14.5	14.5	10.1	14.5	14.5
shear static ≥ C 20/25 V_{Rd} [kN]	7.2	12.0	3.8	8.3	11.3	3.8	10.4	11.3	12.0	18.4	6.3	12.8	17.3	6.3	16.0	17.3
Anchor type	**Superbond M12**								**Superbond M16**							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	110								125							
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	28.7	35.9	15.0	31.6	35.9	15.0	35.9	35.9	47.1	47.1	27.6	47.1	47.1	27.6	47.1	47.1
C 50/60 N_{Rd} [kN]	28.7	39.5	15.0	31.6	39.5	15.0	39.3	39.5	52.7	59.9	27.6	58.8	59.9	27.6	59.9	59.9
shear static ≥ C 20/25 V_{Rd} [kN]	16.8	27.2	8.8	19.2	25.6	8.8	24.0	25.6	31.2	50.4	16.4	35.3	47.4	16.4	44.0	47.4
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	20.7	20.7	15.0	20.7	20.7	15.0	20.7	20.7	31.4	31.4	27.6	31.4	31.4	27.6	31.4	31.4
C 50/60 N_{Rd} [kN]	22.8	22.8	15.0	22.8	22.8	15.0	22.8	22.8	34.6	34.6	27.6	34.6	34.6	27.6	34.6	34.6
shear static ≥ C 20/25 V_{Rd} [kN]	16.8	27.2	8.8	19.2	25.6	8.8	24.0	25.6	31.2	50.4	16.4	35.3	47.4	16.4	44.0	47.4
Anchor type	**Superbond M20**								**Superbond M24**							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	170								210							
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	74.6	74.6	43.0	74.6	74.6	43.0	74.6	74.6	102.5	102.5	61.9	102.5	102.5	61.9	102.5	102.5
C 50/60 N_{Rd} [kN]	82.0	101.8	43.0	92.0	101.8	43.0	101.8	101.8	118.0	139.3	61.9	132.1	139.3	61.9	139.3	139.3
shear static ≥ C 20/25 V_{Rd} [kN]	48.8	78.4	25.6	55.1	73.7	25.6	68.8	73.7	71.2	112.8	37.4	79.5	106.0	37.4	99.2	106.0
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	53.2	53.2	43.0	53.2	53.2	43.0	53.2	53.2	73.0	73.0	61.9	73.0	73.0	61.9	73.0	73.0
C 50/60 N_{Rd} [kN]	58.7	58.7	43.0	58.7	58.7	43.0	58.7	58.7	87.1	87.1	61.9	87.1	87.1	61.9	87.1	87.1
shear static ≥ C 20/25 V_{Rd} [kN]	48.8	78.4	25.6	55.1	73.7	25.6	68.8	73.7	71.2	112.8	37.4	79.5	106.0	37.4	99.2	106.0
Anchor type	**Superbond M27**								**Superbond M30**							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	250								280							
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	133.1	133.1	80.4	133.1	133.1	80.4	133.1	133.1	157.7	157.7	98.3	157.7	157.7	98.3	157.7	157.7
C 50/60 N_{Rd} [kN]	153.3	155.5	80.4	155.5	155.5	80.4	155.5	155.5	187.3	193.5	98.3	193.5	193.5	98.3	193.5	193.5
shear static ≥ C 20/25 V_{Rd} [kN]	92.0	147.2	48.3	103.2	138.3	48.3	128.8	138.3	112.8	180.0	59.2	126.3	169.2	59.2	157.6	169.2
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	94.9	94.9	80.4	94.9	94.9	80.4	94.9	94.9	112.4	112.4	98.3	112.4	112.4	98.3	112.4	112.4
C 50/60 N_{Rd} [kN]	116.6	116.6	80.4	116.6	116.6	80.4	116.6	116.6	145.1	145.1	98.3	145.1	145.1	98.3	145.1	145.1
shear static ≥ C 20/25 V_{Rd} [kN]	92.0	147.2	48.3	103.2	138.3	48.3	128.8	138.3	112.8	180.0	59.2	126.3	169.2	59.2	157.6	169.2

1) The loads apply to fischer threaded rods with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)

3.3 Recommended resistance [1) 3)]

Anchor type	Superbond M8								Superbond M10							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	80								90							
non-cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	9.0	11.5	4.7	9.9	11.5	4.7	11.5	11.5	13.8	17.5	7.2	15.7	17.5	7.2	17.5	17.5
C 50/60 N_{Rd} [kN]	9.0	12.6	4.7	9.9	12.6	4.7	12.4	12.6	13.8	19.3	7.2	15.7	19.3	7.2	19.3	19.3
shear static ≧ C 20/25 V_{Rd} [kN]	5.1	8.6	2.7	6.0	8.1	2.7	7.4	8.1	8.6	13.1	4.5	9.2	12.4	4.5	11.4	12.4
cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	6.2	6.2	4.7	6.2	6.2	4.7	6.2	6.2	9.4	9.4	7.2	9.4	9.4	7.2	9.4	9.4
C 50/60 N_{Rd} [kN]	6.8	6.8	4.7	6.8	6.8	4.7	6.8	6.8	10.4	10.4	7.2	10.4	10.4	7.2	10.4	10.4
shear static ≧ C 20/25 V_{Rd} [kN]	5.1	8.6	2.7	6.0	8.1	2.7	7.4	8.1	8.6	13.1	4.5	9.2	12.4	4.5	11.4	12.4

Anchor type	Superbond 12								Superbond M16							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	110								125							
non-cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	20.5	25.7	10.7	22.5	25.7	10.7	25.7	25.7	33.6	33.6	19.7	33.6	33.6	19.7	33.6	33.6
C 50/60 N_{Rd} [kN]	20.5	28.2	10.7	22.5	28.2	10.7	28.1	28.2	37.6	42.8	19.7	42.0	42.8	19.7	42.8	42.8
shear static ≧ C 20/25 V_{Rd} [kN]	12.0	19.4	6.3	13.7	18.3	6.3	17.1	18.3	22.3	36.0	11.7	25.2	33.8	11.7	31.4	33.8
cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	14.8	14.8	10.7	14.8	14.8	10.7	14.8	14.8	22.4	22.4	19.7	22.4	22.4	19.7	22.4	22.4
C 50/60 N_{Rd} [kN]	16.3	16.3	10.7	16.3	16.3	10.7	16.3	16.3	24.7	24.7	19.7	24.7	24.7	19.7	24.7	24.7
shear static ≧ C 20/25 V_{Rd} [kN]	12.0	19.4	6.3	13.7	18.3	6.3	17.1	18.3	22.3	36.0	11.7	25.2	33.8	11.7	31.4	33.8

Anchor type	Superbond M20								Superbond M24							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	170								210							
non-cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	53.3	53.3	30.7	53.3	53.3	30.7	53.3	53.3	73.2	73.2	44.2	73.2	73.2	44.2	73.2	73.2
C 50/60 N_{Rd} [kN]	58.6	72.7	30.7	65.7	72.7	30.7	72.7	72.7	84.3	99.5	44.2	94.3	99.5	44.2	99.5	99.5
shear static ≧ C 20/25 V_{Rd} [kN]	34.9	56.0	18.3	39.4	52.6	18.3	49.1	52.6	50.9	80.6	26.7	56.8	75.7	26.7	70.9	75.7
cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	38.0	38.0	30.7	38.0	38.0	30.7	38.0	38.0	52.2	52.2	44.2	52.2	52.2	44.2	52.2	52.2
C 50/60 N_{Rd} [kN]	42.0	42.0	30.7	42.0	42.0	30.7	42.0	42.0	62.2	62.2	44.2	62.2	62.2	44.2	62.2	62.2
shear static ≧ C 20/25 V_{Rd} [kN]	34.9	56.0	18.3	39.4	52.6	18.3	49.1	52.6	50.9	80.6	26.7	56.8	75.7	26.7	70.9	75.7

Anchor type	Superbond M27								Superbond M30							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	250								280							
non-cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	95.1	95.1	57.4	95.1	95.1	57.4	95.1	95.1	112.7	112.7	70.2	112.7	112.7	70.2	112.7	112.7
C 50/60 N_{Rd} [kN]	109.5	111.1	57.4	111.1	111.1	57.4	111.1	111.1	133.8	138.2	70.2	138.2	138.2	70.2	138.2	138.2
shear static ≧ C 20/25 V_{Rd} [kN]	65.7	105.1	34.5	73.7	98.8	34.5	92.0	98.8	80.6	128.6	42.3	90.2	120.8	42.3	112.6	120.8
cracked concrete																
temperature range (+ 40 °C / + 24 °C)[2)]																
tension static C 20/25 N_{Rd} [kN]	67.8	67.8	57.4	67.8	67.8	57.4	67.8	67.8	80.3	80.3	70.2	80.3	80.3	70.2	80.3	80.3
C 50/60 N_{Rd} [kN]	83.3	83.3	57.4	83.3	83.3	57.4	83.3	83.3	103.7	103.7	70.2	103.7	103.7	70.2	103.7	103.7
shear static ≧ C 20/25 V_{Rd} [kN]	65.7	105.1	34.5	73.7	98.8	34.5	92.0	98.8	80.6	128.6	42.3	90.2	120.8	42.3	112.6	120.8

1) The loads apply to fischer threaded rods with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

3) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on the failure mode of the anchor.

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			Superbond M8								Superbond M10							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance	$N_{Rd,s}$	[kN]	12.7	20.0	6.6	13.9	18.8	6.6	17.3	18.8	19.3	31.3	10.1	21.9	29.4	10.1	27.3	29.4

Anchor type			Superbond M12								Superbond M16							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance	$N_{Rd,s}$	[kN]	28.7	45.3	15.0	31.6	42.5	15.0	39.3	42.5	52.7	84.0	27.6	58.8	78.8	27.6	73.3	78.8

Anchor type			Superbond M20								Superbond M24							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance	$N_{Rd,s}$	[kN]	82.0	130.7	43.0	92.0	122.5	43.0	114.7	122.5	118.0	188.0	61.9	132.1	176.3	61.9	164.7	176.3

Anchor type			Superbond M27								Superbond M30							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance	$N_{Rd,s}$	[kN]	153.3	245.3	80.4	172.2	230.0	80.4	214.7	230.0	187.3	299.3	98.3	210.2	280.6	98.3	262.0	280.6

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Hammer drilled

Anchor type			Superbond M8 [1]			Superbond M10 [1]			Superbond M12			Superbond M16		
eff. anchorage depth	h_{ef}	[mm]	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**80**	**125**	**320**
non-cracked concrete														
temperature range (+40°C / +24°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	12.1	16.1	32.2	16.3	24.5	54.5	22.9	35.9	78.4	34.9	54.5	139.4
temperature range (+80°C / +50°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	12.1	16.1	32.2	15.1	22.6	50.3	21.1	33.2	72.4	34.9	54.5	139.4
temperature range (+120°C / +72°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	10.1	13.4	26.8	13.8	20.7	46.1	19.4	30.4	66.4	29.5	46.1	118.0
temperature range (+150°C / +90°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	10.1	13.4	26.8	12.6	18.8	41.9	17.6	27.6	60.3	29.5	46.1	118.0
cracked concrete														
temperature range (+40°C / +24°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	6.5	8.7	17.4	8.2	13.2	29.3	13.2	20.7	45.2	20.1	31.4	80.4
temperature range (+80°C / +50°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	6.0	8.0	16.1	7.5	12.3	27.2	13.2	20.7	45.2	20.1	31.4	80.4
temperature range (+120°C / +72°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	5.5	7.4	14.7	6.9	11.3	25.1	11.4	18.0	39.2	17.4	27.2	69.7
temperature range (+150°C / +90°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	5.0	6.7	13.4	6.3	10.4	23.0	10.6	16.6	36.2	16.1	25.1	64.3

Anchor type			Superbond M20			Superbond M24			Superbond M27			Superbond 30		
eff. anchorage depth	h_{ef}	[mm]	**90**	**170**	**400**	**96**	**210**	**480**	**108**	**250**	**540**	**120**	**280**	**600**
non-cracked concrete														
temperature range (+40°C / +24°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	49.0	92.6	217.8	57.9	126.7	289.5	61.1	141.4	305.4	75.4	175.9	377.0
temperature range (+80°C / +50°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	49.0	92.6	217.8	57.9	126.7	289.5	61.1	141.4	305.4	75.4	175.9	377.0
temperature range (+120°C / +72°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	41.5	78.3	184.3	53.1	116.1	265.4	55.0	127.2	274.8	67.9	158.3	339.3
temperature range (+150°C / +90°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	37.7	71.2	167.6	48.3	105.6	241.3	48.9	113.1	244.3	60.3	140.7	301.6
cracked concrete														
temperature range (+40°C / +24°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	28.3	53.4	125.7	36.2	79.2	181.0	45.8	106.0	229.0	56.5	131.9	282.7
temperature range (+80°C / +50°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	28.3	53.4	125.7	36.2	79.2	181.0	42.8	99.0	213.8	52.8	123.2	263.9
temperature range (+120°C / +72°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	24.5	46.3	108.9	31.4	68.6	156.8	36.6	84.8	183.2	45.2	105.6	226.2
temperature range (+150°C / +90°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	22.6	42.7	100.5	29.0	63.3	144.8	33.6	77.8	167.9	41.5	96.8	207.3

[1] For underwater installation the resistance values have to be multiplied by a factor of 0.83.

[2] (short term temperature / long term temperature)

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fischer Superbond-System FSB

Anchor design according to fischer specification

Diamond drilled

Anchor type			Superbond M8 [1]			Superbond M10 [1]			Superbond M12			Superbond M16		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	80	125	320
non-cracked concrete														
temperature range (+40°C / +24°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	13.1	17.4	34.9	16.3	24.5	54.5	24.6	38.7	84.4	37.5	58.6	150.1
temperature range (+80°C / +50°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	12.1	16.1	32.2	16.3	24.5	54.5	22.9	35.9	78.4	37.5	58.6	150.1
temperature range (+120°C / +72°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	11.1	14.7	29.5	15.1	22.6	50.3	21.1	33.2	72.4	32.2	50.3	128.7
temperature range (+150°C / +90°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	11.1	14.7	29.5	15.1	22.6	50.3	21.1	33.2	72.4	32.2	50.3	128.7
cracked concrete														
temperature range (+40°C / +24°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	-	-	-	-	-	-	-	-	-	20.1	31.4	80.4
temperature range (+80°C / +50°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	-	-	-	-	-	-	-	-	-	20.1	31.4	80.4
temperature range (+120°C / +72°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	-	-	-	-	-	-	-	-	-	17.4	27.2	69.7
temperature range (+150°C / +90°C) [2]														
design resistance	$N^0_{Rd,p}$	[kN]	-	-	-	-	-	-	-	-	-	16.1	25.1	64.3

Anchor type			Superbond M20			Superbond M24			Superbond M30		
eff. anchorage depth	h_{ef}	[mm]	90	170	400	96	210	480	120	280	600
non-cracked concrete											
temperature range (+40°C / +24°C) [2]											
design resistance	$N^0_{Rd,p}$	[kN]	52.8	99.7	234.6	62.7	137.2	313.7	82.9	193.5	414.7
temperature range (+80°C / +50°C) [2]											
design resistance	$N^0_{Rd,p}$	[kN]	49.0	92.6	217.8	62.7	137.2	313.7	75.4	175.9	377.0
temperature range (+120°C / +72°C) [2]											
design resistance	$N^0_{Rd,p}$	[kN]	45.2	85.5	201.1	53.1	116.1	265.4	71.6	167.1	358.1
temperature range (+150°C / +90°C) [2]											
design resistance	$N^0_{Rd,p}$	[kN]	41.5	78.3	184.3	48.3	105.6	241.3	64.1	149.5	320.4
cracked concrete											
temperature range (+40°C / +24°C) [2]											
design resistance	$N^0_{Rd,p}$	[kN]	28.3	53.4	125.7	36.2	79.2	181.0	56.5	131.9	282.7
temperature range (+80°C / +50°C) [2]											
design resistance	$N^0_{Rd,p}$	[kN]	28.3	53.4	125.7	36.2	79.2	181.0	52.8	123.2	263.9
temperature range (+120°C / +72°C) [2]											
design resistance	$N^0_{Rd,p}$	[kN]	24.5	46.3	108.9	31.4	68.6	156.8	49.0	114.4	245.0
temperature range (+150°C / +90°C) [2]											
design resistance	$N^0_{Rd,p}$	[kN]	22.6	42.7	100.5	29.0	63.3	144.8	45.2	105.6	226.2

[1] For underwater installation the resistance values have to be multiplied by a factor of 0.83.

[2] (short term temperature / long term temperature)

4

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	55
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,p}$	[-]	0,95	0,98	1,00	1,02	1,04	1,07	1,08	1,09	1,10

4.2.2 Characteristic edge distance and spacing for design

Hammer drilled

Anchor type			Superbond M8			Superbond M10			Superbond M12			Superbond M16		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	80	125	320
temperature range (+40°C / +24°C) [1]														
	$s_{cr,Np}$	[kN]	175	175	175	180	228	228	210	274	274	240	365	365
	$c_{cr,Np}$	[kN]	88	88	88	90	114	114	105	137	137	120	182	182
temperature range (+80°C / +50°C) [1]														
	$s_{cr,Np}$	[kN]	175	175	175	180	219	219	210	263	263	240	365	365
	$c_{cr,Np}$	[kN]	88	88	88	90	110	110	105	131	131	120	182	182
temperature range (+120°C / +72°C) [1]														
	$s_{cr,Np}$	[kN]	160	160	160	180	210	210	210	252	252	240	336	336
	$c_{cr,Np}$	[kN]	80	80	80	90	105	105	105	126	126	120	168	168
temperature range (+150°C / +90°C) [1]														
	$s_{cr,Np}$	[kN]	160	160	160	180	200	200	210	240	240	240	336	336
	$c_{cr,Np}$	[kN]	80	80	80	90	100	100	105	120	120	120	168	168

Anchor type			Superbond M20			Superbond M24			Superbond M27			Superbond M30		
eff. anchorage depth	h_{ef}	[mm]	90	170	400	96	210	480	108	250	540	120	280	600
temperature range (+40°C / +24°C) [1]														
	$s_{cr,Np}$	[kN]	270	456	456	288	526	526	324	540	540	360	600	600
	$c_{cr,Np}$	[kN]	135	228	228	144	263	263	162	270	270	180	300	300
temperature range (+80°C / +50°C) [1]														
	$s_{cr,Np}$	[kN]	270	456	456	288	526	526	324	540	540	360	600	600
	$c_{cr,Np}$	[kN]	135	228	228	144	263	263	162	270	270	180	300	300
temperature range (+120°C / +72°C) [1]														
	$s_{cr,Np}$	[kN]	270	420	420	288	503	503	324	512	512	360	569	569
	$c_{cr,Np}$	[kN]	135	210	210	144	252	252	162	256	256	180	285	285
temperature range (+150°C / +90°C) [1]														
	$s_{cr,Np}$	[kN]	270	400	400	288	480	480	324	483	483	360	537	537
	$c_{cr,Np}$	[kN]	135	200	200	144	240	240	162	241	241	180	268	268

[1] (short term temperature / long term temperature)

continued next page

Diamond drilled

Anchor type		**Superbond M8**			**Superbond M10**			**Superbond M12**			**Superbond M16**		
eff. anchorage depth h_{ef}	**[mm]**	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**80**	**125**	**320**
temperature range (+40°C / +24°C) [1]													
$s_{cr,Np}$	[kN]	180	182	182	180	228	228	210	284	284	240	375	379
$c_{cr,Np}$	[kN]	90	91	91	90	114	114	105	142	142	120	188	189
temperature range (+80°C / +50°C) [1]													
$s_{cr,Np}$	[kN]	175	175	175	180	228	228	210	274	274	240	375	379
$c_{cr,Np}$	[kN]	88	88	88	90	114	114	105	137	137	120	188	189
temperature range (+120°C / +72°C) [1]													
$s_{cr,Np}$	[kN]	168	168	168	180	219	219	210	263	263	240	351	351
$c_{cr,Np}$	[kN]	84	84	84	90	110	110	105	131	131	120	175	175
temperature range (+150°C / +90°C) [1]													
$s_{cr,Np}$	[kN]	160	160	160	180	210	210	210	252	252	240	336	336
$c_{cr,Np}$	[kN]	80	80	80	90	105	105	105	126	126	120	168	168

Anchor type		**Superbond M20**			**Superbond M24**			**Superbond M27**			**Superbond M30**		
eff. anchorage depth h_{ef}	**[mm]**	**90**	**170**	**400**	**96**	**210**	**480**	**108**	**250**	**540**	**120**	**280**	**600**
temperature range (+40°C / +24°C) [1]													
$s_{cr,Np}$	[kN]	270	473	473	288	547	547				360	629	629
$c_{cr,Np}$	[kN]	135	237	237	144	274	274				180	315	315
temperature range (+80°C / +50°C) [1]													
$s_{cr,Np}$	[kN]	270	456	456	288	547	547				360	600	600
$c_{cr,Np}$	[kN]	135	228	228	144	274	274				180	300	300
temperature range (+120°C / +72°C) [1]													
$s_{cr,Np}$	[kN]	270	438	438	288	503	503				360	585	585
$c_{cr,Np}$	[kN]	135	219	219	144	252	252				180	292	292
temperature range (+150°C / +90°C) [1]													
$s_{cr,Np}$	[kN]	270	420	420	288	480	480				360	553	553
$c_{cr,Np}$	[kN]	135	210	210	144	240	240				180	277	277

[1] (short term temperature / long term temperature)

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type			Superbond M8 [1]			Superbond M10 [1]			Superbond M12			Superbond M16		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	80	125	320
non-cracked concrete														
design resistance	$N^0_{Rd,c}$	[kN]	15.6	24.1	68.1	15.6	28.7	95.2	19.7	38.8	125.2	24.1	47.1	192.7
cracked concrete														
design resistance	$N^0_{Rd,c}$	[kN]	11.2	17.2	48.6	11.2	20.5	67.9	14.1	27.7	89.2	17.2	33.5	137.4

Anchor type			Superbond M20			Superbond M24			Superbond M27			Superbond M30		
eff. anchorage depth	h_{ef}	[mm]	90	170	400	96	210	480	108	250	540	120	280	600
non-cracked concrete														
design resistance	$N^0_{Rd,c}$	[kN]	28.7	74.6	269.3	31.7	102.5	354.0	37.8	133.1	422.5	44.3	157.7	494.8
cracked concrete														
design resistance	$N^0_{Rd,c}$	[kN]	20.5	53.2	192.0	22.6	73.0	252.4	26.9	94.9	301.2	31.5	112.4	352.7

[1] For underwater installation the resistance values have to be multiplied by a factor of 0.83.

4

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,c}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type			Superbond M8			Superbond M10			Superbond M12			Superbond M16		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	80	125	320
	$s_{cr,N}$	[mm]	180	240	480	180	270	600	210	330	720	240	375	960
	$c_{cr,N}$	[mm]	90	120	240	90	135	300	105	165	360	120	187.5	480

Anchor type			Superbond M20			Superbond M24			Superbond M27			Superbond M30		
eff. anchorage depth	h_{ef}	[mm]	90	170	400	96	210	480	108	250	540	120	280	600
	$s_{cr,N}$	[mm]	270	510	1200	288	630	1440	324	750	1620	360	840	1800
	$c_{cr,N}$	[mm]	135	255	600	144	315	720	162	375	810	180	420	900

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_s	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type				**Superbond M8**			**Superbond M10**			**Superbond M12**			**Superbond M16**		
eff. anchorage depth		h_{ef}	**[mm]**	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**80**	**125**	**320**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	120	160	320	120	180	400	140	220	480	160	250	640
		$c_{cr,sp}$	[mm]	60	80	160	60	90	200	70	110	240	80	125	320
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)											
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$											
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	271	362	723	271	407	904	316	497	1085	362	565	1446
		$c_{cr,sp}$	[mm]	136	181	362	136	203	452	158	249	542	181	283	723
		h_{min}	[mm]	100	110	190	100	120	230	100	140	270	116	161	356

Anchor type				**Superbond M20**			**Superbond M24**			**Superbond M27**			**Superbond M230**		
eff. anchorage depth		h_{ef}	**[mm]**	**90**	**170**	**400**	**96**	**210**	**480**	**108**	**250**	**540**	**120**	**280**	**600**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	180	340	800	192	420	960	216	500	1080	240	560	1200
		$c_{cr,sp}$	[mm]	90	170	400	96	210	480	108	250	540	120	280	600
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)											
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$											
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	407	768	1808	434	949	2170	488	1130	2441	542	1266	2712
		$c_{cr,sp}$	[mm]	203	384	904	217	475	1085	244	565	1220	271	633	1356
		h_{min}	[mm]	138 / 140[1)]	218 / 220[1)]	448 / 450[1)]	152	266	536	168	310	600	190	350	670

$f_{scr,sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.80	3.62	3.44	3.26	3.08	2.90	2.72	2.54	2.36	2.18	2.00

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.80	3.62	3.44	3.26	3.08	2.90	2.72	2.54	2.36	2.18	2.00

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\,(N_{Rd,p}\,;\,N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type	Superbond M8								Superbond M10							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance $V_{Rd,s}$ [kN]	7.2	12.0	3.8	8.3	11.3	3.8	10.4	11.3	12.0	18.4	6.3	12.8	17.3	6.3	16.0	17.3

Anchor type	Superbond M12								Superbond M16							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance $V_{Rd,s}$ [kN]	16.8	27.2	8.8	19.2	25.6	8.8	24.0	25.6	31.2	50.4	16.4	35.3	47.4	16.4	44.0	47.4

Anchor type	Superbond M20								Superbond M24							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance $V_{Rd,s}$ [kN]	48.8	78.4	25.6	55.1	73.7	25.6	68.8	73.7	71.2	112.8	37.4	79.5	106.0	37.4	99.2	106.0

Anchor type	Superbond M27								Superbond M30							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance $V_{Rd,s}$ [kN]	92.0	147.2	48.3	103.2	138.3	48.3	128.8	138.3	112.8	180.0	59.2	126.3	169.2	59.2	157.6	169.2

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\,(\,N_{Rd,p}\,;\,\,N_{Rd,c}\,)$$

k-factor

Anchor type	Superbond M8 to M30
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- $c < \max(10\ h_{ef}\ ;\ 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]																	
	Superbond M8						Superbond M10						Superbond M12					
h_{ef}	60	60	80	80	160	160	60	60	90	90	200	200	70	70	110	110	240	240
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
40	3.5	2.5	3.7	2.6	4.4	3.1												
45	4.1	2.9	4.3	3.1	5.1	3.6	4.3	3.0	4.7	3.3	5.8	4.1						
50	4.7	3.3	5.0	3.5	5.8	4.1	4.9	3.5	5.3	3.8	6.6	4.7						
55	5.4	3.8	5.6	4.0	6.6	4.7	5.6	3.9	6.0	4.3	7.4	5.2	5.9	4.2	6.6	4.6	8.2	5.8
60	6.0	4.3	6.3	4.5	7.3	5.2	6.2	4.4	6.8	4.8	8.2	5.8	6.6	4.7	7.3	5.2	9.1	6.4
65	6.7	4.7	7.0	5.0	8.1	5.7	6.9	4.9	7.5	5.3	9.0	6.4	7.3	5.2	8.1	5.7	10.0	7.1
70	7.4	5.2	7.8	5.5	8.9	6.3	7.7	5.4	8.3	5.8	9.9	7.0	8.1	5.7	8.9	6.3	10.9	7.7
75	8.1	5.8	8.5	6.0	9.7	6.9	8.4	5.9	9.0	6.4	10.8	7.6	8.9	6.3	9.7	6.9	11.8	8.4
80	8.9	6.3	9.3	6.6	10.6	7.5	9.2	6.5	9.8	7.0	11.7	8.3	9.7	6.8	10.6	7.5	12.8	9.1
85	9.6	6.8	10.1	7.1	11.4	8.1	9.9	7.0	10.7	7.5	12.6	8.9	10.5	7.4	11.4	8.1	13.8	9.8
90	10.4	7.4	10.9	7.7	12.3	8.7	10.7	7.6	11.5	8.1	13.5	9.6	11.3	8.0	12.3	8.7	14.8	10.5
95	11.2	7.9	11.7	8.3	13.2	9.4	11.5	8.2	12.3	8.7	14.5	10.3	12.1	8.6	13.2	9.4	15.8	11.2
100	12.0	8.5	12.6	8.9	14.1	10.0	12.4	8.8	13.2	9.4	15.5	11.0	13.0	9.2	14.1	10.0	16.8	11.9
105	12.9	9.1	13.4	9.5	15.1	10.7	13.2	9.4	14.1	10.0	16.5	11.7	13.9	9.8	15.1	10.7	17.9	12.7
120	15.5	10.9	16.1	11.4	18.0	12.7	15.9	11.2	16.9	12.0	19.5	13.8	16.6	11.8	17.9	12.7	21.1	15.0
125	16.4	11.6	17.0	12.0	19.0	13.4	16.8	11.9	17.8	12.6	20.6	14.6	17.6	12.4	18.9	13.4	22.2	15.7
130	17.3	12.2	17.9	12.7	20.0	14.1	17.7	12.5	18.8	13.3	21.7	15.3	18.5	13.1	20.0	14.1	23.4	16.5
135	18.2	12.9	18.9	13.4	21.0	14.9	18.7	13.2	19.8	14.0	22.8	16.1	19.5	13.8	21.0	14.9	24.5	17.4
140	19.1	13.6	19.9	14.1	22.0	15.6	19.6	13.9	20.8	14.7	23.9	16.9	20.5	14.5	22.0	15.6	25.7	18.2
160	23.0	16.3	23.9	16.9	26.3	18.7	23.6	16.7	24.9	17.7	28.4	20.1	24.6	17.4	26.3	18.6	30.4	21.6
180	27.1	19.2	28.1	19.9	30.9	21.9	27.8	19.7	29.3	20.7	33.2	23.5	28.9	20.5	30.8	21.8	35.4	25.1
200	31.4	22.3	32.5	23.0	35.6	25.2	32.1	22.8	33.8	23.9	38.1	27.0	33.4	23.6	35.6	25.2	40.6	28.8
250	43.0	30.5	44.3	31.4	48.2	34.1	43.9	31.1	46.0	32.6	51.3	36.4	45.5	32.2	48.2	34.1	54.4	38.5
300	55.6	39.4	57.2	40.5	61.9	43.8	56.7	40.2	59.2	42.0	65.6	46.5	58.6	41.5	61.9	43.8	69.2	49.0
350	69.2	49.0	71.1	50.3	76.5	54.2	70.5	49.9	73.4	52.0	80.9	57.3	72.7	51.5	76.5	54.2	85.1	60.3
400	83.7	59.3	85.8	60.8	92.1	65.2	85.1	60.3	88.5	62.7	97.0	68.7	87.7	62.1	92.0	65.2	101.8	72.1
450	98.9	70.1	101.4	71.8	108.4	76.8	100.6	71.2	104.4	74.0	114.0	80.8	103.5	73.3	108.4	76.8	119.4	84.6
500	115.0	81.4	117.7	83.4	125.6	89.0	116.8	82.7	121.2	85.8	131.8	93.4	120.1	85.0	125.6	89.0	137.8	97.6
550	131.8	93.3	134.8	95.5	143.5	101.7	133.8	94.8	138.6	98.2	150.4	106.5	137.4	97.3	143.5	101.7	156.9	111.2
600	149.2	105.7	152.6	108.1	162.1	114.9	151.5	107.3	156.8	111.0	169.6	120.2	155.4	110.1	162.1	114.8	176.8	125.2
650	167.4	118.6	171.0	121.2	181.4	128.5	169.8	120.3	175.6	124.4	189.6	134.3	174.1	123.4	181.4	128.5	197.3	139.8
700			190.1	134.7	201.4	142.7			195.1	138.2	210.2	148.9	193.5	137.1	201.4	142.7	218.5	154.8
750			209.9	148.6	222.0	157.2			215.1	152.4	231.4	163.9	213.5	151.2	222.0	157.2	240.3	170.2
800			230.2	163.0	243.1	172.2			235.8	167.1	253.2	179.4			243.2	172.2	262.8	186.1
850			251.1	177.8	264.9	187.6			257.1	182.1	275.6	195.3			264.9	187.7	285.8	202.5
900					287.2	203.5			279.0	197.6	298.6	211.5			287.3	203.5	309.4	219.2
950					310.1	219.7			301.3	213.4	322.2	228.2			310.1	219.7	333.6	236.3
1000					333.5	236.2					346.3	245.3			333.6	236.3	358.3	253.8
1100					381.9	270.5					396.0	280.5			381.9	270.5	409.3	289.9
1200					432.3	306.2					447.7	317.1			432.3	306.2	462.3	327.4
1300					484.5	343.2					501.4	355.1					517.2	366.3
1400					538.6	381.5					556.8	394.4					573.9	406.5
1600					652.0	461.8					673.0	476.7					692.7	490.6
1800					771.9	546.7					795.8	563.7					818.1	579.5
2200											1059.5	750.5					1087.2	770.1
2600																	1378.9	976.7

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fischer Superbond-System FSB

Anchor design according to fischer specification

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]																	
	Superbond M16						Superbond M20						Superbond M24					
h_{ef}	80	80	125	125	320	320	90	90	170	170	400	400	96	96	210	210	480	480
edge distance [mm]	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
	concrete						concrete						concrete					
65	7,9	5,6	8,9	6,3	12,0	8,5												
70	8,7	6,2	9,7	6,9	13,0	9,2												
75	9,5	6,8	10,6	7,5	14,1	10,0												
80	10,4	7,4	11,5	8,1	15,1	10,7												
85	11,2	8,0	12,4	8,8	16,2	11,5	12,0	8,5	14,1	10,0	18,8	13,3						
90	12,1	8,6	13,3	9,4	17,3	12,3	12,9	9,1	15,1	10,7	20,0	14,2						
95	13,0	9,2	14,3	10,1	18,5	13,1	13,8	9,8	16,1	11,4	21,2	15,0						
100	13,9	9,8	15,2	10,8	19,6	13,9	14,7	10,4	17,2	12,2	22,5	15,9						
105	14,8	10,5	16,2	11,5	20,8	14,7	15,7	11,1	18,2	12,9	23,7	16,8	16,4	11,6	20,1	14,2	26,9	19,0
120	17,7	12,5	19,3	13,7	24,3	17,2	18,7	13,2	21,5	15,2	27,6	19,6	19,5	13,8	23,6	16,7	31,1	22,0
125	18,7	13,2	20,3	14,4	25,5	18,1	19,7	13,9	22,6	16,0	28,9	20,5	20,5	14,5	24,8	17,6	32,5	23,0
130	19,7	13,9	21,4	15,1	26,8	19,0	20,7	14,7	23,8	16,8	30,3	21,4	21,6	15,3	26,0	18,4	33,9	24,0
135	20,7	14,6	22,5	15,9	28,0	19,8	21,8	15,4	24,9	17,7	31,6	22,4	22,7	16,1	27,2	19,3	35,4	25,1
140	21,7	15,4	23,5	16,7	29,3	20,7	22,9	16,2	26,1	18,5	33,0	23,4	23,8	16,8	28,5	20,2	36,8	26,1
160	26,0	18,4	28,1	19,9	34,5	24,4	27,3	19,3	30,9	21,9	38,6	27,3	28,3	20,0	33,6	23,8	42,8	30,3
180	30,4	21,6	32,8	23,2	39,9	28,3	31,9	22,6	36,0	25,5	44,4	31,5	33,1	23,4	38,9	27,6	49,0	34,7
200	35,1	24,9	37,7	26,7	45,5	32,2	36,7	26,0	41,2	29,2	50,4	35,7	38,0	26,9	44,5	31,5	55,5	39,3
250	47,6	33,7	50,8	36,0	60,4	42,8	49,7	35,2	55,2	39,1	66,3	47,0	51,2	36,3	59,1	41,9	72,3	51,2
300	61,2	43,4	65,0	46,1	76,3	54,0	63,6	45,1	70,2	49,7	83,3	59,0	65,5	46,4	74,9	53,0	90,2	63,9
350	75,8	53,7	80,2	56,8	93,2	66,0	78,6	55,7	86,2	61,1	101,2	71,7	80,8	57,2	91,6	64,9	109,1	77,3
400	91,2	64,6	96,3	68,2	111,0	78,7	94,5	66,9	103,2	73,1	120,0	85,0	97,0	68,7	109,3	77,4	128,9	91,3
450	107,5	76,1	113,2	80,2	129,7	91,9	111,2	78,7	120,9	85,7	139,7	98,9	114,0	80,8	127,8	90,5	149,5	105,9
500	124,5	88,2	130,9	92,8	149,2	105,7	128,6	91,1	139,5	98,8	160,2	113,5	131,8	93,4	147,1	104,2	170,9	121,1
550	142,4	100,8	149,4	105,8	169,4	120,0	146,9	104,0	158,8	112,5	181,4	128,5	150,4	106,5	167,1	118,4	193,1	136,8
600	160,9	113,9	168,6	119,4	190,4	134,8	165,8	117,5	178,9	126,7	203,4	144,1	169,7	120,2	187,9	133,1	216,1	153,1
650	180,1	127,5	188,5	133,5	212,0	150,2	185,5	131,4	199,6	141,4	226,1	160,1	189,7	134,3	209,4	148,3	239,7	169,8
700	199,9	141,6	209,0	148,0	234,3	166,0	205,8	145,7	221,0	156,5	249,4	176,7	210,3	149,0	231,5	164,0	264,0	187,0
750	220,4	156,1	230,1	163,0	257,3	182,2	226,7	160,6	243,0	172,1	273,4	193,6	231,6	164,0	254,3	180,1	288,9	204,7
800	241,5	171,0	251,9	178,4	280,8	198,9	248,2	175,8	265,7	188,2	298,0	211,0	253,4	179,5	277,7	196,7	314,5	222,8
850	263,1	186,4	274,2	194,3	305,0	216,0	270,3	191,5	288,9	204,6	323,1	228,9	275,9	195,4	301,7	213,7	340,6	241,3
900	285,3	202,1	297,2	210,5	329,7	233,6	293,0	207,5	312,7	221,5	348,9	247,1	298,9	211,7	326,3	231,1	367,4	260,2
950	308,1	218,2	320,6	227,1	355,0	251,5	316,2	224,0	337,1	238,8	375,2	265,8	322,5	228,4	351,4	248,9	394,7	279,6
1000	331,4	234,8	344,6	244,1	380,9	269,8	340,0	240,8	362,0	256,4	402,1	284,8	346,6	245,5	377,1	267,1	422,6	299,3
1100			394,2	279,2	434,1	307,5	389,1	275,6	413,4	292,8	457,5	324,1	396,5	280,8	430,1	304,6	479,9	339,9
1200			445,8	315,8	489,4	346,7	440,2	311,8	466,9	330,7	514,9	364,7	448,3	317,5	485,1	343,6	539,2	381,9
1300			499,3	353,7	546,6	387,2	493,2	349,4	522,2	369,9	574,2	406,7	502,0	355,6	542,0	383,9	600,5	425,4
1400					605,7	429,1			579,4	410,4	635,4	450,1	557,6	395,0	600,8	425,5	663,7	470,1
1500					666,6	472,2			638,4	452,2	698,5	494,7	614,9	435,6	661,3	468,5	728,7	516,2
1600					729,2	516,5			699,1	495,2	763,2	540,6			723,7	512,6	795,5	563,5
1800					859,4	608,7			825,4	584,7	897,7	635,9			853,2	604,4	934,0	661,6
2000					995,8	705,4					1038,5	735,6			989,1	700,6	1078,8	764,2
2200					1138,2	806,2					1185,3	839,6			1130,9	801,1	1229,7	871,1
2400					1286,3	911,1					1337,8	947,6					1386,4	982,0
2600					1439,8	1019,8					1495,8	1059,5					1548,5	1096,8
2800					1598,5	1132,3					1659,0	1175,1					1715,8	1215,4
3000					1762,2	1248,2					1827,3	1294,3					1888,3	1337,5
3200					1930,7	1367,6					2000,4	1416,9					2065,6	1463,1
3400					2103,9	1490,3					2178,2	1542,9					2247,6	1592,1
3600											2360,5	1672,1					2434,3	1724,3
3800											2547,3	1804,4					2625,4	1859,6
4000											2738,4	1939,7					2820,8	1998,0
4500											3234,3	2291,0					3327,5	2357,0
5000																	3859,0	2733,5

continued next page

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]											
	Superbond M27						Superbond M30					
h_{ef}	108	108	250	250	540	540	120	120	280	280	600	600
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
120	20,3	14,4	25,5	18,1	33,7	23,9						
125	21,4	15,2	26,8	19,0	35,2	25,0						
130	22,5	16,0	28,0	19,9	36,8	26,0						
135	23,7	16,8	29,3	20,8	38,3	27,1						
140	24,8	17,6	30,6	21,7	39,8	28,2	25,8	18,3	32,4	23,0	42,9	30,4
160	29,5	20,9	36,0	25,5	46,1	32,7	30,6	21,7	38,0	26,9	49,4	35,0
180	34,4	24,3	41,6	29,4	52,6	37,2	35,6	25,2	43,8	31,0	56,2	39,8
200	39,5	27,9	47,4	33,5	59,3	42,0	40,9	28,9	49,8	35,2	63,2	44,8
250	53,0	37,5	62,6	44,4	76,8	54,4	54,8	38,8	65,5	46,4	81,4	57,7
300	67,7	47,9	79,0	56,0	95,4	67,6	69,7	49,4	82,4	58,4	100,7	71,3
350	83,3	59,0	96,3	68,2	115,0	81,5	85,7	60,7	100,2	71,0	120,9	85,7
400	99,8	70,7	114,6	81,2	135,5	96,0	102,6	72,6	119,0	84,3	142,1	100,7
450	117,2	83,0	133,7	94,7	156,8	111,1	120,3	85,2	138,6	98,2	164,1	116,2
500	135,4	95,9	153,6	108,8	178,9	126,7	138,8	98,3	159,0	112,6	186,9	132,4
550	154,3	109,3	174,3	123,5	201,8	143,0	158,1	112,0	180,2	127,7	210,5	149,1
600	173,9	123,2	195,7	138,6	225,5	159,7	178,1	126,1	202,1	143,2	234,8	166,3
650	194,3	137,6	217,8	154,3	249,8	176,9	198,8	140,8	224,7	159,2	259,7	184,0
700	215,3	152,5	240,6	170,4	274,8	194,6	220,1	155,9	248,0	175,7	285,4	202,2
750	236,9	167,8	264,0	187,0	300,4	212,8	242,1	171,5	271,9	192,6	311,7	220,8
800	259,2	183,6	288,1	204,0	326,6	231,4	264,7	187,5	296,5	210,0	338,6	239,9
850	282,0	199,7	312,7	221,5	353,5	250,4	287,9	203,9	321,6	227,8	366,1	259,4
900	305,4	216,3	337,9	239,4	380,9	269,8	311,7	220,8	347,4	246,1	394,3	279,3
950	329,4	233,3	363,7	257,6	408,9	289,7	336,0	238,0	373,7	264,7	422,9	299,6
1000	353,9	250,7	390,0	276,3	437,5	309,9	360,9	255,6	400,5	283,7	452,2	320,3
1100	404,5	286,5	444,3	314,7	496,2	351,5	412,2	292,0	455,8	322,9	512,2	362,8
1200	457,1	323,8	500,6	354,6	556,9	394,5	465,6	329,8	513,1	363,5	574,3	406,8
1300	511,6	362,4	558,8	395,8	619,7	438,9	520,9	368,9	572,4	405,5	638,4	452,2
1400	568,0	402,3	618,9	438,4	684,3	484,7	578,0	409,4	633,6	448,8	704,4	498,9
1500	626,2	443,5	680,8	482,2	750,7	531,7	636,9	451,2	696,6	493,4	772,1	546,9
1600	686,0	485,9	744,5	527,3	818,8	580,0	697,6	494,1	761,3	539,2	841,7	596,2
1800	810,7	574,2	876,7	621,0	960,2	680,1	823,8	583,5	895,7	634,5	985,8	698,3
2000			1015,3	719,2	1107,9	784,8	956,3	677,4	1036,5	734,2	1136,3	804,9
2200			1159,9	821,6	1261,7	893,7			1183,3	838,1	1292,8	915,8
2400			1310,2	928,1	1421,3	1006,7			1335,8	946,2	1455,2	1030,7
2600			1466,0	1038,4	1586,3	1123,6			1493,7	1058,1	1623,0	1149,6
2800					1756,6	1244,3			1657,0	1173,7	1796,1	1272,3
3000					1932,0	1368,5			1825,2	1292,9	1974,4	1398,5
3200					2112,3	1496,2					2157,5	1528,3
3400					2297,4	1627,3					2345,4	1661,4
3600					2487,0	1761,6					2538,0	1797,7
3800					2681,1	1899,1					2735,0	1937,3
4000					2879,6	2039,7					2936,3	2079,9
4500					3394,0	2404,1					3458,0	2449,5
5000					3933,2	2786,0					4004,7	2836,7
5500					4496,1	3184,7					4575,0	3240,7
6000											5167,9	3660,6
6500											5782,2	4095,7

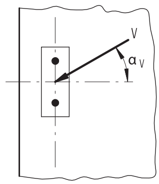
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

6.3 Combined tension and shear load:

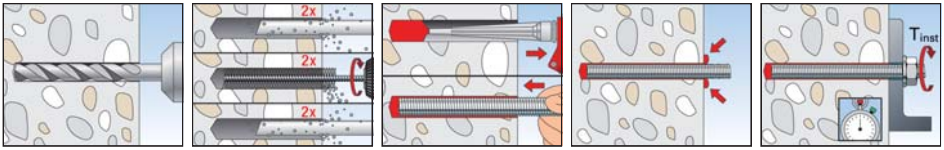
$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

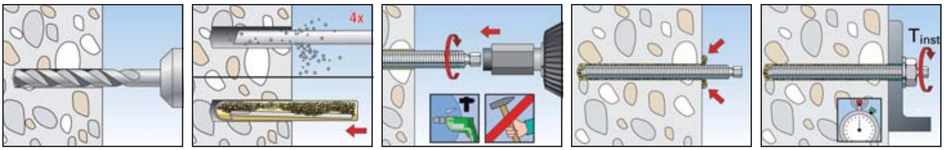
N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details

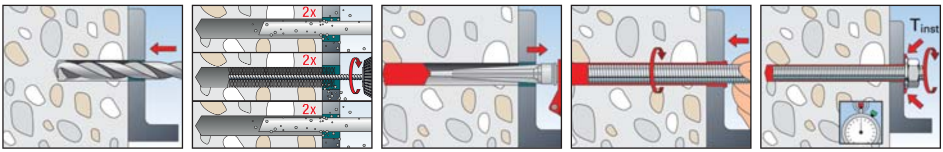
Pre-positioned installation with injection mortar:



Pre-positioned installation with capsule:



Push-through installation:

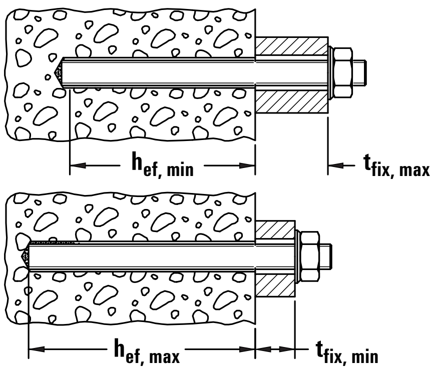


8. Anchor characteristics

Anchor type			Superbond M8			Superbond M10			Superbond M12			Superbond M16		
	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	80	125	320
diameter of thread				M 8			M 10			M 12			M 16	
nominal drill hole diameter	d_0	[mm]		10			12			14			18	
drill depth = effective anchorage depth	$h_0 = h_{ef}$	[mm]	60	80	160	60	90	200	70	110	240	80	125	320
clearance-hole in fixture to be attached pre-positioned installation [2]	d_f	[mm]		≤ 9			≤ 12			≤ 14			≤ 18	
clearance-hole in fixture to be attached push-through installation [1]	d_f	[mm]		≤ 11			≤ 14			≤ 16			≤ 20	
wrench size	SW	[mm]		13			17			19			24	
maximum torque moment	$T_{inst, max}$	[Nm]		10			20			40			60	
minimum thickness of concrete member	h_{min}	[mm]	100	110	190	100	120	230	100	140	270	116	161	356
minimum spacing	s_{min}	[mm]		40			45			55			65	
minimum edge distance	c_{min}	[mm]		40			45			55			65	
mortar filling quantity		[scale units]	3	4	8	4	6	13	5	8	18	7	10	28

Anchor type			Superbond M20			Superbond M24			Superbond M27			Superbond M30		
	h_{ef}	[mm]	90	170	400	96	210	480	108	250	540	120	280	600
diameter of thread				M 20			M 24			M 27			M 30	
nominal drill hole diameter	d_0	[mm]		24			28			30			35	
drill depth = effective anchorage depth	$h_0 = h_{ef}$	[mm]	90	170	400	96	210	480	108	250	540	120	280	600
clearance-hole in fixture to be attached pre-positioned installation [2]	d_f	[mm]		≤ 22			≤ 26			≤ 30			≤ 33	
clearance-hole in fixture to be attached push-through installation [1]	d_f	[mm]		≤ 26			≤ 30			≤ 33			≤ 40	
wrench size	SW	[mm]		30			36			41			46	
maximum torque moment	$T_{inst, max}$	[Nm]		120			150			200			300	
minimum thickness of concrete member	h_{min}	[mm]	138	218	448	152	266	536	168	310	600	190	350	670
minimum spacing	s_{min}	[mm]		89			105			120			140	
minimum edge distance	c_{min}	[mm]		85			105			120			140	
mortar filling quantity		[scale units]	11	20	45	14	29	66	17	39	84	25	58	125

[1] Hole clearance has to be filled with excess mortar.
[2] For larger diameters the clearance has to be filled with excess mortar.



9. Gelling and curing times

System temperature	Max. processing time FIS SB
– 30 °C to – 20 °C	-
> – 20 °C to – 15 °C	-
> – 15 °C to – 10 °C	60 min.
> – 10 °C to – 5°C	30 min.
> – 5 °C to 0 °C	20 min.
> 0 °C to + 5 °C	13 min.
> + 5 °C to + 10 °C	9 min.
> + 10 °C to + 20 °C	5 min.
> + 20 °C to + 30 °C	4 min.
> + 30 °C to + 40 °C	2 min.

Temperature at anchoring base	Curing time FIS SB	Curing time RSB
– 30 °C to – 20 °C	-	120 h
> – 20 °C to – 15 °C	-	48 h
> – 15 °C to – 10 °C	36 h	30 h
> – 10 °C to – 5°C	24 h	16 h
> – 5 °C to 0 °C	8 h	10 h
> 0 °C to + 5 °C	4 h	45 min.
> + 5 °C to + 10 °C	120 min.	30 min.
> + 10 °C to + 20 °C	60 min.	20 min.
> + 20 °C to + 30 °C	45 min.	5 min.
> + 30 °C to + 40 °C	30 min.	3 min.

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least 0 °C, resp. - 15 °C for the resin capsule.
For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.

10. Mechanical characteristics of anchor rods FIS A and RGM

Anchor type			Superbond M8				Superbond M10				Superbond M12			
			gvz		A4-70	C-70	gvz		A4-70	C-70	gvz		A4-70	C-70
property class			5.8	8.8			5.8	8.8			5.8	8.8		
stressed cross sectional area anchor rod	A_s	[mm²]	36.6				58.0				84.3			
section modulus	W	[mm³]	31.2				62.3				109.2			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	15.2	24.0	16.7	20.8	29.6	48.0	33.3	41.6	52.0	84.0	59.0	73.6
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	700	700

Anchor type			Superbond M16				Superbond M20				Superbond M24			
			gvz		A4-70	C-70	gvz		A4-70	C-70	gvz		A4-70	C-70
property class			5.8	8.8			5.8	8.8			5.8	8.8		
stressed cross sectional area anchor rod	A_s	[mm²]	157.0				245.0				353.0			
section modulus	W	[mm³]	277.5				540.9				935.5			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	132.8	212.8	148.7	185.6	259.2	415.2	291.0	363.2	448.0	716.8	502.6	627.2
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	700	700

Anchor type			Superbond M27				Superbond M30			
			gvz		A4-70	C-70	gvz		A4-70	C-70
property class			5.8	8.8			5.8	8.8		
stressed cross sectional area anchor rod	A_s	[mm²]	459.0				561.0			
section modulus	W	[mm³]	1387				1874			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	666.4	1066	748.1	933.6	898.4	1438	1008	1258
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700

fischer Superbond FSB Internal-threaded anchor RG MI

Anchor design according to fischer specification

1. Types

RG MI, M8 - M20 – Internal-threaded anchor (gvz)

RG MI A4, M8 - M20 – Internal-threaded anchor (A4)

Resin capsule RSB

Injection mortar FIS SB

4

ETA CE
ETA-12/0258
ETAG 001-5
Option 1 for cracked concrete *)

Fire resistance classification
R 120
Anchor types see test report

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval *) for cracked and non-cracked concrete.
- The injection mortar FIS SB and resin capsule RSB are approved for use in cracked and non-cracked concrete and have the same performance at the same anchorage depth. This gives the installer maximum flexibility.
- Superbond can even be used at extremely high temperatures of up to +150°C. This opens up new fields of application which chemical anchors could not serve until now.
- The resin capsule RSB can be installed in compliance with the approval up to -30°C; installation at up to -15°C is possible with the injection mortar FIS SB.
- The resin capsule RSB is fast curing and enables installation without waiting times.
- The resin capsule RSB is approved for water-filled and diamond drill holes, thus providing more flexibility on the construction site.
- Superbond is a combined injection and capsule system based on a vinyl ester hybrid with silane technology.
- The internal-threaded anchor RG MI can be optionally set with injection mortar FIS SB or resin capsule RSB.
- Resin and hardener are stored in two separate chambers and are not mixed and activated until extrusion through the static mixer or destruction of the capsule during the setting procedure.
- The mortar bonds the entire surface of the threaded rod with the drill hole wall and seals the drill hole.

*) The conditions of use (e.g. design resistances, characteristic disistance, ...) in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Internal-threaded anchor:	- Carbon steel, zinc plated (5 µm) and passivated (gvz)
	- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
Injection mortar:	- Vinylester resin (styrene-free), hydraulic additives, quartz sand and hardener

fischer Superbond FSB Internal-threaded anchor RG MI

Anchor design according to fischer specification

2. Ultimate resistances of single anchors with large spacing and large edge distance[1)]

Mean values

Anchor type				Superbond RG M8 I				Superbond RG M10 I				Superbond RG M12 I			
				gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef}			[mm]	90				90				125			
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]															
tension static	C 20/25	N_u	[kN]	20.0	30.5	27.3	27.3	30.5	49.4	43.1	43.1	45.2	71.4	62.0	62.0
	C 50/60	N_u	[kN]	20.0	30.5	27.3	27.3	30.5	49.4	43.1	43.1	45.2	71.4	62.0	62.0
shear static	≧ C 20/25	V_u	[kN]	10.0	15.2	13.7	13.7	15.2	24.7	21.5	21.5	22.6	35.7	31.0	31.0
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]															
tension static	C 20/25	N_u	[kN]	20.0	30.5	27.3	27.3	30.5	40.9	40.9	40.9	45.2	67.0	62.0	62.0
	C 50/60	N_u	[kN]	20.0	30.5	27.3	27.3	30.5	49.4	43.1	43.1	45.2	71.4	62.0	62.0
shear static	≧ C 20/25	V_u	[kN]	10.0	15.2	13.7	13.7	15.2	24.7	21.5	21.5	22.6	35.7	31.0	31.0

Anchor type				Superbond RG M16 I				Superbond RG M20 I			
				gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef}			[mm]	160				200			
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]											
tension static	C 20/25	N_u	[kN]	83.0	113.4	115.5	115.5	129.2	188.0	180.6	180.6
	C 50/60	N_u	[kN]	83.0	113.4	115.5	115.5	129.2	188.0	180.6	180.6
shear static	≧ C 20/25	V_u	[kN]	41.5	56.7	57.8	57.8	64.6	94.0	90.3	90.3
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]											
tension static	C 20/25	N_u	[kN]	83.0	97.0	97.0	97.0	129.2	135.6	135.6	135.6
	C 50/60	N_u	[kN]	83.0	113.4	115.5	115.5	129.2	188.0	180.6	180.6
shear static	≧ C 20/25	V_u	[kN]	41.5	56.7	57.8	57.8	64.6	94.0	90.3	90.3

1) The loads apply to fischer internal-threaded anchors with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

Anchor design according to fischer specification

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance[1)]

Anchor type				Superbond RG M8 I				Superbond RG M10 I				Superbond RG M12 I			
				gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	A4-80	C-50	C-70	C-80
h_{ef}			[mm]	90				90				125			
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]															
tension static	C 20/25	N_{Rk}	[kN]	19.0	29.0	26.0	26.0	29.0	43.1	41.0	41.0	43.0	68.0	59.0	59.0
	C 50/60	N_{Rk}	[kN]	19.0	29.0	26.0	26.0	29.0	47.0	41.0	41.0	43.0	68.0	59.0	59.0
shear static	≧ C 20/25	V_{Rk}	[kN]	9.2	14.6	12.8	12.8	14.5	23.2	20.3	20.3	21.1	33.7	29.5	29.5
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]															
tension static	C 20/25	N_{Rk}	[kN]	17.0	17.0	17.0	17.0	22.6	22.6	22.6	22.6	35.3	35.3	35.3	35.3
	C 50/60	N_{Rk}	[kN]	18.7	18.7	18.7	18.7	24.9	24.9	24.9	24.9	38.9	38.9	38.9	38.9
shear static	≧ C 20/25	V_{Rk}	[kN]	9.2	14.6	12.8	12.8	14.5	23.2	20.3	20.3	21.1	33.7	29.5	29.5

Anchor type				Superbond RG M16 I				Superbond RG M20 I			
				gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef}			[mm]	160				200			
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]											
tension static	C 20/25	N_{Rk}	[kN]	79.0	102.2	102.2	102.2	123.0	142.8	142.8	142.8
	C 50/60	N_{Rk}	[kN]	79.0	108.0	110.0	110.0	123.0	179.0	172.0	172.0
shear static	≧ C 20/25	V_{Rk}	[kN]	39.2	54.0	54.8	54.8	69.0	90.0	86.0	86.0
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]											
tension static	C 20/25	N_{Rk}	[kN]	55.3	55.3	55.3	55.3	88.0	88.0	88.0	88.0
	C 50/60	N_{Rk}	[kN]	60.8	60.8	60.8	60.8	96.8	96.8	96.8	96.8
shear static	≧ C 20/25	V_{Rk}	[kN]	39.2	54.0	54.8	54.8	69.0	90.0	86.0	86.0

1) The loads apply to fischer internal-threaded anchors with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

fischer Superbond FSB Internal-threaded anchor RG MI

Anchor design according to fischer specification

3.2 Design resistance[1)]

Anchor type			Superbond RG M8 I				Superbond RG M10 I				Superbond RG M12 I			
			gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	A4-80	C-50	C-70	C-80
h_{ef}		[mm]	90				90				125			
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]														
tension static	C 20/25 N_{Rd}	[kN]	12.7	19.3	13.9	13.9	19.3	28.7	21.9	21.9	28.7	45.3	31.6	31.6
	C 50/60 N_{Rd}	[kN]	12.7	19.3	13.9	13.9	19.3	31.3	21.9	21.9	28.7	45.3	31.6	31.6
shear static	≧ C 20/25 V_{Rd}	[kN]	7.4	11.7	8.2	8.2	11.6	18.6	13.0	13.0	16.9	27.0	18.9	18.9
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]														
tension static	C 20/25 N_{Rd}	[kN]	11.3	11.3	11.3	11.3	15.1	15.1	15.1	15.1	23.6	23.6	23.6	23.6
	C 50/60 N_{Rd}	[kN]	12.4	12.4	12.4	12.4	16.6	16.6	16.6	16.6	25.9	25.9	25.9	25.9
shear static	≧ C 20/25 V_{Rd}	[kN]	7.4	11.7	8.2	8.2	11.6	18.6	13.0	13.0	16.9	27.0	18.9	18.9

Anchor type			Superbond RG M16 I				Superbond RG M20 I			
			gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef}		[mm]	160				200			
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]										
tension static	C 20/25 N_{Rd}	[kN]	52.7	68.1	58.8	58.8	82.0	95.2	92.0	92.0
	C 50/60 N_{Rd}	[kN]	52.7	72.0	58.8	58.8	82.0	119.3	92.0	92.0
shear static	≧ C 20/25 V_{Rd}	[kN]	31.4	43.2	35.1	35.1	55.2	72.0	55.1	55.1
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]										
tension static	C 20/25 N_{Rd}	[kN]	36.9	36.9	36.9	36.9	58.6	58.6	58.6	58.6
	C 50/60 N_{Rd}	[kN]	40.5	40.5	40.5	40.5	64.5	64.5	64.5	64.5
shear static	≧ C 20/25 V_{Rd}	[kN]	31.4	43.2	35.1	35.1	55.2	72.0	55.1	55.1

1) The loads apply to fischer internal-threaded anchors with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

fischer Superbond FSB Internal-threaded anchor RG MI

Anchor design according to fischer specification

3.3 Recommended resistance [1) 3)]

Anchor type	Superbond RG M8 I				Superbond RG M10 I				Superbond RG M12 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	90				90				125			
non-cracked concrete temperature range (+ 40 °C / + 24 °C) [2)]												
tension static C 20/25 N_{Rd} [kN]	9.0	13.8	9.9	9.9	13.8	20.5	15.7	15.7	20.5	32.4	22.5	22.5
C 50/60 N_{Rd} [kN]	9.0	13.8	9.9	9.9	13.8	22.4	15.7	15.7	20.5	32.4	22.5	22.5
shear static ≥ C 20/25 V_{Rd} [kN]	5.3	8.3	5.9	5.9	8.3	13.3	9.3	9.3	12.1	19.3	13.5	13.5
cracked concrete temperature range (+ 40 °C / + 24 °C) [2)]												
tension static C 20/25 N_{Rd} [kN]	8.1	8.1	8.1	8.1	10.8	10.8	10.8	10.8	16.8	16.8	16.8	16.8
C 50/60 N_{Rd} [kN]	8.9	8.9	8.9	8.9	11.8	11.8	11.8	11.8	18.5	18.5	18.5	18.5
shear static ≥ C 20/25 V_{Rd} [kN]	5.3	8.3	5.9	5.9	8.3	13.3	9.3	9.3	12.1	19.3	13.5	13.5

Anchor type	Superbond RG M16 I				Superbond RG M20 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	160				200			
non-cracked concrete temperature range (+ 40 °C / + 24 °C) [2)]								
tension static C 20/25 N_{Rk} [kN]	37.6	48.7	42.0	42.0	58.6	68.0	65.7	65.7
C 50/60 N_{Rk} [kN]	37.6	51.4	42.0	42.0	58.6	85.2	65.7	65.7
shear static ≥ C 20/25 V_{Rk} [kN]	22.4	30.9	25.1	25.1	39.4	51.4	39.4	39.4
cracked concrete temperature range (+ 40 °C / + 24 °C) [2)]								
tension static C 20/25 N_{Rk} [kN]	26.3	26.3	26.3	26.3	41.9	41.9	41.9	41.9
C 50/60 N_{Rk} [kN]	29.0	29.0	29.0	29.0	46.1	46.1	46.1	46.1
shear static ≥ C 20/25 V_{Rk} [kN]	22.4	30.9	25.1	25.1	39.4	51.4	39.4	39.4

1) The loads apply to fischer internal-threaded anchors with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete
2) (short term temperature / long term temperature)
3) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on the failure mode of the anchor.

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type	Superbond RG M8 I				Superbond RG M10 I				Superbond RG M12 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
design resistance $N_{Rd,s}$ [kN]	12.7	19.3	13.9	13.9	19.3	31.3	21.9	21.9	28.7	45.3	31.6	31.6

Anchor type	Superbond RG M16 I				Superbond RG M20 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
design resistance $N_{Rd,s}$ [kN]	52.7	72.0	58.8	58.8	82.0	119.3	92.0	92.0

fischer Superbond FSB Internal-threaded anchor RG MI

Anchor design according to fischer specification

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Hammer drilled

Anchor type			Superbond RG M8 I [1)]	Superbond RG M10 I	Superbond RG M12 I	Superbond RG M16 I	Superbond RG M20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
non-cracked concrete							
temperature range (+40°C / +24°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]	27.1	36.2	51.8	81.1	111.4
temperature range (+80°C / +50°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]	27.1	33.2	51.8	73.7	105.6
temperature range (+120°C / +72°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]	24.9	30.2	47.1	66.4	93.8
temperature range (+150°C / +90°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]	22.6	28.7	42.4	62.7	88.0
cracked concrete							
temperature range (+40°C / +24°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]	11.3	15.1	23.6	36.9	58.6
temperature range (+80°C / +50°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]	11.3	15.1	23.6	36.9	58.6
temperature range (+120°C / +72°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]	10.2	13.6	21.2	33.2	52.8
temperature range (+150°C / +90°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]	9.0	12.1	18.8	29.5	46.9

Diamond drilled

Anchor type			Superbond RG M8 I [1)]	Superbond RG M10 I	Superbond RG M12 I	Superbond RG M16 I	Superbond RG M20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
non-cracked concrete							
temperature range (+40°C / +24°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]	29.4	36.2	56.5	81.1	117.3
temperature range (+80°C / +50°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]	29.4	36.2	56.5	81.1	111.4
temperature range (+120°C / +72°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]	24.9	33.2	47.1	70.0	99.7
temperature range (+150°C / +90°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]	22.6	30.2	44.8	66.4	93.8
cracked concrete							
temperature range (+40°C / +24°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]		15.1	23.6	36.9	58.6
temperature range (+80°C / +50°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]		15.1	23.6	36.9	58.6
temperature range (+120°C / +72°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]		13.6	21.2	33.2	52.8
temperature range (+150°C / +90°C) [2)]							
design resistance	$N^0_{Rd,p}$	[kN]		12.1	18.8	29.5	46.9

[1)] For underwater installation the resistance values have to be multiplied by a factor of 0.83.

[2)] (short term temperature / long term temperature)

fischer Superbond FSB Internal-threaded anchor RG MI

Anchor design according to fischer specification

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	55
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,p}$	[-]	0.95	0.98	1.00	1.02	1.04	1.07	1.08	1.09	1.10

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4.2.2 Characteristic edge distance and spacing for design

Anchor type			Superbond RG M8 I	Superbond RG M10 I	Superbond RG M12 I	Superbond RG M16 I	Superbond RG M20 I
eff. anchorage depth	h_{ef}	**[mm]**	**90**	**90**	**125**	**160**	**200**
hammer drilled							
temperature range (+40°C / +24°C) [1]							
	$s_{cr,Np}$	[kN]	263	270	375	461	546
	$c_{cr,Np}$	[kN]	131	135	188	231	273
temperature range (+80°C / +50°C) [1]							
	$s_{cr,Np}$	[kN]	263	270	375	440	531
	$c_{cr,Np}$	[kN]	131	135	188	220	266
temperature range (+120°C / +72°C) [1]							
	$s_{cr,Np}$	[kN]	252	270	360	417	501
	$c_{cr,Np}$	[kN]	126	135	180	209	250
temperature range (+150°C / +90°C) [1]							
	$s_{cr,Np}$	[kN]	240	270	342	406	485
	$c_{cr,Np}$	[kN]	120	135	171	203	242
diamond drilled							
temperature range (+40°C / +24°C) [1]							
	$s_{cr,Np}$	[kN]	270	270	375	461	560
	$c_{cr,Np}$	[kN]	135	135	188	231	280
temperature range (+80°C / +50°C) [1]							
	$s_{cr,Np}$	[kN]	270	270	375	461	546
	$c_{cr,Np}$	[kN]	135	135	188	231	273
temperature range (+120°C / +72°C) [1]							
	$s_{cr,Np}$	[kN]	252	270	360	429	516
	$c_{cr,Np}$	[kN]	126	135	180	214	258
temperature range (+150°C / +90°C) [1]							
	$s_{cr,Np}$	[kN]	240	270	351	417	501
	$c_{cr,Np}$	[kN]	120	135	175	209	250

[1] (short term temperature / long term temperature)

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4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type	Superbond RG M8 I [1)]	Superbond RG M10 I	Superbond RG M12 I	Superbond RG M16 I	Superbond RG M20 I
eff. anchorage depth h_{ef} [mm]	90	90	125	160	200
non-cracked concrete					
design resistance $N^0_{Rd,c}$ [kN]	28.7	28.7	47.1	68.1	95.2
cracked concrete					
design resistance $N^0_{Rd,c}$ [kN]	20.5	20.5	33.5	48.6	67.9

[1)] For underwater installation the resistance values have to be multiplied by a factor of 0.83.

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,c}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type	Superbond RG M8 I	Superbond RG M10 I	Superbond RG M12 I	Superbond RG M16 I	Superbond RG M20 I
eff. anchorage depth h_{ef} [mm]	90	90	125	160	200
$s_{cr,N}$ [mm]	270	270	375	480	600
$c_{cr,N}$ [mm]	135	135	188	240	300

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
f_s	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

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4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type				**Superbond RG M8 I**	**Superbond RG M10 I**	**Superbond RG M12 I**	**Superbond RG M16 I**	**Superbond RG M20 I**
eff. anchorage depth		h_{ef}	**[mm]**	**90**	**90**	**125**	**160**	**200**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	180	180	250	320	400
		$c_{cr,sp}$	[mm]	90	90	125	160	200
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)				
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$				
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	407	407	565	723	904
		$c_{cr,sp}$	[mm]	203	203	283	362	452
		h_{min}	[mm]	120	125	165	205	260

$f_{scr,sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.80	3.62	3.44	3.26	3.08	2.90	2.72	2.54	2.36	2.18	2.00

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.80	3.62	3.44	3.26	3.08	2.90	2.72	2.54	2.36	2.18	2.00

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\,(N_{Rd,p}\,;\,N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type			Superbond RG M8 I				Superbond RG M10 I				Superbond RG M12 I			
			gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
design resistance	$V_{Rd,s}$	[kN]	7.4	11.7	8.2	8.2	11.6	18.6	13.0	13.0	16.9	27.0	18.9	18.9

Anchor type			Superbond RG M16 I				Superbond RG M20 I			
			gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
design resistance	$V_{Rd,s}$	[kN]	31.4	43.2	35.1	35.1	55.2	72.0	55.1	55.1

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\,(\,N_{Rd,p}\,;\;N_{Rd,c}\,)$$

k-factor

Anchor type	Superbond RG M8 I to RG M30 I
k	2.0

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5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- $c < \max(10\ h_{ef}\ ;\ 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]									
	Superbond RG M8 I		Superbond RG M10 I		Superbond RG M12 I		Superbond RG M16 I		Superbond RG M20 I	
h_{ef}	90	90	90	90	125	125	160	160	200	200
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
55	6.2	4.4								
60	7.0	4.9								
65	7.7	5.5	8.2	5.8						
70	8.5	6.0	9.0	6.4						
75	9.3	6.6	9.8	6.9	10.8	7.7				
80	10.1	7.2	10.6	7.5	11.8	8.3				
85	11.0	7.8	11.5	8.2	12.7	9.0				
90	11.8	8.4	12.4	8.8	13.6	9.7				
95	12.7	9.0	13.3	9.4	14.6	10.3	16.2	11.4		
100	13.6	9.6	14.2	10.1	15.6	11.0	17.2	12.2		
105	14.5	10.3	15.2	10.7	16.6	11.7	18.3	12.9		
120	17.3	12.3	18.1	12.8	19.7	13.9	21.6	15.3		
125	18.3	13.0	19.1	13.5	20.7	14.7	22.7	16.1	25.2	17.9
130	19.3	13.7	20.1	14.2	21.8	15.4	23.8	16.9	26.5	18.8
135	20.3	14.4	21.1	15.0	22.9	16.2	25.0	17.7	27.7	19.6
140	21.3	15.1	22.2	15.7	24.0	17.0	26.2	18.5	29.0	20.5
160	25.5	18.1	26.5	18.8	28.6	20.2	31.0	22.0	34.2	24.2
180	29.9	21.2	31.0	22.0	33.3	23.6	36.1	25.6	39.5	28.0
200	34.5	24.5	35.8	25.3	38.3	27.1	41.3	29.3	45.1	32.0
250	46.9	33.2	48.4	34.3	51.6	36.6	55.3	39.2	60.0	42.5
300	60.3	42.7	62.2	44.0	66.0	46.7	70.4	49.9	75.9	53.7
350	74.7	52.9	76.9	54.4	81.3	57.6	86.4	61.2	92.8	65.7
400	90.0	63.8	92.5	65.5	97.5	69.1	103.4	73.2	110.6	78.3
450	106.1	75.2	108.9	77.1	114.6	81.2	121.2	85.8	129.2	91.6
500	123.0	87.1	126.1	89.3	132.5	93.8	139.8	99.0	148.7	105.3
550	140.7	99.6	144.1	102.1	151.1	107.0	159.2	112.7	168.9	119.7
600	159.0	112.6	162.8	115.3	170.5	120.7	179.2	127.0	189.9	134.5
650	178.1	126.1	182.1	129.0	190.5	134.9	200.0	141.7	211.6	149.8
700	197.7	140.1	202.2	143.2	211.2	149.6	221.4	156.9	233.9	165.7
750	218.0	154.4	222.8	157.8	232.5	164.7	243.5	172.5	256.8	181.9
800	238.9	169.3	244.1	172.9	254.4	180.2	266.2	188.5	280.4	198.6
850	260.4	184.5	265.9	188.3	276.9	196.2	289.5	205.0	304.6	215.7
900	282.5	200.1	288.3	204.2	300.0	212.5	313.3	221.9	329.3	233.3
950	305.1	216.1	311.2	220.5	323.6	229.2	337.7	239.2	354.6	251.2
1000			334.7	237.1	347.8	246.4	362.7	256.9	380.5	269.5
1100					397.8	281.7	414.2	293.4	433.8	307.3
1200					449.7	318.5	467.7	331.3	489.2	346.5
1300					503.5	356.7	523.1	370.5	546.5	387.1
1400							580.4	411.1	605.6	429.0
1500							639.4	452.9	666.6	472.2
1600							700.2	496.0	729.3	516.6
1800							826.7	585.6	859.6	608.9
2000									996.3	705.7

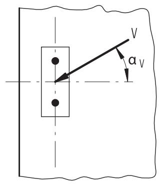
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

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5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1} \right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

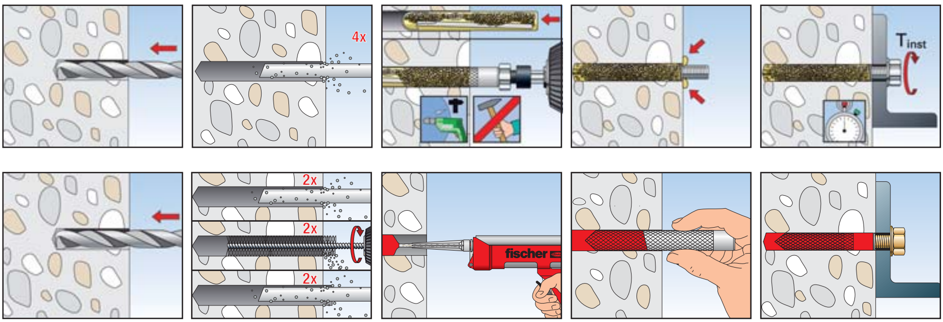
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details



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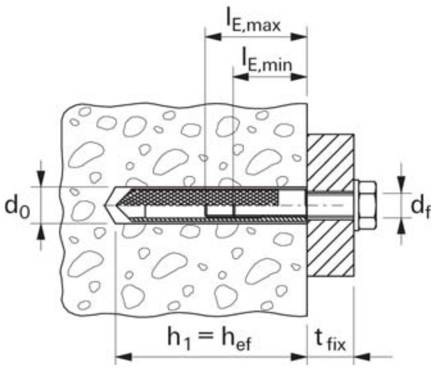
Anchor design according to fischer specification

8. Anchor characteristics

Anchor type			Superbond RG M8 I	Superbond RG M10 I	Superbond RG M12 I	Superbond RG M16 I	Superbond RG M20 I
diameter of thread			M 8	M 10	M 12	M 16	M 20
nominal drill hole diameter	d_0	[mm]	14	18	20	24	32
drill depth	h_0	[mm]	90	90	125	160	200
effective anchorage depth	h_{ef}	[mm]	90	90	125	160	200
clearance-hole in fixture to be attached	d_f	[mm]	≦ 9	≦ 12	≦ 14	≦ 18	≦ 22
screw penetration depth	min l_s	[mm]	8	10	12	16	20
	max l_s	[mm]	18	23	26	35	45
wrench size	SW	[mm]	13	17	19	24	30
maximum torque moment	$T_{inst,max}$	[Nm]	10	20	40	80	120
minimum thickness of concrete member	h_{min}	[mm]	120	125	165	205	260
minimum spacing	s_{min}	[mm]	55	65	75	95	125
minimum edge distances	c_{min}	[mm]	55	65	75	95	125
mortar filling quantity		[scale units]	5	7	11	17	48



fischer Superbond FSB Internal-threaded anchor RG MI

Anchor design according to fischer specification

9. Gelling and curing times

System temperature				Max. processing time FIS SB
	– 30 °C	to	– 20 °C	-
>	– 20 °C	to	– 15 °C	-
>	– 15 °C	to	– 10 °C	60 min.
>	– 10 °C	to	– 5°C	30 min.
>	– 5 °C	to	0 ° C	20 min.
>	0 °C	to	+ 5 °C	13 min.
>	+ 5 °C	to	+ 10 °C	9 min.
>	+ 10 °C	to	+ 20 °C	5 min.
>	+ 20 °C	to	+ 30 °C	4 min.
>	+ 30 °C	to	+ 40 °C	2 min.

Temperature at anchoring base				Curing time FIS SB	Curing time RSB
	– 30 °C	to	– 20 °C	-	120 h
>	– 20 °C	to	– 15 °C	-	48 h
>	– 15 °C	to	– 10 °C	36 h	30 h
>	– 10 °C	to	– 5°C	24 h	16 h
>	– 5 °C	to	0 ° C	8 h	10 h
>	0 °C	to	+ 5 °C	4 h	45 min.
>	+ 5 °C	to	+ 10 °C	120 min.	30 min.
>	+ 10 °C	to	+ 20 °C	60 min.	20 min.
>	+ 20 °C	to	+ 30 °C	45 min.	5 min.
>	+ 30 °C	to	+ 40 °C	30 min.	3 min.

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least 0 °C, resp. - 15 °C for the resin capsule.

For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.

4

10. Mechanical characteristics of RG MI

Anchor type			Superbond RG M8 I				Superbond RG M10 I				Superbond RG M12 I			
screw property class			**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**
stressed cross sectional area - screw	A_s	[mm²]	36.6				58.0				84.3			
resisting moment - screw	W	[mm³]	31.2				62.3				109.2			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	16.0	24.0	16.7	20.8	31.2	48.0	33.3	41.6	54.4	84.0	59.0	73.6
yield strength - screw	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength - screw	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	700	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm²]	72.5				137.1				161.8			
resisting moment - internal-threaded anchor	W	[mm³]	147.8				361.4				496.6			
yield strength - internal-threaded anchor	f_{yk}	[N/mm²]	420		450	560	420		450	560	420		450	560
tensile strength - internal-threaded anchor	f_{uk}	[N/mm²]	525		700	700	525		700	700	525		700	700

Anchor type			Superbond RG M16 I				Superbond RG M20 I			
screw property class			**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**
stressed cross sectional area - screw	A_s	[mm²]	157.0				245.0			
resisting moment - screw	W	[mm³]	277.5				540.9			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	138.4	212.8	148.7	185.6	269.6	415.2	291.0	363.2
yield strength - screw	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560
tensile strength - screw	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm²]	210.4				350.5			
resisting moment - internal-threaded anchor	W	[mm³]	836.9				1755.3			
yield strength - internal-threaded anchor	f_{yk}	[N/mm²]	420		450	560	420		450	560
tensile strength - internal-threaded anchor	f_{uk}	[N/mm²]	525		700	700	525		700	700

Notes

fischer Superbond Injection mortar FIS SB with rebars

Anchor design according to fischer specification

1. Types

Reinforcement bars Ø 8 - Ø 32 mm

Injection mortar FIS SB

ETA-12/0258
ETAG 001-5
Option 1 for cracked concrete
*)

Fire resistance classification
R 120
Anchor types see test report

Features and Advantages

- European Technical Approval *) for cracked and non-cracked concrete.
- Superbond can even be used at extremely high temperatures of up to +150°C. This opens up new fields of application which chemical anchors could not serve until now.
- Superbond is a combined injection and capsule system based on a vinyl ester hybrid with silane technology.
- Rebars can only be set with injection mortar FIS SB.
- Resin and hardener are stored in two separate chambers and are not mixed and activated until extrusion through the static mixer.
- The mortar bonds the entire surface of the rebar with the drill hole wall and seals the drill hole.

*) The conditions of use (e.g. design resistances, characteristic disistance, ...) in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Reinforcing steel :	Approved with f_{yk} = 400 - 600 N/mm². Static values in the Technical Handbook based on f_{yk} = 500 N/mm²
Injection mortar:	Vinylester resin (styrene-free), hydraulic additives, quartz sand and hardener

fischer Superbond Injection mortar FIS SB with rebars

Anchor design according to fischer specification

2. Ultimate resistances of single anchors with large spacing and large edge distance[1)]

Mean values

Rebar type				Superbond Ø8	Superbond Ø10	Superbond Ø12	Superbond Ø14	Superbond Ø16	Superbond Ø20	Superbond Ø25	Superbond Ø28	Superbond Ø32
h_{ef}			[mm]	80	90	110	120	125	170	250	250	300
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]												
tension static	C 20/25	N_u	[kN]	25.1	45.2	66.2	88.7	94.3	149.6	266.8	266.8	350.7
	C 50/60	N_u	[kN]	27.7	46.2	66.2	89.3	116.6	181.7	283.5	345.3	465.2
shear static	≧ C 20/25	V_u	[kN]	17.6	27.7	39.7	53.6	69.9	109.0	170.1	213.6	279.1
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]												
tension static	C 20/25	N_u	[kN]	18.1	38.5	55.3	63.0	67.0	106.2	189.4	189.4	249.0
	C 50/60	N_u	[kN]	19.9	42.4	62.6	76.0	90.5	142.1	282.7	293.5	385.8
shear static	≧ C 20/25	V_u	[kN]	17.6	27.7	39.7	53.6	69.9	109.0	170.1	213.6	279.1

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² with hammer drilling and careful drill hole cleaning according to the approval. The rebar may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

4

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance[1)]

Rebar type				Superbond Ø8	Superbond Ø10	Superbond Ø12	Superbond Ø14	Superbond Ø16	Superbond Ø20	Superbond Ø25	Superbond Ø28	Superbond Ø32
h_{ef}			[mm]	80	90	110	120	125	170	250	250	300
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]												
tension static	C 20/25	N_{Rk}	[kN]	16.1	24.0	37.3	50.1	59.7	106.8	186.5	197.9	226.2
	C 50/60	N_{Rk}	[kN]	17.7	26.4	41.1	55.2	65.7	117.5	205.2	217.7	248.8
shear static	≧ C 20/25	V_{Rk}	[kN]	13.8	21.6	31.1	42.4	55.3	87.0	135.0	170.0	221.0
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]												
tension static	C 20/25	N_{Rk}	[kN]	9.0	17.0	24.9	31.7	44.0	64.1	117.8	131.9	181.0
	C 50/60	N_{Rk}	[kN]	10.0	18.7	27.4	34.8	48.4	70.5	129.6	145.1	199.1
shear static	≧ C 20/25	V_{Rk}	[kN]	13.8	21.6	31.1	42.4	55.3	87.0	135.0	170.0	221.0

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² with hammer drilling and careful drill hole cleaning according to the approval. The rebar may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

3.2 Design resistance[1)]

Rebar type				Superbond Ø8	Superbond Ø10	Superbond Ø12	Superbond Ø14	Superbond Ø16	Superbond Ø20	Superbond Ø25	Superbond Ø28	Superbond Ø32
h_{ef}			[mm]	80	90	110	120	125	170	250	250	300
non-cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]												
tension static	C 20/25	N_{Rd}	[kN]	10.7	16.0	24.9	33.4	39.8	71.2	124.4	131.9	150.8
	C 50/60	N_{Rd}	[kN]	11.8	17.6	27.4	36.8	43.8	78.3	136.8	145.1	165.9
shear static	≧ C 20/25	V_{Rd}	[kN]	9.2	14.4	20.7	28.3	36.9	58.0	90.0	113.3	147.3
cracked concrete temperature range (+ 40 °C / + 24 °C)[2)]												
tension static	C 20/25	N_{Rd}	[kN]	6.0	11.3	16.6	21.1	29.3	42.7	78.5	88.0	120.6
	C 50/60	N_{Rd}	[kN]	6.6	12.4	18.2	23.2	32.3	47.0	86.4	96.8	132.7
shear static	≧ C 20/25	V_{Rd}	[kN]	9.2	14.4	20.7	28.3	36.9	58.0	90.0	113.3	147.3

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² with hammer drilling and careful drill hole cleaning according to the approval. The rebar may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

3.3 Allowable resistance [1) 3)]

Rebar type	Superbond Ø8	Superbond Ø10	Superbond Ø12	Superbond Ø14	Superbond Ø16	Superbond Ø20	Superbond Ø25	Superbond Ø28	Superbond Ø32
h_{ef} [mm]	80	90	110	120	125	170	250	250	300
non-cracked concrete									
temperature range (+ 40 °C / + 24 °C) [2)]									
tension static C 20/25 N_{Rd} [kN]	7.7	11.4	17.8	23.9	28.4	50.9	88.8	94.2	107.7
C 50/60 N_{Rd} [kN]	8.4	12.6	19.5	26.3	31.3	56.0	97.7	103.7	118.5
shear static ≧ C 20/25 V_{Rd} [kN]	6.6	10.3	14.8	20.2	26.3	41.4	64.3	81.0	105.2
cracked concrete									
temperature range (+ 40 °C / + 24 °C) [2)]									
tension static C 20/25 N_{Rd} [kN]	4.3	8.1	11.8	15.1	20.9	30.5	56.1	62.8	86.2
C 50/60 N_{Rd} [kN]	4.7	8.9	13.0	16.6	23.0	33.6	61.7	69.1	94.8
shear static ≧ C 20/25 V_{Rd} [kN]	6.6	10.3	14.8	20.2	26.3	41.4	64.3	81.0	105.2

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² with hammer drilling and careful drill hole cleaning according to the approval. The rebar may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)
3) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on the failure mode of the anchor.

4

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single rebar

Rebar type	Superbond Ø8	Superbond Ø10	Superbond Ø12	Superbond Ø14	Superbond Ø16	Superbond Ø20	Superbond Ø25	Superbond Ø28	Superbond Ø32
design resistance $N_{Rd,s}$ [kN]	20.0	31.4	45.0	60.7	79.3	123.6	192.9	242.1	316.4

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single rebar
Hammer drilled

Rebar type			Superbond Ø8			Superbond Ø10			Superbond Ø12		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240
non-cracked concrete											
temperature range (+40°C / +24°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	8.0	10.7	21.4	10.7	16.0	35.6	15.8	24.9	54.3
temperature range (+80°C / +50°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	8.0	10.7	21.4	10.7	16.0	35.6	15.8	24.9	54.3
temperature range (+120°C / +72°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	7.0	9.4	18.8	9.4	14.1	31.4	14.1	22.1	48.3
temperature range (+150°C / +90°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	6.5	8.7	17.4	8.8	13.2	29.3	12.3	19.4	42.2
cracked concrete											
temperature range (+40°C / +24°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	4.5	6.0	12.1	7.5	11.3	25.1	10.6	16.6	36.2
temperature range (+80°C / +50°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	4.5	6.0	12.1	6.9	10.4	23.0	9.7	15.2	33.2
temperature range (+120°C / +72°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	4.0	5.4	10.7	6.3	9.4	20.9	8.8	13.8	30.2
temperature range (+150°C / +90°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	3.5	4.7	9.4	5.7	8.5	18.8	7.9	12.4	27.1

Rebar type			Superbond Ø14			Superbond Ø16			Superbond Ø20		
eff. anchorage depth	h_{ef}	[mm]	75	120	280	80	125	320	90	170	400
non-cracked concrete											
temperature range (+40°C / +24°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	20,9	33,4	78,0	25,5	39,8	101,9	37,7	71,2	167,6
temperature range (+80°C / +50°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	19,8	31,7	73,9	25,5	39,8	101,9	35,8	67,6	159,2
temperature range (+120°C / +72°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	17,6	28,1	65,7	22,8	35,6	91,1	32,0	60,5	142,4
temperature range (+150°C / +90°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	16,5	26,4	61,6	20,1	31,4	80,4	30,2	57,0	134,0
cracked concrete											
temperature range (+40°C / +24°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	13,2	21,1	49,3	18,8	29,3	75,1	22,6	42,7	100,5
temperature range (+80°C / +50°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	12,1	19,4	45,2	17,4	27,2	69,7	22,6	42,7	100,5
temperature range (+120°C / +72°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	11,0	17,6	41,1	16,1	25,1	64,3	20,7	39,2	92,2
temperature range (+150°C / +90°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	9,9	15,8	36,9	14,7	23,0	59,0	18,8	35,6	83,8

1) (short term temperature / long term temperature)

continued next page

fischer Superbond Injection mortar FIS SB with rebars

Anchor design according to fischer specification

Rebar type			Superbond Ø25			Superbond Ø28			Superbond Ø32		
eff. anchorage depth	h_{ef}	[mm]	100	250	500	112	250	560	128	300	640
non-cracked concrete											
temperature range (+40°C / +24°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	49.7	124.4	248.7	59.1	131.9	295.6	64.3	150.8	321.7
temperature range (+80°C / +50°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	47.1	117.8	235.6	55.8	124.6	279.1	64.3	150.8	321.7
temperature range (+120°C / +72°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	41.9	104.7	209.4	49.3	110.0	246.3	55.8	130.7	278.8
temperature range (+150°C / +90°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	39.3	98.2	196.3	46.0	102.6	229.9	51.5	120.6	257.4
cracked concrete											
temperature range (+40°C / +24°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	31.4	78.5	157.1	39.4	88.0	197.0	51.5	120.6	257.4
temperature range (+80°C / +50°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	31.4	78.5	157.1	39.4	88.0	197.0	51.5	120.6	257.4
temperature range (+120°C / +72°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	28.8	72.0	144.0	36.1	80.6	180.6	47.2	110.6	235.9
temperature range (+150°C / +90°C) 2)											
design resistance	$N^0_{Rd,p}$	[kN]	26.2	65.4	130.9	32.8	73.3	164.2	42.9	100.5	214.5

1) (short term temperature / long term temperature)

4

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	55
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,p}$	[-]	0.95	0.98	1.00	1.02	1.04	1.07	1.08	1.09	1.10

4.2.2 Characteristic edge distance and spacing for design

Rebar type			Superbond Ø8			Superbond Ø10			Superbond Ø12		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240
hammer drilled											
temperature range (+40°C / +24°C) [1]											
	$s_{cr, Np}$	[kN]	143	143	143	180	184	184	210	228	228
	$c_{cr, Np}$	[kN]	72	72	72	90	92	92	105	114	114
temperature range (+80°C / +50°C) [1]											
	$s_{cr, Np}$	[kN]	143	143	143	180	184	184	210	228	228
	$c_{cr, Np}$	[kN]	72	72	72	90	92	92	105	114	114
temperature range (+120°C / +72°C) [1]											
	$s_{cr, Np}$	[kN]	134	134	134	173	173	173	210	215	215
	$c_{cr, Np}$	[kN]	67	67	67	87	87	87	105	107	107
temperature range (+150°C / +90°C) [1]											
	$s_{cr, Np}$	[kN]	129	129	129	167	167	167	201	201	201
	$c_{cr, Np}$	[kN]	64	64	64	84	84	84	100	100	100

Rebar type			Superbond Ø14			Superbond Ø16			Superbond Ø20		
eff. anchorage depth	h_{ef}	[mm]	75	120	280	80	125	320	90	170	400
hammer drilled											
temperature range (+40°C / +24°C) [1]											
	$s_{cr, Np}$	[kN]	225	273	273	240	312	312	270	400	400
	$c_{cr, Np}$	[kN]	113	136	136	120	156	156	135	200	200
temperature range (+80°C / +50°C) [1]											
	$s_{cr, Np}$	[kN]	225	266	266	240	312	312	270	390	390
	$c_{cr, Np}$	[kN]	113	133	133	120	156	156	135	195	195
temperature range (+120°C / +72°C) [1]											
	$s_{cr, Np}$	[kN]	225	250	250	240	295	295	270	369	369
	$c_{cr, Np}$	[kN]	113	125	125	120	148	148	135	184	184
temperature range (+150°C / +90°C) [1]											
	$s_{cr, Np}$	[kN]	225	242	242	240	277	277	270	358	358
	$c_{cr, Np}$	[kN]	113	121	121	120	139	139	135	179	179

Rebar type			Superbond Ø25			Superbond Ø28			Superbond Ø32		
eff. anchorage depth	h_{ef}	[mm]	100	250	500	112	250	560	128	300	640
hammer drilled											
temperature range (+40°C / +24°C) [1]											
	$s_{cr, Np}$	[kN]	300	487	487	336	531	531	384	554	554
	$c_{cr, Np}$	[kN]	150	244	244	168	266	266	192	277	277
temperature range (+80°C / +50°C) [1]											
	$s_{cr, Np}$	[kN]	300	474	474	336	516	516	384	554	554
	$c_{cr, Np}$	[kN]	150	237	237	168	258	258	192	277	277
temperature range (+120°C / +72°C) [1]											
	$s_{cr, Np}$	[kN]	300	447	447	336	485	485	384	516	516
	$c_{cr, Np}$	[kN]	150	224	224	168	242	242	192	258	258
temperature range (+150°C / +90°C) [1]											
	$s_{cr, Np}$	[kN]	300	433	433	336	469	469	384	496	496
	$c_{cr, Np}$	[kN]	150	217	217	168	234	234	192	248	248

[1] (short term temperature / long term temperature)

4

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\, c_{cr,sp}$

Design resistance of single rebar

Rebar type	Superbond Ø8			Superbond Ø10			Superbond Ø12		
eff. anchorage depth h_{ef} [mm]	60	80	160	60	90	200	70	110	240
non-cracked concrete									
design resistance $N^0_{Rd,c}$ [kN]	15.6	24.1	68.1	15.6	28.7	95.2	19.7	38.8	125.2
cracked concrete									
design resistance $N^0_{Rd,c}$ [kN]	11.2	17.2	48.6	11.2	20.5	67.9	14.1	27.7	89.2

Rebar type	Superbond Ø14			Superbond Ø16			Superbond Ø20		
eff. anchorage depth h_{ef} [mm]	75	120	280	80	125	320	90	170	400
non-cracked concrete									
design resistance $N^0_{Rd,c}$ [kN]	21.9	44.3	157.7	24.1	47.1	192.7	28.7	74.6	269.3
cracked concrete									
design resistance $N^0_{Rd,c}$ [kN]	15.6	31.5	112.4	17.2	33.5	137.4	20.5	53.2	192.0

Rebar type	Superbond Ø25			Superbond Ø28			Superbond Ø32		
eff. anchorage depth h_{ef} [mm]	100	250	500	112	250	560	128	300	640
non-cracked concrete									
design resistance $N^0_{Rd,c}$ [kN]	33.7	133.1	376.4	39.9	133.1	446.2	48.8	174.9	545.1
cracked concrete									
design resistance $N^0_{Rd,c}$ [kN]	24.0	94.9	268.3	28.4	94.9	318.0	34.8	124.7	388.6

fischer Superbond Injection mortar FIS SB with rebars

Anchor design according to fischer specification

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,c}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Rebar type			Superbond Ø8			Superbond Ø10			Superbond Ø12		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240
	$s_{cr,N}$	[mm]	180	240	480	180	270	600	210	330	720
	$c_{cr,N}$	[mm]	90	120	240	90	135	300	105	165	360

Rebar type			Superbond Ø14			Superbond Ø16			Superbond Ø20		
eff. anchorage depth	h_{ef}	[mm]	75	120	280	80	125	320	90	170	400
	$s_{cr,N}$	[mm]	225	360	840	240	375	960	270	510	1200
	$c_{cr,N}$	[mm]	113	180	420	120	188	480	135	255	600

Rebar type			Superbond Ø25			Superbond Ø28			Superbond Ø32		
eff. anchorage depth	h_{ef}	[mm]	100	250	500	112	250	560	128	300	640
	$s_{cr,N}$	[mm]	300	750	1500	336	750	1680	384	900	1920
	$c_{cr,N}$	[mm]	150	375	750	168	375	840	192	450	960

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4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_s	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic values for design

Rebar type				Superbond Ø8			Superbond Ø10			Superbond Ø12		
eff. anchorage depth		h_{ef}	[mm]	60	80	160	60	90	200	70	110	240
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	120	160	320	120	180	400	140	220	480
		$c_{cr,sp}$	[mm]	60	80	160	60	90	200	70	110	240
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)								
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$								
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	271	362	723	271	407	904	316	497	1085
		$c_{cr,sp}$	[mm]	136	181	362	136	203	452	158	249	542
		h_{min}	[mm]	100	110	190	100	120	230	100 / 102[1]	140 / 142[1]	270 / 272[1]

Rebar type				Superbond Ø14			Superbond Ø16			Superbond Ø20		
eff. anchorage depth		h_{ef}	[mm]	75	120	280	80	125	320	90	170	400
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	150	240	560	160	250	640	180	340	800
		$c_{cr,sp}$	[mm]	75	120	280	80	125	320	90	170	400
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)								
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$								
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	339	542	1266	362	565	1446	407	768	1808
		$c_{cr,sp}$	[mm]	170	271	633	181	283	723	203	384	904
		h_{min}	[mm]	111	156	316	120	165	360	140	220	450

Rebar type				Superbond Ø25			Superbond Ø28			Superbond Ø32		
eff. anchorage depth		h_{ef}	[mm]	100	250	500	112	250	560	128	300	640
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	200	500	1000	224	500	1120	256	600	1280
		$c_{cr,sp}$	[mm]	100	250	500	112	250	560	128	300	640
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)								
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$								
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	452	1130	2260	506	1130	2531	579	1356	2893
		$c_{cr,sp}$	[mm]	226	565	1130	253	565	1266	289	678	1446
		h_{min}	[mm]	160	310	560	182	320	630	208	380	720

$f_{scr,sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.80	3.62	3.44	3.26	3.08	2.90	2.72	2.54	2.36	2.18	2.00

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.80	3.62	3.44	3.26	3.08	2.90	2.72	2.54	2.36	2.18	2.00

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≥1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\ (N_{Rd,p}\ ;\ N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single rebar

Rebar type	Superbond Ø8	Superbond Ø10	Superbond Ø12	Superbond Ø14	Superbond Ø16	Superbond Ø20	Superbond Ø25	Superbond Ø28	Superbond Ø32
design resistance $V_{Rd,s}$ [kN]	9.2	14.4	20.7	28.3	36.9	58.0	90.0	113.3	147.3

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\ (\ N_{Rd,p}\ ;\ N_{Rd,c}\ )$$

k-factor

Anchor type	Superbond Ø8 to Ø30
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- $c < \max(10\ h_{ef}\ ;\ 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]											
	Superbond Ø8						Superbond Ø10					
h_{ef}	60	60	80	80	160	160	60	60	90	90	200	200
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
40	3.5	2.5	3.7	2.6	4.4	3.1						
45	4.1	2.9	4.3	3.1	5.1	3.6	4.3	3.0	4.7	3.3	5.8	4.1
50	4.7	3.3	5.0	3.5	5.8	4.1	4.9	3.5	5.3	3.8	6.6	4.7
55	5.4	3.8	5.6	4.0	6.6	4.7	5.6	3.9	6.0	4.3	7.4	5.2
60	6.0	4.3	6.3	4.5	7.3	5.2	6.2	4.4	6.8	4.8	8.2	5.8
65	6.7	4.7	7.0	5.0	8.1	5.7	6.9	4.9	7.5	5.3	9.0	6.4
70	7.4	5.2	7.8	5.5	8.9	6.3	7.7	5.4	8.3	5.8	9.9	7.0
75	8.1	5.8	8.5	6.0	9.7	6.9	8.4	5.9	9.0	6.4	10.8	7.6
80	8.9	6.3	9.3	6.6	10.6	7.5	9.2	6.5	9.8	7.0	11.7	8.3
85	9.6	6.8	10.1	7.1	11.4	8.1	9.9	7.0	10.7	7.5	12.6	8.9
90	10.4	7.4	10.9	7.7	12.3	8.7	10.7	7.6	11.5	8.1	13.5	9.6
95	11.2	7.9	11.7	8.3	13.2	9.4	11.5	8.2	12.3	8.7	14.5	10.3
100	12.0	8.5	12.6	8.9	14.1	10.0	12.4	8.8	13.2	9.4	15.5	11.0
110	13.7	9.7	14.3	10.1	16.0	11.3	14.1	10.0	15.0	10.6	17.5	12.4
120	15.5	10.9	16.1	11.4	18.0	12.7	15.9	11.2	16.9	12.0	19.5	13.8
125	16.4	11.6	17.0	12.0	19.0	13.4	16.8	11.9	17.8	12.6	20.6	14.6
130	17.3	12.2	17.9	12.7	20.0	14.1	17.7	12.5	18.8	13.3	21.7	15.3
135	18.2	12.9	18.9	13.4	21.0	14.9	18.7	13.2	19.8	14.0	22.8	16.1
140	19.1	13.6	19.9	14.1	22.0	15.6	19.6	13.9	20.8	14.7	23.9	16.9
160	23.0	16.3	23.9	16.9	26.3	18.7	23.6	16.7	24.9	17.7	28.4	20.1
180	27.1	19.2	28.1	19.9	30.9	21.9	27.8	19.7	29.3	20.7	33.2	23.5
200	31.4	22.3	32.5	23.0	35.6	25.2	32.1	22.8	33.8	23.9	38.1	27.0
250	43.0	30.5	44.3	31.4	48.2	34.1	43.9	31.1	46.0	32.6	51.3	36.4
300	55.6	39.4	57.2	40.5	61.9	43.8	56.7	40.2	59.2	42.0	65.6	46.5
350	69.2	49.0	71.1	50.3	76.5	54.2	70.5	49.9	73.4	52.0	80.9	57.3
400	83.7	59.3	85.8	60.8	92.1	65.2	85.1	60.3	88.5	62.7	97.0	68.7
450	98.9	70.1	101.4	71.8	108.4	76.8	100.6	71.2	104.4	74.0	114.0	80.8
500	115.0	81.4	117.7	83.4	125.6	89.0	116.8	82.7	121.2	85.8	131.8	93.4
550	131.8	93.3	134.8	95.5	143.5	101.7	133.8	94.8	138.6	98.2	150.4	106.5
600	149.2	105.7	152.6	108.1	162.1	114.9	151.5	107.3	156.8	111.0	169.6	120.2
650	167.4	118.6	171.0	121.2	181.4	128.5	169.8	120.3	175.6	124.4	189.6	134.3
700			190.1	134.7	201.4	142.7			195.1	138.2	210.2	148.9
750			209.9	148.6	222.0	157.2			215.1	152.4	231.4	163.9
800			230.2	163.0	243.1	172.2			235.8	167.1	253.2	179.4
850			251.1	177.8	264.9	187.6			257.1	182.1	275.6	195.3
900					287.2	203.5			279.0	197.6	298.6	211.5
950					310.1	219.7			301.3	213.4	322.2	228.2
1000					333.5	236.2					346.3	245.3
1100					381.9	270.5					396.0	280.5
1200					432.3	306.2					447.7	317.1
1300					484.5	343.2					501.4	355.1
1400					538.6	381.5					556.8	394.4
1600					652.0	461.8					673.0	476.7
1800					771.9	546.7					795.8	563.7
2000											924.7	655.0
2200											1059.5	750.5

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fischer Superbond Injection mortar FIS SB with rebars

Anchor design according to fischer specification

	$V^0_{Rd,c}$ [kN]											
	Superbond Ø12						Superbond Ø14					
h_{ef}	70	70	110	110	240	240	75	75	120	120	280	280
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
55	5.9	4.2	6.6	4.6	8.2	5.8						
60	6.6	4.7	7.3	5.2	9.1	6.4	6.9	4.9	7.7	5.5	10.0	7.1
65	7.3	5.2	8.1	5.7	10.0	7.1	7.6	5.4	8.5	6.0	11.0	7.8
70	8.1	5.7	8.9	6.3	10.9	7.7	8.4	6.0	9.4	6.6	11.9	8.5
75	8.9	6.3	9.7	6.9	11.8	8.4	9.2	6.5	10.2	7.2	12.9	9.2
80	9.7	6.8	10.6	7.5	12.8	9.1	10.0	7.1	11.1	7.9	14.0	9.9
85	10.5	7.4	11.4	8.1	13.8	9.8	10.9	7.7	12.0	8.5	15.0	10.6
90	11.3	8.0	12.3	8.7	14.8	10.5	11.7	8.3	12.9	9.1	16.0	11.4
95	12.1	8.6	13.2	9.4	15.8	11.2	12.6	8.9	13.8	9.8	17.1	12.1
100	13.0	9.2	14.1	10.0	16.8	11.9	13.5	9.5	14.8	10.5	18.2	12.9
110	14.8	10.5	16.0	11.3	18.9	13.4	15.3	10.8	16.7	11.8	20.4	14.5
120	16.6	11.8	17.9	12.7	21.1	15.0	17.2	12.2	18.7	13.2	22.7	16.1
125	17.6	12.4	18.9	13.4	22.2	15.7	18.1	12.8	19.7	14.0	23.9	16.9
130	18.5	13.1	20.0	14.1	23.4	16.5	19.1	13.5	20.8	14.7	25.1	17.7
135	19.5	13.8	21.0	14.9	24.5	17.4	20.1	14.2	21.8	15.5	26.3	18.6
140	20.5	14.5	22.0	15.6	25.7	18.2	21.1	15.0	22.9	16.2	27.5	19.5
160	24.6	17.4	26.3	18.6	30.4	21.6	25.3	17.9	27.3	19.3	32.5	23.0
180	28.9	20.5	30.8	21.8	35.4	25.1	29.7	21.0	31.9	22.6	37.7	26.7
200	33.4	23.6	35.6	25.2	40.6	28.8	34.3	24.3	36.8	26.0	43.1	30.5
250	45.5	32.2	48.2	34.1	54.4	38.5	46.6	33.0	49.7	35.2	57.4	40.6
300	58.6	41.5	61.9	43.8	69.2	49.0	59.9	42.5	63.7	45.1	72.8	51.6
350	72.7	51.5	76.5	54.2	85.1	60.3	74.3	52.6	78.6	55.7	89.2	63.2
400	87.7	62.1	92.0	65.2	101.8	72.1	89.5	63.4	94.5	66.9	106.5	75.4
450	103.5	73.3	108.4	76.8	119.4	84.6	105.5	74.7	111.2	78.7	124.6	88.3
500	120.1	85.0	125.6	89.0	137.8	97.6	122.4	86.7	128.6	91.1	143.6	101.7
550	137.4	97.3	143.5	101.7	156.9	111.2	139.9	99.1	146.9	104.0	163.2	115.6
600	155.4	110.1	162.1	114.8	176.8	125.2	158.2	112.1	165.8	117.5	183.7	130.1
650	174.1	123.4	181.4	128.5	197.3	139.8	177.2	125.5	185.4	131.4	204.8	145.0
700	193.5	137.1	201.4	142.7	218.5	154.8	196.8	139.4	205.7	145.7	226.5	160.5
750	213.5	151.2	222.0	157.2	240.3	170.2	217.0	153.7	226.6	160.5	248.9	176.3
800			243.2	172.2	262.8	186.1	237.9	168.5	248.1	175.8	272.0	192.6
850			264.9	187.7	285.8	202.5	259.3	183.6	270.2	191.4	295.6	209.4
900			287.3	203.5	309.4	219.2			292.9	207.5	319.7	226.5
950			310.1	219.7	333.6	236.3			316.1	223.9	344.5	244.0
1000			333.6	236.3	358.3	253.8			339.9	240.8	369.8	261.9
1100			381.9	270.5	409.3	289.9			389.0	275.5	421.9	298.9
1200			432.3	306.2	462.3	327.4			440.0	311.7	476.1	337.2
1300					517.2	366.3			493.0	349.2	532.2	377.0
1400					573.9	406.5					590.1	418.0
1500					632.4	448.0					649.9	460.3
1600					692.7	490.6					711.3	503.9
1800					818.1	579.5					839.2	594.4
2000					949.7	672.7					973.3	689.4
2200					1087.2	770.1					1113.3	788.6
2400					1230.3	871.5					1259.0	891.8
2600					1378.9	976.7					1410.1	998.8
2800											1566.3	1109.5
3000											1727.6	1223.7

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fischer Superbond Injection mortar FIS SB with rebars

Anchor design according to fischer specification

	$V^0_{Rd,c}$ [kN]											
	Superbond Ø16						Superbond Ø20					
h_{ef}	80	80	125	125	320	320	90	90	170	170	400	400
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
65	7.9	5.6	8.9	6.3	12.0	8.5						
70	8.7	6.2	9.7	6.9	13.0	9.2						
75	9.5	6.8	10.6	7.5	14.1	10.0						
80	10.4	7.4	11.5	8.1	15.1	10.7						
85	11.2	8.0	12.4	8.8	16.2	11.5	12.0	8.5	14.1	10.0	18.8	13.3
90	12.1	8.6	13.3	9.4	17.3	12.3	12.9	9.1	15.1	10.7	20.0	14.2
95	13.0	9.2	14.3	10.1	18.5	13.1	13.8	9.8	16.1	11.4	21.2	15.0
100	13.9	9.8	15.2	10.8	19.6	13.9	14.7	10.4	17.2	12.2	22.5	15.9
110	15.8	11.2	17.2	12.2	21.9	15.5	16.7	11.8	19.3	13.7	25.0	17.7
120	17.7	12.5	19.3	13.7	24.3	17.2	18.7	13.2	21.5	15.2	27.6	19.6
125	18.7	13.2	20.3	14.4	25.5	18.1	19.7	13.9	22.6	16.0	28.9	20.5
130	19.7	13.9	21.4	15.1	26.8	19.0	20.7	14.7	23.8	16.8	30.3	21.4
135	20.7	14.6	22.5	15.9	28.0	19.8	21.8	15.4	24.9	17.7	31.6	22.4
140	21.7	15.4	23.5	16.7	29.3	20.7	22.9	16.2	26.1	18.5	33.0	23.4
160	26.0	18.4	28.1	19.9	34.5	24.4	27.3	19.3	30.9	21.9	38.6	27.3
180	30.4	21.6	32.8	23.2	39.9	28.3	31.9	22.6	36.0	25.5	44.4	31.5
200	35.1	24.9	37.7	26.7	45.5	32.2	36.7	26.0	41.2	29.2	50.4	35.7
250	47.6	33.7	50.8	36.0	60.4	42.8	49.7	35.2	55.2	39.1	66.3	47.0
300	61.2	43.4	65.0	46.1	76.3	54.0	63.6	45.1	70.2	49.7	83.3	59.0
350	75.8	53.7	80.2	56.8	93.2	66.0	78.6	55.7	86.2	61.1	101.2	71.7
400	91.2	64.6	96.3	68.2	111.0	78.7	94.5	66.9	103.2	73.1	120.0	85.0
450	107.5	76.1	113.2	80.2	129.7	91.9	111.2	78.7	120.9	85.7	139.7	98.9
500	124.5	88.2	130.9	92.8	149.2	105.7	128.6	91.1	139.5	98.8	160.2	113.5
550	142.4	100.8	149.4	105.8	169.4	120.0	146.9	104.0	158.8	112.5	181.4	128.5
600	160.9	113.9	168.6	119.4	190.4	134.8	165.8	117.5	178.9	126.7	203.4	144.1
650	180.1	127.5	188.5	133.5	212.0	150.2	185.5	131.4	199.6	141.4	226.1	160.1
700	199.9	141.6	209.0	148.0	234.3	166.0	205.8	145.7	221.0	156.5	249.4	176.7
750	220.4	156.1	230.1	163.0	257.3	182.2	226.7	160.6	243.0	172.1	273.4	193.6
800	241.5	171.0	251.9	178.4	280.8	198.9	248.2	175.8	265.7	188.2	298.0	211.0
850	263.1	186.4	274.2	194.3	305.0	216.0	270.3	191.5	288.9	204.6	323.1	228.9
900	285.3	202.1	297.2	210.5	329.7	233.6	293.0	207.5	312.7	221.5	348.9	247.1
950	308.1	218.2	320.6	227.1	355.0	251.5	316.2	224.0	337.1	238.8	375.2	265.8
1000	331.4	234.8	344.6	244.1	380.9	269.8	340.0	240.8	362.0	256.4	402.1	284.8
1100			394.2	279.2	434.1	307.5	389.1	275.6	413.4	292.8	457.5	324.1
1200			445.8	315.8	489.4	346.7	440.2	311.8	466.9	330.7	514.9	364.7
1300			499.3	353.7	546.6	387.2	493.2	349.4	522.2	369.9	574.2	406.7
1400					605.7	429.1			579.4	410.4	635.4	450.1
1500					666.6	472.2			638.4	452.2	698.5	494.7
1600					729.2	516.5			699.1	495.2	763.2	540.6
1800					859.4	608.7			825.4	584.7	897.7	635.9
2000					995.8	705.4					1038.5	735.6
2200					1138.2	806.2					1185.3	839.6
2400					1286.3	911.1					1337.8	947.6
2600					1439.8	1019.8					1495.8	1059.5
2800					1598.5	1132.3					1659.0	1175.1
3000					1762.2	1248.2					1827.3	1294.3
3200					1930.7	1367.6					2000.4	1416.9
3400											2178.2	1542.9
3600											2360.5	1672.1
3800											2547.3	1804.4
4000											2738.4	1939.7
4500											3234.3	2291.0

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fischer Superbond Injection mortar FIS SB with rebars

Anchor design according to fischer specification

	$V^0_{Rd,c}$ [kN]											
	Superbond Ø25						Superbond Ø28					
h_{ef}	100	100	250	250	500	500	112	112	250	250	560	560
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
110	17,7	12,5	22,6	16,0	29,1	20,6						
120	19,8	14,0	25,1	17,7	31,9	22,6						
125	20,8	14,7	26,3	18,6	33,4	23,7						
130	21,9	15,5	27,6	19,5	34,9	24,7	22,9	16,2	28,3	20,0	37,7	26,7
135	23,0	16,3	28,8	20,4	36,3	25,7	24,0	17,0	29,6	20,9	39,3	27,8
140	24,1	17,1	30,1	21,3	37,8	26,8	25,1	17,8	30,9	21,9	40,8	28,9
160	28,7	20,3	35,4	25,1	43,9	31,1	29,9	21,1	36,3	25,7	47,2	33,4
180	33,5	23,7	41,0	29,0	50,2	35,6	34,8	24,6	41,9	29,7	53,8	38,1
200	38,5	27,3	46,7	33,1	56,7	40,2	39,9	28,3	47,7	33,8	60,6	42,9
250	51,8	36,7	61,8	43,8	73,8	52,3	53,6	38,0	63,0	44,6	78,3	55,5
300	66,2	46,9	78,0	55,3	91,9	65,1	68,3	48,4	79,5	56,3	97,2	68,8
350	81,6	57,8	95,2	67,5	111,0	78,7	84,1	59,6	96,9	68,6	117,0	82,9
400	97,9	69,4	113,4	80,3	131,1	92,8	100,7	71,3	115,2	81,6	137,7	97,5
450	115,1	81,5	132,3	93,7	151,9	107,6	118,2	83,7	134,4	95,2	159,2	112,8
500	133,0	94,2	152,1	107,7	173,6	123,0	136,5	96,7	154,4	109,4	181,6	128,6
550	151,7	107,5	172,6	122,3	196,1	138,9	155,6	110,2	175,1	124,1	204,7	145,0
600	171,1	121,2	193,9	137,3	219,2	155,3	175,3	124,2	196,6	139,3	228,6	161,9
650	191,2	135,4	215,8	152,9	243,1	172,2	195,8	138,7	218,8	155,0	253,1	179,3
700	212,0	150,1	238,5	168,9	267,6	189,5	216,9	153,6	241,6	171,2	278,3	197,1
750	233,4	165,3	261,7	185,4	292,8	207,4	238,7	169,0	265,1	187,8	304,2	215,5
800	255,4	180,9	285,6	202,3	318,6	225,6	261,0	184,9	289,2	204,9	330,6	234,2
850	277,9	196,9	310,1	219,6	345,0	244,3	284,0	201,2	314,0	222,4	357,7	253,4
900	301,1	213,3	335,1	237,4	371,9	263,4	307,5	217,8	339,2	240,3	385,4	273,0
950	324,8	230,1	360,8	255,5	399,5	283,0	331,6	234,9	365,1	258,6	413,6	293,0
1000	349,1	247,3	386,9	274,1	427,6	302,9	356,3	252,3	391,5	277,3	442,4	313,4
1100	399,2	282,7	440,9	312,3	485,3	343,8	407,1	288,4	445,9	315,9	501,6	355,3
1200	451,3	319,6	496,9	351,9	545,2	386,2	460,0	325,8	502,4	355,8	562,8	398,6
1300			554,8	393,0	607,0	429,9	514,7	364,6	560,7	397,2	625,9	443,4
1400			614,6	435,3	670,6	475,0	571,4	404,7	621,0	439,9	691,0	489,5
1500			676,1	478,9	736,1	521,4	629,8	446,1	683,1	483,8	757,9	536,8
1600			739,4	523,8	803,3	569,0	689,9	488,7	746,9	529,0	826,5	585,4
1800			871,1	617,0	942,8	667,8	815,1	577,4	879,5	622,9	968,8	686,2
2000			1009,0	714,7	1088,6	771,1			1018,4	721,4	1117,5	791,5
2200			1152,9	816,6	1240,5	878,7			1163,3	824,0	1272,2	901,1
2400			1302,5	922,6	1398,1	990,3			1313,9	930,7	1432,7	1014,8
2600			1457,5	1032,4	1561,2	1105,9			1470,0	1041,2	1598,6	1132,4
2800					1729,6	1225,1					1769,9	1253,7
3000					1903,0	1348,0					1946,3	1378,6
3200					2081,4	1474,3					2127,5	1507,0
3400					2264,4	1604,0					2313,6	1638,8
3600					2452,1	1736,9					2504,2	1773,8
3800					2644,2	1873,0					2699,3	1912,0
4000					2840,6	2012,1					2898,7	2053,2
4500					3349,9	2372,9					3415,6	2419,4
5000					3884,1	2751,2					3957,3	2803,1
5500					4441,8	3146,3					4522,7	3203,6
6000											5110,6	3620,0

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fischer Superbond Injection mortar FIS SB with rebars

Anchor design according to fischer specification

h_{ef}	$V^0_{Rd,c}$ [kN] Superbond Ø30					
	128	128	300	300	640	640
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
160	31.4	22.2	39.3	27.9	51.7	36.6
180	36.5	25.8	45.3	32.1	58.7	41.6
200	41.8	29.6	51.4	36.4	65.8	46.6
250	55.9	39.6	67.5	47.8	84.5	59.9
300	71.1	50.4	84.6	60.0	104.2	73.8
350	87.3	61.8	102.8	72.8	124.9	88.5
400	104.3	73.9	121.9	86.3	146.5	103.8
450	122.3	86.6	141.8	100.5	169.0	119.7
500	141.0	99.9	162.6	115.2	192.2	136.1
550	160.5	113.7	184.1	130.4	216.2	153.1
600	180.8	128.0	206.3	146.2	240.9	170.7
650	201.7	142.8	229.3	162.4	266.4	188.7
700	223.2	158.1	252.9	179.1	292.5	207.2
750	245.5	173.9	277.1	196.3	319.2	226.1
800	268.3	190.0	302.0	213.9	346.5	245.5
850	291.7	206.6	327.5	232.0	374.5	265.3
900	315.7	223.7	353.5	250.4	403.0	285.5
950	340.3	241.1	380.2	269.3	432.2	306.1
1000	365.4	258.8	407.4	288.5	461.8	327.1
1100	417.2	295.5	463.3	328.2	522.8	370.3
1200	471.1	333.7	521.3	369.3	585.7	414.9
1300	526.8	373.2	581.3	411.7	650.7	460.9
1400	584.5	414.0	643.1	455.6	717.5	508.3
1500	643.9	456.1	706.8	500.6	786.2	556.9
1600	705.0	499.4	772.2	547.0	856.6	606.8
1800	832.3	589.5	908.0	643.2	1002.5	710.1
2000	965.8	684.1	1050.2	743.9	1154.8	818.0
2200			1198.4	848.9	1313.2	930.2
2400			1352.3	957.9	1477.3	1046.4
2600			1511.7	1070.8	1646.9	1166.6
2800			1676.4	1187.5	1821.9	1290.5
3000			1846.1	1307.7	2002.0	1418.1
3200			2020.8	1431.4	2187.0	1549.1
3400					2376.7	1683.5
3600					2571.1	1821.2
3800					2770.0	1962.1
4000					2973.2	2106.0
4500					3499.6	2478.9
5000					4051.1	2869.5
5500					4626.2	3276.9
6000					5223.9	3700.2
6500					5843.1	4138.9

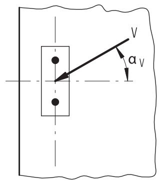
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,V}$	[-]	0,77	0,89	1,00	1,10	1,22	1,34	1,41	1,48	1,55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

4

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

4

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

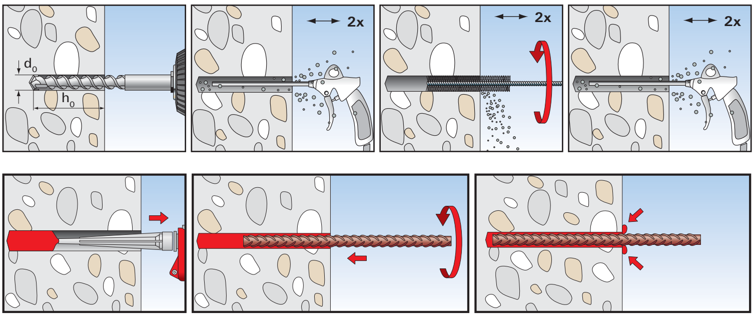
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details



fischer Superbond Injection mortar FIS SB with rebars

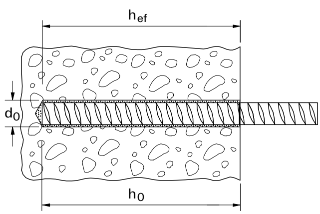
Anchor design according to fischer specification

8. Anchor characteristics FIS SB with rebars

Rebar type			Superbond Ø8			Superbond Ø10			Superbond Ø12		
	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240
diameter of rebar				8			10			12	
nominal drill hole diameter	d_0	[mm]		12			14			16	
drill depth = effective anchorage depth	$h_0 = h_{ef}$	[mm]	60	80	160	60	90	200	70	110	240
minimum thickness of concrete member	h_{min}	[mm]	100	110	190	100	120	230	100	140	270
minimum spacing	s_{min}	[mm]		40			45			55	
minimum edge distance	c_{min}	[mm]		40			45			55	
mortar filling quantity		[scale units]	3	4	7	3	5	10	4	6	13

Rebar type			Superbond Ø14			Superbond Ø16			Superbond Ø20		
	h_{ef}	[mm]	75	120	280	80	125	320	90	170	400
diameter of rebar				14			16			20	
nominal drill hole diameter	d_0	[mm]		18			20			25	
drill depth = effective anchorage depth	$h_0 = h_{ef}$	[mm]	75	120	280	80	125	320	90	170	400
minimum thickness of concrete member	h_{min}	[mm]	105	150	310	120	165	360	140	220	450
minimum spacing	s_{min}	[mm]		60			65			85	
minimum edge distance	c_{min}	[mm]		60			65			85	
mortar filling quantity		[scale units]	5	8	13	6	9	23	10	19	43

Rebar type			Superbond Ø25			Superbond Ø28			Superbond Ø32		
	h_{ef}	[mm]	100	250	500	112	250	560	128	300	640
diameter of rebar				25			28			32	
nominal drill hole diameter	d_0	[mm]		30			35			40	
drill depth = effective anchorage depth	$h_0 = h_{ef}$	[mm]	100	250	500	112	250	560	128	300	640
minimum thickness of concrete member	h_{min}	[mm]	160	310	560	182	320	630	208	380	720
minimum spacing	s_{min}	[mm]		110			130			160	
minimum edge distance	c_{min}	[mm]		110			130			160	
mortar filling quantity		[scale units]	13	33	65	24	52	116	35	81	172



9. Gelling and curing times

System temperature	Max. processing time FIS SB
– 30 °C to – 20 °C	-
> – 20 °C to – 15 °C	-
> – 15 °C to – 10 °C	60 min.
> – 10 °C to – 5°C	30 min.
> – 5 °C to 0 ° C	20 min.
> 0 °C to + 5 °C	13 min.
> + 5 °C to + 10 °C	9 min.
> + 10 °C to + 20 °C	5 min.
> + 20 °C to + 30 °C	4 min.
> + 30 °C to + 40 °C	2 min.

Temperature at anchoring base	Curing time FIS SB
– 30 °C to – 20 °C	-
> – 20 °C to – 15 °C	-
> – 15 °C to – 10 °C	36 h
> – 10 °C to – 5°C	24 h
> – 5 °C to 0 ° C	8 h
> 0 °C to + 5 °C	4 h
> + 5 °C to + 10 °C	120 min.
> + 10 °C to + 20 °C	60 min.
> + 20 °C to + 30 °C	45 min.
> + 30 °C to + 40 °C	30 min.

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least 0 °C. For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.

4

10. Mechanical characteristics of rebars B 500 B

Anchor type			Superbond ⌀ 8	Superbond ⌀ 10	Superbond ⌀ 12	Superbond ⌀ 14	Superbond ⌀ 16	Superbond ⌀ 18	Superbond ⌀ 20
stressed cross sectional area reinforcing steel	A_s	[mm²]	50	79	113	154	201	254	314
resisting moment reinforcing steel	W	[mm³]	50	98	170	269	402	573	785
yield strength reinforcing steel	f_{yk}	[N/mm²]	500						
tensile strength reinforcing steel	f_{uk}	[N/mm²]	550						

Anchor type			Superbond ⌀ 22	Superbond ⌀ 24	Superbond ⌀ 25	Superbond ⌀ 26	Superbond ⌀ 28	Superbond ⌀ 30	Superbond ⌀ 32
stressed cross sectional area reinforcing steel	A_s	[mm²]	380	452	491	531	616	707	804
resisting moment reinforcing steel	W	[mm³]	1045	1357	1534	1726	2155	2651	3217
yield strength reinforcing steel	f_{yk}	[N/mm²]	500						
tensile strength reinforcing steel	f_{uk}	[N/mm²]	550						

Notes

fischer Injection mortar FIS EM

Anchor design according to fischer specification

1. Types

FIS A M8 - M42 - threaded rod (gvz, A4 and C)

RG M8 - M30 - threaded rod (gvz, A4 and C)

Injection mortar FIS EM 390 S, FIS EM 585 S, FIS EM 1500 S

ETA CE *)
ETA-10/0012
ETAG 001-5
Option 1 for cracked concrete

ICC ES *)
ESR-1990
See ICC-ES Evaluation Report at www.ic-es.org
Inspection agency: AA-707

Fire resistance classification
R 120
Anchor types see test report

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval *) for cracked and non-cracked concrete.
- ICC-ES Evaluation Report *) for cracked and non-cracked concrete, Seismic categories A-F.
- Expansion stress free anchoring guarantees for a save use with small spacings and edge distances.
- Less cleaning procedures of the drill hole due to the high-quality epoxy resin.
- The resin seals the drill hole and avoids penetration of dampness and therefore gives corrosion protection for the embedded steel.
- Variable embedment depth enables the application in all kinds of building structure.
- Large range of available fixing length gives perfect allocation to the given fixture.
- Suitable for underwater installations. (See reduction factor; Section 4.2).
- Suitable for diamond drilled holes guarantees highest flexibility on site. (See reduction factor; Section 4.2).
- Longer curing time for simple installation, especially for large embedment depth.
- Low shrinkage of the mortar enables the use of large anchor diameters.
- Approved for temperatures from −40 °C to +72 °C.
- Suitable for pre-positioned and push-through installation.

*) The conditions of use (e.g. design resistances, characteristic disistance, ...) in the European Technical Approval or in the ICC-ES Evaluation Report may vary from those of the Technical Handbook. ETA is currently only valid for diameters up to M30 and carbon steel grade up to 8.8. The ICC-ES Evaluation Report is valid for diameters up to M30 and carbon steel grade up to 8.8.

Materials

Threaded rod :
- Carbon steel grade 5.8 and 8.8 zinc plated (5 µm) and passivated (gvz)
- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
- Highly corrosion-resistant steel of the corrosion resistance class IV, e.g. 1.4529

Injection mortar:
- Epoxy resin, cement and hardener

fischer Injection mortar FIS EM

Anchor design according to fischer specification

2. Ultimate resistances of single anchors with large spacing and large edge distance[1)]

Mean values

Anchor type	FIS EM M8							FIS EM M10						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	80							90						
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_u [kN]	20.0	31.5	20.0	27.3	20.0	27.3	31.5	30.5	49.4	30.5	43.1	30.5	43.1	49.4
C 50/60 N_u [kN]	20.0	31.5	20.0	27.3	20.0	27.3	31.5	30.5	49.4	30.5	43.1	30.5	43.1	49.4
shear static ≥ C 20/25 V_u [kN]	12.0	18.9	12.0	16.4	12.0	16.4	18.9	18.3	29.6	18.3	25.8	18.3	25.8	29.6
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_u [kN]	20.0	31.5	20.0	27.3	20.0	27.3	31.5	30.5	39.2	30.5	39.2	30.5	39.2	39.2
C 50/60 N_u [kN]	20.0	31.5	20.0	27.3	20.0	27.3	31.5	30.5	49.4	30.5	43.1	30.5	43.1	49.4
shear static ≥ C 20/25 V_u [kN]	12.0	18.9	12.0	16.4	12.0	16.4	18.9	18.3	29.6	18.3	25.8	18.3	25.8	29.6

Anchor type	FIS EM M12							FIS EM M14						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	110							120						
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_u [kN]	45.2	71.4	45.2	62.0	45.2	62.0	71.4	60.9	88.7	60.9	85.1	60.9	85.1	88.7
C 50/60 N_u [kN]	45.2	71.4	45.2	62.0	45.2	62.0	71.4	60.9	96.6	60.9	85.1	60.9	85.1	96.6
shear static ≥ C 20/25 V_u [kN]	27.1	42.8	27.1	37.2	27.1	37.2	42.8	36.5	58.0	36.5	51.0	36.5	51.0	58.0
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_u [kN]	45.2	53.0	45.2	53.0	45.2	53.0	53.0	60.3	60.3	60.3	60.3	60.3	60.3	60.3
C 50/60 N_u [kN]	45.2	71.4	45.2	62.0	45.2	62.0	71.4	60.9	93.5	60.9	85.1	60.9	85.1	93.5
shear static ≥ C 20/25 V_u [kN]	27.1	42.8	27.1	37.2	27.1	37.2	42.8	36.5	58.0	36.5	51.0	36.5	51.0	58.0

Anchor type	FIS EM M16							FIS EM M20						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	125							170						
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_u [kN]	83.0	94.3	83.0	94.3	83.0	94.3	94.3	129.2	149.6	129.2	149.6	129.2	149.6	149.6
C 50/60 N_u [kN]	83.0	132.3	83.0	115.5	83.0	115.5	132.3	129.2	205.8	129.2	180.6	129.2	180.6	205.8
shear static ≥ C 20/25 V_u [kN]	49.8	79.4	49.8	69.3	49.8	69.3	79.4	77.5	123.5	77.5	108.4	77.5	108.4	123.5
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_u [kN]	64.1	64.1	64.1	64.1	64.1	64.1	64.1	101.7	101.7	101.7	101.7	101.7	101.7	101.7
C 50/60 N_u [kN]	83.0	99.4	83.0	99.4	83.0	99.4	99.4	129.2	157.6	129.2	157.6	129.2	157.6	157.6
shear static ≥ C 20/25 V_u [kN]	49.8	79.4	49.8	69.3	49.8	69.3	79.4	77.5	123.5	77.5	108.4	77.5	108.4	123.5

Anchor type	FIS EM M22							FIS EM M24						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	190							210						
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_u [kN]	159.6	176.8	159.6	176.8	159.6	176.8	176.8	185.9	205.4	185.9	205.4	185.9	205.4	205.4
C 50/60 N_u [kN]	159.6	255.2	159.6	222.6	159.6	222.6	255.2	185.9	296.1	185.9	259.4	185.9	259.4	296.1
shear static ≥ C 20/25 V_u [kN]	95.8	153.1	95.8	133.6	95.8	133.6	153.1	111.5	177.7	111.5	155.6	111.5	155.6	177.7
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_u [kN]	120.2	120.2	120.2	120.2	120.2	120.2	120.2	139.7	139.7	139.7	139.7	139.7	139.7	139.7
C 50/60 N_u [kN]	159.6	186.2	159.6	186.2	159.6	186.2	186.2	185.9	216.4	185.9	216.4	185.9	216.4	216.4
shear static ≥ C 20/25 V_u [kN]	95.8	153.1	95.8	133.6	95.8	133.6	153.1	111.5	177.7	111.5	155.6	111.5	155.6	177.7

fischer Injection mortar FIS EM

Anchor design according to fischer specification

Anchor type	FIS EM M27							FIS EM M30						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	250							280						
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2]														
tension static C 20/25 N_u [kN]	241.5	266.8	241.5	266.8	241.5	266.8	266.8	295.1	316.3	295.1	316.3	295.1	316.3	316.3
C 50/60 N_u [kN]	241.5	386.4	241.5	338.1	241.5	338.1	386.4	295.1	471.5	295.1	412.7	295.1	412.7	471.5
shear static ≧ C 20/25 V_u [kN]	144.9	231.8	144.9	202.9	144.9	202.9	231.8	177.0	282.9	177.0	247.6	177.0	247.6	282.9
cracked concrete temperature range (+ 60 °C / + 35 °C) [2]														
tension static C 20/25 N_u [kN]	181.4	181.4	181.4	181.4	181.4	181.4	181.4	215.1	215.1	215.1	215.1	215.1	215.1	215.1
C 50/60 N_u [kN]	241.5	281.1	241.5	281.1	241.5	281.1	281.1	295.1	333.2	295.1	333.2	295.1	333.2	333.2
shear static ≧ C 20/25 V_u [kN]	144.9	231.8	144.9	202.9	144.9	202.9	231.8	177.0	282.9	177.0	247.6	177.0	247.6	282.9

Anchor type	FIS EM M36	FIS EM M39	FIS EM M42
	gvz 5.8	gvz 5.8	gvz 5.8
h_{ef} [mm]	330	360	400
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2]			
tension static C 20/25 N_u [kN]	404.6	461.1	540.0
C 50/60 N_u [kN]			
shear static ≧ C 20/25 V_u [kN]	257.4	307.4	353.1
cracked concrete temperature range (+ 60 °C / + 35 °C) [2]			
tension static C 20/25 N_u [kN]	245.5	290.2	347.2
C 50/60 N_u [kN]			
shear static ≧ C 20/25 V_u [kN]	257.4	307.4	353.1

1) The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 60 °C and long term temperature T ≤ + 35 °C (see also „Installation details", section 7).

2) (short term temperature / long term temperature)

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance[1)]

Anchor type	FIS EM M8							FIS EM M10						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	80							90						
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rk} [kN]	19.0	30.0	19.0	26.0	19.0	26.0	30.0	29.0	43.1	29.0	41.0	29.0	41.0	43.1
C 50/60 N_{Rk} [kN]	19.0	30.0	19.0	26.0	19.0	26.0	30.0	29.0	47.0	29.0	41.0	29.0	41.0	47.0
shear static ≧ C 20/25 V_{Rk} [kN]	9.0	15.0	9.0	13.0	9.0	13.0	15.0	15.0	23.0	15.0	20.0	15.0	20.0	23.0
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rk} [kN]	14.1	14.1	14.1	14.1	14.1	14.1	14.1	19.8	19.8	19.8	19.8	19.8	19.8	19.8
C 50/60 N_{Rk} [kN]	15.3	15.3	15.3	15.3	15.3	15.3	15.3	21.6	21.6	21.6	21.6	21.6	21.6	21.6
shear static ≧ C 20/25 V_{Rk} [kN]	9.0	15.0	9.0	13.0	9.0	13.0	15.0	15.0	23.0	15.0	20.0	15.0	20.0	23.0

Anchor type	FIS EM M12							FIS EM M14						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	110							120						
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rk} [kN]	43.0	58.3	43.0	58.3	43.0	58.3	58.3	58.0	66.4	58.0	66.4	58.0	66.4	66.4
C 50/60 N_{Rk} [kN]	43.0	67.8	43.0	59.0	43.0	59.0	67.8	58.0	80.5	58.0	80.5	58.0	80.5	80.5
shear static ≧ C 20/25 V_{Rk} [kN]	21.0	34.0	21.0	30.0	21.0	30.0	34.0	29.0	46.0	29.0	40.0	29.0	40.0	46.0
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rk} [kN]	29.0	29.0	29.0	29.0	29.0	29.0	29.0	36.9	36.9	36.9	36.9	36.9	36.9	36.9
C 50/60 N_{Rk} [kN]	31.6	31.6	31.6	31.6	31.6	31.6	31.6	40.3	40.3	40.3	40.3	40.3	40.3	40.3
shear static ≧ C 20/25 V_{Rk} [kN]	21.0	34.0	21.0	30.0	21.0	30.0	34.0	29.0	46.0	29.0	40.0	29.0	40.0	46.0

Anchor type	FIS EM M16							FIS EM M20						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	125							170						
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rk} [kN]	70.6	70.6	70.6	70.6	70.6	70.6	70.6	111.9	111.9	111.9	111.9	111.9	111.9	111.9
C 50/60 N_{Rk} [kN]	79.0	95.9	79.0	95.9	79.0	95.9	95.9	123.0	151.4	123.0	151.4	123.0	151.4	151.4
shear static ≧ C 20/25 V_{Rk} [kN]	39.0	63.0	39.0	55.0	39.0	55.0	63.0	61.0	98.0	61.0	86.0	61.0	86.0	98.0
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rk} [kN]	37.7	37.7	37.7	37.7	37.7	37.7	37.7	64.1	64.1	64.1	64.1	64.1	64.1	64.1
C 50/60 N_{Rk} [kN]	41.1	41.1	41.1	41.1	41.1	41.1	41.1	69.9	69.9	69.9	69.9	69.9	69.9	69.9
shear static ≧ C 20/25 V_{Rk} [kN]	39.0	63.0	39.0	55.0	39.0	55.0	63.0	61.0	98.0	61.0	86.0	61.0	86.0	98.0

Anchor type	FIS EM M22							FIS EM M24						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	190							210						
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rk} [kN]	132.3	132.3	132.3	132.3	132.3	132.3	132.3	153.7	153.7	153.7	153.7	153.7	153.7	153.7
C 50/60 N_{Rk} [kN]	152.0	186.1	152.0	186.1	152.0	186.1	186.1	177.0	224.4	177.0	224.4	177.0	224.4	224.4
shear static ≧ C 20/25 V_{Rk} [kN]	76.0	122.0	76.0	107.0	76.0	107.0	122.0	89.0	141.0	89.0	124.0	89.0	124.0	141.0
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rk} [kN]	91.9	91.9	91.9	91.9	91.9	91.9	91.9	109.6	109.6	109.6	109.6	109.6	109.6	109.6
C 50/60 N_{Rk} [kN]	100.2	100.2	100.2	100.2	100.2	100.2	100.2	120.8	120.8	120.8	120.8	120.8	120.8	120.8
shear static ≧ C 20/25 V_{Rk} [kN]	76.0	122.0	76.0	107.0	76.0	107.0	122.0	89.0	141.0	89.0	124.0	89.0	124.0	141.0

fischer Injection mortar FIS EM

Anchor design according to fischer specification

Anchor type				FIS EM M27							FIS EM M30						
			gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef}		[mm]	250							280						
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2]																
tension static	C 20/25 N_{Rk}	[kN]	199.6	199.6	199.6	199.6	199.6	199.6	199.6	236.6	236.6	236.6	236.6	236.6	236.6	236.6
	C 50/60 N_{Rk}	[kN]	230.0	277.4	230.0	277.4	230.0	277.4	277.4	281.0	345.2	281.0	345.2	281.0	345.2	345.2
shear static	≧ C 20/25 V_{Rk}	[kN]	115.0	184.0	115.0	161.0	115.0	161.0	184.0	141.0	225.0	141.0	197.0	141.0	197.0	225.0
cracked concrete temperature range (+ 60 °C / + 35 °C) [2]																
tension static	C 20/25 N_{Rk}	[kN]	142.3	142.3	142.3	142.3	142.3	142.3	142.3	168.7	168.7	168.7	168.7	168.7	168.7	168.7
	C 50/60 N_{Rk}	[kN]	161.8	161.8	161.8	161.8	161.8	161.8	161.8	201.4	201.4	201.4	201.4	201.4	201.4	201.4
shear static	≧ C 20/25 V_{Rk}	[kN]	115.0	184.0	115.0	161.0	115.0	161.0	184.0	141.0	225.0	141.0	197.0	141.0	197.0	225.0

Anchor type			FIS EM M36	FIS EM M39	FIS EM M42
			gvz 5.8	gvz 5.8	gvz 5.8
h_{ef}		[mm]	330	360	400
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2]					
tension static	C 20/25 N_{Rk}	[kN]	302.7	344.9	404.0
	C 50/60 N_{Rk}	[kN]	408.5	488.0	560.5
shear static	≧ C 20/25 V_{Rk}	[kN]	204.3	244.0	280.3
cracked concrete temperature range (+ 60 °C / + 35 °C) [2]					
tension static	C 20/25 N_{Rk}	[kN]	186.6	220.5	263.9
	C 50/60 N_{Rk}	[kN]	203.4	240.4	287.6
shear static	≧ C 20/25 V_{Rk}	[kN]	204.3	244.0	280.3

1) The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 60 °C and long term temperature T ≤ + 35 °C (see also „Installation details", section 7).

2) (short term temperature / long term temperature)

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fischer Injection mortar FIS EM

Anchor design according to fischer specification

3.2 Design resistance[1)]

Anchor type	FIS EM M8							FIS EM M10						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	80							90						
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rd} [kN]	12.7	20.0	6.6	13.9	6.6	17.3	18.8	19.3	28.7	10.1	21.9	10.1	27.3	28.7
C 50/60 N_{Rd} [kN]	12.7	20.0	6.6	13.9	6.6	17.3	18.8	19.3	31.3	10.1	21.9	10.1	27.3	29.4
shear static ≧ C 20/25 V_{Rd} [kN]	7.2	12.0	3.8	8.3	3.8	10.4	11.3	12.0	18.4	6.3	12.8	6.3	16.0	17.3
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rd} [kN]	9.4	9.4	6.6	9.4	6.6	9.4	9.4	13.2	13.2	10.1	13.2	10.1	13.2	13.2
C 50/60 N_{Rd} [kN]	10.2	10.2	6.6	10.2	6.6	10.2	10.2	14.4	14.4	10.1	14.4	10.1	14.4	14.4
shear static ≧ C 20/25 V_{Rd} [kN]	7.2	12.0	3.8	8.3	3.8	10.4	11.3	12.0	18.4	6.3	12.8	6.3	16.0	17.3

Anchor type	FIS EM M12							FIS EM M14						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	110							120						
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rd} [kN]	28.7	38.8	15.0	31.6	15.0	38.8	38.8	38.7	44.3	20.3	43.3	20.3	44.3	44.3
C 50/60 N_{Rd} [kN]	28.7	45.2	15.0	31.6	15.0	39.3	42.5	38.7	53.7	20.3	43.3	20.3	53.7	53.7
shear static ≧ C 20/25 V_{Rd} [kN]	16.8	27.2	8.8	19.2	8.8	24.0	25.6	23.2	36.8	12.2	25.6	12.2	32.0	34.6
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rd} [kN]	19.4	19.4	15.0	19.4	15.0	19.4	19.4	24.6	24.6	20.3	24.6	20.3	24.6	24.6
C 50/60 N_{Rd} [kN]	21.1	21.1	15.0	21.1	15.0	21.1	21.1	26.8	26.8	20.3	26.8	20.3	26.8	26.8
shear static ≧ C 20/25 V_{Rd} [kN]	16.8	27.2	8.8	19.2	8.8	24.0	25.6	23.2	36.8	12.2	25.6	12.2	32.0	34.6

Anchor type	FIS EM M16							FIS EM M20						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	125							170						
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rd} [kN]	47.1	47.1	27.6	47.1	27.6	47.1	47.1	74.6	74.6	43.0	74.6	43.0	74.6	74.6
C 50/60 N_{Rd} [kN]	52.7	63.9	27.6	58.8	27.6	63.9	63.9	82.0	100.9	43.0	92.0	43.0	100.9	100.9
shear static ≧ C 20/25 V_{Rd} [kN]	31.2	50.4	16.4	35.3	16.4	44.0	47.4	48.8	78.4	25.6	55.1	25.6	68.8	73.7
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rd} [kN]	25.1	25.1	25.1	25.1	25.1	25.1	25.1	42.7	42.7	42.7	42.7	42.7	42.7	42.7
C 50/60 N_{Rd} [kN]	27.4	27.4	27.4	27.4	27.4	27.4	27.4	46.6	46.6	43.0	46.6	43.0	46.6	46.6
shear static ≧ C 20/25 V_{Rd} [kN]	31.2	50.3	16.4	35.3	16.4	44.0	47.4	48.8	78.4	25.6	55.1	25.6	68.8	73.7

Anchor type	FIS EM M22							FIS EM M24						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	190							210						
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rd} [kN]	73.5	73.5	53.1	73.5	53.1	73.5	73.5	85.4	85.4	61.9	85.4	61.9	85.4	85.4
C 50/60 N_{Rd} [kN]	101.3	103.4	53.1	103.4	53.1	103.4	103.4	118.0	124.6	61.9	124.6	61.9	124.6	124.6
shear static ≧ C 20/25 V_{Rd} [kN]	60.8	97.6	31.9	68.6	31.9	85.6	91.7	71.2	112.8	37.4	79.5	37.4	99.2	106.0
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]														
tension static C 20/25 N_{Rd} [kN]	51.1	51.1	51.1	51.1	51.1	51.1	51.1	60.9	60.9	60.9	60.9	60.9	60.9	60.9
C 50/60 N_{Rd} [kN]	55.7	55.7	53.1	55.7	53.1	55.7	55.7	67.1	67.1	61.9	67.1	61.9	67.1	67.1
shear static ≧ C 20/25 V_{Rd} [kN]	60.8	97.6	31.9	68.6	31.9	85.6	91.7	71.2	112.8	37.4	79.5	37.4	99.2	106.0

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fischer Injection mortar FIS EM

Anchor design according to fischer specification

Anchor type	FIS EM M27							FIS EM M30						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	250							280						
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2]														
tension static C 20/25 N_{Rd} [kN]	110.9	110.9	80.4	110.9	80.4	110.9	110.9	131.4	131.4	98.3	131.4	98.3	131.4	131.4
C 50/60 N_{Rd} [kN]	153.3	154.1	80.4	154.1	80.4	154.1	154.1	187.3	191.8	98.3	191.8	98.3	191.8	191.8
shear static ≧ C 20/25 V_{Rd} [kN]	92.0	147.2	48.3	103.2	48.3	128.8	138.3	112.8	180.0	59.2	126.3	59.2	157.6	169.2
cracked concrete temperature range (+ 60 °C / + 35 °C) [2]														
tension static C 20/25 N_{Rd} [kN]	79.1	79.1	79.1	79.1	79.1	79.1	79.1	93.7	93.7	93.7	93.7	93.7	93.7	93.7
C 50/60 N_{Rd} [kN]	89.9	89.9	80.4	89.9	80.4	89.9	89.9	111.9	111.9	98.3	111.9	98.3	111.9	111.9
shear static ≧ C 20/25 V_{Rd} [kN]	92.0	147.2	48.3	103.2	48.3	128.8	138.3	112.8	180.0	59.2	126.3	59.2	157.6	169.2

Anchor type	FIS EM M36	FIS EM M39	FIS EM M42
	gvz 5.8	gvz 5.8	gvz 5.8
h_{ef} [mm]	330	360	400
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2]			
tension static C 20/25 N_{Rd} [kN]	201.8	230.0	269.3
C 50/60 N_{Rd} [kN]	271.2	320.5	373.7
shear static ≧ C 20/25 V_{Rd} [kN]	163.4	195.2	224.2
cracked concrete temperature range (+ 60 °C / + 35 °C) [2]			
tension static C 20/25 N_{Rd} [kN]	103.7	122.5	146.6
C 50/60 N_{Rd} [kN]	113.0	133.5	159.8
shear static ≧ C 20/25 V_{Rd} [kN]	163.4	195.2	224.2

[1] The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 60 °C and long term temperature T ≤ + 35 °C (see also „Installation details“, section 7).

[2] (short term temperature / long term temperature)

fischer Injection mortar FIS EM

Anchor design according to fischer specification

3.3 Recommended resistance [1) 3)]

Anchor type	FIS EM M8							FIS EM M10						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	80							90						
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]														
tension static C 20/25 N_R [kN]	9.0	14.3	4.7	9.9	4.7	12.4	13.4	13.8	20.5	7.2	15.7	7.2	19.5	20.5
C 50/60 N_R [kN]	9.0	14.3	4.7	9.9	4.7	12.4	13.4	13.8	22.4	7.2	15.7	7.2	19.5	21.0
shear static ≧ C 20/25 V_R [kN]	5.1	8.6	2.7	6.0	2.7	7.4	8.1	8.6	13.1	4.5	9.2	4.5	11.4	12.4
cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]														
tension static C 20/25 N_R [kN]	6.7	6.7	4.7	6.7	4.7	6.7	6.7	9.4	9.4	7.2	9.4	7.2	9.4	9.4
C 50/60 N_R [kN]	7.3	7.3	4.7	7.3	4.7	7.3	7.3	10.3	10.3	7.2	10.3	7.2	10.3	10.3
shear static ≧ C 20/25 V_R [kN]	5.1	8.6	2.7	6.0	2.7	7.4	8.1	8.6	13.1	4.5	9.2	4.5	11.4	12.4

Anchor type	FIS EM M12							FIS EM M14						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	110							120						
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]														
tension static C 20/25 N_R [kN]	20.5	27.7	10.7	22.5	10.7	27.7	27.7	27.6	31.6	14.5	30.9	14.5	31.6	31.6
C 50/60 N_R [kN]	20.5	32.3	10.7	22.5	10.7	28.1	30.4	27.6	38.4	14.5	30.9	14.5	38.4	38.4
shear static ≧ C 20/25 V_R [kN]	12.0	19.4	6.3	13.7	6.3	17.1	18.3	16.6	26.3	8.7	18.3	8.7	22.9	24.7
cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]														
tension static C 20/25 N_R [kN]	13.8	13.8	10.7	13.8	10.7	13.8	13.8	17.6	17.6	14.5	17.6	14.5	17.6	17.6
C 50/60 N_R [kN]	15.1	15.1	10.7	15.1	10.7	15.1	15.1	19.2	19.2	14.5	19.2	14.5	19.2	19.2
shear static ≧ C 20/25 V_R [kN]	12.0	19.4	6.3	13.7	6.3	17.1	18.3	16.6	26.3	8.7	18.3	8.7	22.9	24.7

Anchor type	FIS EM M16							FIS EM M20						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	125							170						
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]														
tension static C 20/25 N_R [kN]	33.6	33.6	19.7	33.6	19.7	33.6	33.6	53.3	53.3	30.7	53.3	30.7	53.3	53.3
C 50/60 N_R [kN]	37.6	45.7	19.7	42.0	19.7	45.7	45.7	58.6	72.1	30.7	65.7	30.7	72.1	72.1
shear static ≧ C 20/25 V_R [kN]	22.3	36.0	11.7	25.2	11.7	31.4	33.8	34.9	56.0	18.3	39.4	18.3	49.1	52.6
cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]														
tension static C 20/25 N_R [kN]	18.0	18.0	18.0	18.0	18.0	18.0	18.0	30.5	30.5	30.5	30.5	30.5	30.5	30.5
C 50/60 N_R [kN]	19.6	19.6	19.6	19.6	19.6	19.6	19.6	33.3	33.3	30.7	33.3	30.7	33.3	33.3
shear static ≧ C 20/25 V_R [kN]	22.3	35.9	11.7	25.2	11.7	31.4	33.8	34.9	56.0	18.3	39.4	18.3	49.1	52.6

Anchor type	FIS EM M22							FIS EM M24						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef} [mm]	190							210						
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]														
tension static C 20/25 N_R [kN]	52.5	52.5	38.0	52.5	38.0	52.5	52.5	61.0	61.0	44.2	61.0	44.2	61.0	61.0
C 50/60 N_R [kN]	72.4	73.8	38.0	73.8	38.0	73.8	73.8	84.3	89.0	44.2	89.0	44.2	89.0	89.0
shear static ≧ C 20/25 V_R [kN]	43.4	69.7	22.8	49.0	22.8	61.1	65.5	50.9	80.6	26.7	56.8	26.7	70.9	75.7
cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]														
tension static C 20/25 N_R [kN]	36.5	36.5	36.5	36.5	36.5	36.5	36.5	43.5	43.5	43.5	43.5	43.5	43.5	43.5
C 50/60 N_R [kN]	39.8	39.8	38.0	39.8	38.0	39.8	39.8	47.9	47.9	44.2	47.9	44.2	47.9	47.9
shear static ≧ C 20/25 V_R [kN]	43.4	69.7	22.8	49.0	22.8	61.1	65.5	50.9	80.6	26.7	56.8	26.7	70.9	75.7

fischer Injection mortar FIS EM

Anchor design according to fischer specification

Anchor type				FIS EM M27							FIS EM M30						
				gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
h_{ef}			[mm]	250							280						
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2]																	
tension static	C 20/25	N_R	[kN]	79.2	79.2	57.4	79.2	57.4	79.2	79.2	93.9	93.9	70.2	93.9	70.2	93.9	93.9
	C 50/60	N_R	[kN]	109.5	110.1	57.4	110.1	57.4	110.1	110.1	133.8	137.0	70.2	137.0	70.2	137.0	137.0
shear static	≧ C 20/25	V_R	[kN]	65.7	105.1	34.5	73.7	34.5	92.0	98.8	80.6	128.6	42.3	90.2	42.3	112.6	120.8
cracked concrete temperature range (+ 60 °C / + 35 °C) [2]																	
tension static	C 20/25	N_R	[kN]	56.5	56.5	56.5	56.5	56.5	56.5	56.5	66.9	66.9	66.9	66.9	66.9	66.9	66.9
	C 50/60	N_R	[kN]	64.2	64.2	57.4	64.2	57.4	64.2	64.2	79.9	79.9	70.2	79.9	70.2	79.9	79.9
shear static	≧ C 20/25	V_R	[kN]	65.7	105.1	34.5	73.7	34.5	92.0	98.8	80.6	128.6	42.3	90.2	42.3	112.6	120.8

Anchor type				FIS EM M36	FIS EM M39	FIS EM M42
				gvz 5.8	gvz 5.8	gvz 5.8
h_{ef}			[mm]	330	360	400
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2]						
tension static	C 20/25	N_R	[kN]	144.2	164.3	192.4
	C 50/60	N_R	[kN]	193.7	228.9	266.9
shear static	≧ C 20/25	V_R	[kN]	116.7	139.4	160.2
cracked concrete temperature range (+ 60 °C / + 35 °C) [2]						
tension static	C 20/25	N_R	[kN]	74.1	87.5	104.7
	C 50/60	N_R	[kN]	80.7	95.4	114.1
shear static	≧ C 20/25	V_R	[kN]	116.7	139.4	160.2

[1] The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 60 °C and long term temperature T ≤ + 35 °C (see also „Installation details", section 7).

[2] Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on failure mode of the anchor.

[3] (short term temperature / long term temperature)

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type	FIS EM M8							FIS EM M10						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
design resistance $N_{Rd,s}$ [kN]	12.7	20.0	6.6	13.9	6.6	17.3	18.8	19.3	31.3	10.1	21.9	10.1	27.3	29.4

Anchor type	FIS EM M12							FIS EM M14						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
design resistance $N_{Rd,s}$ [kN]	28.7	45.3	15.0	31.6	15.0	39.3	42.5	38.7	61.3	20.3	43.3	20.3	54.0	57.5

Anchor type	FIS EM M16							FIS EM M20						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
design resistance $N_{Rd,s}$ [kN]	52.7	84.0	27.6	58.8	27.6	73.3	78.8	82.0	130.7	43.0	92.0	43.0	114.7	122.5

Anchor type	FIS EM M22							FIS EM M24						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
design resistance $N_{Rd,s}$ [kN]	101.3	162.0	53.1	113.4	53.1	141.3	151.9	118.0	188.0	61.9	132.1	61.9	164.7	176.3

Anchor type	FIS EM M27							FIS EM M30						
	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
design resistance $N_{Rd,s}$ [kN]	153.3	245.3	80.4	172.2	80.4	214.7	230.0	187.3	299.3	98.3	210.2	98.3	262.0	280.6

Anchor type	FIS EM M36	FIS EM M39	FIS EM M42
	gvz 5.8	gvz 5.8	gvz 5.8
design resistance $N_{Rd,s}$ [kN]	272.3	325.3	373.7

4

fischer Injection mortar FIS EM

Anchor design according to fischer specification

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Hammer drilled

Anchor type			FIS EM M8			FIS EM M10			FIS EM M12			FIS EM M14			FIS EM M16		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320
non-cracked concrete																	
temperature range (+60°C / +35°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	16.1	21.4	42.9	20.1	30.2	67.0	26.4	41.5	90.5	30.8	49.3	114.9	37.5	58.6	150.1
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	11.5	15.3	30.6	14.4	21.5	47.9	18.8	29.6	64.6	20.4	32.7	76.2	24.9	38.9	99.6
temperature range (+72°C / +50°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	15.1	20.1	40.2	17.6	26.4	58.6	24.6	38.7	84.4	28.6	45.7	106.7	34.9	54.5	139.4
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	10.8	14.4	28.7	12.6	18.8	41.9	17.6	27.6	60.3	20.4	32.7	76.2	23.0	35.9	91.9
cracked concrete																	
temperature range (+60°C / +35°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	7.0	9.4	18.8	8.8	13.2	29.3	12.3	19.4	42.2	15.4	24.6	57.5	16.1	25.1	64.3
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	5.0	6.7	13.4	8.1	12.1	26.9	11.3	17.8	38.8	12.6	20.1	46.9	15.3	23.9	61.3
temperature range (+72°C / +50°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	7.0	9.4	18.8	8.8	13.2	29.3	12.3	19.4	42.2	15.4	24.6	57.5	16.1	25.1	64.3
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	5.0	6.7	13.4	7.2	10.8	23.9	10.1	15.8	34.5	12.6	20.1	46.9	13.4	20.9	53.6

Anchor type			FIS EM M20			FIS EM M22			FIS EM M24			FIS EM M27			FIS EM M30		
eff. anchorage depth	h_{ef}	[mm]	90	170	400	93	190	440	96	210	480	108	250	540	120	280	600
non-cracked concrete																	
temperature range (+60°C / +35°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	49.0	92.6	217.8	46.4	94.8	219.6	52.3	114.4	261.4	61.1	141.4	305.4	75.4	175.9	377.0
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	29.6	56.0	131.6	33.7	68.8	159.3	34.5	75.4	172.3	43.6	101.0	218.1	48.5	113.1	242.4
temperature range (+72°C / +50°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	45.2	85.5	201.1	42.9	87.5	202.7	48.3	105.6	241.3	56.0	129.6	279.9	69.1	161.3	345.6
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	29.6	56.0	131.6	30.6	62.5	144.8	34.5	75.4	172.3	39.3	90.9	196.3	48.5	113.1	242.4
cracked concrete																	
temperature range (+60°C / +35°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	22.6	42.7	100.5	42.9	87.5	202.7	48.3	105.6	241.3	56.0	129.6	279.9	69.1	161.3	345.6
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	18.8	35.6	83.8	30.6	62.5	144.8	34.5	75.4	172.3	39.3	90.9	196.3	48.5	113.1	242.4
temperature range (+72°C / +50°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	22.6	42.7	100.5	25.0	51.1	118.3	28.1	61.6	140.7	35.6	82.5	178.1	44.0	102.6	219.9
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	18.8	35.6	83.8	18.4	37.5	86.9	20.7	45.2	103.4	26.2	60.6	130.9	32.3	75.4	161.6

Anchor type			FIS EM M36			FIS EM M39			FIS EM M42		
eff. anchorage depth	h_{ef}	[mm]	144	330	540	156	360	585	168	400	630
non-cracked concrete											
temperature range (+60°C / +35°C) [1]											
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	108.6	248.8	407.2	127.4	294.1	477.8	147.8	351.9	554.2
temperature range (+72°C / +50°C) [1]											
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	86.0	197.0	322.3	100.9	232.8	378.3	117.0	278.6	438.7
cracked concrete											
temperature range (+60°C / +35°C) [1]											
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	45.2	103.7	169.6	53.1	122.5	199.1	61.6	146.6	230.9
temperature range (+72°C / +50°C) [1]											
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	38.9	89.2	145.9	45.7	105.4	171.2	53.0	126.1	198.6

[1] (short term temperature / long term temperature)

Diamond drilled

Anchor type			FIS EM M8			FIS EM M10			FIS EM M12			FIS EM M14			FIS EM M16			FIS EM M20		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	90	170	400
non-cracked concrete																				
temperature range (+60°C / +35°C) 1)																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	16.1	21.4	42.9	18.8	28.3	62.8	22.9	35.9	78.4	26.4	42.2	98.5	32.2	50.3	128.7	37.7	71.2	167.6
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	11.5	15.3	30.6	13.5	20.2	44.9	16.3	25.7	56.0	18.8	30.2	70.4	23.0	35.9	91.9	26.9	50.9	119.7
temperature range (+72°C / +50°C) 1)																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	15.1	20.1	40.2	17.6	26.4	58.6	21.1	33.2	72.4	24.2	38.7	90.3	29.5	46.1	118.0	37.7	71.2	167.6
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	10.8	14.4	28.7	12.6	18.8	41.9	15.1	23.7	51.7	17.3	27.6	64.5	21.1	32.9	84.3	26.9	50.9	119.7
cracked concrete																				
temperature range (+60°C / +35°C) 1)																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	7.0	9.4	18.8	8.8	13.2	29.3	12.3	19.4	42.2	15.4	24.6	57.5	16.1	25.1	64.3	22.6	42.7	100.5
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	5.0	6.7	13.4	8.1	12.1	26.9	11.3	17.8	38.8	12.6	20.1	46.9	15.3	23.9	61.3	18.8	35.6	83.8
temperature range (+72°C / +50°C) 1)																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	7.0	9.4	18.8	8.8	13.2	29.3	12.3	19.4	42.2	15.4	24.6	57.5	16.1	25.1	64.3	22.6	42.7	100.5
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	5.0	6.7	13.4	7.2	10.8	23.9	10.1	15.8	34.5	12.6	20.1	46.9	13.4	20.9	53.6	18.8	35.6	83.8

Anchor type			FIS EM M22			FIS EM M24			FIS EM M27			FIS EM M30		
eff. anchorage depth	h_{ef}	[mm]	93	190	440	96	210	480	108	250	540	120	280	600
non-cracked concrete														
temperature range (+60°C / +35°C) 1)														
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	35.7	73.0	168.9	40.2	88.0	201.1	45.8	106.0	229.0	56.5	131.9	282.7
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	30.6	62.5	144.8	34.5	75.4	172.3	39.3	90.9	196.3	48.5	113.1	242.4
temperature range (+72°C / +50°C) 1)														
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	32.1	65.7	152.1	36.2	79.2	181.0	40.7	94.2	203.6	50.3	117.3	251.3
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	27.5	56.3	130.3	31.0	67.9	155.1	34.9	80.8	174.5	43.1	100.5	215.4
cracked concrete														
temperature range (+60°C / +35°C) 1)														
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	25.0	51.1	118.3	28.1	61.6	140.7	35.6	82.5	178.1	44.0	102.6	219.9
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	21.4	43.8	101.4	20.7	45.2	103.4	26.2	60.6	130.9	32.3	75.4	161.6
temperature range (+72°C / +50°C) 1)														
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	25.0	51.1	118.3	28.1	61.6	140.7	35.6	82.5	178.1	44.0	102.6	219.9
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	18.4	37.5	86.9	20.7	45.2	103.4	26.2	60.6	130.9	32.3	75.4	161.6

1) (short term temperature / long term temperature)

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	55
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,p}$	[-]	0.98	0.99	1.00	1.02	1.04	1.06	1.07	1.08	1.09

4.2.2 Characteristic edge distance and spacing for design

Hammer drilled

Anchor type			FIS EM M8			FIS EM M10			FIS EM M12			FIS EM M14			FIS EM M16			FIS EM M20		
eff. anchorage depth	h_{ef}	**[mm]**	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**75**	**120**	**280**	**80**	**125**	**320**	**90**	**170**	**400**
temperature range (+60°C / +35°C) [1)]																				
wet and dry concrete	$s_{cr, Np}$	[mm]	180	234	234	180	270	292	210	330	339	225	360	383	240	375	437	270	510	527
	$c_{cr, Np}$	[mm]	90	117	117	90	135	146	105	165	170	113	180	191	120	188	219	135	255	263
waterfilled hole	$s_{cr, Np}$	[mm]	180	234	234	180	270	292	210	330	339	225	360	369	240	375	421	270	484	484
	$c_{cr, Np}$	[mm]	90	117	117	90	135	146	105	165	170	113	180	184	120	188	211	135	242	242
temperature range (+72°C / +50°C) [1)]																				
wet and dry concrete	$s_{cr, Np}$	[mm]	180	226	226	180	270	273	210	328	328	225	360	369	240	375	421	270	506	506
	$c_{cr, Np}$	[mm]	90	113	113	90	135	137	105	164	164	113	180	184	120	188	211	135	253	253
waterfilled hole	$s_{cr, Np}$	[mm]	180	226	226	180	270	273	210	328	328	225	360	369	240	375	405	270	484	484
	$c_{cr, Np}$	[mm]	90	113	113	90	135	137	105	164	164	113	180	184	120	188	202	135	242	242

Anchor type			FIS EM M22			FIS EM M24			FIS EM M27			FIS EM M30		
eff. anchorage depth	h_{ef}	**[mm]**	**93**	**190**	**440**	**96**	**210**	**480**	**108**	**250**	**540**	**120**	**280**	**600**
temperature range (+60°C / +35°C) [1)]														
wet and dry concrete	$s_{cr, Np}$	[mm]	279	570	579	288	630	632	324	683	683	360	759	759
	$c_{cr, Np}$	[mm]	140	285	290	144	315	316	162	342	342	180	379	379
waterfilled hole	$s_{cr, Np}$	[mm]	279	533	533	288	554	554	324	624	624	360	657	657
	$c_{cr, Np}$	[mm]	140	266	266	144	277	277	162	312	312	180	329	329
temperature range (+72°C / +50°C) [1)]														
wet and dry concrete	$s_{cr, Np}$	[mm]	279	557	557	288	607	607	324	654	654	360	727	727
	$c_{cr, Np}$	[mm]	140	278	278	144	304	304	162	327	327	180	363	363
waterfilled hole	$s_{cr, Np}$	[mm]	279	508	508	288	554	554	324	592	592	360	657	657
	$c_{cr, Np}$	[mm]	140	254	254	144	277	277	162	296	296	180	329	329

Anchor type			FIS EM M36			FIS EM M39			FIS EM M42		
eff. anchorage depth	h_{ef}	**[mm]**	**144**	**330**	**540**	**156**	**360**	**585**	**168**	**400**	**630**
temperature range (+60°C / +35°C) [1)]											
wet and dry concrete	$s_{cr, Np}$	[mm]	432	911	911	468	987	987	504	1063	1063
	$c_{cr, Np}$	[mm]	216	455	455	234	493	493	252	531	531
temperature range (+72°C / +50°C) [1)]											
wet and dry concrete	$s_{cr, Np}$	[mm]	432	810	810	468	878	878	504	945	945
	$c_{cr, Np}$	[mm]	216	405	405	234	439	439	252	473	473

[1)] (short term temperature / long term temperature)

continued next page

Diamond drilled

Anchor type			FIS EM M8			FIS EM M10			FIS EM M12			FIS EM M14			FIS EM M16			FIS EM M20		
eff. anchorage depth	h_{ef}	[mm]	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**75**	**120**	**280**	**80**	**125**	**320**	**90**	**170**	**400**
temperature range (+60°C / +35°C) [1]																				
wet and dry concrete	$s_{cr,Np}$	[mm]	180	234	234	180	270	283	210	316	316	225	354	354	240	375	405	270	462	462
	$c_{cr,Np}$	[mm]	90	117	117	90	135	141	105	158	158	113	177	177	120	188	202	135	231	231
waterfilled hole	$s_{cr,Np}$	[mm]	180	234	234	180	270	283	210	316	316	225	354	354	240	375	405	270	462	462
	$c_{cr,Np}$	[mm]	90	117	117	90	135	141	105	158	158	113	177	177	120	188	202	135	231	231
temperature range (+72°C / +50°C) [1]																				
wet and dry concrete	$s_{cr,Np}$	[mm]	180	226	226	180	270	273	210	304	304	225	339	339	240	375	388	270	462	462
	$c_{cr,Np}$	[mm]	90	113	113	90	135	137	105	152	152	113	170	170	120	188	194	135	231	231
waterfilled hole	$s_{cr,Np}$	[mm]	180	226	226	180	270	273	210	304	304	225	339	339	240	375	388	270	462	462
	$c_{cr,Np}$	[mm]	90	113	113	90	135	137	105	152	152	113	170	170	120	188	194	135	231	231

Anchor type			FIS EM M22			FIS EM M24			FIS EM M27			FIS EM M30		
eff. anchorage depth	h_{ef}	[mm]	**93**	**190**	**440**	**96**	**210**	**480**	**108**	**250**	**540**	**120**	**280**	**600**
temperature range (+60°C / +35°C) [1]														
wet and dry concrete	$s_{cr,Np}$	[mm]	279	508	508	288	554	554	324	592	592	360	657	657
	$c_{cr,Np}$	[mm]	140	254	254	144	277	277	162	296	296	180	329	329
waterfilled hole	$s_{cr,Np}$	[mm]	279	508	508	288	554	554	324	592	592	360	657	657
	$c_{cr,Np}$	[mm]	140	254	254	144	277	277	162	296	296	180	329	329
temperature range (+72°C / +50°C) [1]														
wet and dry concrete	$s_{cr,Np}$	[mm]	279	482	482	288	526	526	324	558	558	360	620	620
	$c_{cr,Np}$	[mm]	140	241	241	144	263	263	162	279	279	180	310	310
waterfilled hole	$s_{cr,Np}$	[mm]	279	482	482	288	526	526	324	558	558	360	620	620
	$c_{cr,Np}$	[mm]	140	241	241	144	263	263	162	279	279	180	310	310

[1] (short term temperature / long term temperature)

4

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type			FIS EM M8 [1]			FIS EM M10 [1]			FIS EM M12 [1]			FIS EM M14 [1]			FIS EM M16 [1]			FIS EM M20 [1]			FIS EM M22 [1]		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	90	170	400	93	190	440
non-cracked concrete																							
design resistance	$N^0_{Rd,c}$	[kN]	15.6	24.1	68.1	15.6	28.7	95.2	19.7	38.8	125.2	21.9	44.3	157.7	24.1	47.1	192.7	28.7	74.6	269.3	25.2	73.5	258.9
cracked concrete																							
design resistance	$N^0_{Rd,c}$	[kN]	11.2	17.2	48.6	11.2	20.5	67.9	14.1	27.7	89.2	15.6	31.5	112.4	17.2	33.5	137.4	20.5	53.2	192.0	17.9	52.4	184.6

Anchor type			FIS EM M24 [2]			FIS EM M27 [2]			FIS EM M30 [2]			FIS EM M36			FIS EM M39			FIS EM M42		
eff. anchorage depth	h_{ef}	[mm]	96	210	480	108	250	540	120	280	600	144	330	540	156	360	585	168	400	630
non-cracked concrete																				
design resistance	$N^0_{Rd,c}$	[kN]	26.4	85.4	295.0	31.5	110.9	352.1	36.9	131.4	412.3	58.2	201.8	422.5	65.6	230.0	476.4	73.3	269.3	532.4
cracked concrete																				
design resistance	$N^0_{Rd,c}$	[kN]	18.8	60.9	210.3	22.4	79.1	251.0	26.3	93.7	293.9	41.5	143.9	301.2	46.8	163.9	339.6	52.3	192.0	379.5

[1] For underwater installation the resistance values have to be multiplied by a factor of 0.71.
[2] For underwater installation the resistance values have to be multiplied by a factor of 0.86.

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,c}$	[-]	0,77	0,89	1,00	1,10	1,22	1,34	1,41	1,48	1,55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type			FIS EM M8			FIS EM M10			FIS EM M12			FIS EM M14			FIS EM M16			FIS EM M20			FIS EM M22		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	90	170	400	93	190	440
	$s_{cr,N}$	[mm]	180	240	480	180	270	600	210	330	720	225	360	840	240	375	960	270	510	1200	279	570	1320
	$c_{cr,N}$	[mm]	90	120	240	90	135	300	105	165	360	113	180	420	120	188	480	135	255	600	140	285	660

Anchor type			FIS EM M24			FIS EM M27			FIS EM M30			FIS EM M36			FIS EM M39			FIS EM M42		
eff. anchorage depth	h_{ef}	[mm]	96	210	480	108	250	540	120	280	600	144	330	540	156	360	585	168	400	630
	$s_{cr,N}$	[mm]	288	630	1440	324	750	1620	360	840	1800	432	990	1620	468	1080	1755	504	1200	1890
	$c_{cr,N}$	[mm]	144	315	720	162	375	810	180	420	900	216	495	810	234	540	878	252	600	945

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_s	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}} \right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type				**FIS EM M8**			**FIS EM M10**			**FIS EM M12**			**FIS EM M14**			**FIS EM M16**			**FIS EM M20**			**FIS EM M22**		
eff. anchorage depth		h_{ef}	**[mm]**	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**75**	**120**	**280**	**80**	**125**	**320**	**90**	**170**	**400**	**93**	**190**	**440**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	120	160	320	120	180	400	140	220	480	150	240	560	160	250	640	180	340	800	186	380	880
		$c_{cr,sp}$	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	90	170	400	93	190	440
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)																				
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$																				
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	271	362	723	271	407	904	316	497	1085	339	542	1266	362	565	1446	407	768	1808	420	859	1989
		$c_{cr,sp}$	[mm]	136	181	362	136	203	452	158	249	542	170	271	633	181	283	723	203	384	904	210	429	994
		h_{min}	[mm]	100	110	190	100	120	230	100	140	270	105	150	310	110	155	350	138	218	448	143	240	490

Anchor type				**FIS EM M24**			**FIS EM M27**			**FIS EM M30**			**FIS EM M36**			**FIS EM M39**			**FIS EM M42**		
eff. anchorage depth		h_{ef}	**[mm]**	**96**	**210**	**480**	**108**	**250**	**540**	**120**	**280**	**600**	**144**	**330**	**540**	**156**	**360**	**585**	**168**	**400**	**630**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	192	420	960	216	500	1080	240	560	1200	288	660	1080	312	720	1170	336	800	1260
		$c_{cr,sp}$	[mm]	96	210	480	108	250	540	120	280	600	144	330	540	156	360	585	168	400	630
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)																	
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$																	
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	434	949	2170	488	1130	2441	542	1266	2712	651	1492	2441	705	1627	2644	759	1808	2848
		$c_{cr,sp}$	[mm]	217	475	1085	244	565	1220	271	633	1356	325	746	1220	353	814	1322	380	904	1424
		h_{min}	[mm]	152	266	536	168	310	600	190	350	670	228	414	624	246	450	675	268	500	730

$f_{scr,sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2.0
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.8	3.62	3.44	3.26	3.08	2.9	2.72	2.54	2.36	2.18	2.0

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}} \right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}} \right) \cdot 0.5 \leqq 1.0$$

h/h_{ef}	1,3	1,35	1,4	1,45	1,5	1,55	1,6	1,65	1,7	1,75	1,8	1,85	1,9	1,95	2
$f_{scr,sp}$	4,52	4,34	4,16	3,98	3,80	3,62	3,44	3,26	3,08	2,90	2,72	2,54	2,36	2,18	2,00

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≥1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\ (N_{Rd,p}\ ;\ N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

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5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type			FIS EM M8							FIS EM M10						
			gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
design resistance	$V_{Rd,s}$	[kN]	7.2	12.0	3.8	8.3	3.8	10.4	11.3	12.0	18.4	6.3	12.8	6.3	16.0	17.3

Anchor type			FIS EM M12							FIS EM M14						
			gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
design resistance	$V_{Rd,s}$	[kN]	16.8	27.2	8.8	19.2	8.8	24.0	25.6	23.2	36.8	12.2	25.6	12.2	32.0	34.6

Anchor type			FIS EM M16							FIS EM M20						
			gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
design resistance	$V_{Rd,s}$	[kN]	31.2	50.4	16.4	35.3	16.4	44.0	47.4	48.8	78.4	25.6	55.1	25.6	68.8	73.7

Anchor type			FIS EM M22							FIS EM M24						
			gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
design resistance	$V_{Rd,s}$	[kN]	60.8	97.6	31.9	68.6	31.9	85.6	91.7	71.2	112.8	37.4	79.5	37.4	99.2	106.0

Anchor type			FIS EM M27							FIS EM M30						
			gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	C-50	C-70	C-80
design resistance	$V_{Rd,s}$	[kN]	92.0	147.2	48.3	103.2	48.3	128.8	138.3	112.8	180.0	59.2	126.3	59.2	157.6	169.2

Anchor type			FIS EM M36	FIS EM M39	FIS EM M42
			gvz 5.8	gvz 5.8	gvz 5.8
design resistance	$V_{Rd,s}$	[kN]	163.4	195.2	224.2

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\ (\ N_{Rd,p}\ ;\ \ N_{Rd,c}\ )$$

k-factor

Anchor type	FIS EM M8 to M42
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]																	
	FIS EM M8						FIS EM M10						FIS EM M12					
h_{ef}	60	60	80	80	160	160	60	60	90	90	200	200	70	70	110	110	240	240
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
40	3.5	2.5	3.7	2.6	4.4	3.1												
45	4.1	2.9	4.3	3.1	5.1	3.6	4.3	3.0	4.7	3.3	5.8	4.1						
50	4.7	3.3	5.0	3.5	5.8	4.1	4.9	3.5	5.3	3.8	6.6	4.7						
55	5.4	3.8	5.6	4.0	6.6	4.7	5.6	3.9	6.0	4.3	7.4	5.2	5.9	4.2	6.6	4.6	8.2	5.8
60	6.0	4.3	6.3	4.5	7.3	5.2	6.2	4.4	6.8	4.8	8.2	5.8	6.6	4.7	7.3	5.2	9.1	6.4
65	6.7	4.7	7.0	5.0	8.1	5.7	6.9	4.9	7.5	5.3	9.0	6.4	7.3	5.2	8.1	5.7	10.0	7.1
70	7.4	5.2	7.8	5.5	8.9	6.3	7.7	5.4	8.3	5.8	9.9	7.0	8.1	5.7	8.9	6.3	10.9	7.7
75	8.1	5.8	8.5	6.0	9.7	6.9	8.4	5.9	9.0	6.4	10.8	7.6	8.9	6.3	9.7	6.9	11.8	8.4
80	8.9	6.3	9.3	6.6	10.6	7.5	9.2	6.5	9.8	7.0	11.7	8.3	9.7	6.8	10.6	7.5	12.8	9.1
85	9.6	6.8	10.1	7.1	11.4	8.1	9.9	7.0	10.7	7.5	12.6	8.9	10.5	7.4	11.4	8.1	13.8	9.8
90	10.4	7.4	10.9	7.7	12.3	8.7	10.7	7.6	11.5	8.1	13.5	9.6	11.3	8.0	12.3	8.7	14.8	10.5
95	11.2	7.9	11.7	8.3	13.2	9.4	11.5	8.2	12.3	8.7	14.5	10.3	12.1	8.6	13.2	9.4	15.8	11.2
100	12.0	8.5	12.6	8.9	14.1	10.0	12.4	8.8	13.2	9.4	15.5	11.0	13.0	9.2	14.1	10.0	16.8	11.9
105	12.9	9.1	13.4	9.5	15.1	10.7	13.2	9.4	14.1	10.0	16.5	11.7	13.9	9.8	15.1	10.7	17.9	12.7
120	15.5	10.9	16.1	11.4	18.0	12.7	15.9	11.2	16.9	12.0	19.5	13.8	16.6	11.8	17.9	12.7	21.1	15.0
125	16.4	11.6	17.0	12.0	19.0	13.4	16.8	11.9	17.8	12.6	20.6	14.6	17.6	12.4	18.9	13.4	22.2	15.7
130	17.3	12.2	17.9	12.7	20.0	14.1	17.7	12.5	18.8	13.3	21.7	15.3	18.5	13.1	20.0	14.1	23.4	16.5
135	18.2	12.9	18.9	13.4	21.0	14.9	18.7	13.2	19.8	14.0	22.8	16.1	19.5	13.8	21.0	14.9	24.5	17.4
140	19.1	13.6	19.9	14.1	22.0	15.6	19.6	13.9	20.8	14.7	23.9	16.9	20.5	14.5	22.0	15.6	25.7	18.2
160	23.0	16.3	23.9	16.9	26.3	18.7	23.6	16.7	24.9	17.7	28.4	20.1	24.6	17.4	26.3	18.6	30.4	21.6
175	26.1	18.5	27.0	19.1	29.7	21.0	26.7	18.9	28.2	19.9	31.9	22.6	27.8	19.7	29.7	21.0	34.1	24.2
180	27.1	19.2	28.1	19.9	30.9	21.9	27.8	19.7	29.3	20.7	33.2	23.5	28.9	20.5	30.8	21.8	35.4	25.1
190	29.3	20.7	30.3	21.4	33.2	23.5	29.9	21.2	31.5	22.3	35.6	25.2	31.1	22.0	33.2	23.5	38.0	26.9
200	31.4	22.3	32.5	23.0	35.6	25.2	32.1	22.8	33.8	23.9	38.1	27.0	33.4	23.6	35.6	25.2	40.6	28.8
250	43.0	30.5	44.3	31.4	48.2	34.1	43.9	31.1	46.0	32.6	51.3	36.4	45.5	32.2	48.2	34.1	54.4	38.5
300	55.6	39.4	57.2	40.5	61.9	43.8	56.7	40.2	59.2	42.0	65.6	46.5	58.6	41.5	61.9	43.8	69.2	49.0
350	69.2	49.0	71.1	50.3	76.5	54.2	70.5	49.9	73.4	52.0	80.9	57.3	72.7	51.5	76.5	54.2	85.1	60.3
400	83.7	59.3	85.8	60.8	92.1	65.2	85.1	60.3	88.5	62.7	97.0	68.7	87.7	62.1	92.0	65.2	101.8	72.1
450	98.9	70.1	101.4	71.8	108.4	76.8	100.6	71.2	104.4	74.0	114.0	80.8	103.5	73.3	108.4	76.8	119.4	84.6
500	115.0	81.4	117.7	83.4	125.6	89.0	116.8	82.7	121.2	85.8	131.8	93.4	120.1	85.0	125.6	89.0	137.8	97.6
550	131.8	93.3	134.8	95.5	143.5	101.7	133.8	94.8	138.6	98.2	150.4	106.5	137.4	97.3	143.5	101.7	156.9	111.2
600	149.2	105.7	152.6	108.1	162.1	114.9	151.5	107.3	156.8	111.0	169.6	120.2	155.4	110.1	162.1	114.8	176.8	125.2
650	167.4	118.6	171.0	121.2	181.4	128.5	169.8	120.3	175.6	124.4	189.6	134.3	174.1	123.4	181.4	128.5	197.3	139.8
700			190.1	134.7	201.4	142.7			195.1	138.2	210.2	148.9	193.5	137.1	201.4	142.7	218.5	154.8
750			209.9	148.6	222.0	157.2			215.1	152.4	231.4	163.9	213.5	151.2	222.0	157.2	240.3	170.2
800			230.2	163.0	243.1	172.2			235.8	167.1	253.2	179.4			243.2	172.2	262.8	186.1
850			251.1	177.8	264.9	187.6			257.1	182.1	275.6	195.3			264.9	187.7	285.8	202.5
900					287.2	203.5			279.0	197.6	298.6	211.5			287.3	203.5	309.4	219.2
950					310.1	219.7			301.3	213.4	322.2	228.2			310.1	219.7	333.6	236.3
1000					333.5	236.2					346.3	245.3			333.6	236.3	358.3	253.8
1200					432.3	306.2					447.7	317.1			432.3	306.2	462.3	327.4
1400					538.6	381.5					556.8	394.4					573.9	406.5
1600					652.0	461.8					673.0	476.7					692.7	490.6
1800					771.9	546.7					795.8	563.7					818.1	579.5
2000											924.7	655.0					949.7	672.7
2200											1059.5	750.5					1087.2	770.1

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Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]																	
	FIS EM M14						FIS EM M16						FIS EM M20					
h_{ef}	75	75	120	120	280	280	80	80	125	125	320	320	90	90	170	170	400	400
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
60	6.9	4.9	7.7	5.5	10.0	7.1												
65	7.6	5.4	8.5	6.0	11.0	7.8	7.9	5.6	8.9	6.3	12.0	8.5						
70	8.4	6.0	9.4	6.6	11.9	8.5	8.7	6.2	9.7	6.9	13.0	9.2						
75	9.2	6.5	10.2	7.2	12.9	9.2	9.5	6.8	10.6	7.5	14.1	10.0						
80	10.0	7.1	11.1	7.9	14.0	9.9	10.4	7.4	11.5	8.1	15.1	10.7						
85	10.9	7.7	12.0	8.5	15.0	10.6	11.2	8.0	12.4	8.8	16.2	11.5	12.0	8.5	14.1	10.0	18.8	13.3
90	11.7	8.3	12.9	9.1	16.0	11.4	12.1	8.6	13.3	9.4	17.3	12.3	12.9	9.1	15.1	10.7	20.0	14.2
95	12.6	8.9	13.8	9.8	17.1	12.1	13.0	9.2	14.3	10.1	18.5	13.1	13.8	9.8	16.1	11.4	21.2	15.0
100	13.5	9.5	14.8	10.5	18.2	12.9	13.9	9.8	15.2	10.8	19.6	13.9	14.7	10.4	17.2	12.2	22.5	15.9
105	14.4	10.2	15.7	11.1	19.3	13.7	14.8	10.5	16.2	11.5	20.8	14.7	15.7	11.1	18.2	12.9	23.7	16.8
120	17.2	12.2	18.7	13.2	22.7	16.1	17.7	12.5	19.3	13.7	24.3	17.2	18.7	13.2	21.5	15.2	27.6	19.6
125	18.1	12.8	19.7	14.0	23.9	16.9	18.7	13.2	20.3	14.4	25.5	18.1	19.7	13.9	22.6	16.0	28.9	20.5
130	19.1	13.5	20.8	14.7	25.1	17.7	19.7	13.9	21.4	15.1	26.8	19.0	20.7	14.7	23.8	16.8	30.3	21.4
135	20.1	14.2	21.8	15.5	26.3	18.6	20.7	14.6	22.5	15.9	28.0	19.8	21.8	15.4	24.9	17.7	31.6	22.4
140	21.1	15.0	22.9	16.2	27.5	19.5	21.7	15.4	23.5	16.7	29.3	20.7	22.9	16.2	26.1	18.5	33.0	23.4
160	25.3	17.9	27.3	19.3	32.5	23.0	26.0	18.4	28.1	19.9	34.5	24.4	27.3	19.3	30.9	21.9	38.6	27.3
175	28.6	20.2	30.8	21.8	36.3	25.7	29.3	20.8	31.6	22.4	38.5	27.3	30.7	21.8	34.7	24.6	43.0	30.4
180	29.7	21.0	31.9	22.6	37.7	26.7	30.4	21.6	32.8	23.2	39.9	28.3	31.9	22.6	36.0	25.5	44.4	31.5
190	32.0	22.6	34.3	24.3	40.3	28.6	32.8	23.2	35.2	24.9	42.7	30.2	34.3	24.3	38.6	27.3	47.4	33.6
200	34.3	24.3	36.8	26.0	43.1	30.5	35.1	24.9	37.7	26.7	45.5	32.2	36.7	26.0	41.2	29.2	50.4	35.7
250	46.6	33.0	49.7	35.2	57.4	40.6	47.6	33.7	50.8	36.0	60.4	42.8	49.7	35.2	55.2	39.1	66.3	47.0
300	59.9	42.5	63.7	45.1	72.8	51.6	61.2	43.4	65.0	46.1	76.3	54.0	63.6	45.1	70.2	49.7	83.3	59.0
350	74.3	52.6	78.6	55.7	89.2	63.2	75.8	53.7	80.2	56.8	93.2	66.0	78.6	55.7	86.2	61.1	101.2	71.7
400	89.5	63.4	94.5	66.9	106.5	75.4	91.2	64.6	96.3	68.2	111.0	78.7	94.5	66.9	103.2	73.1	120.0	85.0
450	105.5	74.7	111.2	78.7	124.6	88.3	107.5	76.1	113.2	80.2	129.7	91.9	111.2	78.7	120.9	85.7	139.7	98.9
500	122.4	86.7	128.6	91.1	143.6	101.7	124.5	88.2	130.9	92.8	149.2	105.7	128.6	91.1	139.5	98.8	160.2	113.5
550	139.9	99.1	146.9	104.0	163.2	115.6	142.4	100.8	149.4	105.8	169.4	120.0	146.9	104.0	158.8	112.5	181.4	128.5
600	158.2	112.1	165.8	117.5	183.7	130.1	160.9	113.9	168.6	119.4	190.4	134.8	165.8	117.5	178.9	126.7	203.4	144.1
650	177.2	125.5	185.4	131.4	204.8	145.0	180.1	127.5	188.5	133.5	212.0	150.2	185.5	131.4	199.6	141.4	226.1	160.1
700	196.8	139.4	205.7	145.7	226.5	160.5	199.9	141.6	209.0	148.0	234.3	166.0	205.8	145.7	221.0	156.5	249.4	176.7
750	217.0	153.7	226.6	160.5	248.9	176.3	220.4	156.1	230.1	163.0	257.3	182.2	226.7	160.6	243.0	172.1	273.4	193.6
800	237.9	168.5	248.1	175.8	272.0	192.6	241.5	171.0	251.9	178.4	280.8	198.9	248.2	175.8	265.7	188.2	298.0	211.0
850	259.3	183.6	270.2	191.4	295.6	209.4	263.1	186.4	274.2	194.3	305.0	216.0	270.3	191.5	288.9	204.6	323.1	228.9
900			292.9	207.5	319.7	226.5	285.3	202.1	297.2	210.5	329.7	233.6	293.0	207.5	312.7	221.5	348.9	247.1
950			316.1	223.9	344.5	244.0	308.1	218.2	320.6	227.1	355.0	251.5	316.2	224.0	337.1	238.8	375.2	265.8
1000			339.9	240.8	369.8	261.9	331.4	234.8	344.6	244.1	380.9	269.8	340.0	240.8	362.0	256.4	402.1	284.8
1100			389.0	275.5	421.9	298.9			394.2	279.2	434.1	307.5	389.1	275.6	413.4	292.8	457.5	324.1
1200			440.0	311.7	476.1	337.2			445.8	315.8	489.4	346.7	440.2	311.8	466.9	330.7	514.9	364.7
1300			493.0	349.2	532.2	377.0			499.3	353.7	546.6	387.2	493.2	349.4	522.2	369.9	574.2	406.7
1400			547.8	388.0	590.1	418.0					605.7	429.1			579.4	410.4	635.4	450.1
1500					649.9	460.3					666.6	472.2			638.4	452.2	698.5	494.7
1600					711.3	503.9					729.2	516.5			699.1	495.2	763.2	540.6
1800					839.2	594.4					859.4	608.7			825.4	584.7	897.7	635.9
2000					973.3	689.4					995.8	705.4					1038.5	735.6
2200					1113.3	788.6					1138.2	806.2					1185.3	839.6
2400					1259.0	891.8					1286.3	911.1					1337.8	947.6
2600					1410.1	998.8					1439.8	1019.8					1495.8	1059.5
2800					1566.3	1109.5					1598.5	1132.3					1659.0	1175.1
3000					1727.6	1223.7					1762.2	1248.2					1827.3	1294.3
3400											2103.9	1490.3					2178.2	1542.9
3600																	2360.5	1672.1
4000																	2738.4	1939.7
4500																	3234.3	2291.0

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Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]																	
	FIS EM M22						FIS EM M24						FIS EM M27					
h_{ef}	93	93	190	190	440	440	96	96	210	210	480	480	108	108	250	250	540	540
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
95	14.1	10.0	17.0	12.0	22.7	16.1												
100	15.1	10.7	18.0	12.8	24.0	17.0												
105	16.0	11.4	19.1	13.6	25.3	17.9	16.4	11.6	20.1	14.2	26.9	19.0						
120	19.1	13.5	22.5	16.0	29.3	20.8	19.5	13.8	23.6	16.7	31.1	22.0	20.3	14.4	25.5	18.1	33.7	23.9
125	20.1	14.2	23.7	16.8	30.7	21.7	20.5	14.5	24.8	17.6	32.5	23.0	21.4	15.2	26.8	19.0	35.2	25.0
130	21.2	15.0	24.9	17.6	32.1	22.7	21.6	15.3	26.0	18.4	33.9	24.0	22.5	16.0	28.0	19.9	36.8	26.0
135	22.2	15.7	26.1	18.5	33.5	23.7	22.7	16.1	27.2	19.3	35.4	25.1	23.7	16.8	29.3	20.8	38.3	27.1
140	23.3	16.5	27.3	19.3	34.9	24.7	23.8	16.8	28.5	20.2	36.8	26.1	24.8	17.6	30.6	21.7	39.8	28.2
160	27.8	19.7	32.3	22.9	40.7	28.8	28.3	20.0	33.6	23.8	42.8	30.3	29.5	20.9	36.0	25.5	46.1	32.7
175	31.3	22.2	36.1	25.6	45.2	32.0	31.8	22.6	37.6	26.6	47.5	33.6	33.1	23.5	40.2	28.4	50.9	36.1
180	32.5	23.0	37.5	26.5	46.7	33.1	33.1	23.4	38.9	27.6	49.0	34.7	34.4	24.3	41.6	29.4	52.6	37.2
190	34.9	24.7	40.1	28.4	49.8	35.3	35.5	25.2	41.7	29.5	52.2	37.0	36.9	26.1	44.4	31.5	55.9	39.6
200	37.4	26.5	42.9	30.4	52.9	37.5	38.0	26.9	44.5	31.5	55.5	39.3	39.5	27.9	47.4	33.5	59.3	42.0
250	50.5	35.7	57.2	40.5	69.3	49.1	51.2	36.3	59.1	41.9	72.3	51.2	53.0	37.5	62.6	44.4	76.8	54.4
300	64.6	45.8	72.6	51.4	86.7	61.4	65.5	46.4	74.9	53.0	90.2	63.9	67.7	47.9	79.0	56.0	95.4	67.6
350	79.7	56.5	88.9	63.0	105.1	74.5	80.8	57.2	91.6	64.9	109.1	77.3	83.3	59.0	96.3	68.2	115.0	81.5
400	95.7	67.8	106.2	75.3	124.4	88.1	97.0	68.7	109.3	77.4	128.9	91.3	99.8	70.7	114.6	81.2	135.5	96.0
450	112.6	79.8	124.4	88.1	144.6	102.4	114.0	80.8	127.8	90.5	149.5	105.9	117.2	83.0	133.7	94.7	156.8	111.1
500	130.3	92.3	143.3	101.5	165.6	117.3	131.8	93.4	147.1	104.2	170.9	121.1	135.4	95.9	153.6	108.8	178.9	126.7
550	148.7	105.3	163.0	115.5	187.3	132.7	150.4	106.5	167.1	118.4	193.1	136.8	154.3	109.3	174.3	123.5	201.8	143.0
600	167.8	118.9	183.4	129.9	209.8	148.6	169.7	120.2	187.9	133.1	216.1	153.1	173.9	123.2	195.7	138.6	225.5	159.7
650	187.6	132.9	204.6	144.9	232.9	165.0	189.7	134.3	209.4	148.3	239.7	169.8	194.3	137.6	217.8	154.3	249.8	176.9
700	208.1	147.4	226.3	160.3	256.7	181.9	210.3	149.0	231.5	164.0	264.0	187.0	215.3	152.5	240.6	170.4	274.8	194.6
750	229.2	162.3	248.7	176.2	281.2	199.2	231.6	164.0	254.3	180.1	288.9	204.7	236.9	167.8	264.0	187.0	300.4	212.8
800	250.9	177.7	271.8	192.5	306.3	216.9	253.4	179.5	277.7	196.7	314.5	222.8	259.2	183.6	288.1	204.0	326.6	231.4
850	273.2	193.5	295.4	209.2	332.0	235.1	275.9	195.4	301.7	213.7	340.6	241.3	282.0	199.7	312.7	221.5	353.5	250.4
900	296.0	209.7	319.6	226.4	358.2	253.7	298.9	211.7	326.3	231.1	367.4	260.2	305.4	216.3	337.9	239.4	380.9	269.8
950	319.4	226.3	344.4	243.9	385.1	272.7	322.5	228.4	351.4	248.9	394.7	279.6	329.4	233.3	363.7	257.6	408.9	289.7
1000	343.4	243.2	369.7	261.9	412.4	292.1	346.6	245.5	377.1	267.1	422.6	299.3	353.9	250.7	390.0	276.3	437.5	309.9
1100	392.9	278.3	421.9	298.8	468.8	332.1	396.5	280.8	430.1	304.6	479.9	339.9	404.5	286.5	444.3	314.7	496.2	351.5
1200	444.3	314.7	476.1	337.2	527.2	373.4	448.3	317.5	485.1	343.6	539.2	381.9	457.1	323.8	500.6	354.6	556.9	394.5
1300	497.7	352.5	532.2	377.0	587.5	416.2	502.0	355.6	542.0	383.9	600.5	425.4	511.6	362.4	558.8	395.8	619.7	438.9
1400	552.9	391.7	590.3	418.1	649.7	460.2	557.6	395.0	600.8	425.5	663.7	470.1	568.0	402.3	618.9	438.4	684.3	484.7
1500			650.0	460.5	713.8	505.6	614.9	435.6	661.3	468.5	728.7	516.2	626.2	443.5	680.8	482.2	750.7	531.7
1600			711.6	504.0	779.5	552.2			723.7	512.6	795.5	563.5	686.0	485.9	744.5	527.3	818.8	580.0
1800			839.6	594.7	916.0	648.9			853.2	604.4	934.0	661.6	810.7	574.2	876.7	621.0	960.2	680.1
2000			973.8	689.8	1058.9	750.1			989.1	700.6	1078.8	764.2			1015.3	719.2	1107.9	784.8
2200					1207.8	855.5			1130.9	801.1	1229.7	871.1			1159.9	821.6	1261.7	893.7
2400					1362.4	965.0					1386.4	982.0			1310.2	928.1	1421.3	1006.7
2600					1522.5	1078.4					1548.5	1096.8			1466.0	1038.4	1586.3	1123.6
2800					1687.8	1195.5					1715.8	1215.4					1756.6	1244.3
3000					1858.2	1316.2					1888.3	1337.5					1932.0	1368.5
3200					2033.4	1440.4					2065.6	1463.1					2112.3	1496.2
3400					2213.4	1567.8					2247.6	1592.1					2297.4	1627.3
3600					2398.0	1698.6					2434.3	1724.3					2487.0	1761.6
3800					2586.9	1832.4					2625.4	1859.6					2681.1	1899.1
4000					2780.2	1969.3					2820.8	1998.0					2879.6	2039.7
4500					3281.6	2324.5					3327.5	2357.0					3394.0	2404.1
5000											3859.0	2733.5					3933.2	2786.0
5500																	4496.1	3184.7

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Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

h_{ef}	$V^0_{Rd,c}$ [kN]																	
	FIS EM M30						FIS EM M36						FIS EM M39					
	120	120	280	280	600	600	144	144	330	330	540	540	156	156	360	360	585	585
edge distance [mm]	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
	concrete						concrete						concrete					
140	25.8	18.3	32.4	23.0	42.9	30.4												
160	30.6	21.7	38.0	26.9	49.4	35.0	32.9	23.3	41.7	29.5	49.9	35.3						
175	34.4	24.3	42.3	30.0	54.5	38.6	36.8	26.1	46.2	32.7	55.0	38.9	38.0	26.9	48.4	34.3	58.0	41.1
180	35.6	25.2	43.8	31.0	56.2	39.8	38.2	27.0	47.8	33.8	56.7	40.2	39.4	27.9	50.0	35.4	59.8	42.4
190	38.2	27.1	46.7	33.1	59.7	42.3	40.9	29.0	50.9	36.1	60.2	42.6	42.2	29.9	53.3	37.7	63.4	44.9
200	40.9	28.9	49.8	35.2	63.2	44.8	43.6	30.9	54.1	38.3	63.7	45.1	45.0	31.9	56.6	40.1	67.0	47.5
250	54.8	38.8	65.5	46.4	81.4	57.7	58.2	41.2	70.8	50.1	82.1	58.1	59.8	42.4	73.7	52.2	85.9	60.9
300	69.7	49.4	82.4	58.4	100.7	71.3	73.8	52.2	88.5	62.7	101.5	71.9	75.7	53.7	91.8	65.1	105.9	75.0
350	85.7	60.7	100.2	71.0	120.9	85.7	90.4	64.0	107.2	75.9	121.9	86.3	92.6	65.6	111.0	78.6	126.9	89.9
400	102.6	72.6	119.0	84.3	142.1	100.7	107.9	76.4	126.8	89.8	143.2	101.4	110.5	78.2	131.1	92.9	148.7	105.3
450	120.3	85.2	138.6	98.2	164.1	116.2	126.2	89.4	147.3	104.3	165.3	117.1	129.1	91.5	152.0	107.7	171.4	121.4
500	138.8	98.3	159.0	112.6	186.9	132.4	145.4	103.0	168.6	119.4	188.2	133.3	148.6	105.3	173.8	123.1	194.9	138.0
550	158.1	112.0	180.2	127.7	210.5	149.1	165.3	117.1	190.6	135.0	212.0	150.1	168.9	119.6	196.3	139.0	219.1	155.2
600	178.1	126.1	202.1	143.2	234.8	166.3	186.0	131.8	213.4	151.2	236.4	167.4	189.8	134.5	219.6	155.5	244.1	172.9
650	198.8	140.8	224.7	159.2	259.7	184.0	207.4	146.9	236.9	167.8	261.5	185.2	211.5	149.8	243.5	172.5	269.8	191.1
700	220.1	155.9	248.0	175.7	285.4	202.2	229.4	162.5	261.0	184.9	287.3	203.5	233.9	165.6	268.1	189.9	296.1	209.8
750	242.1	171.5	271.9	192.6	311.7	220.8	252.0	178.5	285.8	202.5	313.8	222.2	256.8	181.9	293.4	207.8	323.1	228.9
800	264.7	187.5	296.5	210.0	338.6	239.9	275.3	195.0	311.3	220.5	340.8	241.4	280.4	198.6	319.3	226.2	350.8	248.5
850	287.9	203.9	321.6	227.8	366.1	259.4	299.2	211.9	337.3	238.9	368.5	261.0	304.6	215.8	345.8	244.9	379.0	268.4
900	311.7	220.8	347.4	246.1	394.3	279.3	323.7	229.3	363.9	257.8	396.8	281.0	329.4	233.3	372.8	264.1	407.8	288.9
950	336.0	238.0	373.7	264.7	422.9	299.6	348.7	247.0	391.1	277.0	425.6	301.5	354.8	251.3	400.5	283.7	437.2	309.7
1000	360.9	255.6	400.5	283.7	452.2	320.3	374.3	265.1	418.8	296.7	455.0	322.3	380.7	269.6	428.7	303.7	467.1	330.9
1100	412.2	292.0	455.8	322.9	512.2	362.8	427.0	302.4	475.9	337.1	515.4	365.0	434.1	307.5	486.7	344.8	528.6	374.4
1200	465.6	329.8	513.1	363.5	574.3	406.8	481.7	341.2	535.0	379.0	577.8	409.3	489.5	346.7	546.8	387.3	592.1	419.4
1300	520.9	368.9	572.4	405.5	638.4	452.2	538.4	381.4	596.1	422.3	642.2	454.9	546.9	387.4	608.8	431.3	657.6	465.8
1400	578.0	409.4	633.6	448.8	704.4	498.9	597.0	422.9	659.1	466.9	708.5	501.8	606.1	429.3	672.8	476.6	725.0	513.6
1500	636.9	451.2	696.6	493.4	772.1	546.9	657.4	465.6	723.9	512.8	776.6	550.1	667.2	472.6	738.5	523.1	794.2	562.6
1600	697.6	494.1	761.3	539.2	841.7	596.2	719.5	509.6	790.4	559.9	846.5	599.6	729.9	517.0	806.0	570.9	865.2	612.9
1800	823.8	583.5	895.7	634.5	985.8	698.3	848.6	601.1	928.6	657.7	991.3	702.2	860.5	609.5	946.1	670.2	1012.3	717.0
2000	956.3	677.4	1036.5	734.2	1136.3	804.9	984.1	697.1	1073.1	760.1	1142.5	809.3	997.4	706.5	1092.6	773.9	1165.7	825.7
2200			1183.3	838.1	1292.8	915.8	1125.5	797.3	1223.6	866.7	1299.8	920.7	1140.2	807.7	1245.1	881.9	1325.2	938.7
2400			1335.8	946.2	1455.2	1030.7			1379.9	977.4	1462.8	1036.2	1288.8	912.9	1403.4	994.1	1490.6	1055.8
2600			1493.7	1058.1	1623.0	1149.6			1541.7	1092.0	1631.4	1155.6			1567.2	1110.1	1661.5	1176.9
2800			1657.0	1173.7	1796.1	1272.3			1708.8	1210.4	1805.3	1278.8			1736.3	1229.9	1837.7	1301.7
3000			1825.2	1292.9	1974.4	1398.5			1880.9	1332.3	1984.4	1405.6			1910.5	1353.2	2019.0	1430.1
3200					2157.5	1528.3			2058.0	1457.8	2168.3	1535.9			2089.6	1480.1	2205.2	1562.0
3400					2345.4	1661.4			2239.8	1586.5	2357.0	1669.5			2273.4	1610.3	2396.3	1697.3
3600					2538.0	1797.7					2550.3	1806.5			2461.9	1743.8	2591.9	1835.9
3800					2735.0	1937.3					2748.2	1946.6			2654.8	1880.5	2792.1	1977.7
4000					2936.3	2079.9					2950.3	2089.8					2996.6	2122.6
4500					3458.0	2449.5					3474.2	2460.9					3526.4	2497.9
5000					4004.7	2836.7					4023.0	2849.6					4081.2	2890.9
5500					4575.0	3240.7					4595.5	3255.2					4659.8	3300.7
6000					5167.9	3660.6											5261.0	3726.5

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]					
	FIS EM M42					
h_{ef}	168	168	400	400	630	630
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
190	43.5	30.8	56.1	39.8	66.6	47.2
200	46.4	32.8	59.5	42.2	70.4	49.9
250	61.5	43.6	77.2	54.7	89.9	63.7
300	77.7	55.0	95.9	67.9	110.4	78.2
350	94.9	67.2	115.6	81.9	131.9	93.4
400	113.0	80.1	136.2	96.5	154.3	109.3
450	132.0	93.5	157.7	111.7	177.5	125.7
500	151.8	107.5	180.0	127.5	201.5	142.7
550	172.3	122.1	203.1	143.8	226.3	160.3
600	193.6	137.1	226.8	160.7	251.8	178.4
650	215.6	152.7	251.3	178.0	278.0	197.0
700	238.2	168.8	276.5	195.8	304.9	216.0
750	261.5	185.3	302.3	214.1	332.5	235.5
800	285.5	202.2	328.7	232.8	360.6	255.4
850	310.0	219.6	355.8	252.0	389.4	275.8
900	335.1	237.3	383.4	271.6	418.7	296.6
950	360.7	255.5	411.6	291.5	448.6	317.8
1000	387.0	274.1	440.3	311.9	479.1	339.4
1100	441.0	312.4	499.4	353.8	541.6	383.7
1200	497.1	352.1	560.6	397.1	606.3	429.4
1300	555.1	393.2	623.8	441.8	672.8	476.6
1400	615.0	435.6	688.8	487.9	741.3	525.1
1500	676.7	479.3	755.7	535.3	811.6	574.9
1600	740.2	524.3	824.3	583.9	883.7	625.9
1800	872.0	617.7	966.6	684.7	1032.9	731.6
2000	1010.3	715.6	1115.3	790.0	1188.5	841.9
2200	1154.5	817.8	1270.1	899.6	1350.3	956.4
2400	1304.5	924.0	1430.7	1013.4	1517.8	1075.1
2600	1459.9	1034.1	1596.7	1131.0	1690.9	1197.7
2800			1768.2	1252.4	1869.3	1324.1
3000			1944.7	1377.5	2052.9	1454.1
3200			2126.1	1506.0	2241.4	1587.6
3400			2312.3	1637.9	2434.7	1724.5
3600			2503.1	1773.1	2632.6	1864.7
3800			2698.5	1911.4	2835.0	2008.1
4000			2898.1	2052.8	3041.8	2154.6
4500			3415.7	2419.4	3577.4	2534.0
5000					4138.0	2931.1
5500					4722.4	3345.0
6000					5329.5	3775.1
6500					5958.2	4220.4

4

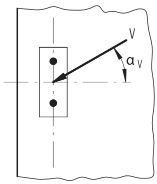
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

6.3 Combined tension and shear load:

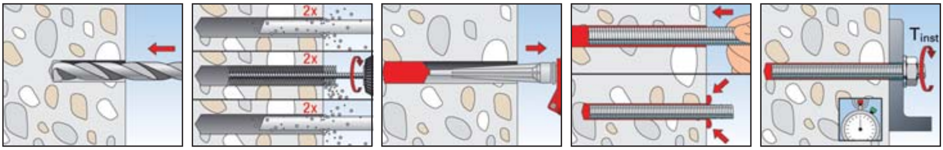
$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = **tension/shear component of the design load acting on the most unfavourable single anchor**

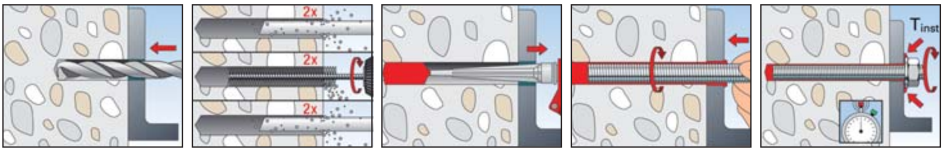
N_{Rd} ; V_{Rd} = **tension/shear design resistance including safety factors of the most unfavourable single anchor**

7. Installation details

Pre-positioned installation:



Push-through installation:



8. Anchor characteristics

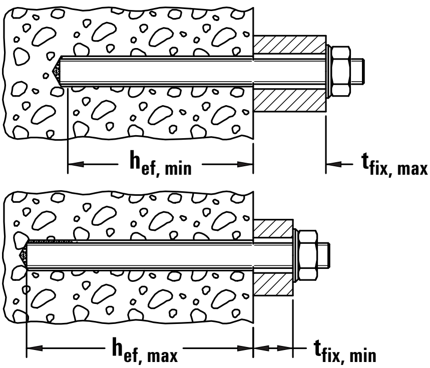
Anchor type			FIS EM M8			FIS EM M10			FIS EM M12			FIS EM M14			FIS EM M16			FIS EM M20			FIS EM M22		
	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	90	170	400	93	190	440
diameter of thread			M 8			M 10			M 12			M 14			M 16			M 20			M 22		
nominal drill hole diameter	d_0	[mm]	12			14			14			16			18			24			25		
drill depth = effective anchorage depth	$h_0 = h_{ef}$	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	90	170	400	93	190	440
clearance-hole in fixture to be attached pre-positioned installation [2]	d_f	[mm]	≦ 9			≦ 12			≦ 14			≦ 16			≦ 18			≦ 22			≦ 24		
clearance-hole in fixture to be attached push-through installation [1]	d_f	[mm]	≦ 14			≦ 16			≦ 16			≦ 18			≦ 20			≦ 26			≦ 28		
wrench size	SW	[mm]	13			17			19			22			24			30			34		
maximum torque moment	$T_{inst, max}$	[Nm]	10			20			40			50			60			120			135		
minimum thickness of concrete member	h_{min}	[mm]	100	110	190	100	120	230	100	140	270	105	150	310	116	161	356	138	218	448	143	240	490
minimum spacing	s_{min}	[mm]	40			45			55			60			65			85			95		
minimum edge distance	c_{min}	[mm]	40			45			55			60			65			85			95		
mortar filling quantity		[scale units]	3	4	8	4	6	13	5	8	18	6	10	24	7	10	28	11	20	45	12	24	60

4

Anchor type			FIS EM M24			FIS EM M27			FIS EM M30			FIS EM M36			FIS EM M39			FIS EM M42		
	h_{ef}	[mm]	96	210	480	108	250	540	120	280	600	144	330	540	156	360	585	168	400	630
diameter of thread			M 24			M 27			M 30			M 36			M 39			M 42		
nominal drill hole diameter	d_0	[mm]	28			30			35			42			45			50		
drill depth = effective anchorage depth	$h_0 = h_{ef}$	[mm]	96	210	480	108	250	540	120	280	600	144	330	540	156	360	585	168	400	630
clearance-hole in fixture to be attached pre-positioned installation [2]	d_f	[mm]	≦ 26			≦ 30			≦ 33			≦ 40			≦ 43			≦ 46		
clearance-hole in fixture to be attached push-through installation [1]	d_f	[mm]	≦ 30			≦ 33			≦ 40			≦ 45			≦ 50			≦ 55		
wrench size	SW	[mm]	36			41			46			55			60			65		
maximum torque moment	$T_{inst, max}$	[Nm]	150			200			300			400			450			450		
minimum thickness of concrete member	h_{min}	[mm]	152	266	536	240	310	600	190	350	670	228	414	624	246	450	675	268	500	730
minimum spacing	s_{min}	[mm]	105			120			140			180			195			200		
minimum edge distance	c_{min}	[mm]	105			120			140			180			195			200		
mortar filling quantity		[scale units]	14	29	66	17	39	84	25	58	125	39	90	146	46	105	171	69	164	258

[1] Hole clearance has to be filled with excess mortar.

[2] For larger diameters the clearance has to be filled with excess mortar.



9. Gelling and curing times

System temperature	Max. processing time FIS EM
+ 5 °C	4 h
> + 5 °C to + 10 °C	2 h
> + 10 °C to + 20 °C	30 min.
> + 20 °C to + 30 °C	14 min.
> + 30 °C to + 40 °C	7 min.

Temperature at anchoring base	Curing time [1] FIS EM
+ 5 °C	40 h
+ 10 °C	18 h
+ 20 °C	10 h
≥ 30 °C	5 h

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least + 5 °C.
With temperatures above + 30 °C to + 40 °C the cartridges have to be cooled down to + 15 °C or + 20 °C.
For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.
[1] In wet concrete the curing time has to be doubled.

10. Mechanical characteristics of anchor rods FIS A and RGM

Anchor type			FIS EM M8				FIS EM M10				FIS EM M12				FIS EM M14			
			gvz		A4-70	C-70	gvz		A4-70	C-70	gvz		A4-70	C-70	gvz		A4-70	C-70
property class			**5.8**	**8.8**			**5.8**	**8.8**			**5.8**	**8.8**			**5.8**	**8.8**		
stressed cross sectional area anchor rod	A_s	[mm^2]	36.6				58.0				84.3				115.0			
section modulus	W	[mm^3]	31.2				62.3				109.2				173.9			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	15.2	24.0	16.7	20.8	29.6	48.0	33.3	41.6	52.0	84.0	59.0	73.6	83.2	133.6	93.6	116.8
yield strength anchor rod	f_{yk}	[N/mm^2]	400	640	450	560	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength anchor rod	f_{uk}	[N/mm^2]	500	800	700	700	500	800	700	700	500	800	700	700	500	800	700	700

Anchor type			FIS EM M16				FIS EM M20				FIS EM M22				FIS EM M24			
			gvz		A4-70	C-70	gvz		A4-70	C-70	gvz		A4-70	C-70	gvz		A4-70	C-70
property class			**5.8**	**8.8**			**5.8**	**8.8**			**5.8**	**8.8**			**5.8**	**8.8**		
stressed cross sectional area anchor rod	A_s	[mm^2]	157.0				245.0				303				353.0			
section modulus	W	[mm^3]	277.5				540.9				743.9				935.5			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	132.8	212.8	148.7	185.6	259.2	415.2	291.0	363.2	357.6	572.8	401.3	500.8	448.0	716.8	502.6	627.2
yield strength anchor rod	f_{yk}	[N/mm^2]	400	640	450	560	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength anchor rod	f_{uk}	[N/mm^2]	500	800	700	700	500	800	700	700	500	800	700	700	500	800	700	700

Anchor type			FIS EM M27				FIS EM M30				FIS EM M36	FIS EM M39	FIS EM M42
			gvz		A4-70	C-70	gvz		A4-70	C-70	gvz	gvz	gvz
property class			**5.8**	**8.8**			**5.8**	**8.8**			**5.8**	**5.8**	**5.8**
stressed cross sectional area anchor rod	A_s	[mm^2]	459.0				561.0				817.0	976.0	1121
section modulus	W	[mm^3]	1387				1874				3294	4301	5294
design value of bending moment	$M^0_{Rd,s}$	[Nm]	666.4	1066	748.1	933.6	898.4	1438	1008	1258	1581	2069	2551
yield strength anchor rod	f_{yk}	[N/mm^2]	400	640	450	560	400	640	450	560	400	400	400
tensile strength anchor rod	f_{uk}	[N/mm^2]	500	800	700	700	500	800	700	700	500	500	500

fischer Injection mortar FIS EM Internal-threaded anchor RG MI

Anchor design according to fischer specification

1. Types

RG MI, M8 - M20 – Internal-threaded anchor (gvz)

RG MI A4, M8 - M20 – Internal-threaded anchor (A4)

Injection mortar FIS EM 390 S, FIS EM 585 S, FIS EM 1500 S

ETA
CE
ETA-10/0012
ETAG 001-5
Option 1 for cracked concrete
*)

Fire resistance classification
R 120
Anchor types see test report

CALCULATION WITH
CC
COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval *) for cracked and non-cracked concrete.
- Expansion stress free anchoring guarantees for a save use with small spacings and edge distances.
- Less cleaning procedures of the drill hole due to the high-quality epoxy resin.
- The resin seals the drill hole and avoids penetration of dampness and therefore gives corrosion protection for the embedded steel.
- Variable embedment depth enables the application in all kinds of building structure.
- Large range of available fixing length gives perfect allocation to the given fixture.
- Suitable for underwater installations. (See reduction factor; Section 4.2).
- Suitable for diamond drilled holes guarantees highest flexibility on site. (See reduction factor; Section 4.2).
- Longer curing time for simple installation, especially for large embedment depth.
- Low shrinkage of the mortar enables the use of lanrge anchor diameters.
- Approved for temperatures from −40 °C to +72 °C.

*) The conditions of use (e.g. design resistances, characteristic disistance, ...) in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Internal-threaded anchor and screw for internal threaded anchor:	- Carbon steel grade 5.8 and 8.8 zinc plated (5 µm) and passivated (gvz) - Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
Injection mortar:	- Epoxy resin, cement and hardener

2. Ultimate resistances of single anchors with large spacing and large edge distance[1)]

Mean values

Anchor type				FIS EM RG M8 I				FIS EM RG M10 I				FIS EM RG M12 I			
				gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef}			[mm]	90				90				125			
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]															
tension static	C 20/25	N_u	[kN]	20.0	30.5	27.3	27.3	30.5	49.4	43.1	43.1	45.2	71.4	62.0	62.0
	C 50/60	N_u	[kN]	20.0	30.5	27.3	27.3	30.5	49.4	43.1	43.1	45.2	71.4	62.0	62.0
shear static	≧ C 20/25	V_u	[kN]	10.0	15.2	13.7	13.7	15.2	24.7	21.5	21.5	22.6	35.7	31.0	31.0
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]															
tension static	C 20/25	N_u	[kN]	20.0	30.5	27.3	27.3	30.5	39.2	39.2	39.2	45.2	64.1	62.0	62.0
	C 50/60	N_u	[kN]	20.0	30.5	27.3	27.3	30.5	49.4	43.1	43.1	45.2	71.4	62.0	62.0
shear static	≧ C 20/25	V_u	[kN]	10.0	15.2	13.7	13.7	15.2	24.7	21.5	21.5	22.6	35.7	31.0	31.0

Anchor type				FIS EM RG M16 I				FIS EM RG M20 I			
				gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef}			[mm]	160				200			
non-cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]											
tension static	C 20/25	N_u	[kN]	83.0	113.4	115.5	115.5	129.2	188.0	180.6	180.6
	C 50/60	N_u	[kN]	83.0	113.4	115.5	115.5	129.2	188.0	180.6	180.6
shear static	≧ C 20/25	V_u	[kN]	41.5	56.7	57.8	57.8	64.6	94.0	90.3	90.3
cracked concrete temperature range (+ 60 °C / + 35 °C)[2)]											
tension static	C 20/25	N_u	[kN]	83.0	92.9	92.9	92.9	129.2	129.8	129.8	129.8
	C 50/60	N_u	[kN]	83.0	113.4	115.5	115.5	129.2	188.0	180.6	180.6
shear static	≧ C 20/25	V_u	[kN]	41.5	56.7	57.8	57.8	64.6	94.0	90.3	90.3

1) The loads apply to fischer internal-threaded anchors with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance [1)]

Anchor type				FIS EM RG M8				FIS EM RG M10 I				FIS EM RG M12			
				gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef}			[mm]	90				90				125			
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]															
tension static	C 20/25	N_u	[kN]	19.0	29.0	26.0	26.0	29.0	43.1	41.0	41.0	43.0	68.0	59.0	59.0
	C 50/60	N_u	[kN]	19.0	29.0	26.0	26.0	29.0	47.0	41.0	41.0	43.0	68.0	59.0	59.0
shear static	≧ C 20/25	V_u	[kN]	9.2	14.6	12.8	12.8	14.8	23.2	20.3	20.3	21.1	33.7	29.5	29.5
cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]															
tension static	C 20/25	N_u	[kN]	19.0	23.8	23.8	23.8	27.1	27.1	27.1	27.1	42.4	42.4	42.4	42.4
	C 50/60	N_u	[kN]	19.0	25.9	25.9	25.9	29.0	29.6	29.6	29.6	43.0	46.2	46.2	46.2
shear static	≧ C 20/25	V_u	[kN]	9.2	14.6	12.8	12.8	14.8	23.2	20.3	20.3	21.1	33.7	29.5	29.5

Anchor type				FIS EM RG M16				FIS EM RG M20 I			
				gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef}			[mm]	160				200			
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]											
tension static	C 20/25	N_u	[kN]	79.0	102.2	102.2	102.2	123.0	142.8	142.8	142.8
	C 50/60	N_u	[kN]	79.0	108.0	110.0	110.0	123.0	179.0	172.0	172.0
shear static	≧ C 20/25	V_u	[kN]	39.2	54.0	54.8	54.8	62.0	90.0	86.0	86.0
cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]											
tension static	C 20/25	N_u	[kN]	72.9	72.9	72.9	72.9	101.8	101.8	101.8	101.8
	C 50/60	N_u	[kN]	79.0	84.4	84.4	84.4	123.0	134.2	134.2	134.2
shear static	≧ C 20/25	V_u	[kN]	39.2	54.0	54.8	54.8	62.0	90.0	86.0	86.0

1) The loads apply to fischer internal-threaded anchors with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

fischer Injection mortar FIS EM Internal-threaded anchor RG MI

Anchor design according to fischer specification

4

3.2 Design resistance [1)]

Anchor type	FIS EM RG M8				FIS EM RG M10 I				FIS EM RG M12			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	90				90				125			
non-cracked concrete												
temperature range (+ 60 °C / + 35 °C) [2)]												
tension static C 20/25 N_{Rd} [kN]	12.7	19.3	13.9	13.9	19.3	28.7	21.9	21.9	28.7	45.3	31.6	31.6
C 50/60 N_{Rd} [kN]	12.7	19.3	13.9	13.9	19.3	31.3	21.9	21.9	28.7	45.3	31.6	31.6
shear static ≧ C 20/25 V_{Rd} [kN]	7.4	11.7	8.2	8.2	11.8	18.6	13.0	13.0	16.9	27.0	18.9	18.9
cracked concrete												
temperature range (+ 60 °C / + 35 °C) [2)]												
tension static C 20/25 N_{Rd} [kN]	12.7	15.8	13.9	13.9	18.1	18.1	18.1	18.1	28.3	28.3	28.3	28.3
C 50/60 N_{Rd} [kN]	12.7	17.3	13.9	13.9	19.3	19.7	19.7	19.7	28.7	30.8	30.8	30.8
shear static ≧ C 20/25 V_{Rd} [kN]	7.4	11.7	8.2	8.2	11.8	18.6	13.0	13.0	16.9	27.0	18.9	18.9

Anchor type	FIS EM RG M16				FIS EM RG M20 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	160				200			
non-cracked concrete								
temperature range (+ 60 °C / + 35 °C) [2)]								
tension static C 20/25 N_{Rd} [kN]	52.7	56.8	56.8	56.8	79.4	79.4	79.4	79.4
C 50/60 N_{Rd} [kN]	52.7	72.0	58.8	58.8	82.0	119.3	92.0	92.0
shear static ≧ C 20/25 V_{Rd} [kN]	31.4	43.2	35.1	35.1	49.6	72.0	55.1	55.1
cracked concrete								
temperature range (+ 60 °C / + 35 °C) [2)]								
tension static C 20/25 N_{Rd} [kN]	40.5	40.5	40.5	40.5	56.6	56.6	56.6	56.6
C 50/60 N_{Rd} [kN]	46.9	46.9	46.9	46.9	74.6	74.6	74.6	74.6
shear static ≧ C 20/25 V_{Rd} [kN]	31.4	43.2	35.1	35.1	49.6	72.0	55.1	55.1

1) The loads apply to fischer internal-threaded anchors with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

3.3 Recommended resistance [1) 2)]

Anchor type	FIS EM RG M8				FIS EM RG M10 I				FIS EM RG M12			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	90				90				125			
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]												
tension static C 20/25 N_R [kN]	9.0	13.8	9.9	9.9	13.8	20.5	15.7	15.7	20.5	32.4	22.5	22.5
C 50/60 N_R [kN]	9.0	13.8	9.9	9.9	13.8	22.4	15.7	15.7	20.5	32.4	22.5	22.5
shear static ≧ C 20/25 V_R [kN]	5.3	8.3	5.9	5.9	8.5	13.3	9.3	9.3	12.1	19.3	13.5	13.5
cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]												
tension static C 20/25 N_R [kN]	9.0	11.3	9.9	9.9	12.9	12.9	12.9	12.9	20.2	20.2	20.2	20.2
C 50/60 N_R [kN]	9.0	12.3	9.9	9.9	13.8	14.1	14.1	14.1	20.5	22.0	22.0	22.0
shear static ≧ C 20/25 V_R [kN]	5.3	8.3	5.9	5.9	8.5	13.3	9.3	9.3	12.1	19.3	13.5	13.5

Anchor type	FIS EM RG M16				FIS EM RG M20 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	160				200			
non-cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]								
tension static C 20/25 N_R [kN]	37.6	40.6	40.6	40.6	56.7	56.7	56.7	56.7
C 50/60 N_R [kN]	37.6	51.4	42.0	42.0	58.6	85.2	65.7	65.7
shear static ≧ C 20/25 V_R [kN]	22.4	30.9	25.1	25.1	35.4	51.4	39.4	39.4
cracked concrete temperature range (+ 60 °C / + 35 °C) [2)]								
tension static C 20/25 N_R [kN]	28.9	28.9	28.9	28.9	40.4	40.4	40.4	40.4
C 50/60 N_R [kN]	33.5	33.5	33.5	33.5	53.3	53.3	53.3	53.3
shear static ≧ C 20/25 V_R [kN]	22.4	30.9	25.1	25.1	35.4	51.4	39.4	39.4

1) The loads apply to fischer internal-threaded anchors with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)
3) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on the failure mode of the anchor.

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure for the highest loaded anchor

Design resistance for single anchor

Anchor type	FIS EM RG M8 I				FIS EM RG M10 I				FIS EM RG M12 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	5.8	8.8	A4-70	C-70	5.8	8.8	A4-70	C-70
	90				90				125			
design resistance $N_{Rd,s}$ [kN]	12.7	19.3	13.9	13.9	19.3	31.3	21.9	21.9	28.7	45.3	31.6	31.6

Anchor type	FIS EM RG M16 I				FIS EM RG M20 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
	160				200			
design resistance $N_{Rd,s}$ [kN]	52.7	72.0	58.8	58.8	82.0	119.3	92.0	92.0

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Hammer drilled

Anchor type			FIS EM RG M8 I	FIS EM RG M10 I	FIS EM RG M12 I	FIS EM RG M16 I	FIS EM RG M20 I
eff. anchorage depth	h_{ef}	[mm]	**90**	**90**	**125**	**160**	**200**
non-cracked concrete							
temperature range (+60°C / +35°C) [1]							
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	33.9	42.2	66.0	79.9	117.3
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	22.6	25.9	40.4	57.9	83.8
temperature range (+72°C / +50°C) [1]							
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	31.7	39.2	61.3	73.7	107.5
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	21.0	25.9	37.0	52.7	75.4
cracked concrete							
temperature range (+60°C / +35°C) [1]							
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	15.8	18.1	28.3	43.0	68.4
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	12.9	17.2	23.6	36.9	50.3
temperature range (+72°C / +50°C) [1]							
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	15.8	18.1	28.3	43.0	68.4
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	12.9	15.1	23.6	31.6	50.3

Diamond drilled

Anchor type			FIS EM RG M8 I	FIS EM RG M10 I	FIS EM RG M12 I	FIS EM RG M16 I	FIS EM RG M20 I
eff. anchorage depth	h_{ef}	[mm]	**90**	**90**	**125**	**160**	**200**
non-cracked concrete							
temperature range (+60°C / +35°C) [1]							
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	29.4	36.2	51.8	61.4	88.0
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	21.0	25.9	37.0	52.7	75.4
temperature range (+72°C / +50°C) [1]							
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	27.1	33.2	47.1	55.3	78.2
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	19.4	23.7	33.7	47.4	67.0
cracked concrete							
temperature range (+60°C / +35°C) [1]							
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	15.8	18.1	28.3	43.0	68.4
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	12.9	17.2	23.6	36.9	50.3
temperature range (+72°C / +50°C) [1]							
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	15.8	18.1	28.3	43.0	68.4
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	12.9	15.1	23.6	31.6	50.3

[1] (short term temperature / long term temperature)

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	55
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,p}$	[-]	0.98	0.99	1.00	1.02	1.04	1.06	1.07	1.08	1.09

Anchor design according to fischer specification

4.2.2 Characteristic edge distance and spacing for design of combined pull-out and concrete cone failure

Anchor type			FIS EM RG M8 I	FIS EM RG M10 I	FIS EM RG M12 I	FIS EM RG M16 I	FIS EM RG M20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
hammer drilled							
temperature range (+60°C / +35°C) [1]							
wet and dry concrete	$s_{cr,Np}$	[kN]	270	270	375	480	600
	$c_{cr,Np}$	[kN]	135	135	188	240	300
waterfilled hole	$s_{cr,Np}$	[kN]	270	270	375	480	600
	$c_{cr,Np}$	[kN]	135	135	188	240	300
temperature range (+72°C / +50°C) [1]							
wet and dry concrete	$s_{cr,Np}$	[kN]	270	270	375	480	600
	$c_{cr,Np}$	[kN]	135	135	188	240	300
waterfilled hole	$s_{cr,Np}$	[kN]	270	270	375	480	600
	$c_{cr,Np}$	[kN]	135	135	188	240	300
diamond drilled							
temperature range (+60°C / +35°C) [1]							
wet and dry concrete	$s_{cr,Np}$	[kN]	270	270	375	480	600
	$c_{cr,Np}$	[kN]	135	135	188	240	300
waterfilled hole	$s_{cr,Np}$	[kN]	270	270	375	480	600
	$c_{cr,Np}$	[kN]	135	135	188	240	300
temperature range (+72°C / +50°C) [1]							
wet and dry concrete	$s_{cr,Np}$	[kN]	270	270	375	480	578
	$c_{cr,Np}$	[kN]	135	135	188	240	289
waterfilled hole	$s_{cr,Np}$	[kN]	270	270	375	480	578
	$c_{cr,Np}$	[kN]	135	135	188	240	289

[1] (short term temperature / long term temperature)

4

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type	FIS EM RG M8 I 1)	FIS EM RG M10 I 1)	FIS EM RG M12 I 1)	FIS EM RG M16 I 2)	FIS EM RG M20 I 2)
eff. anchorage depth h_{ef} [mm]	90	90	125	160	200
non-cracked concrete					
design resistance $N^0_{Rd,c}$ [kN]	28.7	28.7	47.1	56.8	79.4
cracked concrete					
design resistance $N^0_{Rd,c}$ [kN]	20.5	20.5	33.5	40.5	56.6

1) For underwater installation the resistance values have to be multiplied by a factor of 0.71.
2) For underwater installation the resistance values have to be multiplied by a factor of 0.86.

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,c}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type	FIS EM RG M8 I	FIS EM RG M10 I	FIS EM RG M12 I	FIS EM RG M16 I	FIS EM RG M20 I
eff. anchorage depth h_{ef} [mm]	90	90	125	160	200
$s_{cr,N}$ [mm]	270	270	375	480	600
$c_{cr,N}$ [mm]	135	135	188	240	300

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_s	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type				FIS EM RG M8 I	FIS EM RG M10 I	FIS EM RG M12 I	FIS EM RG M16 I	FIS EM RG M20 I
eff. anchorage depth		h_{ef}	[mm]	90	90	125	160	200
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	180	180	250	320	400
		$c_{cr,sp}$	[mm]	90	90	125	160	200
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)				
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$				
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	407	407	565	723	904
		$c_{cr,sp}$	[mm]	203	203	283	362	452
		h_{min}	[mm]	120	125	165	205	260

$f_{scr,sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2.0
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.8	3.62	3.44	3.26	3.08	2.9	2.72	2.54	2.36	2.18	2.0

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4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2
f_h	4.52	4.34	4.16	3.98	3.80	3.62	3.44	3.26	3.08	2.90	2.72	2.54	2.36	2.18	2.00

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\ (N_{Rd,p}\ ;\ N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type	FIS EM RG M8 I				FIS EM RG M10 I				FIS EM RG M12 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
design resistance $V_{Rd,s}$ [kN]	7.4	11.7	8.2	8.2	11.8	18.6	13.0	13.0	16.9	27.0	18.9	18.9

Anchor type	FIS EM RG M16 I				FIS EM RG M20 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
design resistance $V_{Rd,s}$ [kN]	31.4	43.2	35.1	35.1	49.6	72.0	55.1	55.1

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\ (\ N_{Rd,p}\ ;\ N_{Rd,c}\ )$$

k-factor

Anchor type	FIS EM RG M8 I to FIS EM RG M20 I
k	2.0

4

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- $c < \max(10\ h_{ef}\ ;\ 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]									
	FIS EM RG M8 I		FIS EM RG M10 I		FIS EM RG M12 I		FIS EM RG M16 I		FIS EM RG M20 I	
h_{ef}	90		90		125		160		200	
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
55	6.2	4.4								
60	7.0	4.9								
65	7.7	5.5	8.2	5.8						
70	8.5	6.0	9.0	6.4						
75	9.3	6.6	9.8	6.9	10.8	7.7				
80	10.1	7.2	10.6	7.5	11.8	8.3				
85	11.0	7.8	11.5	8.2	12.7	9.0				
90	11.8	8.4	12.4	8.8	13.6	9.7				
95	12.7	9.0	13.3	9.4	14.6	10.3	16.2	11.4		
100	13.6	9.6	14.2	10.1	15.6	11.0	17.2	12.2		
105	14.5	10.3	15.2	10.7	16.6	11.7	18.3	12.9		
120	17.3	12.3	18.1	12.8	19.7	13.9	21.6	15.3		
125	18.3	13.0	19.1	13.5	20.7	14.7	22.7	16.1	25.2	17.9
130	19.3	13.7	20.1	14.2	21.8	15.4	23.8	16.9	26.5	18.8
135	20.3	14.4	21.1	15.0	22.9	16.2	25.0	17.7	27.7	19.6
140	21.3	15.1	22.2	15.7	24.0	17.0	26.2	18.5	29.0	20.5
160	25.5	18.1	26.5	18.8	28.6	20.2	31.0	22.0	34.2	24.2
180	29.9	21.2	31.0	22.0	33.3	23.6	36.1	25.6	39.5	28.0
200	34.5	24.5	35.8	25.3	38.3	27.1	41.3	29.3	45.1	32.0
250	46.9	33.2	48.4	34.3	51.6	36.6	55.3	39.2	60.0	42.5
300	60.3	42.7	62.2	44.0	66.0	46.7	70.4	49.9	75.9	53.7
350	74.7	52.9	76.9	54.4	81.3	57.6	86.4	61.2	92.8	65.7
400	90.0	63.8	92.5	65.5	97.5	69.1	103.4	73.2	110.6	78.3
450	106.1	75.2	108.9	77.1	114.6	81.2	121.2	85.8	129.2	91.6
500	123.0	87.1	126.1	89.3	132.5	93.8	139.8	99.0	148.7	105.3
550	140.7	99.6	144.1	102.1	151.1	107.0	159.2	112.7	168.9	119.7
600	159.0	112.6	162.8	115.3	170.5	120.7	179.2	127.0	189.9	134.5
650	178.1	126.1	182.1	129.0	190.5	134.9	200.0	141.7	211.6	149.8
700	197.7	140.1	202.2	143.2	211.2	149.6	221.4	156.9	233.9	165.7
750	218.0	154.4	222.8	157.8	232.5	164.7	243.5	172.5	256.8	181.9
800	238.9	169.3	244.1	172.9	254.4	180.2	266.2	188.5	280.4	198.6
850	260.4	184.5	265.9	188.3	276.9	196.2	289.5	205.0	304.6	215.7
900	282.5	200.1	288.3	204.2	300.0	212.5	313.3	221.9	329.3	233.3
950	305.1	216.1	311.2	220.5	323.6	229.2	337.7	239.2	354.6	251.2
1000			334.7	237.1	347.8	246.4	362.7	256.9	380.5	269.5
1100					397.8	281.7	414.2	293.4	433.8	307.3
1200					449.7	318.5	467.7	331.3	489.2	346.5
1300					503.5	356.7	523.1	370.5	546.5	387.1
1400							580.4	411.1	605.6	429.0
1500							639.4	452.9	666.6	472.2
1600							700.2	496.0	729.3	516.6
1800							826.7	585.6	859.6	608.9
2000									996.3	705.7

4

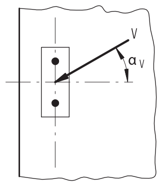
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

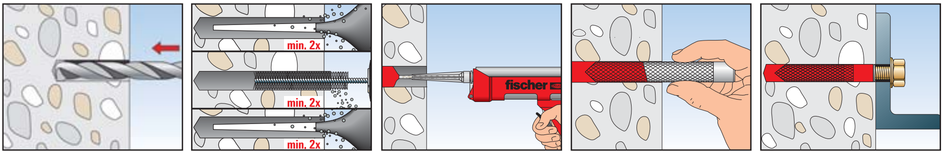
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

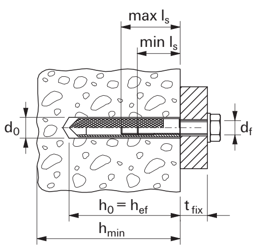
N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details



8. Anchor characteristics

Anchor type			FIS EM RG M8 I	FIS EM RG M10 I	FIS EM RG M12 I	FIS EM RG M16 I	FIS EM RG M20 I
diameter of thread			M 8	M 10	M 12	M 16	M 20
nominal drill hole diameter	d_0	[mm]	14	18	20	24	32
drill depth	h_0	[mm]	90	90	125	160	200
effective anchorage depth	h_{ef}	[mm]	90	90	125	160	200
clearance-hole in fixture to be attached	d_f	[mm]	≦ 9	≦ 12	≦ 14	≦ 18	≦ 22
screw penetration depth	min l_s	[mm]	8	10	12	16	20
	max l_s	[mm]	18	23	26	35	45
wrench size	SW	[mm]	13	17	19	24	30
maximum torque moment	$T_{inst,max}$	[Nm]	10	20	40	80	120
minimum thickness of concrete member	h_{min}	[mm]	120	125	165	205	260
minimum spacing	s_{min}	[mm]	55	65	75	95	125
minimum edge distances	c_{min}	[mm]	55	65	75	95	125
mortar filling quantity		[scale units]	5	7	11	17	48



9. Gelling and curing times

System temperature	Max. processing time FIS EM
+ 5 °C	4 h
> + 5 °C to + 10 °C	2 h
> + 10 °C to + 20 °C	30 min.
> + 20 °C to + 30 °C	14 min.
> + 30 °C to + 40 °C	7 min.

Temperature at anchoring base	Curing time FIS EM
+ 5 °C	40 h
+ 10 °C	18 h
+ 20 °C	10 h
≥ 30 °C	5 h

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least + 5 °C.
With temperatures above + 30 °C to + 40 °C the cartridges have to be cooled down to + 15 °C or + 20 °C. In wet concrete the curing time has to be doubled.
For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.

10. Mechanical characteristics of RG MI

Anchor type			FIS EM RG M8 I				FIS EM RG M10 I				FIS EM RG M12 I			
screw property class			**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**
stressed cross sectional area - screw	A_s	[mm²]	36.6				58.0				84.3			
resisting moment - screw	W	[mm³]	31.2				62.3				109.2			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	16.0	24.0	16.7	20.8	31.2	48.0	33.3	41.6	54.4	84.0	59.0	73.6
yield strength - screw	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength - screw	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	700	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm²]	72.5				137.1				161.8			
resisting moment - internal-threaded anchor	W	[mm³]	147.8				361.4				496.6			
yield strength - internal-threaded anchor	f_{yk}	[N/mm²]	420		450	560	420		450	560	420		450	560
tensile strength - internal-threaded anchor	f_{uk}	[N/mm²]	525		700	700	525		700	700	525		700	700

Anchor type			FIS EM RG M16 I				FIS EM RG M20 I			
screw property class			**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**
stressed cross sectional area - screw	A_s	[mm²]	157.0				245.0			
resisting moment - screw	W	[mm³]	277.5				540.9			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	138.4	212.8	148.7	185.6	269.6	415.2	291.0	363.2
yield strength - screw	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560
tensile strength - screw	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm²]	210.4				350.5			
resisting moment - internal-threaded anchor	W	[mm³]	836.9				1755.3			
yield strength - internal-threaded anchor	f_{yk}	[N/mm²]	420		450	560	420		450	560
tensile strength - internal-threaded anchor	f_{uk}	[N/mm²]	525		700	700	525		700	700

fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

1. Types

Reinforcement bars Ø 8 - Ø 40 mm

Injection mortar FIS EM 390 S, FIS EM 585 S, FIS EM 1500 S

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ETA-10/0012
ETAG 001-5
Option 1 for cracked concrete *)

ICC ES
ESR-1990
See ICC-ES Evaluation Report at www.ic-es.org
Inspection agency: AA-707 *)

Fire resistance classification
R 120
Anchor types see test report

Features and Advantages

- European Technical Approval *) for cracked and non-cracked concrete.
- ICC-ES Evaluation Report *) for cracked and non-cracked concrete, Seismic categories A-F.
- Expansion stress free anchoring guarantees for a save use with small spacings and edge distances.
- Less cleaning procedures of the drill hole due to the high-quality epoxy resin.
- The resin seals the drill hole and avoids penetration of dampness and therefore gives corrosion protection for the embedded steel.
- Variable embedment depth enables the application in all kinds of building structure.
- Large range of available fixing length gives perfect allocation to the given fixture.
- Suitable for underwater installations. (See reduction factor; Section 4.2).
- Suitable for diamond drilled holes guarantees highest flexibility on site. (See reduction factor; Section 4.2).
- Longer curing time for simple installation, especially for large embedment depth.
- Low shrinkage of the mortar enables the use of large anchor diameters.
- Approved for temperatures from −40 °C to +72 °C.

*) The conditions of use (e.g. design resistances, characteristic disistance, ...) in the European Technical Approval or in the ICC-ES Evaluation Report may vary from those of the Technical Handbook. The ICC-ES Evaluation Report is currently valid for diameters 10 - 32 mm.

Materials

Reinforcing steel :	Approved with f_{yk} = 400 - 600 N/mm². Static values in the Technical Handbook based on f_{yk} = 500 N/mm²
Injection mortar:	Epoxy resin. cement and hardener

fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

2. Ultimate resistances of single anchors with large spacing and large edge distance [1)]

Mean values

Rebar type				FIS EM Ø 8	FIS EM Ø 10	FIS EM Ø 12	FIS EM Ø 14	FIS EM Ø 16	FIS EM Ø 18	FIS EM Ø 20	FIS EM Ø 22	FIS EM Ø 24
h_{ef}			[mm]	80	90	110	120	125	140	170	190	210
non-cracked concrete temperature range (+60°C / +35°C) [2)]												
tension static	C 20/25	N_u	[kN]	29.4	46.2	66.2	88.7	94.3	111.8	149.6	176.8	205.4
	C 50/60	N_u	[kN]	29.4	46.2	66.2	89.3	116.6	147.0	181.7	219.5	261.5
shear static	≧ C 20/25	V_u	[kN]	17.6	27.7	39.7	53.6	69.9	88.2	109.0	131.7	156.9
cracked concrete temperature range (+60°C / +35°C) [2)]												
tension static	C 20/25	N_u	[kN]	29.4	39.2	53.0	60.3	64.1	76.0	101.7	120.2	139.7
	C 50/60	N_u	[kN]	29.4	46.2	66.2	89.3	99.4	117.8	157.6	186.2	216.4
shear static	≧ C 20/25	V_u	[kN]	17.6	27.7	39.7	53.6	69.9	88.2	109.0	131.7	156.9

Rebar type				FIS EM Ø 25	FIS EM Ø 26	FIS EM Ø 28	FIS EM Ø 30	FIS EM Ø 32	FIS EM Ø 34	FIS EM Ø 36	FIS EM Ø 40
h_{ef}			[mm]	250	250	250	280	300	300	350	400
non-cracked concrete temperature range (+60°C / +35°C) [2)]											
tension static	C 20/25	N_u	[kN]	266.8	266.8	266.8	316.3	350.7	350.7	442.0	540.0
	C 50/60	N_u	[kN]	283.5	306.6	356.0	408.5	465.2	524.0	588.0	725.6
shear static	≧ C 20/25	V_u	[kN]	170.1	184.0	213.6	245.1	279.1	314.4	352.8	435.3
cracked concrete temperature range (+60°C / +35°C) [2)]											
tension static	C 20/25	N_u	[kN]	181.4	181.4	181.4	215.1	238.5	238.5	300.5	367.2
	C 50/60	N_u	[kN]	281.1	281.1	281.1	333.2	369.5	369.5	465.6	568.9
shear static	≧ C 20/25	V_u	[kN]	170.1	184.0	213.6	245.1	279.1	314.4	352.8	435.3

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² with hammer drilling and careful drill hole cleaning according to the approval. The rebar may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)

4

3. Characteristic. design and recommended resistances of single anchors with large spacing and large edge distance

3.1 Characteristic resistance[1)]

Rebar type			FIS EM Ø 8	FIS EM Ø 10	FIS EM Ø 12	FIS EM Ø 14	FIS EM Ø 16	FIS EM Ø 18	FIS EM Ø 20	FIS EM Ø 22	FIS EM Ø 24
h_{ef}		[mm]	80	90	110	120	125	140	170	190	210
non-cracked concrete											
temperature range (+60°C / +35°C) [2)]											
tension static	C 20/25 N_{Rk}	[kN]	28,0	43,1	58,3	66,4	70,6	83,7	111,9	132,3	153,7
	C 50/60 N_{Rk}	[kN]	28,0	44,0	63,0	80,5	95,9	120,8	151,4	186,1	224,4
shear static	≧ C 20/25 V_{Rk}	[kN]	13,8	21,6	31,1	42,4	55,3	70,0	87,0	105,0	125,0
cracked concrete											
temperature range (+60°C / +35°C) [2)]											
tension static	C 20/25 N_{Rk}	[kN]	14,1	19,8	29,0	36,9	37,7	47,5	64,1	91,9	109,6
	C 50/60 N_{Rk}	[kN]	15,3	21,6	31,6	40,3	41,1	51,8	69,9	100,2	120,8
shear static	≧ C 20/25 V_{Rk}	[kN]	13,8	21,6	31,1	42,4	55,3	70,0	87,0	105,0	125,0

Rebar type			FIS EM Ø 25	FIS EM Ø 26	FIS EM Ø 28	FIS EM Ø 30	FIS EM Ø 32	FIS EM Ø 34	FIS EM Ø 36	FIS EM Ø 40
h_{ef}		[mm]	250	250	250	280	300	300	350	400
non-cracked concrete										
temperature range (+60°C / +35°C) [2)]										
tension static	C 20/25 N_{Rk}	[kN]	199,6	199,6	199,6	236,6	262,4	262,4	330,7	404,0
	C 50/60 N_{Rk}	[kN]	270,0	289,4	309,4	345,2	394,5	406,7	512,5	626,2
shear static	≧ C 20/25 V_{Rk}	[kN]	135,0	146,0	170,0	195,0	221,0	250,0	280,0	346,0
cracked concrete										
temperature range (+60°C / +35°C) [2)]										
tension static	C 20/25 N_{Rk}	[kN]	137,4	142,3	142,3	168,7	150,8	160,2	197,9	251,3
	C 50/60 N_{Rk}	[kN]	149,8	155,8	167,8	201,4	164,4	174,6	215,7	273,9
shear static	≧ C 20/25 V_{Rk}	[kN]	135,0	146,0	170,0	195,0	221,0	250,0	280,0	346,0

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² with hammer drilling and careful drill hole cleaning according to the approval. The rebar may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

3.2 Design resistance[1)]

Rebar type			FIS EM ⌀ 8	FIS EM ⌀ 10	FIS EM ⌀ 12	FIS EM ⌀ 14	FIS EM ⌀ 16	FIS EM ⌀ 18	FIS EM ⌀ 20	FIS EM ⌀ 22	FIS EM ⌀ 24
h_{ef}		[mm]	80	90	110	120	125	140	170	190	210
non-cracked concrete temperature range (+60°C / +35°C) [2)]											
tension static	C 20/25 N_{Rd}	[kN]	20.0	28.7	38.8	44.3	47.1	55.8	74.6	73.5	85.4
	C 50/60 N_{Rd}	[kN]	20.0	31.4	45.0	53.7	63.9	80.5	100.9	103.4	124.6
shear static	≧ C 20/25 V_{Rd}	[kN]	9.2	14.4	20.7	28.3	36.9	46.7	58.0	70.0	83.3
cracked concrete temperature range (+60°C / +35°C) [2)]											
tension static	C 20/25 N_{Rd}	[kN]	9.4	13.2	19.4	24.6	25.1	31.7	42.7	51.1	60.9
	C 50/60 N_{Rd}	[kN]	10.2	14.4	21.1	26.8	27.4	34.5	46.6	55.7	67.1
shear static	≧ C 20/25 V_{Rd}	[kN]	9.2	14.4	20.7	28.3	36.9	46.7	58.0	70.0	83.3

Rebar type			FIS EM ⌀ 25	FIS EM ⌀ 26	FIS EM ⌀ 28	FIS EM ⌀ 30	FIS EM ⌀ 32	FIS EM ⌀ 34	FIS EM ⌀ 36	FIS EM ⌀ 40
h_{ef}		[mm]	250	250	250	280	300	300	350	400
non-cracked concrete temperature range (+60°C / +35°C) [2)]										
tension static	C 20/25 N_{Rd}	[kN]	110.9	110.9	110.9	131.4	145.8	145.8	183.7	224.4
	C 50/60 N_{Rd}	[kN]	154.6	160.8	171.9	191.8	219.2	226.0	284.7	347.9
shear static	≧ C 20/25 V_{Rd}	[kN]	90.0	97.3	113.3	130.0	147.3	166.7	186.7	230.7
cracked concrete temperature range (+60°C / +35°C) [2)]										
tension static	C 20/25 N_{Rd}	[kN]	76.4	79.1	79.1	93.7	83.8	89.0	110.0	139.6
	C 50/60 N_{Rd}	[kN]	83.2	86.6	93.2	111.9	91.3	97.0	119.9	152.2
shear static	≧ C 20/25 V_{Rd}	[kN]	90.0	97.3	113.3	130.0	147.3	166.7	186.7	230.7

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² with hammer drilling and careful drill hole cleaning according to the approval. The rebar may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)

4

fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

3.3 Recommended resistance[1) 3)]

Rebar type				FIS EM ⌀ 8	FIS EM ⌀ 10	FIS EM ⌀ 12	FIS EM ⌀ 14	FIS EM ⌀ 16	FIS EM ⌀ 18	FIS EM ⌀ 20	FIS EM ⌀ 22	FIS EM ⌀ 24
h_{ef}			[mm]	80	90	110	120	125	140	170	190	210
non-cracked concrete temperature range (+60°C / +35°C) [2)]												
tension static	C 20/25	N_R	[kN]	14.3	20.5	27.7	31.6	33.6	39.8	53.3	52.5	61.0
	C 50/60	N_R	[kN]	14.3	22.4	32.1	38.4	45.7	57.5	72.1	73.8	89.0
shear static	≥ C 20/25	V_R	[kN]	6.6	10.3	14.8	20.2	26.3	33.3	41.4	50.0	59.5
cracked concrete temperature range (+60°C / +35°C) [2)]												
tension static	C 20/25	N_R	[kN]	6.7	9.4	13.8	17.6	18.0	22.6	30.5	36.5	43.5
	C 50/60	N_R	[kN]	7.3	10.3	15.1	19.2	19.6	24.7	33.3	39.8	47.9
shear static	≥ C 20/25	V_R	[kN]	6.6	10.3	14.8	20.2	26.3	33.3	41.4	50.0	59.5

Rebar type				FIS EM ⌀ 25	FIS EM ⌀ 26	FIS EM ⌀ 28	FIS EM ⌀ 30	FIS EM ⌀ 32	FIS EM ⌀ 34	FIS EM ⌀ 36	FIS EM ⌀ 40
h_{ef}			[mm]	250	250	250	280	300	300	350	400
non-cracked concrete temperature range (+60°C / +35°C) [2)]											
tension static	C 20/25	N_R	[kN]	79.2	79.2	79.2	93.9	104.1	104.1	131.2	160.3
	C 50/60	N_R	[kN]	110.4	114.8	122.8	137.0	156.5	161.4	203.4	248.5
shear static	≥ C 20/25	V_R	[kN]	64.3	69.5	81.0	92.9	105.2	119.0	133.3	164.8
cracked concrete temperature range (+60°C / +35°C) [2)]											
tension static	C 20/25	N_R	[kN]	54.5	56.5	56.5	66.9	59.8	63.6	78.5	99.7
	C 50/60	N_R	[kN]	59.5	61.8	66.6	79.9	65.2	69.3	85.6	108.7
shear static	≥ C 20/25	V_R	[kN]	64.3	69.5	81.0	92.9	105.2	119.0	133.3	164.8

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² with hammer drilling and careful drill hole cleaning according to the approval. The rebar may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

3) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on the failure mode of the anchor.

4

4. Calculation of tension resistance

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

Steel failure: $N_{Rd.s}$

Combined pull-out and concrete cone failure:

$$N_{Rd.p} = N^0_{Rd.p} \cdot f_{b.N.p} \cdot f_{s1.p} \cdot f_{s2.p} \cdot f_{s3.p} \cdot f_{c1.p.A} \cdot f_{c1.p.B} \cdot f_{c2.p}$$

Concrete cone failure: $N_{Rd.c} = N^0_{Rd.c} \cdot f_{b.N.c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1.A} \cdot f_{c1.B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd.sp} = N^0_{Rd.c} \cdot f_{b.N.c} \cdot f_{s1.sp} \cdot f_{s2.sp} \cdot f_{s3.sp} \cdot f_{c1.sp.A} \cdot f_{c1.sp.B} \cdot f_{c2.sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Rebar type			FIS EM ⌀ 8	FIS EM ⌀ 10	FIS EM ⌀ 12	FIS EM ⌀ 14	FIS EM ⌀ 16	FIS EM ⌀ 18	FIS EM ⌀ 20	FIS EM ⌀ 22	FIS EM ⌀ 24
design resistance	$N_{Rd.s}$	[kN]	20.0	31.4	45.0	60.7	79.3	100.0	123.6	149.3	177.9

Rebar type			FIS EM ⌀ 25	FIS EM ⌀ 26	FIS EM ⌀ 28	FIS EM ⌀ 30	FIS EM ⌀ 32	FIS EM ⌀ 34	FIS EM ⌀ 36	FIS EM ⌀ 40
design resistance	$N_{Rd.s}$	[kN]	192.9	208.6	242.1	277.9	316.4	356.4	400.0	493.6

4.2 Combined pull-out and concrete cone failure

$$N_{Rd.p} = N^0_{Rd.p} \cdot f_{b.N.p} \cdot f_{s1.p} \cdot f_{s2.p} \cdot f_{s3.p} \cdot f_{c1.p.A} \cdot f_{c1.p.B} \cdot f_{c2.p}$$

Design resistance of single anchor

Hammer drilled

Rebar type			FIS EM ∅ 8			FIS EM ∅ 10			FIS EM ∅ 12			FIS EM ∅ 14			FIS EM ∅ 16			FIS EM ∅ 18		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	85	140	360
non-cracked concrete																				
temperature range (+60°C / +35°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	16.1	21.4	42.9	20.1	30.2	67.0	26.4	41.5	90.5	30.8	49.3	114.9	37.5	58.6	150.1	44.9	73.9	190.0
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	11.5	15.3	30.6	14.4	21.5	47.9	17.6	27.6	60.3	20.4	32.7	76.2	23.0	35.9	91.9	27.5	45.2	116.3
temperature range (+72°C / +50°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	15.1	20.1	40.2	17.6	26.4	58.6	24.6	38.7	84.4	28.6	45.7	106.7	34.9	54.5	139.4	41.7	68.6	176.4
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	10.8	14.4	28.7	12.6	18.8	41.9	16.3	25.7	56.0	18.8	30.2	70.4	21.1	32.9	84.3	27.5	45.2	116.3
cracked concrete																				
temperature range (+60°C / +35°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	7.0	9.4	18.8	8.8	13.2	29.3	12.3	19.4	42.2	15.4	24.6	57.5	16.1	25.1	64.3	19.2	31.7	81.4
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	5.0	6.7	13.4	8.1	12.1	26.9	10.1	15.8	34.5	12.6	20.1	46.9	15.3	23.9	61.3	16.0	26.4	67.9
temperature range (+72°C / +50°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	7.0	9.4	18.8	8.8	13.2	29.3	12.3	19.4	42.2	15.4	24.6	57.5	16.1	25.1	64.3	19.2	31.7	81.4
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	5.0	6.7	13.4	7.2	10.8	23.9	10.1	15.8	34.5	11.0	17.6	41.1	13.4	20.9	53.6	16.0	26.4	67.9

Rebar type			FIS EM ∅ 20			FIS EM ∅ 22			FIS EM ∅ 24			FIS EM ∅ 25			FIS EM ∅ 26			FIS EM ∅ 28		
eff. anchorage depth	h_{ef}	[mm]	90	170	400	94	190	440	98	210	480	100	250	500	104	250	520	112	250	560
non-cracked concrete																				
temperature range (+60°C / +35°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	49,0	92,6	217,8	46,9	94,8	219,6	53,4	114,4	261,4	56,7	141,8	283,6	61,4	147,5	306,8	71,2	158,8	355,8
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	29,6	56,0	131,6	34,0	68,8	159,3	35,2	75,4	172,3	37,4	93,5	187,0	40,5	97,2	202,3	46,9	104,7	234,6
temperature range (+72°C / +50°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	45,2	85,5	201,1	43,3	87,5	202,7	49,3	105,6	241,3	52,4	130,9	261,8	51,9	124,8	259,6	60,2	134,4	301,0
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	29,6	56,0	131,6	30,9	62,5	144,8	35,2	75,4	172,3	33,7	84,1	168,3	36,4	87,5	182,0	42,2	94,2	211,1
cracked concrete																				
temperature range (+60°C / +35°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	22,6	42,7	100,5	25,3	51,1	118,3	28,7	61,6	140,7	30,5	76,4	152,7	33,0	79,4	165,2	38,3	85,5	191,6
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	18,8	35,6	83,8	21,7	43,8	101,4	21,1	45,2	103,4	22,4	56,1	112,2	24,3	58,3	121,4	28,1	62,8	140,7
temperature range (+72°C / +50°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	22,6	42,7	100,5	25,3	51,1	118,3	28,7	61,6	140,7	30,5	76,4	152,7	33,0	79,4	165,2	38,3	85,5	191,6
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	16,2	30,5	71,8	18,6	37,5	86,9	21,1	45,2	103,4	22,4	56,1	112,2	24,3	58,3	121,4	28,1	62,8	140,7

Rebar type			FIS EM ∅ 30			FIS EM ∅ 32			FIS EM ∅ 34			FIS EM ∅ 36			FIS EM ∅ 40		
eff. anchorage depth	h_{ef}	[mm]	120	280	600	128	300	640	136	300	680	144	350	720	160	400	800
non-cracked concrete																	
temperature range (+60°C / +35°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	75,4	175,9	377,0	85,8	201,1	428,9	96,8	213,6	484,2	108,6	263,9	542,9	134,0	335,1	670,2
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	48,5	113,1	242,4	55,1	129,3	275,7	62,3	137,3	311,3	62,0	150,8	310,2	76,6	191,5	383,0
temperature range (+72°C / +50°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	69,1	161,3	345,6	78,6	184,3	393,2	88,8	195,8	443,9	99,5	241,9	497,6	111,7	279,3	558,5
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	48,5	113,1	242,4	49,0	114,9	245,1	55,3	122,1	276,7	62,0	150,8	310,2	76,6	191,5	383,0
cracked concrete																	
temperature range (+60°C / +35°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	44,0	102,6	219,9	35,7	83,8	178,7	40,4	89,0	201,8	45,2	110,0	226,2	55,9	139,6	279,3
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	32,3	75,4	161,6	36,8	86,2	183,8	41,5	91,6	207,5	38,8	94,2	193,9	47,9	119,7	239,4
temperature range (+72°C / +50°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	44,0	102,6	219,9	35,7	83,8	178,7	40,4	89,0	201,8	45,2	110,0	226,2	55,9	139,6	279,3
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	32,3	75,4	161,6	30,6	71,8	153,2	34,6	76,3	172,9	38,8	94,2	193,9	47,9	119,7	239,4

[1] (short term temperature / long term temperature)

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fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

4

Diamond drilled

Rebar type			FIS EM Ø 8			FIS EM Ø 10			FIS EM Ø 12			FIS EM Ø 14			FIS EM Ø 16			FIS EM Ø 18		
eff. anchorage depth	h_{ef}	**[mm]**	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**75**	**120**	**280**	**80**	**125**	**320**	**85**	**140**	**360**
non-cracked concrete																				
temperature range (+60°C / +35°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	16.1	21.4	42.9	18.8	28.3	62.8	22.9	35.9	78.4	26.4	42.2	98.5	32.2	50.3	128.7	32.0	52.8	135.7
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	11.5	15.3	30.6	13.5	20.2	44.9	16.3	25.7	56.0	18.8	30.2	70.4	23.0	35.9	91.9	25.2	41.5	106.6
temperature range (+72°C / +50°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	15.1	20.1	40.2	17.6	26.4	58.6	21.1	33.2	72.4	24.2	38.7	90.3	29.5	46.1	118.0	32.0	52.8	135.7
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	10.8	14.4	28.7	12.6	18.8	41.9	15.1	23.7	51.7	17.3	27.6	64.5	21.1	32.9	84.3	22.9	37.7	96.9
cracked concrete																				
temperature range (+60°C / +35°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	7.0	9.4	18.8	8.8	13.2	29.3	12.3	19.4	42.2	15.4	24.6	57.5	16.1	25.1	64.3	19.2	31.7	81.4
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	5.0	6.7	13.4	8.1	12.1	26.9	10.1	15.8	34.5	12.6	20.1	46.9	15.3	23.9	61.3	16.0	26.4	67.9
temperature range (+72°C / +50°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	7.0	9.4	18.8	8.8	13.2	29.3	12.3	19.4	42.2	15.4	24.6	57.5	16.1	25.1	64.3	19.2	31.7	81.4
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	5.0	6.7	13.4	7.2	10.8	23.9	10.1	15.8	34.5	11.0	17.6	41.1	13.4	20.9	53.6	16.0	26.4	67.9

Rebar type			FIS EM Ø 20			FIS EM Ø 22			FIS EM Ø 24			FIS EM Ø 25			FIS EM Ø 26			FIS EM Ø 28		
eff. anchorage depth	h_{ef}	**[mm]**	**90**	**170**	**400**	**94**	**190**	**440**	**98**	**210**	**480**	**100**	**250**	**500**	**104**	**250**	**520**	**112**	**250**	**560**
non-cracked concrete																				
temperature range (+60°C / +35°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	37,7	71,2	167,6	36,1	73,0	168,9	41,1	88,0	201,1	39,3	98,2	196,3	42,5	102,1	212,4	49,3	110,0	246,3
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	26,9	50,9	119,7	30,9	62,5	144,8	35,2	75,4	172,3	33,7	84,1	168,3	36,4	87,5	182,0	42,2	94,2	211,1
temperature range (+72°C / +50°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	37,7	71,2	167,6	32,5	65,7	152,1	36,9	79,2	181,0	39,3	98,2	196,3	37,8	90,8	188,8	43,8	97,7	218,9
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	26,9	50,9	119,7	27,8	56,3	130,3	31,7	67,9	155,1	33,7	84,1	168,3	32,4	77,8	161,8	37,5	83,8	187,7
cracked concrete																				
temperature range (+60°C / +35°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	22,6	42,7	100,5	25,3	51,1	118,3	28,7	61,6	140,7	30,5	76,4	152,7	33,0	79,4	165,2	38,3	85,5	191,6
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	18,8	35,6	83,8	21,7	43,8	101,4	21,1	45,2	103,4	22,4	56,1	112,2	24,3	58,3	121,4	28,1	62,8	140,7
temperature range (+72°C / +50°C) [1]																				
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	22,6	42,7	100,5	25,3	51,1	118,3	28,7	61,6	140,7	30,5	76,4	152,7	33,0	79,4	165,2	38,3	85,5	191,6
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	16,2	30,5	71,8	18,6	37,5	86,9	21,1	45,2	103,4	22,4	56,1	112,2	24,3	58,3	121,4	28,1	62,8	140,7

Rebar type			FIS EM Ø 30			FIS EM Ø 32			FIS EM Ø 34			FIS EM Ø 36			FIS EM Ø 40		
eff. anchorage depth	h_{ef}	**[mm]**	**120**	**280**	**600**	**128**	**300**	**640**	**136**	**300**	**680**	**144**	**350**	**720**	**160**	**400**	**800**
non-cracked concrete																	
temperature range (+60°C / +35°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	56.5	131.9	282.7	57.2	134.0	286.0	64.6	142.4	322.8	72.4	175.9	361.9	78.2	195.5	391.0
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	48.5	113.1	242.4	49.0	114.9	245.1	55.3	122.1	276.7	62.0	150.8	310.2	67.0	167.6	335.1
temperature range (+72°C / +50°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	50.3	117.3	251.3	57.2	134.0	286.0	56.5	124.6	282.5	63.3	153.9	316.7	78.2	195.5	391.0
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	43.1	100.5	215.4	49.0	114.9	245.1	48.4	106.8	242.1	54.3	131.9	271.4	67.0	167.6	335.1
cracked concrete																	
temperature range (+60°C / +35°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	44.0	102.6	219.9	35.7	83.8	178.7	40.4	89.0	201.8	45.2	110.0	226.2	55.9	139.6	279.3
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	32.3	75.4	161.6	36.8	86.2	183.8	41.5	91.6	207.5	38.8	94.2	193.9	47.9	119.7	239.4
temperature range (+72°C / +50°C) [1]																	
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	44.0	102.6	219.9	35.7	83.8	178.7	40.4	89.0	201.8	45.2	110.0	226.2	55.9	139.6	279.3
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	32.3	75.4	161.6	30.6	71.8	153.2	34.6	76.3	172.9	38.8	94.2	193.9	47.9	119.7	239.4

[1] (short term temperature / long term temperature)

fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b.N.p}$

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck.cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	55
cube compressive strength	$f_{ck.cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b.N.p}$	[-]	0.98	0.99	1.00	1.02	1.04	1.06	1.07	1.08	1.09

4.2.2 Characteristic edge distance and spacing for design

Hammer drilled

Rebar type			FIS EM ∅ 8			FIS EM ∅ 10			FIS EM ∅ 12			FIS EM ∅ 14			FIS EM ∅ 16			FIS EM ∅ 18		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	85	140	360
temperature range (+60°C / +35°C) [1]																				
wet and dry concrete	$s_{cr, Np}$	[kN]	180	234	234	180	270	292	210	330	339	225	360	383	240	375	437	255	420	492
	$c_{cr, Np}$	[kN]	90	117	117	90	135	146	105	165	170	113	180	191	120	188	219	128	210	246
waterfilled hole	$s_{cr, Np}$	[kN]	180	234	234	180	270	292	210	328	328	225	360	369	240	375	405	255	420	455
	$c_{cr, Np}$	[kN]	90	117	117	90	135	146	105	164	164	113	180	184	120	188	202	128	210	228
temperature range (+72°C / +50°C) [1]																				
wet and dry concrete	$s_{cr, Np}$	[kN]	180	226	226	180	270	273	210	328	328	225	360	369	240	375	421	255	420	474
	$c_{cr, Np}$	[kN]	90	113	113	90	135	137	105	164	164	113	180	184	120	188	211	128	210	237
waterfilled hole	$s_{cr, Np}$	[kN]	180	226	226	180	270	273	210	316	316	225	354	354	240	375	388	255	420	455
	$c_{cr, Np}$	[kN]	90	113	113	90	135	137	105	158	158	113	177	177	120	188	194	128	210	228

Rebar type			FIS EM ∅ 20			FIS EM ∅ 22			FIS EM ∅ 24			FIS EM ∅ 25			FIS EM ∅ 26			FIS EM ∅ 28		
eff. anchorage depth	h_{ef}	[mm]	90	170	400	94	190	440	98	210	480	100	250	500	104	250	520	112	250	560
temperature range (+60°C / +35°C) [1]																				
wet and dry concrete	$s_{cr, Np}$	[kN]	270	510	527	282	570	579	294	630	632	300	658	658	312	685	685	336	737	737
	$c_{cr, Np}$	[kN]	135	255	263	141	285	290	147	315	316	150	329	329	156	342	342	168	369	369
waterfilled hole	$s_{cr, Np}$	[kN]	270	484	484	282	533	533	294	554	554	300	577	577	312	600	600	336	647	647
	$c_{cr, Np}$	[kN]	135	242	242	141	266	266	147	277	277	150	289	289	156	300	300	168	323	323
temperature range (+72°C / +50°C) [1]																				
wet and dry concrete	$s_{cr, Np}$	[kN]	270	506	506	282	557	557	294	607	607	300	632	632	312	630	630	336	678	678
	$c_{cr, Np}$	[kN]	135	253	253	141	278	278	147	304	304	150	316	316	156	315	315	168	339	339
waterfilled hole	$s_{cr, Np}$	[kN]	270	484	484	282	508	508	294	554	554	300	548	548	312	570	570	336	613	613
	$c_{cr, Np}$	[kN]	135	242	242	141	254	254	147	277	277	150	274	274	156	285	285	168	307	307

Rebar type			FIS EM ∅ 30			FIS EM ∅ 32			FIS EM ∅ 34			FIS EM ∅ 36			FIS EM ∅ 40		
eff. anchorage depth	h_{ef}	[mm]	120	280	600	128	300	640	136	300	680	144	350	720	160	400	800
temperature range (+60°C / +35°C) [1]																	
wet and dry concrete	$s_{cr, Np}$	[kN]	360	759	759	384	810	810	408	860	860	432	911	911	480	1012	1012
	$c_{cr, Np}$	[kN]	180	379	379	192	405	405	204	430	430	216	455	455	240	506	506
waterfilled hole	$s_{cr, Np}$	[kN]	360	657	657	384	701	701	408	745	745	432	744	744	480	826	826
	$c_{cr, Np}$	[kN]	180	329	329	192	351	351	204	372	372	216	372	372	240	413	413
temperature range (+72°C / +50°C) [1]																	
wet and dry concrete	$s_{cr, Np}$	[kN]	360	727	727	384	775	775	408	824	824	432	872	872	480	924	924
	$c_{cr, Np}$	[kN]	180	363	363	192	388	388	204	412	412	216	436	436	240	462	462
waterfilled hole	$s_{cr, Np}$	[kN]	360	657	657	384	661	661	408	702	702	432	744	744	480	826	826
	$c_{cr, Np}$	[kN]	180	329	329	192	330	330	204	351	351	216	372	372	240	413	413

[1] (short term temperature / long term temperature)

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fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

Diamond drilled

Rebar type			**FIS EM ∅ 8**			**FIS EM ∅ 10**			**FIS EM ∅ 12**			**FIS EM ∅ 14**			**FIS EM ∅ 16**			**FIS EM ∅ 18**		
eff. anchorage depth	h_{ef}	**[mm]**	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**75**	**120**	**280**	**80**	**125**	**320**	**85**	**140**	**360**
temperature range (+60°C / +35°C) 1)																				
wet and dry concrete	$s_{cr, Np}$	[kN]	180	234	234	180	270	283	210	316	316	225	354	354	240	375	405	255	416	416
	$c_{cr, Np}$	[kN]	90	117	117	90	135	141	105	158	158	113	177	177	120	188	202	128	208	208
waterfilled hole	$s_{cr, Np}$	[kN]	180	234	234	180	270	283	210	316	316	225	354	354	240	375	405	255	420	436
	$c_{cr, Np}$	[kN]	90	117	117	90	135	141	105	158	158	113	177	177	120	188	202	128	210	218
temperature range (+72°C / +50°C) 1)																				
wet and dry concrete	$s_{cr, Np}$	[kN]	180	226	226	180	270	273	210	304	304	225	339	339	240	375	388	255	416	416
	$c_{cr, Np}$	[kN]	90	113	113	90	135	137	105	152	152	113	170	170	120	188	194	128	208	208
waterfilled hole	$s_{cr, Np}$	[kN]	180	226	226	180	270	273	210	304	304	225	339	339	240	375	388	255	416	416
	$c_{cr, Np}$	[kN]	90	113	113	90	135	137	105	152	152	113	170	170	120	188	194	128	208	208

Rebar type			**FIS EM ∅ 20**			**FIS EM ∅ 22**			**FIS EM ∅ 24**			**FIS EM ∅ 25**			**FIS EM ∅ 26**			**FIS EM ∅ 28**		
eff. anchorage depth	h_{ef}	**[mm]**	**90**	**170**	**400**	**94**	**190**	**440**	**98**	**210**	**480**	**100**	**250**	**500**	**104**	**250**	**520**	**112**	**250**	**560**
temperature range (+60°C / +35°C) 1)																				
wet and dry concrete	$s_{cr, Np}$	[kN]	270	462	462	282	508	508	294	554	554	300	548	548	312	570	570	336	613	613
	$c_{cr, Np}$	[kN]	135	231	231	141	254	254	147	277	277	150	274	274	156	285	285	168	307	307
waterfilled hole	$s_{cr, Np}$	[kN]	270	462	462	282	508	508	294	554	554	300	548	548	312	570	570	336	613	613
	$c_{cr, Np}$	[kN]	135	231	231	141	254	254	147	277	277	150	274	274	156	285	285	168	307	307
temperature range (+72°C / +50°C) 1)																				
wet and dry concrete	$s_{cr, Np}$	[kN]	270	462	462	282	482	482	294	526	526	300	548	548	312	537	537	336	578	578
	$c_{cr, Np}$	[kN]	135	231	231	141	241	241	147	263	263	150	274	274	156	269	269	168	289	289
waterfilled hole	$s_{cr, Np}$	[kN]	270	462	462	282	482	482	294	526	526	300	548	548	312	537	537	336	578	578
	$c_{cr, Np}$	[kN]	135	231	231	141	241	241	147	263	263	150	274	274	156	269	269	168	289	289

Rebar type			**FIS EM ∅ 30**			**FIS EM ∅ 32**			**FIS EM ∅ 34**			**FIS EM ∅ 36**			**FIS EM ∅ 40**		
eff. anchorage depth	h_{ef}	**[mm]**	**120**	**280**	**600**	**128**	**300**	**640**	**136**	**300**	**680**	**144**	**350**	**720**	**160**	**400**	**800**
temperature range (+60°C / +35°C) 1)																	
wet and dry concrete	$s_{cr, Np}$	[kN]	360	657	657	384	661	661	408	702	702	432	744	744	480	773	773
	$c_{cr, Np}$	[kN]	180	329	329	192	330	330	204	351	351	216	372	372	240	386	386
waterfilled hole	$s_{cr, Np}$	[kN]	360	657	657	384	661	661	408	702	702	432	744	744	480	773	773
	$c_{cr, Np}$	[kN]	180	329	329	192	330	330	204	351	351	216	372	372	240	386	386
temperature range (+72°C / +50°C) 1)																	
wet and dry concrete	$s_{cr, Np}$	[kN]	360	620	620	384	661	661	408	657	657	432	696	696	480	773	773
	$c_{cr, Np}$	[kN]	180	310	310	192	330	330	204	328	328	216	348	348	240	386	386
waterfilled hole	$s_{cr, Np}$	[kN]	360	620	620	384	661	661	408	657	657	432	696	696	480	773	773
	$c_{cr, Np}$	[kN]	180	310	310	192	330	330	204	328	328	216	348	348	240	386	386

1) (short term temperature / long term temperature)

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr.Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s1.p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr.Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1.p.A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1.p.B}$ $f_{c2.p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd.c} = N^0_{Rd.c} \cdot f_{b.N.c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1.A} \cdot f_{c1.B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd.sp} = N^0_{Rd.c} \cdot f_{b.N.c} \cdot f_{s1.sp} \cdot f_{s2.sp} \cdot f_{s3.sp} \cdot f_{c1.sp.A} \cdot f_{c1.sp.B} \cdot f_{c2.sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr.sp} > c_{cr.N}$
- $c < 1.2\ c_{cr.sp}$

Design resistance of single anchor

Rebar type			FIS EM Ø 8 [1]			FIS EM Ø10 [1]			FIS EM Ø12 [1]			FIS EM Ø14 [1]			FIS EM Ø16 [1]			FIS EM Ø 18 [1]		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	85	140	360
non-cracked concrete																				
design resistance	$N^0_{Rd.c}$	[kN]	15.6	24.1	68.1	15.6	28.7	95.2	19.7	38.8	125.2	21.9	44.3	157.7	24.1	47.1	192.7	26.4	55.8	230.0
cracked concrete																				
design resistance	$N^0_{Rd.c}$	[kN]	11.2	17.2	48.6	11.2	20.5	67.9	14.1	27.7	89.2	15.6	31.5	112.4	17.2	33.5	137.4	18.8	39.8	163.9

Rebar type			FIS EM Ø 20 [1]			FIS EM Ø 22 [2]			FIS EM Ø 24 [2]			FIS EM Ø 25 [2]			FIS EM Ø 26 [2]			FIS EM Ø 28 [2]		
eff. anchorage depth	h_{ef}	[mm]	90	170	400	94	190	440	98	210	480	100	250	500	104	250	520	112	250	560
non-cracked concrete																				
design resistance	$N^0_{Rd.c}$	[kN]	28.7	74.6	269.3	25.6	73.5	258.9	27.2	85.4	295.0	28.1	110.9	313.7	29.8	110.9	332.7	33.3	110.9	371.8
cracked concrete																				
design resistance	$N^0_{Rd.c}$	[kN]	20.5	53.2	192.0	18.2	52.4	184.6	19.4	60.9	210.3	20.0	79.1	223.6	21.2	79.1	237.2	23.7	79.1	265.0

Rebar type			FIS EM Ø 30 [2]			FIS EM Ø 32 [2]			FIS EM Ø 34 [2]			FIS EM Ø 36 [2]			FIS EM Ø 40 [2]		
eff. anchorage depth	h_{ef}	[mm]	120	280	600	128	300	640	136	300	680	144	350	720	160	400	800
non-cracked concrete																		
design resistance	$N^0_{Rd.c}$	[kN]	36.9	131.4	412.3	40.6	145.8	454.2	44.5	145.8	497.5	48.5	183.7	542.0	56.8	224.4	634.8
cracked concrete																		
design resistance	$N^0_{Rd.c}$	[kN]	26.3	93.7	293.9	29.0	103.9	323.8	31.7	103.9	354.6	34.6	131.0	386.4	40.5	160.0	452.5

[1] For underwater installation the resistance values have to be multiplied by a factor of 0.71.
[2] For underwater installation the resistance values have to be multiplied by a factor of 0.86.

fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Cylinder compressive strength	$f_{ck.cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck.cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b.N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type			FIS EM ⌀ 8			FIS EM ⌀ 10			FIS EM ⌀ 12			FIS EM ⌀ 14			FIS EM ⌀ 16			FIS EM ⌀ 18		
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	85	140	360
	$s_{cr.N}$	[mm]	180	240	480	180	270	600	210	330	720	225	360	840	240	375	960	255	420	1080
	$c_{cr.N}$	[mm]	90	120	240	90	135	300	105	165	360	113	180	420	120	188	480	128	210	540

Anchor type			FIS EM ⌀ 20			FIS EM ⌀ 22			FIS EM ⌀ 24			FIS EM ⌀ 25			FIS EM ⌀ 26			FIS EM ⌀ 28		
eff. anchorage depth	h_{ef}	[mm]	90	170	400	94	190	440	98	210	480	100	250	500	104	250	520	112	250	560
	$s_{cr.N}$	[mm]	270	510	1200	282	570	1320	294	630	1440	300	750	1500	312	750	1560	336	750	1680
	$c_{cr.N}$	[mm]	135	255	600	141	285	660	147	315	720	150	375	750	156	375	780	168	375	840

Anchor type			FIS EM ⌀ 30			FIS EM ⌀ 32			FIS EM ⌀ 34			FIS EM ⌀ 36			FIS EM ⌀ 40		
eff. anchorage depth	h_{ef}	[mm]	120	280	600	128	300	640	136	300	680	144	350	720	160	400	800
	$s_{cr.N}$	[mm]	360	840	1800	384	900	1920	408	900	2040	432	1050	2160	480	1200	2400
	$c_{cr.N}$	[mm]	180	420	900	192	450	960	204	450	1020	216	525	1080	240	600	1200

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr.N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr.N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1.A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1.B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

4.3.3 Concrete splitting failure

Characteristic edge distance and spacing for design

Rebar type				**FIS EM ∅ 8**			**FIS EM ∅ 10**			**FIS EM ∅ 12**			**FIS EM ∅ 14**			**FIS EM ∅ 16**			**FIS EM ∅ 18**		
eff. anchorage depth		h_{ef}	[mm]	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**75**	**120**	**280**	**80**	**125**	**320**	**85**	**140**	**360**
application with concrete member thickness	$h/h_{ef} \geq 2.0$	$s_{cr.sp}$	[mm]	120	160	320	120	180	400	140	220	480	150	240	560	160	250	640	170	280	720
		$c_{cr.sp}$	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	85	140	360
	$2.0 > h/h_{ef} > 1.3$	$s_{cr.sp}$	[mm]	$f_{scr.sp} \cdot h_{ef}$ ($f_{scr.sp}$ see table below)																	
		$c_{cr.sp}$	[mm]	$= s_{cr.sp}/2$																	
	$h/h_{ef} \leq 1.3$	$s_{cr.sp}$	[mm]	271	362	723	271	407	904	316	497	1085	339	542	1266	362	565	1446	384	633	1627
		$c_{cr.sp}$	[mm]	136	181	362	136	203	452	158	249	542	170	271	633	181	283	723	192	316	814
		h_{min}	[mm]	100	110	190	100	120	230	100	140	270	105	150	310	120	165	360	135	190	410

Rebar type				**FIS EM ∅ 20**			**FIS EM ∅ 22**			**FIS EM ∅ 24**			**FIS EM ∅ 25**			**FIS EM ∅ 26**			**FIS EM ∅ 28**		
eff. anchorage depth		h_{ef}	[mm]	**90**	**170**	**400**	**94**	**190**	**440**	**98**	**210**	**480**	**100**	**250**	**500**	**104**	**250**	**520**	**112**	**250**	**560**
application with concrete member thickness	$h/h_{ef} \geq 2.0$	$s_{cr.sp}$	[mm]	180	340	800	188	380	880	196	420	960	200	500	1000	208	500	1040	224	500	1120
		$c_{cr.sp}$	[mm]	90	170	400	94	190	440	98	210	480	100	250	500	104	250	520	112	250	560
	$2.0 > h/h_{ef} > 1.3$	$s_{cr.sp}$	[mm]	$f_{scr.sp} \cdot h_{ef}$ ($f_{scr.sp}$ see table below)																	
		$c_{cr.sp}$	[mm]	$= s_{cr.sp}/2$																	
	$h/h_{ef} \leq 1.3$	$s_{cr.sp}$	[mm]	407	768	1808	425	859	1989	443	949	2170	452	1130	2260	470	1130	2350	506	1130	2531
		$c_{cr.sp}$	[mm]	203	384	904	212	429	994	221	475	1085	226	565	1130	235	565	1175	253	565	1266
		h_{min}	[mm]	140	220	450	154	250	500	158	270	540	160	310	560	174	320	590	182	320	630

Rebar type				**FIS EM ∅ 30**			**FIS EM ∅ 32**			**FIS EM ∅ 34**			**FIS EM ∅ 36**			**FIS EM ∅ 40**		
eff. anchorage depth		h_{ef}	[mm]	**120**	**280**	**600**	**128**	**300**	**640**	**136**	**300**	**680**	**144**	**350**	**720**	**160**	**400**	**800**
application with concrete member thickness	$h/h_{ef} \geq 2.0$	$s_{cr.sp}$	[mm]	240	560	1200	256	600	1280	272	600	1360	288	700	1440	320	800	1600
		$c_{cr.sp}$	[mm]	120	280	600	128	300	640	136	300	680	144	350	720	160	400	800
	$2.0 > h/h_{ef} > 1.3$	$s_{cr.sp}$	[mm]	$f_{scr.sp} \cdot h_{ef}$ ($f_{scr.sp}$ see below)														
		$c_{cr.sp}$	[mm]	$s_{cr.sp}/2$														
	$h/h_{ef} \leq 1.3$	$s_{cr.sp}$	[mm]	542	1266	2712	579	1356	2893	615	1356	3074	651	1582	3254	723	1808	3616
		$c_{cr.sp}$	[mm]	271	633	1356	289	678	1446	307	678	1537	325	791	1627	362	904	1808
		h_{min}	[mm]	200	360	680	208	380	720	216	380	760	234	440	810	270	510	910

$f_{scr.sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2.0
$f_{scr.sp}$	4.52	4.34	4.16	3.98	3.8	3.62	3.44	3.26	3.08	2.9	2.72	2.54	2.36	2.18	2.0

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr.sp}$	1,3	1,35	1,4	1,45	1,5	1,55	1,6	1,65	1,7	1,75	1,8	1,85	1,9	1,95	2
$f_{s.sp}$	4,52	4,34	4,16	3,98	3,80	3,62	3,44	3,26	3,08	2,90	2,72	2,54	2,36	2,18	2,00

4.3.3.2 Influence of edge distance / concrete splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr.sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1.sp.A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1.sp.B}$ $f_{c2.sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd.s}$

Pryout failure: $V_{Rd.cp} = k \cdot min\,(N_{Rd.p}\,;\,N_{Rd.c})$

Concrete edge failure: $V_{Rd.c} = V^0_{Rd.c} \cdot f_{cr} \cdot f_{b.V} \cdot f_{\alpha.V} \cdot f_{s1.V} \cdot f_{s2.V} \cdot f_{c2.V} \cdot f_{h.V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single rebar

Anchor type			FIS EM ∅ 8	FIS EM ∅ 10	FIS EM ∅ 12	FIS EM ∅ 14	FIS EM ∅ 16	FIS EM ∅ 18	FIS EM ∅ 20	FIS EM ∅ 22	FIS EM ∅ 24
design resistance	$V_{Rd.s}$	[kN]	9.2	14.4	20.7	28.3	36.9	46.7	58.0	70.0	83.3

Anchor type			FIS EM ∅ 25	FIS EM ∅ 26	FIS EM ∅ 28	FIS EM ∅ 30	FIS EM ∅ 32	FIS EM ∅ 34	FIS EM ∅ 36	FIS EM ∅ 40
design resistance	$V_{Rd.s}$	[kN]	90.0	97.3	113.3	130.0	147.3	166.7	186.7	230.7

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd.cp} = k \cdot min\,(N_{Rd.p}\,;\,N_{Rd.c})$$

k-factor

Anchor type	FIS EM ∅ 8 to FIS EM ∅ 40
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd.c} = V^0_{Rd.c} \cdot f_{cr} \cdot f_{b.V} \cdot f_{\alpha.V} \cdot f_{s1.V} \cdot f_{s2.V} \cdot f_{c2.V} \cdot f_{h.V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]																	
	FIS EM ∅ 8						FIS EM ∅ 10						FIS EM ∅ 12					
h_{ef}	60	60	80	80	160	160	60	60	90	90	200	200	70	70	110	110	240	240
edge distance [mm]	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete	non-cracked concrete	cracked concrete
40	3.5	2.5	3.7	2.6	4.4	3.1												
45	4.1	2.9	4.3	3.1	5.1	3.6	4.3	3.0	4.7	3.3	5.8	4.1						
50	4.7	3.3	5.0	3.5	5.8	4.1	4.9	3.5	5.3	3.8	6.6	4.7						
55	5.4	3.8	5.6	4.0	6.6	4.7	5.6	3.9	6.0	4.3	7.4	5.2	5.9	4.2	6.6	4.6	8.2	5.8
60	6.0	4.3	6.3	4.5	7.3	5.2	6.2	4.4	6.8	4.8	8.2	5.8	6.6	4.7	7.3	5.2	9.1	6.4
65	6.7	4.7	7.0	5.0	8.1	5.7	6.9	4.9	7.5	5.3	9.0	6.4	7.3	5.2	8.1	5.7	10.0	7.1
70	7.4	5.2	7.8	5.5	8.9	6.3	7.7	5.4	8.3	5.8	9.9	7.0	8.1	5.7	8.9	6.3	10.9	7.7
75	8.1	5.8	8.5	6.0	9.7	6.9	8.4	5.9	9.0	6.4	10.8	7.6	8.9	6.3	9.7	6.9	11.8	8.4
80	8.9	6.3	9.3	6.6	10.6	7.5	9.2	6.5	9.8	7.0	11.7	8.3	9.7	6.8	10.6	7.5	12.8	9.1
85	9.6	6.8	10.1	7.1	11.4	8.1	9.9	7.0	10.7	7.5	12.6	8.9	10.5	7.4	11.4	8.1	13.8	9.8
90	10.4	7.4	10.9	7.7	12.3	8.7	10.7	7.6	11.5	8.1	13.5	9.6	11.3	8.0	12.3	8.7	14.8	10.5
95	11.2	7.9	11.7	8.3	13.2	9.4	11.5	8.2	12.3	8.7	14.5	10.3	12.1	8.6	13.2	9.4	15.8	11.2
100	12.0	8.5	12.6	8.9	14.1	10.0	12.4	8.8	13.2	9.4	15.5	11.0	13.0	9.2	14.1	10.0	16.8	11.9
105	12.9	9.1	13.4	9.5	15.1	10.7	13.2	9.4	14.1	10.0	16.5	11.7	13.9	9.8	15.1	10.7	17.9	12.7
110	13.7	9.7	14.3	10.1	16.0	11.3	14.1	10.0	15.0	10.6	17.5	12.4	14.8	10.5	16.0	11.3	18.9	13.4
120	15.5	10.9	16.1	11.4	18.0	12.7	15.9	11.2	16.9	12.0	19.5	13.8	16.6	11.8	17.9	12.7	21.1	15.0
125	16.4	11.6	17.0	12.0	19.0	13.4	16.8	11.9	17.8	12.6	20.6	14.6	17.6	12.4	18.9	13.4	22.2	15.7
130	17.3	12.2	17.9	12.7	20.0	14.1	17.7	12.5	18.8	13.3	21.7	15.3	18.5	13.1	20.0	14.1	23.4	16.5
135	18.2	12.9	18.9	13.4	21.0	14.9	18.7	13.2	19.8	14.0	22.8	16.1	19.5	13.8	21.0	14.9	24.5	17.4
140	19.1	13.6	19.9	14.1	22.0	15.6	19.6	13.9	20.8	14.7	23.9	16.9	20.5	14.5	22.0	15.6	25.7	18.2
160	23.0	16.3	23.9	16.9	26.3	18.7	23.6	16.7	24.9	17.7	28.4	20.1	24.6	17.4	26.3	18.6	30.4	21.6
170	25.1	17.7	25.9	18.4	28.6	20.2	25.6	18.2	27.1	19.2	30.7	21.8	26.7	18.9	28.6	20.2	32.9	23.3
180	27.1	19.2	28.1	19.9	30.9	21.9	27.8	19.7	29.3	20.7	33.2	23.5	28.9	20.5	30.8	21.8	35.4	25.1
200	31.4	22.3	32.5	23.0	35.6	25.2	32.1	22.8	33.8	23.9	38.1	27.0	33.4	23.6	35.6	25.2	40.6	28.8
250	43.0	30.5	44.3	31.4	48.2	34.1	43.9	31.1	46.0	32.6	51.3	36.4	45.5	32.2	48.2	34.1	54.4	38.5
300	55.6	39.4	57.2	40.5	61.9	43.8	56.7	40.2	59.2	42.0	65.6	46.5	58.6	41.5	61.9	43.8	69.2	49.0
350	69.2	49.0	71.1	50.3	76.5	54.2	70.5	49.9	73.4	52.0	80.9	57.3	72.7	51.5	76.5	54.2	85.1	60.3
400	83.7	59.3	85.8	60.8	92.1	65.2	85.1	60.3	88.5	62.7	97.0	68.7	87.7	62.1	92.0	65.2	101.8	72.1
450	98.9	70.1	101.4	71.8	108.4	76.8	100.6	71.2	104.4	74.0	114.0	80.8	103.5	73.3	108.4	76.8	119.4	84.6
500	115.0	81.4	117.7	83.4	125.6	89.0	116.8	82.7	121.2	85.8	131.8	93.4	120.1	85.0	125.6	89.0	137.8	97.6
550	131.8	93.3	134.8	95.5	143.5	101.7	133.8	94.8	138.6	98.2	150.4	106.5	137.4	97.3	143.5	101.7	156.9	111.2
600	149.2	105.7	152.6	108.1	162.1	114.9	151.5	107.3	156.8	111.0	169.6	120.2	155.4	110.1	162.1	114.8	176.8	125.2
650	167.4	118.6	171.0	121.2	181.4	128.5	169.8	120.3	175.6	124.4	189.6	134.3	174.1	123.4	181.4	128.5	197.3	139.8
700			190.1	134.7	201.4	142.7			195.1	138.2	210.2	148.9	193.5	137.1	201.4	142.7	218.5	154.8
750			209.9	148.6	222.0	157.2			215.1	152.4	231.4	163.9	213.5	151.2	222.0	157.2	240.3	170.2
800			230.2	163.0	243.1	172.2			235.8	167.1	253.2	179.4			243.2	172.2	262.8	186.1
850			251.1	177.8	264.9	187.6			257.1	182.1	275.6	195.3			264.9	187.7	285.8	202.5
900					287.2	203.5			279.0	197.6	298.6	211.5			287.3	203.5	309.4	219.2
950					310.1	219.7			301.3	213.4	322.2	228.2			310.1	219.7	333.6	236.3
1000					333.5	236.2					346.3	245.3			333.6	236.3	358.3	253.8
1100					381.9	270.5					396.0	280.5			381.9	270.5	409.3	289.9
1200					432.3	306.2					447.7	317.1			432.3	306.2	462.3	327.4
1400					538.6	381.5					556.8	394.4					573.9	406.5
1600					652.0	461.8					673.0	476.7					692.7	490.6
1800					771.9	546.7					795.8	563.7					818.1	579.5
2000											924.7	655.0					949.7	672.7
2200											1059.5	750.5					1087.2	770.1
2600																	1378.9	976.7

fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

	$V^0_{Rd,c}$ [kN]																	
	FIS EM ∅ 14						FIS EM ∅ 16						FIS EM ∅ 18					
h_{ef}	75	75	120	120	280	280	80	80	125	125	320	320	85	85	140	140	360	360
edge distance [mm]	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
	concrete						concrete						concrete					
60	6.9	4.9	7.7	5.5	10.0	7.1												
65	7.6	5.4	8.5	6.0	11.0	7.8	7.9	5.6	8.9	6.3	12.0	8.5						
70	8.4	6.0	9.4	6.6	11.9	8.5	8.7	6.2	9.7	6.9	13.0	9.2						
75	9.2	6.5	10.2	7.2	12.9	9.2	9.5	6.8	10.6	7.5	14.1	10.0	9.9	7.0	11.2	7.9	15.2	10.8
80	10.0	7.1	11.1	7.9	14.0	9.9	10.4	7.4	11.5	8.1	15.1	10.7	10.7	7.6	12.1	8.6	16.4	11.6
85	10.9	7.7	12.0	8.5	15.0	10.6	11.2	8.0	12.4	8.8	16.2	11.5	11.6	8.2	13.1	9.2	17.5	12.4
90	11.7	8.3	12.9	9.1	16.0	11.4	12.1	8.6	13.3	9.4	17.3	12.3	12.5	8.8	14.0	9.9	18.7	13.2
95	12.6	8.9	13.8	9.8	17.1	12.1	13.0	9.2	14.3	10.1	18.5	13.1	13.4	9.5	15.0	10.6	19.8	14.0
100	13.5	9.5	14.8	10.5	18.2	12.9	13.9	9.8	15.2	10.8	19.6	13.9	14.3	10.1	16.0	11.3	21.0	14.9
105	14.4	10.2	15.7	11.1	19.3	13.7	14.8	10.5	16.2	11.5	20.8	14.7	15.3	10.8	17.0	12.0	22.2	15.7
110	15.3	10.8	16.7	11.8	20.4	14.5	15.8	11.2	17.2	12.2	21.9	15.5	16.2	11.5	18.0	12.8	23.5	16.6
120	17.2	12.2	18.7	13.2	22.7	16.1	17.7	12.5	19.3	13.7	24.3	17.2	18.2	12.9	20.2	14.3	26.0	18.4
125	18.1	12.8	19.7	14.0	23.9	16.9	18.7	13.2	20.3	14.4	25.5	18.1	19.2	13.6	21.2	15.0	27.2	19.3
130	19.1	13.5	20.8	14.7	25.1	17.7	19.7	13.9	21.4	15.1	26.8	19.0	20.2	14.3	22.3	15.8	28.5	20.2
135	20.1	14.2	21.8	15.5	26.3	18.6	20.7	14.6	22.5	15.9	28.0	19.8	21.2	15.0	23.4	16.6	29.8	21.1
140	21.1	15.0	22.9	16.2	27.5	19.5	21.7	15.4	23.5	16.7	29.3	20.7	22.3	15.8	24.6	17.4	31.1	22.1
160	25.3	17.9	27.3	19.3	32.5	23.0	26.0	18.4	28.1	19.9	34.5	24.4	26.6	18.9	29.2	20.7	36.5	25.9
170	27.5	19.5	29.6	21.0	35.0	24.8	28.2	20.0	30.4	21.5	37.2	26.3	28.9	20.5	31.6	22.4	39.3	27.8
180	29.7	21.0	31.9	22.6	37.7	26.7	30.4	21.6	32.8	23.2	39.9	28.3	31.2	22.1	34.0	24.1	42.2	29.9
200	34.3	24.3	36.8	26.0	43.1	30.5	35.1	24.9	37.7	26.7	45.5	32.2	35.9	25.5	39.1	27.7	48.0	34.0
250	46.6	33.0	49.7	35.2	57.4	40.6	47.6	33.7	50.8	36.0	60.4	42.8	48.7	34.5	52.6	37.2	63.3	44.9
300	59.9	42.5	63.7	45.1	72.8	51.6	61.2	43.4	65.0	46.1	76.3	54.0	62.4	44.2	67.1	47.5	79.8	56.5
350	74.3	52.6	78.6	55.7	89.2	63.2	75.8	53.7	80.2	56.8	93.2	66.0	77.2	54.7	82.6	58.5	97.2	68.9
400	89.5	63.4	94.5	66.9	106.5	75.4	91.2	64.6	96.3	68.2	111.0	78.7	92.9	65.8	99.1	70.2	115.5	81.8
450	105.5	74.7	111.2	78.7	124.6	88.3	107.5	76.1	113.2	80.2	129.7	91.9	109.3	77.5	116.3	82.4	134.7	95.4
500	122.4	86.7	128.6	91.1	143.6	101.7	124.5	88.2	130.9	92.8	149.2	105.7	126.6	89.7	134.4	95.2	154.7	109.6
550	139.9	99.1	146.9	104.0	163.2	115.6	142.4	100.8	149.4	105.8	169.4	120.0	144.7	102.5	153.2	108.5	175.5	124.3
600	158.2	112.1	165.8	117.5	183.7	130.1	160.9	113.9	168.6	119.4	190.4	134.8	163.4	115.7	172.7	122.4	196.9	139.5
650	177.2	125.5	185.4	131.4	204.8	145.0	180.1	127.5	188.5	133.5	212.0	150.2	182.8	129.5	193.0	136.7	219.1	155.2
700	196.8	139.4	205.7	145.7	226.5	160.5	199.9	141.6	209.0	148.0	234.3	166.0	202.9	143.7	213.8	151.5	241.9	171.4
750	217.0	153.7	226.6	160.5	248.9	176.3	220.4	156.1	230.1	163.0	257.3	182.2	223.6	158.4	235.3	166.7	265.4	188.0
800	237.9	168.5	248.1	175.8	272.0	192.6	241.5	171.0	251.9	178.4	280.8	198.9	244.9	173.5	257.5	182.4	289.5	205.0
850	259.3	183.6	270.2	191.4	295.6	209.4	263.1	186.4	274.2	194.3	305.0	216.0	266.8	189.0	280.2	198.5	314.2	222.5
900			292.9	207.5	319.7	226.5	285.3	202.1	297.2	210.5	329.7	233.6	289.2	204.9	303.5	215.0	339.4	240.4
950			316.1	223.9	344.5	244.0	308.1	218.2	320.6	227.1	355.0	251.5	312.3	221.2	327.3	231.8	365.3	258.7
1000			339.9	240.8	369.8	261.9	331.4	234.8	344.6	244.1	380.9	269.8	335.8	237.9	351.7	249.1	391.6	277.4
1100			389.0	275.5	421.9	298.9			394.2	279.2	434.1	307.5	384.4	272.3	402.0	284.8	446.0	315.9
1200			440.0	311.7	476.1	337.2			445.8	315.8	489.4	346.7			454.4	321.8	502.3	355.8
1300			493.0	349.2	532.2	377.0			499.3	353.7	546.6	387.2			508.6	360.3	560.6	397.1
1400					590.1	418.0					605.7	429.1			564.7	400.0	620.8	439.7
1500					649.9	460.3					666.6	472.2			622.6	441.0	682.8	483.6
1600					711.3	503.9					729.2	516.5					746.5	528.7
1800					839.2	594.4					859.4	608.7					878.8	622.5
2000					973.3	689.4					995.8	705.4					1017.5	720.7
2200					1113.3	788.6					1138.2	806.2					1162.2	823.2
2400					1259.0	891.8					1286.3	911.1					1312.5	929.7
2600					1410.1	998.8					1439.8	1019.8					1468.3	1040.0
2800					1566.3	1109.5					1598.5	1132.3					1629.3	1154.1
3000					1727.6	1223.7					1762.2	1248.2					1795.3	1271.7
3200											1930.7	1367.6					1966.2	1392.7
3400																	2141.7	1517.1
3600																	2321.8	1644.6
3800																	2506.4	1775.3

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fischer
innovative solutions

fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

	$V^0_{Rd,c}$ [kN]																	
	FIS EM ∅ 20						FIS EM ∅ 22						FIS EM ∅ 24					
h_{ef}	90	90	170	170	400	400	94	94	190	190	440	440	98	98	210	210	480	480
edge distance [mm]	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
	concrete						concrete						concrete					
85	12.0	8.5	14.1	10.0	18.8	13.3												
90	12.9	9.1	15.1	10.7	20.0	14.2												
95	13.8	9.8	16.1	11.4	21.2	15.0	14.1	10.0	17.0	12.0	22.7	16.1						
100	14.7	10.4	17.2	12.2	22.5	15.9	15.1	10.7	18.0	12.8	24.0	17.0						
105	15.7	11.1	18.2	12.9	23.7	16.8	16.1	11.4	19.1	13.6	25.3	17.9	16.5	11.7	20.1	14.2	26.9	19.0
110	16.7	11.8	19.3	13.7	25.0	17.7	17.1	12.1	20.3	14.4	26.6	18.9	17.5	12.4	21.2	15.0	28.3	20.0
120	18.7	13.2	21.5	15.2	27.6	19.6	19.1	13.5	22.5	16.0	29.3	20.8	19.5	13.8	23.6	16.7	31.1	22.0
125	19.7	13.9	22.6	16.0	28.9	20.5	20.1	14.3	23.7	16.8	30.7	21.7	20.6	14.6	24.8	17.6	32.5	23.0
130	20.7	14.7	23.8	16.8	30.3	21.4	21.2	15.0	24.9	17.6	32.1	22.7	21.7	15.3	26.0	18.4	33.9	24.0
135	21.8	15.4	24.9	17.7	31.6	22.4	22.3	15.8	26.1	18.5	33.5	23.7	22.8	16.1	27.2	19.3	35.4	25.1
140	22.9	16.2	26.1	18.5	33.0	23.4	23.4	16.5	27.3	19.3	34.9	24.7	23.9	16.9	28.5	20.2	36.8	26.1
160	27.3	19.3	30.9	21.9	38.6	27.3	27.9	19.7	32.3	22.9	40.7	28.8	28.4	20.1	33.6	23.8	42.8	30.3
170	29.6	20.9	33.4	23.7	41.5	29.4	30.2	21.4	34.8	24.7	43.7	30.9	30.8	21.8	36.2	25.7	45.9	32.5
180	31.9	22.6	36.0	25.5	44.4	31.5	32.6	23.1	37.5	26.5	46.7	33.1	33.2	23.5	38.9	27.6	49.0	34.7
200	36.7	26.0	41.2	29.2	50.4	35.7	37.5	26.5	42.9	30.4	52.9	37.5	38.2	27.0	44.5	31.5	55.5	39.3
250	49.7	35.2	55.2	39.1	66.3	47.0	50.5	35.8	57.2	40.5	69.3	49.1	51.4	36.4	59.1	41.9	72.3	51.2
300	63.6	45.1	70.2	49.7	83.3	59.0	64.7	45.8	72.6	51.4	86.7	61.4	65.7	46.6	74.9	53.0	90.2	63.9
350	78.6	55.7	86.2	61.1	101.2	71.7	79.8	56.6	88.9	63.0	105.1	74.5	81.0	57.4	91.6	64.9	109.1	77.3
400	94.5	66.9	103.2	73.1	120.0	85.0	95.9	67.9	106.2	75.3	124.4	88.1	97.3	68.9	109.3	77.4	128.9	91.3
450	111.2	78.7	120.9	85.7	139.7	98.9	112.8	79.9	124.4	88.1	144.6	102.4	114.3	81.0	127.8	90.5	149.5	105.9
500	128.6	91.1	139.5	98.8	160.2	113.5	130.4	92.4	143.3	101.5	165.6	117.3	132.2	93.6	147.1	104.2	170.9	121.1
550	146.9	104.0	158.8	112.5	181.4	128.5	148.9	105.4	163.0	115.5	187.3	132.7	150.8	106.8	167.1	118.4	193.1	136.8
600	165.8	117.5	178.9	126.7	203.4	144.1	168.0	119.0	183.4	129.9	209.8	148.6	170.1	120.5	187.9	133.1	216.1	153.1
650	185.5	131.4	199.6	141.4	226.1	160.1	187.8	133.0	204.6	144.9	232.9	165.0	190.1	134.7	209.4	148.3	239.7	169.8
700	205.8	145.7	221.0	156.5	249.4	176.7	208.3	147.5	226.3	160.3	256.7	181.9	210.8	149.3	231.5	164.0	264.0	187.0
750	226.7	160.6	243.0	172.1	273.4	193.6	229.4	162.5	248.7	176.2	281.2	199.2	232.1	164.4	254.3	180.1	288.9	204.7
800	248.2	175.8	265.7	188.2	298.0	211.0	251.1	177.9	271.8	192.5	306.3	216.9	254.0	179.9	277.7	196.7	314.5	222.8
850	270.3	191.5	288.9	204.6	323.1	228.9	273.4	193.7	295.4	209.2	332.0	235.1	276.5	195.8	301.7	213.7	340.6	241.3
900	293.0	207.5	312.7	221.5	348.9	247.1	296.3	209.9	319.6	226.4	358.2	253.7	299.5	212.2	326.3	231.1	367.4	260.2
950	316.2	224.0	337.1	238.8	375.2	265.8	319.8	226.5	344.4	243.9	385.1	272.7	323.2	228.9	351.4	248.9	394.7	279.6
1000	340.0	240.8	362.0	256.4	402.1	284.8	343.7	243.5	369.7	261.9	412.4	292.1	347.3	246.0	377.1	267.1	422.6	299.3
1100	389.1	275.6	413.4	292.8	457.5	324.1	393.2	278.5	421.9	298.8	468.8	332.1	397.2	281.4	430.1	304.6	479.9	339.9
1200	440.2	311.8	466.9	330.7	514.9	364.7	444.7	315.0	476.1	337.2	527.2	373.4	449.1	318.1	485.1	343.6	539.2	381.9
1300	493.2	349.4	522.2	369.9	574.2	406.7	498.2	352.9	532.2	377.0	587.5	416.2	502.9	356.2	542.0	383.9	600.5	425.4
1400			579.4	410.4	635.4	450.1	553.4	392.0	590.3	418.1	649.7	460.2	558.6	395.7	600.8	425.5	663.7	470.1
1500			638.4	452.2	698.5	494.7			650.0	460.5	713.8	505.6	616.0	436.3	661.3	468.5	728.7	516.2
1600			699.1	495.2	763.2	540.6			711.6	504.0	779.5	552.2			723.7	512.6	795.5	563.5
1800			825.4	584.7	897.7	635.9			839.6	594.7	916.0	648.9			853.2	604.4	934.0	661.6
2000					1038.5	735.6			973.8	689.8	1058.9	750.1			989.1	700.6	1078.8	764.2
2200					1185.3	839.6					1207.8	855.5			1130.9	801.1	1229.7	871.1
2400					1337.8	947.6					1362.4	965.0					1386.4	982.0
2600					1495.8	1059.5					1522.5	1078.4					1548.5	1096.8
2800					1659.0	1175.1					1687.8	1195.5					1715.8	1215.4
3000					1827.3	1294.3					1858.2	1316.2					1888.3	1337.5
3200					2000.4	1416.9					2033.4	1440.4					2065.6	1463.1
3400					2178.2	1542.9					2213.4	1567.8					2247.6	1592.1
3600					2360.5	1672.1					2398.0	1698.6					2434.3	1724.3
3800					2547.3	1804.4					2586.9	1832.4					2625.4	1859.6
4000					2738.4	1939.7					2780.2	1969.3					2820.8	1998.0
4500					3234.3	2291.0					3281.6	2324.5					3327.5	2357.0
5000																	3859.0	2733.5

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fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

h_{ef}	$V^0_{Rd,c}$ [kN]																	
	FIS EM ∅ 25						FIS EM ∅ 26						FIS EM ∅ 28					
	100	100	250	250	500	500	104	104	250	250	520	520	112	112	250	250	560	560
edge distance [mm]	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
	concrete						concrete						concrete					
110	17.7	12.5	22.6	16.0	29.1	20.6												
120	19.8	14.0	25.1	17.7	31.9	22.6	20.1	14.2	25.3	17.9	32.8	23.3						
125	20.8	14.7	26.3	18.6	33.4	23.7	21.1	15.0	26.5	18.8	34.3	24.3						
130	21.9	15.5	27.6	19.5	34.9	24.7	22.2	15.7	27.8	19.7	35.8	25.4	22.9	16.2	28.3	20.0	37.7	26.7
135	23.0	16.3	28.8	20.4	36.3	25.7	23.3	16.5	29.1	20.6	37.3	26.4	24.0	17.0	29.6	20.9	39.3	27.8
140	24.1	17.1	30.1	21.3	37.8	26.8	24.4	17.3	30.4	21.5	38.8	27.5	25.1	17.8	30.9	21.9	40.8	28.9
160	28.7	20.3	35.4	25.1	43.9	31.1	29.1	20.6	35.7	25.3	45.0	31.9	29.9	21.1	36.3	25.7	47.2	33.4
170	31.1	22.0	38.2	27.0	47.0	33.3	31.5	22.3	38.5	27.2	48.2	34.1	32.3	22.9	39.0	27.6	50.5	35.7
180	33.5	23.7	41.0	29.0	50.2	35.6	33.9	24.0	41.3	29.2	51.4	36.4	34.8	24.6	41.9	29.7	53.8	38.1
200	38.5	27.3	46.7	33.1	56.7	40.2	39.0	27.6	47.0	33.3	58.0	41.1	39.9	28.3	47.7	33.8	60.6	42.9
250	51.8	36.7	61.8	43.8	73.8	52.3	52.4	37.1	62.2	44.1	75.3	53.3	53.6	38.0	63.0	44.6	78.3	55.5
300	66.2	46.9	78.0	55.3	91.9	65.1	67.0	47.4	78.5	55.6	93.7	66.3	68.3	48.4	79.5	56.3	97.2	68.8
350	81.6	57.8	95.2	67.5	111.0	78.7	82.5	58.4	95.8	67.9	113.0	80.1	84.1	59.6	96.9	68.6	117.0	82.9
400	97.9	69.4	113.4	80.3	131.1	92.8	98.9	70.0	114.0	80.7	133.3	94.4	100.7	71.3	115.2	81.6	137.7	97.5
450	115.1	81.5	132.3	93.7	151.9	107.6	116.1	82.3	133.0	94.2	154.4	109.3	118.2	83.7	134.4	95.2	159.2	112.8
500	133.0	94.2	152.1	107.7	173.6	123.0	134.2	95.1	152.9	108.3	176.3	124.9	136.5	96.7	154.4	109.4	181.6	128.6
550	151.7	107.5	172.6	122.3	196.1	138.9	153.0	108.4	173.5	122.9	198.9	140.9	155.6	110.2	175.1	124.1	204.7	145.0
600	171.1	121.2	193.9	137.3	219.2	155.3	172.5	122.2	194.8	138.0	222.3	157.5	175.3	124.2	196.6	139.3	228.6	161.9
650	191.2	135.4	215.8	152.9	243.1	172.2	192.8	136.5	216.9	153.6	246.4	174.6	195.8	138.7	218.8	155.0	253.1	179.3
700	212.0	150.1	238.5	168.9	267.6	189.5	213.6	151.3	239.6	169.7	271.2	192.1	216.9	153.6	241.6	171.2	278.3	197.1
750	233.4	165.3	261.7	185.4	292.8	207.4	235.1	166.6	262.9	186.2	296.6	210.1	238.7	169.0	265.1	187.8	304.2	215.5
800	255.4	180.9	285.6	202.3	318.6	225.6	257.3	182.2	286.9	203.2	322.6	228.5	261.0	184.9	289.2	204.9	330.6	234.2
850	277.9	196.9	310.1	219.6	345.0	244.3	280.0	198.3	311.4	220.6	349.2	247.4	284.0	201.2	314.0	222.4	357.7	253.4
900	301.1	213.3	335.1	237.4	371.9	263.4	303.3	214.8	336.6	238.4	376.4	266.6	307.5	217.8	339.2	240.3	385.4	273.0
950	324.8	230.1	360.8	255.5	399.5	283.0	327.1	231.7	362.3	256.6	404.2	286.3	331.6	234.9	365.1	258.6	413.6	293.0
1000	349.1	247.3	386.9	274.1	427.6	302.9	351.5	249.0	388.5	275.2	432.5	306.4	356.3	252.3	391.5	277.3	442.4	313.4
1100	399.2	282.7	440.9	312.3	485.3	343.8	401.8	284.6	442.6	313.5	490.8	347.6	407.1	288.4	445.9	315.9	501.6	355.3
1200	451.3	319.6	496.9	351.9	545.2	386.2	454.2	321.7	498.7	353.3	551.1	390.3	460.0	325.8	502.4	355.8	562.8	398.6
1300	505.3	357.9	554.8	393.0	607.0	429.9	508.5	360.2	556.8	394.4	613.3	434.4	514.7	364.6	560.7	397.2	625.9	443.4
1400	561.1	397.5	614.6	435.3	670.6	475.0	564.6	399.9	616.8	436.9	677.5	479.9	571.4	404.7	621.0	439.9	691.0	489.5
1500	618.7	438.3	676.1	478.9	736.1	521.4	622.5	440.9	678.5	480.6	743.4	526.6	629.8	446.1	683.1	483.8	757.9	536.8
1600	678.1	480.3	739.4	523.8	803.3	569.0	682.1	483.1	742.0	525.6	811.1	574.5	689.9	488.7	746.9	529.0	826.5	585.4
1800			871.1	617.0	942.8	667.8			873.9	619.0	951.5	674.0	815.1	577.4	879.5	622.9	968.8	686.2
2000			1009.0	714.7	1088.6	771.1			1012.2	717.0	1098.3	778.0			1018.4	721.4	1117.5	791.5
2200			1152.9	816.6	1240.5	878.7			1156.5	819.2	1251.2	886.2			1163.3	824.0	1272.2	901.1
2400			1302.5	922.6	1398.1	990.3			1306.4	925.4	1409.7	998.6			1313.9	930.7	1432.7	1014.8
2600			1457.5	1032.4	1561.2	1105.9			1461.8	1035.4	1573.8	1114.8			1470.0	1041.2	1598.6	1132.4
2800					1729.6	1225.1					1743.2	1234.7					1769.9	1253.7
3000					1903.0	1348.0					1917.6	1358.3					1946.3	1378.6
3200					2081.4	1474.3					2096.9	1485.3					2127.5	1507.0
3400					2264.4	1604.0					2281.0	1615.7					2313.6	1638.8
3600					2452.1	1736.9					2469.6	1749.3					2504.2	1773.8
3800					2644.2	1873.0					2662.8	1886.1					2699.3	1912.0
4000					2840.6	2012.1					2860.2	2026.0					2898.7	2053.2
4500					3349.9	2372.9					3372.1	2388.6					3415.6	2419.4
5000					3884.1	2751.2					3908.8	2768.8					3957.3	2803.1
5500					4441.8	3146.3					4469.1	3165.6					4522.7	3203.6
6000																	5110.6	3620.0

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	$V^0_{Rd,c}$ [kN]																		
	FIS EM ∅ 30						FIS EM ∅ 32						FIS EM ∅ 34					
h_{ef}	120	120	280	280	600	600	128	128	300	300	640	640	136	136	300	300	680	680
edge distance [mm]	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
	concrete						concrete						concrete					
140	25.8	18.3	32.4	23.0	42.9	30.4												
160	30.6	21.7	38.0	26.9	49.4	35.0	31.4	22.2	39.3	27.9	51.7	36.6						
170	33.1	23.4	40.9	28.9	52.8	37.4	33.9	24.0	42.3	29.9	55.2	39.1	34.7	24.6	42.8	30.3	57.6	40.8
180	35.6	25.2	43.8	31.0	56.2	39.8	36.5	25.8	45.3	32.1	58.7	41.6	37.3	26.4	45.8	32.5	61.2	43.3
200	40.9	28.9	49.8	35.2	63.2	44.8	41.8	29.6	51.4	36.4	65.8	46.6	42.7	30.3	52.0	36.8	68.5	48.5
250	54.8	38.8	65.5	46.4	81.4	57.7	55.9	39.6	67.5	47.8	84.5	59.9	57.0	40.4	68.2	48.3	87.6	62.1
300	69.7	49.4	82.4	58.4	100.7	71.3	71.1	50.4	84.6	60.0	104.2	73.8	72.4	51.3	85.5	60.6	107.8	76.4
350	85.7	60.7	100.2	71.0	120.9	85.7	87.3	61.8	102.8	72.8	124.9	88.5	88.8	62.9	103.8	73.6	128.9	91.3
400	102.6	72.6	119.0	84.3	142.1	100.7	104.3	73.9	121.9	86.3	146.5	103.8	106.1	75.2	123.1	87.2	151.0	106.9
450	120.3	85.2	138.6	98.2	164.1	116.2	122.3	86.6	141.8	100.5	169.0	119.7	124.3	88.0	143.1	101.4	173.8	123.1
500	138.8	98.3	159.0	112.6	186.9	132.4	141.0	99.9	162.6	115.2	192.2	136.1	143.2	101.5	164.0	116.2	197.5	139.9
550	158.1	112.0	180.2	127.7	210.5	149.1	160.5	113.7	184.1	130.4	216.2	153.1	163.0	115.4	185.7	131.5	221.9	157.2
600	178.1	126.1	202.1	143.2	234.8	166.3	180.8	128.0	206.3	146.2	240.9	170.7	183.4	129.9	208.0	147.4	247.1	175.0
650	198.8	140.8	224.7	159.2	259.7	184.0	201.7	142.8	229.3	162.4	266.4	188.7	204.5	144.9	231.1	163.7	273.0	193.3
700	220.1	155.9	248.0	175.7	285.4	202.2	223.2	158.1	252.9	179.1	292.5	207.2	226.3	160.3	254.8	180.5	299.5	212.1
750	242.1	171.5	271.9	192.6	311.7	220.8	245.5	173.9	277.1	196.3	319.2	226.1	248.8	176.2	279.2	197.8	326.6	231.4
800	264.7	187.5	296.5	210.0	338.6	239.9	268.3	190.0	302.0	213.9	346.5	245.5	271.8	192.6	304.2	215.5	354.4	251.1
850	287.9	203.9	321.6	227.8	366.1	259.4	291.7	206.6	327.5	232.0	374.5	265.3	295.5	209.3	329.9	233.6	382.8	271.2
900	311.7	220.8	347.4	246.1	394.3	279.3	315.7	223.7	353.5	250.4	403.0	285.5	319.7	226.5	356.1	252.2	411.8	291.7
950	336.0	238.0	373.7	264.7	422.9	299.6	340.3	241.1	380.2	269.3	432.2	306.1	344.5	244.0	382.8	271.2	441.3	312.6
1000	360.9	255.6	400.5	283.7	452.2	320.3	365.4	258.8	407.4	288.5	461.8	327.1	369.9	262.0	410.1	290.5	471.4	333.9
1100	412.2	292.0	455.8	322.9	512.2	362.8	417.2	295.5	463.3	328.2	522.8	370.3	422.2	299.0	466.4	330.4	533.2	377.7
1200	465.6	329.8	513.1	363.5	574.3	406.8	471.1	333.7	521.3	369.3	585.7	414.9	476.5	337.5	524.7	371.6	597.1	422.9
1300	520.9	368.9	572.4	405.5	638.4	452.2	526.8	373.2	581.3	411.7	650.7	460.9	532.7	377.3	584.9	414.3	662.9	469.5
1400	578.0	409.4	633.6	448.8	704.4	498.9	584.5	414.0	643.1	455.6	717.5	508.3	590.8	418.5	647.1	458.3	730.6	517.5
1500	636.9	451.2	696.6	493.4	772.1	546.9	643.9	456.1	706.8	500.6	786.2	556.9	650.7	460.9	711.0	503.6	800.1	566.8
1600	697.6	494.1	761.3	539.2	841.7	596.2	705.0	499.4	772.2	547.0	856.6	606.8	712.3	504.6	776.7	550.2	871.4	617.2
1800	823.8	583.5	895.7	634.5	985.8	698.3	832.3	589.5	908.0	643.2	1002.5	710.1	840.5	595.4	913.1	646.8	1019.0	721.8
2000	956.3	677.4	1036.5	734.2	1136.3	804.9	965.8	684.1	1050.2	743.9	1154.8	818.0	975.0	690.6	1055.9	747.9	1173.1	830.9
2200			1183.3	838.1	1292.8	915.8			1198.4	848.9	1313.2	930.2	1115.5	790.1	1204.7	853.3	1333.2	944.3
2400			1335.8	946.2	1455.2	1030.7			1352.3	957.9	1477.3	1046.4			1359.2	962.8	1499.1	1061.9
2600			1493.7	1058.1	1623.0	1149.6			1511.7	1070.8	1646.9	1166.6			1519.2	1076.1	1670.5	1183.3
2800			1657.0	1173.7	1796.1	1272.3			1676.4	1187.5	1821.9	1290.5			1684.5	1193.2	1847.3	1308.5
3000			1825.2	1292.9	1974.4	1398.5			1846.1	1307.7	2002.0	1418.1			1854.9	1313.9	2029.1	1437.3
3200					2157.5	1528.3			2020.8	1431.4	2187.0	1549.1			2030.1	1438.0	2215.9	1569.6
3400					2345.4	1661.4					2376.7	1683.5					2407.5	1705.3
3600					2538.0	1797.7					2571.1	1821.2					2603.7	1844.3
3800					2735.0	1937.3					2770.0	1962.1					2804.4	1986.4
4000					2936.3	2079.9					2973.2	2106.0					3009.4	2131.7
4500					3458.0	2449.5					3499.6	2478.9					3540.5	2507.8
5000					4004.7	2836.7					4051.1	2869.5					4096.5	2901.7
5500					4575.0	3240.7					4626.2	3276.9					4676.3	3312.4
6000					5167.9	3660.6					5223.9	3700.2					5278.7	3739.1
6500					5782.2	4095.7					5843.1	4138.9					5902.7	4181.1
7000																	6547.4	4637.7

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fischer Injection mortar FIS EM with rebars

Anchor design according to fischer specification

	$V^0_{Rd,c}$ [kN]											
	FIS EM ∅ 36						FIS EM ∅ 40					
h_{ef}	144	144	350	350	720	720	160	160	400	400	800	800
edge distance [mm]	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked	non-cracked	cracked
	concrete						concrete					
180	38.2	27.0	48.7	34.5	63.7	45.1						
200	43.6	30.9	55.1	39.0	71.2	50.5	45.5	32.2	58.9	41.7	76.8	54.4
250	58.2	41.2	71.9	50.9	90.8	64.3	60.4	42.8	76.4	54.1	97.2	68.9
300	73.8	52.2	89.8	63.6	111.4	78.9	76.4	54.1	95.0	67.3	118.7	84.1
350	90.4	64.0	108.7	77.0	133.0	94.2	93.4	66.2	114.6	81.2	141.1	99.9
400	107.9	76.4	128.5	91.0	155.4	110.1	111.3	78.9	135.1	95.7	164.4	116.5
450	126.2	89.4	149.2	105.7	178.7	126.6	130.1	92.2	156.4	110.8	188.5	133.6
500	145.4	103.0	170.6	120.9	202.8	143.7	149.7	106.0	178.6	126.5	213.5	151.2
550	165.3	117.1	192.9	136.6	227.7	161.3	170.0	120.4	201.5	142.7	239.2	169.4
600	186.0	131.8	215.8	152.9	253.3	179.4	191.1	135.4	225.2	159.5	265.6	188.1
650	207.4	146.9	239.5	169.6	279.5	198.0	212.9	150.8	249.5	176.8	292.7	207.3
700	229.4	162.5	263.8	186.9	306.5	217.1	235.3	166.7	274.6	194.5	320.5	227.0
750	252.0	178.5	288.8	204.6	334.1	236.6	258.4	183.0	300.2	212.7	348.9	247.1
800	275.3	195.0	314.4	222.7	362.3	256.6	282.1	199.8	326.5	231.3	377.9	267.7
850	299.2	211.9	340.6	241.3	391.1	277.0	306.4	217.1	353.4	250.4	407.5	288.7
900	323.7	229.3	367.4	260.2	420.5	297.8	331.3	234.7	380.9	269.8	437.8	310.1
950	348.7	247.0	394.8	279.6	450.4	319.1	356.8	252.7	409.0	289.7	468.6	331.9
1000	374.3	265.1	422.7	299.4	481.0	340.7	382.8	271.1	437.6	310.0	499.9	354.1
1100	427.0	302.4	480.1	340.1	543.6	385.1	436.4	309.1	496.5	351.7	564.2	399.6
1200	481.7	341.2	539.6	382.2	608.3	430.9	492.0	348.5	557.4	394.8	630.5	446.6
1300	538.4	381.4	601.1	425.8	675.0	478.1	549.6	389.3	620.3	439.3	698.9	495.0
1400	597.0	422.9	664.4	470.6	743.5	526.7	609.1	431.4	685.0	485.2	769.1	544.8
1500	657.4	465.6	729.6	516.8	813.9	576.5	670.4	474.8	751.6	532.4	841.1	595.8
1600	719.5	509.6	796.5	564.2	886.0	627.6	733.4	519.5	820.0	580.8	914.9	648.1
1800	848.6	601.1	935.3	662.5	1035.4	733.4	864.4	612.3	961.7	681.2	1067.6	756.2
2000	984.1	697.1	1080.6	765.4	1191.1	843.7	1001.7	709.5	1109.9	786.2	1226.6	868.9
2200	1125.5	797.3	1231.9	872.6	1353.0	958.3	1145.0	811.1	1264.1	895.4	1391.8	985.9
2400			1388.9	983.8	1520.6	1077.1	1294.1	916.6	1424.1	1008.7	1562.8	1107.0
2600			1551.5	1099.0	1693.8	1199.7	1448.6	1026.1	1589.6	1126.0	1739.4	1232.0
2800			1719.3	1217.8	1872.2	1326.2			1760.5	1247.0	1921.2	1360.9
3000			1892.2	1340.3	2055.9	1456.2			1936.4	1371.6	2108.2	1493.3
3200			2070.0	1466.3	2244.4	1589.8			2117.3	1499.7	2300.2	1629.3
3400			2252.6	1595.6	2437.7	1726.7			2302.9	1631.2	2497.0	1768.7
3600			2439.8	1728.2	2635.7	1867.0			2493.1	1766.0	2698.4	1911.3
3800					2838.2	2010.4			2687.8	1903.9	2904.3	2057.2
4000					3045.0	2156.9			2886.9	2044.9	3114.6	2206.2
4500					3580.5	2536.2			3402.9	2410.4	3658.8	2591.7
5000					4141.2	2933.3					4228.2	2995.0
5500					4725.5	3347.3					4821.4	3415.2
6000					5332.5	3777.2					5437.4	3851.5
6500					5961.2	4222.5					6075.0	4303.1
7000					6610.5	4682.5					6733.4	4769.5
7500					7279.9	5156.6					7411.8	5250.0
8000											8109.6	5744.3
8500											8826.1	6251.8

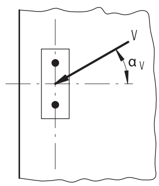
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Cylinder compressive strength	$f_{ck.cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck.cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b.V}$	[-]	0,77	0,89	1,00	1,10	1,22	1,34	1,41	1,48	1,55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha.V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

4

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1.V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2.V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h.V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd.s}$; $N_{Rd.p}$; $N_{Rd.c}$; $N_{Rd.sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd.s}$; $V_{Rd.cp}$; $V_{Rd.c}$

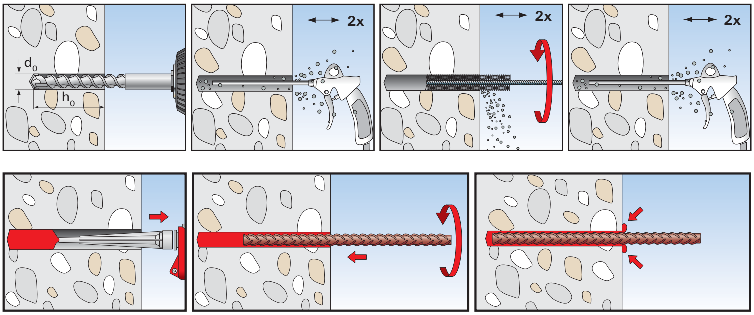
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details



fischer Injection mortar FIS EM with rebars

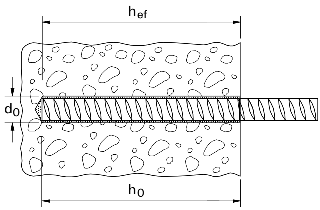
Anchor design according to fischer specification

8. Anchor characteristics

Anchor type			FIS EM ⌀ 8			FIS EM ⌀ 10			FIS EM ⌀ 12			FIS EM ⌀ 14			FIS EM ⌀ 16			FIS EM ⌀ 18		
	h_{ef}	[mm]	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**75**	**120**	**280**	**80**	**125**	**320**	**85**	**140**	**360**
diameter of rebar		[mm]	8			10			12			14			16			18		
nominal drill hole diameter	d_0	[mm]	12			14			16			18			20			25		
drill depth	h_0	[mm]	60	80	160	60	90	200	70	110	240	75	120	280	80	125	320	85	140	360
minimum thickness of concrete member	h_{min}	[mm]	100	110	190	100	120	230	100	140	270	105	150	310	120	165	360	135	190	410
minimum spacing	s_{min}	[mm]	40			45			55			60			65			75		
minimum edge distance	c_{min}	[mm]	40			45			55			60			65			75		
mortar filling quantity		[scale unit]	3	4	7	3	5	10	4	6	13	5	8	18	6	9	23	12	20	51

Anchor type			FIS EM ⌀ 20			FIS EM ⌀ 22			FIS EM ⌀ 24			FIS EM ⌀ 25			FIS EM ⌀ 26			FIS EM ⌀ 28		
	h_{ef}	[mm]	**90**	**170**	**400**	**94**	**190**	**440**	**98**	**210**	**480**	**100**	**250**	**500**	**104**	**250**	**520**	**112**	**250**	**560**
diameter of rebar		[mm]	20			22			24			25			26			28		
nominal drill hole diameter	d_0	[mm]	25			30			30			30			35			35		
drill depth	h_0	[mm]	90	170	400	94	190	440	98	210	480	100	250	500	104	250	520	112	250	560
minimum thickness of concrete member	h_{min}	[mm]	140	220	450	154	250	500	158	270	540	160	310	560	174	320	590	182	320	630
minimum spacing	s_{min}	[mm]	85			95			105			110			120			130		
minimum edge distance	c_{min}	[mm]	85			95			105			110			120			130		
mortar filling quantity		[scale unit]	10	19	43	18	37	85	15	32	73	13	33	65	27	64	132	24	52	116

Anchor type			FIS EM ⌀ 30			FIS EM ⌀ 32			FIS EM ⌀ 34			FIS EM ⌀ 36			FIS EM ⌀ 40		
	h_{ef}	[mm]	**120**	**280**	**600**	**128**	**300**	**640**	**136**	**300**	**680**	**144**	**350**	**720**	**160**	**400**	**800**
diameter of rebar		[mm]	30			32			34			36			40		
nominal drill hole diameter	d_0	[mm]	40			40			40			45			55		
drill depth	h_0	[mm]	120	280	600	128	300	640	136	300	680	144	350	720	160	400	800
minimum thickness of concrete member	h_{min}	[mm]	200	360	680	208	380	720	216	380	760	234	440	810	270	510	910
minimum spacing	s_{min}	[mm]	140			160			170			180			200		
minimum edge distance	c_{min}	[mm]	140			160			170			180			200		
mortar filling quantity		[scale unit]	39	91	194	35	81	172	29	64	144	49	119	245	104	260	520



9. Gelling and curing times

System temperature	Max. processing time FIS EM
+ 5 °C	4 h
> + 5 °C to + 10 °C	2 h
> + 10 °C to + 20 °C	30 min.
> + 20 °C to + 30 °C	14 min.
> + 30 °C to + 40 °C	7 min.

Temperature at anchoring base	Curing time [1)] FIS EM
+ 5 °C	40 h
+ 10 °C	18 h
+ 20 °C	10 h
≥ 30 °C	5 h

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation. the cartridge temperature must be at least + 5 °C.
With temperatures above + 30 °C to + 40 °C the cartridges have to be cooled down to + 15 °C or + 20 °C.
For longer installation times. i.e. when interruptions occur in work. the static mixer shall be replaced.
[1)] In wet concrete the curing time has to be doubled.

10. Mechanical characteristics of rebars B 500 B

Anchor type			FIS EM Ø 8	FIS EM Ø 10	FIS EM Ø 12	FIS EM Ø 14	FIS EM Ø 16	FIS EM Ø 18	FIS EM Ø 20	FIS EM Ø 22	FIS EM Ø 24
stressed cross sectional area reinforcing steel	A_S	[mm²]	50	79	113	154	201	254	314	380	452
resisting moment reinforcing steel	W	[mm³]	50	98	170	269	402	573	785	1045	1357
yield strength reinforcing steel	f_{yk}	[N/mm²]	500								
tensile strength reinforcing steel	f_{uk}	[N/mm²]	550								

Anchor type			FIS EM Ø 25	FIS EM Ø 26	FIS EM Ø 28	FIS EM Ø 30	FIS EM Ø 32	FIS EM Ø 34	FIS EM Ø 36	FIS EM Ø 40
stressed cross sectional area reinforcing steel	A_S	[mm²]	491	531	616	707	804	908	1018	1257
resisting moment reinforcing steel	W	[mm³]	1534	1726	2155	2651	3217	3859	4580	6283
yield strength reinforcing steel	f_{yk}	[N/mm²]	500							
tensile strength reinforcing steel	f_{uk}	[N/mm²]	550							

fischer Injection mortar FIS V, FIS VS and FIS VW

Anchor design according to fischer specification

1. Types

FIS A M6 - M30 – threaded rod (gvz, A4, C)
straight cut

RG M8 - M30 - threaded rod (gvz, A4, C)
some dimensions with external hexagon head

FIS V - Injection mortar FIS V 360 S, FIS V 950 S

FIS VW 300 T

4

ETA-02/0024
ETA G 001-5
Option 7 for non-cracked concrete *)

Fire resistance classification
R 120
Anchor types see test report

ICC ES
ESR-2786
See ICC-ES Evaluation Report at www.ic-es.org
Inspection agency: AA-707 *)

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

FIS VS - Injection mortar
FIS VS 300 T, FIS VS 360 S

FIS VW - Injection mortar
FIS VW 360 S

Features and Advantages

- European Technical Approval option 7*) for non-cracked concrete.
- ICC-ES Evaluation Report *) for non-cracked concrete.
- Fire resistance classifications according to test report independently proved gives the safety in case of fire.
- The Hybrid mortar gives a good combination of organic resin (high bond strength) and mineral cement (avoids corrosion and gives high compressive strength).
- Expansion stress free anchoring guarantees a save use with small spacing and edge distances.
- The approval guarantees the safe function at a large temperature range of -40 °C up to +120 °C.
- Different mortar versions and a large range of accessories gives the opportunity for different applications and a wide temperature range within the anchor base.
- Variable embedment depth enables the application in all kind of building structures.
- The resin seals the drill hole and avoids penetration of dampness and gives therefore corrosion protection for the embedded steel.
- FIS VS mortar version with lower maximum processing time and lower application pressure.
- FIS VW mortar version with accelerated curing especially during winter.
- Suitable for pre-positioned and push-through installation.

*) The conditions of use in the European Technical Approval or in the ICC-ES Evaluation Report may vary from those of the Technical Handbook.

Materials

Threaded rod :	- Carbon steel, zinc plated (5 µm) and passivated (gvz)
	- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
	- Highly corrosion-resistant steel of the corrosion resistance class IV, e.g. 1.4529.
Injection mortar:	- Vinylester resin (styrene-free), hydraulic additives, quartz sand and hardener

2. Ultimate resistances of single anchors with large spacing and large edge distance[1)]

Mean values

Anchor type				FIS V M6								FIS V M8							
				gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}			[mm]	60								80							
non-cracked concrete temperature range (+ 80 °C / + 50 °C)[2)]																			
tension static	C 20/25	N_u	[kN]	11.6	12.3	11.6	12.3	12.3	11.6	12.3	12.3	20.0	26.6	20.0	26.6	26.6	20.0	26.6	26.6
	C 50/60	N_u	[kN]	11.6	15.4	11.6	14.7	15.4	11.6	14.7	15.4	20.0	31.5	20.0	27.3	31.5	20.0	27.3	31.5
shear static	≧ C 20/25	V_u	[kN]	6.9	10.1	6.9	8.8	10.1	6.9	8.8	10.1	12.0	18.9	12.0	16.4	18.9	12.0	16.4	18.9

Anchor type				FIS V M10								FIS V M12							
				gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}			[mm]	90								110							
non-cracked concrete temperature range (+ 80 °C / + 50 °C)[2)]																			
tension static	C 20/25	N_u	[kN]	30.5	37.5	30.5	37.5	37.5	30.5	37.5	37.5	45.2	54.9	45.2	54.9	54.9	45.2	54.9	54.9
	C 50/60	N_u	[kN]	30.5	47.2	30.5	43.1	47.2	30.5	43.1	47.2	45.2	69.2	45.2	62.0	69.2	45.2	62.0	69.2
shear static	≧ C 20/25	V_u	[kN]	18.3	29.6	18.3	25.8	29.6	18.3	25.8	29.6	27.1	42.8	27.1	37.2	42.8	27.1	37.2	42.8

Anchor type				FIS V M16								FIS V M20							
				gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}			[mm]	125								170							
non-cracked concrete temperature range (+ 80 °C / + 50 °C)[2)]																			
tension static	C 20/25	N_u	[kN]	75.7	75.7	75.7	75.7	75.7	75.7	75.7	75.7	122.3	122.3	122.3	122.3	122.3	122.3	122.3	122.3
	C 50/60	N_u	[kN]	83.0	95.4	83.0	95.4	95.4	83.0	95.4	95.4	129.2	154.1	129.2	154.1	154.1	129.2	154.1	154.1
shear static	≧ C 20/25	V_u	[kN]	49.8	79.4	49.8	69.3	79.4	49.8	69.3	79.4	77.5	123.5	77.5	108.4	123.5	77.5	108.4	123.5

Anchor type				FIS V M24								FIS V M30							
				gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}			[mm]	210								280							
non-cracked concrete temperature range (+ 80 °C / + 50 °C)[2)]																			
tension static	C 20/25	N_u	[kN]	171.6	171.6	171.6	171.6	171.6	171.6	171.6	171.6	270.2	270.2	270.2	270.2	270.2	270.2	270.2	270.2
	C 50/60	N_u	[kN]	185.9	216.3	185.9	216.3	216.3	185.9	216.3	216.3	295.1	340.5	295.1	340.5	340.5	295.1	340.5	340.5
shear static	≧ C 20/25	V_u	[kN]	111.5	177.7	111.5	155.6	177.7	111.5	155.6	177.7	177.0	282.9	177.0	247.6	282.9	177.0	247.6	282.9

1) The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7").

2) (short term temperature / long term temperature)

fischer Injection mortar FIS V, FIS VS and FIS VW

Anchor design according to fischer specification

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance [1)]

Anchor type	FIS V M6								FIS V M8							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	60								80							
non-cracked concrete																
temperature range (+ 80 °C / + 50 °C) [2)]																
tension static C 20/25 N_{Rk} [kN]	10.2	10.2	10.2	10.2	10.2	10.2	10.2	10.2	19.0	22.1	19.0	22.1	22.1	19.0	22.1	22.1
C 50/60 N_{Rk} [kN]	11.0	12.8	11.0	12.8	12.8	11.0	12.8	12.8	19.0	27.9	19.0	26.0	27.9	19.0	26.0	27.9
shear static C 20/25 V_{Rk} [kN]	5.0	8.0	5.0	7.0	8.0	5.0	7.0	8.0	9.0	15.0	9.0	13.0	15.0	9.0	13.0	15.0

Anchor type	FIS V M10								FIS V M12							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	90								110							
non-cracked concrete																
temperature range (+ 80 °C / + 50 °C) [2)]																
tension static C 20/25 N_{Rk} [kN]	29.0	31.1	29.0	31.1	31.1	29.0	31.1	31.1	43.0	45.6	43.0	45.6	45.6	43.0	45.6	45.6
C 50/60 N_{Rk} [kN]	29.0	39.2	29.0	39.2	39.2	29.0	39.2	39.2	43.0	57.5	43.0	57.5	57.5	43.0	57.5	57.5
shear static C 20/25 V_{Rk} [kN]	15.0	23.0	15.0	20.0	23.0	15.0	20.0	23.0	21.0	34.0	21.0	30.0	34.0	31.0	30.0	34.0

Anchor type	FIS V M16								FIS V M20							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	125								170							
non-cracked concrete																
temperature range (+ 80 °C / + 50 °C) [2)]																
tension static C 20/25 N_{Rk} [kN]	62.8	62.8	62.8	62.8	62.8	62.8	62.8	62.8	101.5	101.5	101.5	101.5	101.5	101.5	101.5	101.5
C 50/60 N_{Rk} [kN]	79.0	79.2	79.0	79.2	79.2	79.0	79.2	79.2	123.0	127.9	123.0	127.9	127.9	123.0	127.9	127.9
shear static C 20/25 V_{Rk} [kN]	39.0	63.0	39.0	55.0	63.0	39.0	55.0	63.0	61.0	98.0	61.0	86.0	98.0	61.0	86.0	98.0

Anchor type	FIS V M24								FIS V M30							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef} [mm]	210								280							
non-cracked concrete																
temperature range (+ 80 °C / + 50 °C) [2)]																
tension static C 20/25 N_{Rk} [kN]	142.5	142.5	142.5	142.5	142.5	142.5	142.5	142.5	224.3	224.3	224.3	224.3	224.3	224.3	224.3	224.3
C 50/60 N_{Rk} [kN]	177.0	179.6	177.0	179.6	179.6	177.0	179.6	179.6	281.0	282.6	281.0	282.6	282.6	281.0	282.6	282.6
shear static C 20/25 V_{Rk} [kN]	89.0	141.0	89.0	124.0	141.0	89.0	124.0	141.0	141.0	225.0	141.0	197.0	225.0	141.0	197.0	225.0

1) The loads apply to fischer threaded rods and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

3.2 Design resistance [1]

Anchor type			FIS V M6								FIS V M8							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}		[mm]	60								80							
non-cracked concrete																		
temperature range (+ 80 °C / + 50 °C) [2]																		
tension static	C 20/25 N_{Rd}	[kN]	6.8	6.8	3.8	6.8	6.8	3.8	6.8	6.8	12.7	14.7	6.6	13.9	14.7	6.6	14.7	14.7
	C 60/60 N_{Rd}	[kN]	7.3	8.6	3.8	7.5	8.6	3.8	8.6	8.6	12.7	18.6	6.6	13.9	18.6	6.6	17.3	18.6
shear static	C 20/25 V_{Rd}	[kN]	4.0	6.4	2.1	4.5	6.0	2.1	5.6	6.0	7.2	12.0	3.8	8.3	11.3	3.8	10.4	11.3

Anchor type			FIS V M10								FIS V M12							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}		[mm]	90								110							
non-cracked concrete																		
temperature range (+ 80 °C / + 50 °C) [2]																		
tension static	C 20/25 N_{Rd}	[kN]	19.3	20.7	10.1	20.7	20.7	10.1	20.7	20.7	28.7	30.4	15.0	30.4	30.4	15.0	30.4	30.4
	C 60/60 N_{Rd}	[kN]	19.3	26.1	10.1	21.9	26.1	10.1	26.1	26.1	28.7	38.3	15.0	31.6	38.3	15.0	38.3	38.3
shear static	C 20/25 V_{Rd}	[kN]	12.0	18.4	6.3	12.8	17.3	6.3	16.0	17.3	16.8	27.2	8.8	19.2	25.6	13.0	24.0	25.6

Anchor type			FIS V M16								FIS V M20							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}		[mm]	125								170							
non-cracked concrete																		
temperature range (+ 80 °C / + 50 °C) [2]																		
tension static	C 20/25 N_{Rd}	[kN]	41.9	41.9	27.6	41.9	41.9	27.6	41.9	41.9	67.6	67.6	43.0	67.6	67.6	43.0	67.6	67.6
	C 60/60 N_{Rd}	[kN]	52.7	52.8	27.6	52.8	52.8	27.6	52.8	52.8	82.0	85.2	43.0	85.2	85.2	43.0	85.2	85.2
shear static	C 20/25 V_{Rd}	[kN]	31.2	50.4	16.4	35.3	47.4	16.4	44.0	47.4	48.8	78.4	25.6	55.1	73.7	25.6	68.8	73.7

Anchor type			FIS V M24								FIS V M30							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}		[mm]	210								280							
non-cracked concrete																		
temperature range (+ 80 °C / + 50 °C) [2]																		
tension static	C 20/25 N_{Rd}	[kN]	95.0	95.0	61.9	95.0	95.0	61.9	95.0	95.0	149.5	149.5	98.3	149.5	149.5	98.3	149.5	149.5
	C 60/60 N_{Rd}	[kN]	118.0	119.7	61.9	119.7	119.7	61.9	119.7	119.7	187.3	188.4	98.3	188.4	188.4	98.3	188.4	188.4
shear static	C 20/25 V_{Rd}	[kN]	71.2	112.8	37.4	79.5	106.0	37.4	99.2	106.0	112.8	180.0	59.2	126.3	169.2	59.2	157.6	169.2

[1] The loads apply to fischer threaded rods and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

[2] (short term temperature / long term temperature)

3.3 Recommended resistance [1) 3)]

Anchor type			FIS V M6								FIS V M8							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}		[mm]	60								80							
non-cracked concrete temperature range (+ 80 °C / + 50 °C) [2)]																		
tension	C 20/25	N_R [kN]	4.8	4.8	2.7	4.8	4.8	2.7	4.8	4.8	9.0	10.5	4.7	9.9	10.5	4.7	10.5	10.5
	C 50/60	N_R [kN]	5.2	6.1	2.7	5.3	6.1	2.7	6.1	6.1	9.0	13.3	4.7	9.9	13.3	4.7	12.4	13.3
shear	C 20/25	V_R [kN]	2.9	4.6	1.5	3.2	4.3	1.5	4.0	4.3	5.1	8.6	2.7	6.0	8.1	2.7	7.4	8.1

Anchor type			FIS V M10								FIS V M12							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}		[mm]	90								110							
non-cracked concrete temperature range (+ 80 °C / + 50 °C) [2)]																		
tension	C 20/25	N_R [kN]	13.8	14.8	7.2	14.8	14.8	7.2	14.8	14.8	20.5	21.7	10.7	21.7	21.7	10.7	21.7	21.7
	C 50/60	N_R [kN]	13.8	18.7	7.2	15.7	18.7	7.2	18.7	18.7	20.5	27.4	10.7	22.5	27.4	10.7	27.4	27.4
shear	C 20/25	V_R [kN]	8.6	13.1	4.5	9.2	12.4	4.5	11.4	12.4	12.0	19.4	6.3	13.7	18.3	9.3	17.1	18.3

Anchor type			FIS V M16								FIS V M20							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}		[mm]	125								170							
non-cracked concrete temperature range (+ 80 °C / + 50 °C) [2)]																		
tension	C 20/25	N_R [kN]	29.9	29.9	19.7	29.9	29.9	19.7	29.9	29.9	48.3	48.3	30.7	48.3	48.3	30.7	48.3	48.3
	C 50/60	N_R [kN]	37.6	37.7	19.7	37.7	37.7	19.7	37.7	37.7	58.6	60.9	30.7	60.9	60.9	30.7	60.9	60.9
shear	C 20/25	V_R [kN]	22.3	36.0	11.7	25.2	33.8	11.7	31.4	33.8	34.9	56.0	18.3	39.4	52.6	18.3	49.1	52.6

Anchor type			FIS V M24								FIS V M30							
			gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
h_{ef}		[mm]	210								280							
non-cracked concrete temperature range (+ 80 °C / + 50 °C) [2)]																		
tension	C 20/25	N_R [kN]	67.9	67.9	44.2	67.9	67.9	44.2	67.9	67.9	106.8	106.8	70.2	106.8	106.8	70.2	106.8	106.8
	C 50/60	N_R [kN]	84.3	85.5	44.2	85.5	85.5	44.2	85.5	85.5	133.8	134.6	70.2	134.6	134.6	70.2	134.6	134.6
shear	C 20/25	V_R [kN]	50.9	80.6	26.7	56.8	75.7	26.7	70.9	75.7	80.6	128.6	42.3	90.2	120.8	42.3	112.6	120.8

1) The loads apply to fischer threaded rods and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type	FIS V M6								FIS V M8							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance $N_{Rd,s}$ [kN]	7.3	10.7	3.8	7.5	10.0	3.8	9.3	10.0	12.7	20.0	6.6	13.9	18.8	6.6	17.3	18.8

Anchor type	FIS V M10								FIS V M12							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance $N_{Rd,s}$ [kN]	19.3	31.3	10.1	21.9	29.4	10.1	27.3	29.4	28.7	45.3	15.0	31.6	42.5	15.0	39.3	42.5

Anchor type	FIS V M16								FIS V M20							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance $N_{Rd,s}$ [kN]	52.7	84.0	27.6	58.8	78.8	27.6	73.3	78.8	82.0	130.7	43.0	92.0	122.5	43.0	114.7	122.5

Anchor type	FIS V M24								FIS V M30							
	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80	gvz 5.8	gvz 8.8	A4-50	A4-70	A4-80	C-50	C-70	C-80
design resistance $N_{Rd,s}$ [kN]	118.0	188.0	61.9	132.1	176.3	61.9	164.7	176.3	187.3	299.3	98.3	210.2	280.6	98.3	262.0	280.6

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Anchor type			FIS V M6			FIS V M8			FIS V M10			FIS V M12		
eff. anchorage depth	h_{ef}	[mm]	50	60	72	60	80	160	60	90	200	70	110	240
non-cracked concrete														
temperature range (+ 80 °C / + 50 °C) [1]														
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	5.7	6.8	8.1	11.1	14.7	29.5	13.8	20.7	46.1	19.4	30.4	66.4
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	-	-	-	-	-	-	-	-	-	13.9	21.9	47.8
temperature range (+ 120 °C / + 72 °C) [1]														
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	4.1	4.9	5.9	9.6	12.7	25.5	11.9	17.9	39.8	15.8	24.9	54.3
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	-	-	-	-	-	-	-	-	-	11.0	17.3	37.7

Anchor type			FIS V M16			FIS V M20			FIS V M24			FIS V M30		
eff. anchorage depth	h_{ef}	[mm]	80	125	320	90	170	400	96	210	480	120	280	600
non-cracked concrete														
temperature range (+ 80 °C / + 50 °C) [1]														
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	26.8	41.9	107.2	35.8	67.6	159.2	43.4	95.0	217.1	64.1	149.5	320.4
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	19.0	29.7	76.0	25.1	47.5	111.7	30.2	66.0	150.8	44.0	102.6	219.9
temperature range (+ 120 °C / + 72 °C) [1]														
wet and dry concrete design resistance	$N^0_{Rd,p}$	[kN]	22.8	35.6	91.1	30.2	57.0	134.0	36.2	79.2	181.0	52.8	123.2	263.9
waterfilled hole design resistance	$N^0_{Rd,p}$	[kN]	15.6	24.4	62.6	20.4	38.6	90.8	24.1	52.8	120.6	37.7	88.0	188.5

[1] (short term temperature / long term temperature)

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	55
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N,p}$	[-]	0.88	0.95	1.00	1.05	1.10	1.15	1.19	1.22	1.26

4.2.2 Characteristic edge distance and spacing for design of combined pull-out and concrete cone failure

Anchor type			FIS V M6			FIS V M8			FIS V M10			FIS V M12		
eff. anchorage depth	h_{ef}	**[mm]**	**50**	**60**	**72**	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**
temperature range (+ 60 °C / + 35 °C) [1]														
Wet and Dry Concrete	$s_{cr,Np}$	[mm]	131	131	131	180	194	194	180	242	242	210	291	291
	$c_{cr,Np}$	[mm]	66	66	66	90	97	97	90	121	121	105	145	145
Waterfilled hole	$s_{cr,Np}$	[mm]	-	-	-	-	-	-	-	-	-	210	270	270
	$c_{cr,Np}$	[mm]	-	-	-	-	-	-	-	-	-	105	135	135
temperature range (+ 72 °C / + 50 °C) [1]														
Wet and Dry Concrete	$s_{cr,Np}$	[mm]	112	112	112	180	180	180	180	225	225	210	263	263
	$c_{cr,Np}$	[mm]	56	56	56	90	90	90	90	113	113	105	131	131
Waterfilled hole	$s_{cr,Np}$	[mm]	-	-	-	-	-	-	-	-	-	210	240	240
	$c_{cr,Np}$	[mm]	-	-	-	-	-	-	-	-	-	105	120	120

Anchor type			FIS V M16			FIS V M20			FIS V M24			FIS V M30		
eff. anchorage depth	h_{ef}	**[mm]**	**80**	**125**	**320**	**90**	**170**	**400**	**96**	**210**	**480**	**120**	**280**	**600**
temperature range (+ 60 °C / + 35 °C) [1]														
Wet and Dry Concrete	$s_{cr,Np}$	[mm]	240	370	370	270	450	450	288	526	526	360	639	639
	$c_{cr,Np}$	[mm]	120	185	185	135	225	225	144	263	263	180	319	319
Waterfilled hole	$s_{cr,Np}$	[mm]	240	341	341	270	413	413	288	480	480	360	580	580
	$c_{cr,Np}$	[mm]	120	170	170	135	207	207	144	240	240	180	290	290
temperature range (+ 72 °C / + 50 °C) [1]														
Wet and Dry Concrete	$s_{cr,Np}$	[mm]	240	341	341	270	413	413	288	480	480	360	580	580
	$c_{cr,Np}$	[mm]	120	170	170	135	207	207	144	240	240	180	290	290
Waterfilled hole	$s_{cr,Np}$	[mm]	240	309	309	270	372	372	288	429	429	360	537	537
	$c_{cr,Np}$	[mm]	120	155	155	135	186	186	144	215	215	180	268	268

[1] (short term temperature / long term temperature)

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type			FIS V M6			FIS V M8			FIS V M10			FIS V M12		
eff. anchorage depth	h_{ef}	[mm]	50	60	72	60	80	160	60	90	200	70	110	240
non-cracked concrete														
Design resistance	$N^0_{Rd,c}$	[kN]	11.9	15.6	20.6	15.6	24.1	68.1	15.6	28.7	95.2	19.7	38.8	125.2

Anchor type			FIS V M16				FIS V M20		FIS V M24			FIS V M30		
eff. anchorage depth	h_{ef}	[mm]	80	125	125	320	90	400	96	210	480	120	280	600
non-cracked concrete														
Design resistance	$N^0_{Rd,c}$	[kN]	24.1	47.1	47.1	192.7	28.7	269.3	31.7	102.5	354.0	44.3	157.7	494.8

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type			FIS V M6			FIS V M8			FIS V M10			FIS V M12		
eff. anchorage depth	h_{ef}	[mm]	50	60	72	60	80	160	60	90	200	70	110	240
	$s_{cr,N}$	[mm]	150	180	216	180	240	480	180	270	600	210	330	720
	$c_{cr,N}$	[mm]	75	90	108	90	120	240	90	135	300	105	165	360

Anchor type			FIS V M16			FIS V M20			FIS V M24			FIS V M30		
eff. anchorage depth	h_{ef}	[mm]	80	125	320	90	170	400	96	210	480	120	280	600
	$s_{cr,N}$	[mm]	240	375	960	270	510	1200	288	630	1440	360	840	1800
	$c_{cr,N}$	[mm]	120	188	480	135	255	600	144	315	720	180	420	900

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0$$

$$f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4

4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type				**FIS V M6**			**FIS V M8**			**FIS V M10**			**FIS V M12**		
eff. anchorage depth		h_{ef}	[mm]	**50**	**60**	**72**	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	100	120	144	120	160	320	120	180	400	140	220	480
		$c_{cr,sp}$	[mm]	50	60	72	60	80	160	60	90	200	70	110	240
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)											
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$											
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	226	271	325	271	362	723	271	407	904	316	497	1085
		$c_{cr,sp}$	[mm]	113	136	163	136	181	362	136	203	452	158	249	542
		h_{min}	[mm]	100	100	102	100	110	190	100	120	230	100	140	270

Anchor type				**FIS V M16**			**FIS V M20**			**FIS V M24**			**FIS V M30**		
eff. anchorage depth		h_{ef}	[mm]	**80**	**125**	**320**	**90**	**170**	**400**	**96**	**210**	**480**	**120**	**280**	**600**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	160	250	640	180	340	800	192	420	960	240	560	1200
		$c_{cr,sp}$	[mm]	80	125	320	90	170	400	96	210	480	120	280	600
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)											
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$											
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	362	565	1446	407	768	1808	434	949	2170	542	1266	2712
		$c_{cr,sp}$	[mm]	181	283	723	203	384	904	217	475	1085	271	633	1356
		h_{min}	[mm]	116	161	356	138	218	448	152	266	536	190	350	670

$f_{scr,sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.80	3.62	3.44	3.26	3.08	2.90	2.72	2.54	2.36	2.18	2.00

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness at splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\,(N_{Rd,p}\,;\,N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type			**FIS V M6**								**FIS V M8**							
			gvz 5.8	**gvz 8.8**	**A4-50**	**A4-70**	**A4-80**	**C-50**	**C-70**	**C-80**	**gvz 5.8**	**gvz 8.8**	**A4-50**	**A4-70**	**A4-80**	**C-50**	**C-70**	**C-80**
design resistance	$V_{Rd,s}$	[kN]	4.0	6.4	2.1	4.5	6.0	2.1	5.6	6.0	4.0	6.4	2.1	4.5	6.0	2.1	5.6	6.0

Anchor type			**FIS V M10**								**FIS V M12**							
			gvz 5.8	**gvz 8.8**	**A4-50**	**A4-70**	**A4-80**	**C-50**	**C-70**	**C-80**	**gvz 5.8**	**gvz 8.8**	**A4-50**	**A4-70**	**A4-80**	**C-50**	**C-70**	**C-80**
design resistance	$V_{Rd,s}$	[kN]	12.0	18.4	6.3	12.8	17.3	6.3	16.0	17.3	16.8	27.2	8.8	19.2	25.6	13.0	24.0	25.6

Anchor type			**FIS V M16**								**FIS V M20**							
			gvz 5.8	**gvz 8.8**	**A4-50**	**A4-70**	**A4-80**	**C-50**	**C-70**	**C-80**	**gvz 5.8**	**gvz 8.8**	**A4-50**	**A4-70**	**A4-80**	**C-50**	**C-70**	**C-80**
design resistance	$V_{Rd,s}$	[kN]	31.2	50.4	16.4	35.3	47.4	16.4	44.0	47.4	48.8	78.4	25.6	55.1	73.7	25.6	68.8	73.7

Anchor type			**FIS V M24**								**FIS V M30**							
			gvz 5.8	**gvz 8.8**	**A4-50**	**A4-70**	**A4-80**	**C-50**	**C-70**	**C-80**	**gvz 5.8**	**gvz 8.8**	**A4-50**	**A4-70**	**A4-80**	**C-50**	**C-70**	**C-80**
design resistance	$V_{Rd,s}$	[kN]	71.2	112.8	37.4	79.5	106.0	37.4	99.2	106.0	112.8	180.0	59.2	126.3	169.2	59.2	157.6	169.2

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\,(\,N_{Rd,p}\,;\,N_{Rd,c}\,)$$

k-factor

Anchor type	**FIS V M6 to M30**
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]											
	FIS V M6			FIS V M8			FIS V M10			FIS V M12		
h_{ef}	50	60	72	60	80	160	60	90	200	70	110	240
edge distance [mm]	non-cracked concrete			non-cracked concrete			non-cracked concrete			non-cracked concrete		
40	3.2	3.3	3.4	3.6	3.7	3.9						
45	3.8	3.9	4.0	4.2	4.3	4.5	4.5	4.7	5.0			
50	4.4	4.5	4.6	4.8	5.0	5.2	5.2	5.3	5.7			
55	5.0	5.1	5.3	5.4	5.6	5.9	5.9	6.0	6.4	6.3	6.6	7.0
60	5.6	5.8	5.9	6.1	6.3	6.6	6.6	6.8	7.2	7.1	7.3	7.8
65	6.3	6.4	6.6	6.8	7.0	7.3	7.3	7.5	8.0	7.9	8.1	8.7
70	6.9	7.1	7.3	7.5	7.8	8.0	8.1	8.3	8.8	8.6	8.9	9.5
75	7.6	7.8	8.0	8.2	8.5	8.8	8.8	9.0	9.6	9.4	9.7	10.3
80	8.3	8.5	8.8	9.0	9.3	9.6	9.6	9.8	10.4	10.3	10.6	11.2
85	9.1	9.3	9.5	9.7	10.1	10.4	10.4	10.7	11.3	11.1	11.4	12.1
90	9.8	10.0	10.3	10.5	10.9	11.2	11.3	11.5	12.1	12.0	12.3	13.0
95	10.6	10.8	11.1	11.3	11.7	12.1	12.1	12.3	13.0	12.9	13.2	14.0
100	11.3	11.6	11.9	12.1	12.6	12.9	13.0	13.2	13.9	13.8	14.1	14.9
120	14.6	14.9	15.3	15.6	16.1	16.5	16.6	16.9	17.7	17.5	17.9	18.9
140	18.2	18.5	18.9	19.3	19.9	20.4	20.4	20.8	21.8	21.5	22.0	23.1
160	21.9	22.3	22.8	23.2	23.9	24.4	24.5	24.9	26.0	25.8	26.3	27.6
180	25.9	26.4	26.9	27.3	28.1	28.7	28.8	29.3	30.5	30.2	30.8	32.2
200	30.0	30.6	31.1	31.7	32.5	33.2	33.3	33.8	35.2	34.9	35.6	37.1
250	41.2	41.9	42.6	43.3	44.3	45.2	45.3	46.0	47.7	47.3	48.2	50.1
300	53.5	54.3	55.2	56.0	57.2	58.3	58.5	59.2	61.3	60.8	61.9	64.1
350	66.7	67.6	68.7	69.6	71.1	72.4	72.5	73.4	75.8	75.3	76.5	79.1
400	80.7	81.9	83.1	84.1	85.8	87.3	87.5	88.5	91.3	90.6	92.0	95.1
450	95.6	96.9	98.3	99.5	101.4	103.1	103.3	104.4	107.6	106.8	108.4	111.8
500	111.3	112.7	114.2	115.6	117.7	119.6	119.8	121.2	124.6	123.8	125.6	129.4
550		129.2	130.9	132.4	134.8	136.9	137.1	138.6	142.4	141.6	143.5	147.7
600		146.5	148.3	150.0	152.6	154.9	155.1	156.8	161.0	160.0	162.1	166.7
650			166.4	168.2	171.0	173.6	173.8	175.6	180.2	179.1	181.4	186.4
700			185.1		190.1	192.9	193.2	195.1	200.0	198.9	201.4	206.7
750			204.4		209.9	212.8	213.1	215.1	220.5	219.3	222.0	227.7
800					230.2	233.3	233.7	235.8	241.5	240.3	243.2	249.3
900						276.1		279.0	285.4	284.0	287.3	294.2
1000						321.0			331.5	329.9	333.6	341.3
1100									379.7		381.9	390.5
1200									429.8			441.7
1300												494.9
1400												549.8
1500												606.5

continued next page

fischer Injection mortar FIS V, FIS VS and FIS VW

Anchor design according to fischer specification

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]											
	FIS V M16			FIS V M20			FIS V M24			FIS V M30		
h_{ef}	80	125	320	90	170	400	96	210	480	120	280	600
edge distance [mm]	non-cracked concrete			non-cracked concrete			non-cracked concrete			non-cracked concrete		
65	7.9	8.9	12.0									
70	8.7	9.7	13.0									
75	9.5	10.6	14.1									
80	10.4	11.5	15.1									
85	11.2	12.4	16.2	12.0	14.1	18.8						
90	12.1	13.3	17.3	12.9	15.1	20.0						
95	13.0	14.3	18.5	13.8	16.1	21.2						
100	13.9	15.2	19.6	14.7	17.2	22.5						
105	14.8	16.2	20.8	15.7	18.2	23.7	16.4	20.1	26.9			
120	17.7	19.3	24.3	18.7	21.5	27.6	19.5	23.6	31.1			
125	18.7	20.3	25.5	19.7	22.6	28.9	20.5	24.8	32.5			
130	19.7	21.4	26.8	20.7	23.8	30.3	21.6	26.0	33.9			
135	20.7	22.5	28.0	21.8	24.9	31.6	22.7	27.2	35.4			
140	21.7	23.5	29.3	22.9	26.1	33.0	23.8	28.5	36.8	25.8	32.4	42.9
160	26.0	28.1	34.5	27.3	30.9	38.6	28.3	33.6	42.8	30.6	38.0	49.4
175	29.3	31.6	38.5	30.7	34.7	43.0	31.8	37.6	47.5	34.4	42.3	54.5
180	30.4	32.8	39.9	31.9	36.0	44.4	33.1	38.9	49.0	35.6	43.8	56.2
190	32.8	35.2	42.7	34.3	38.6	47.4	35.5	41.7	52.2	38.2	46.7	59.7
200	35.1	37.7	45.5	36.7	41.2	50.4	38.0	44.5	55.5	40.9	49.8	63.2
250	47.6	50.8	60.4	49.7	55.2	66.3	51.2	59.1	72.3	54.8	65.5	81.4
300	61.2	65.0	76.3	63.6	70.2	83.3	65.5	74.9	90.2	69.7	82.4	100.7
350	75.8	80.2	93.2	78.6	86.2	101.2	80.8	91.6	109.1	85.7	100.2	120.9
400	91.2	96.3	111.0	94.5	103.2	120.0	97.0	109.3	128.9	102.6	119.0	142.1
450	107.5	113.2	129.7	111.2	120.9	139.7	114.0	127.8	149.5	120.3	138.6	164.1
500	124.5	130.9	149.2	128.6	139.5	160.2	131.8	147.1	170.9	138.8	159.0	186.9
550	142.4	149.4	169.4	146.9	158.8	181.4	150.4	167.1	193.1	158.1	180.2	210.5
600	160.9	168.6	190.4	165.8	178.9	203.4	169.7	187.9	216.1	178.1	202.1	234.8
650	180.1	188.5	212.0	185.5	199.6	226.1	189.7	209.4	239.7	198.8	224.7	259.7
700	199.9	209.0	234.3	205.8	221.0	249.4	210.3	231.5	264.0	220.1	248.0	285.4
750	220.4	230.1	257.3	226.7	243.0	273.4	231.6	254.3	288.9	242.1	271.9	311.7
800	241.5	251.9	280.8	248.2	265.7	298.0	253.4	277.7	314.5	264.7	296.5	338.6
850	263.1	274.2	305.0	270.3	288.9	323.1	275.9	301.7	340.6	287.9	321.6	366.1
900	285.3	297.2	329.7	293.0	312.7	348.9	298.9	326.3	367.4	311.7	347.4	394.3
950	308.1	320.6	355.0	316.2	337.1	375.2	322.5	351.4	394.7	336.0	373.7	422.9
1000	331.4	344.6	380.9	340.0	362.0	402.1	346.6	377.1	422.6	360.9	400.5	452.2
1100		394.2	434.1	389.1	413.4	457.5	396.5	430.1	479.9	412.2	455.8	512.2
1200		445.8	489.4	440.2	466.9	514.9	448.3	485.1	539.2	465.6	513.1	574.3
1300		499.3	546.6	493.2	522.2	574.2	502.0	542.0	600.5	520.9	572.4	638.4
1400			605.7		579.4	635.4	557.6	600.8	663.7	578.0	633.6	704.4
1500			666.6		638.4	698.5	614.9	661.3	728.7	636.9	696.6	772.1
1600			729.2		699.1	763.2		723.7	795.5	697.6	761.3	841.7
1800			859.4		825.4	897.7		853.2	934.0	823.8	895.7	985.8
2000			995.8			1038.5		989.1	1078.8	956.3	1036.5	1136.3
2200			1138.2			1185.3		1130.9	1229.7		1183.3	1292.8
2600			1439.8			1495.8			1548.5		1493.7	1623.0
2800			1598.5			1659.0			1715.8		1657.0	1796.1
3000			1762.2			1827.3			1888.3		1825.2	1974.4
3200			1930.7			2000.4			2065.6			2157.5
3400			2103.9			2178.2			2247.6			2345.4
3600						2360.5			2434.3			2538.0
4000						2738.4			2820.8			2936.3
4500						3234.3			3327.5			3458.0
5000									3859.0			4004.7
6000												5167.9
6500												5782.2

4

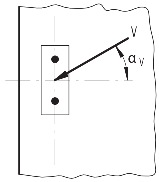
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0,77	0,89	1,00	1,10	1,22	1,34	1,41	1,48	1,55

5.3.2 Influence of load direction

$f_{\alpha.V}$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angel $\alpha \geqq 90°$ the component of the shear load acting away from the edge can be neglected and the proof can be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

4

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

6.3 Combined tension and shear load:

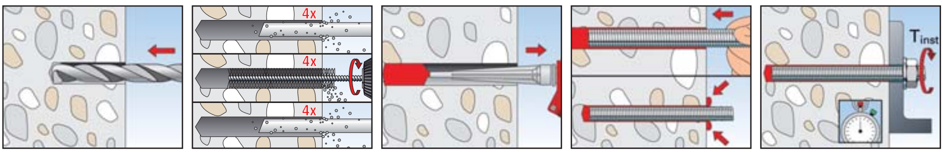
$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = **tension/shear component of the design load acting on the most unfavourable single anchor**

N_{Rd} ; V_{Rd} = **tension/shear design resistance including safety factors of the most unfavourable single anchor**

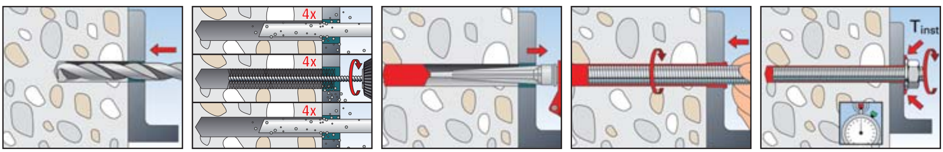
7. Installation details

Pre-positioned installation:



$d_0 \geq 18$ mm with oil free compressed air (P > 6 bar)

Push-through installation:



$d_0 \geq 18$ mm with oil free compressed air (P > 6 bar)

fischer Injection mortar FIS V, FIS VS and FIS VW

Anchor design according to fischer specification

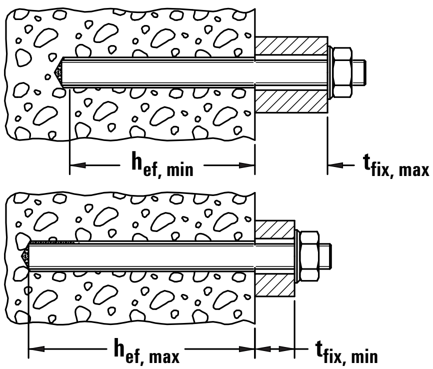
8. Anchor characteristics

Anchor type			FIS V M6			FIS V M8			FIS V M10			FIS V M12		
	h_{ef}	[mm]	50	60	72	60	80	160	60	90	200	70	110	240
diameter of thread			M 6			M 8			M 10			M 12		
nominal drill hole diameter	d_0	[mm]	8			10			12			14		
drill depth	h_0	[mm]	50	60	72	60	80	160	60	90	200	70	110	240
clearance-hole in fixture to be attached pre-positioned installation [2]	d_f	[mm]	≦ 7			≦ 9			≦ 12			≦ 14		
clearance-hole in fixture to be attached push-through installation [1]	d_f	[mm]	≦ 9			≦ 11			≦ 14			≦ 16		
wrench size	SW	[mm]	10			13			17			19		
maximum torque moment	$T_{inst, max}$	[Nm]	5			10			20			40		
minimum thickness of concrete member	h_{min}	[mm]	100	100	102	100	110	190	100	120	230	100	140	270
minimum spacing	s_{min}	[mm]	40			40			45			55		
minimum edge distances	c_{min}	[mm]	40			40			45			55		
mortar filling quantity		[scale units]	2	3	3	3	4	8	4	6	13	5	8	18

Anchor type			FIS V M16			FIS V M20			FIS V M24			FIS V M30		
	h_{ef}	[mm]	80	125	320	90	170	400	96	210	480	120	280	600
diameter of thread			M 16			M 20			M 24			M 30		
nominal drill hole diameter	d_0	[mm]	18			24			28			35		
drill depth	h_0	[mm]	80	125	320	90	170	400	96	210	480	120	280	600
clearance-hole in fixture to be attached pre-positioned installation [2]	d_f	[mm]	≦ 18			≦ 22			≦ 26			≦ 33		
clearance-hole in fixture to be attached push-through installation [1]	d_f	[mm]	≦ 20			≦ 26			≦ 30			≦ 40		
wrench size	SW	[mm]	24			30			36			46		
maximum torque moment	$T_{inst, max}$	[Nm]	60			120			150			300		
minimum thickness of concrete member	h_{min}	[mm]	116	161	356	138	218	448	152	266	536	190	350	670
minimum spacing	s_{min}	[mm]	65			85			105			140		
minimum edge distances	c_{min}	[mm]	65			85			105			140		
mortar filling quantity		[scale units]	7	10	28	11	20	45	14	29	66	25	58	125

1) Hole clearance has to be filled with excess mortar.

2) For larger diameters the clearance has to be filled with excess mortar.



fischer Injection mortar FIS V, FIS VS and FIS VW

Anchor design according to fischer specification

9. Gelling and curing times

System temperature	Max. processing time		
	FIS VW	FIS V	FIS VS
± 0 °C	5 min.	–	–
+ 5 °C	5 min.	13 min.	–
+ 10 °C	3 min.	9 min.	20 min.
+ 20 °C	1 min.	5 min.	10 min.
+ 30 °C	–	4 min.	6 min.
+ 40 °C	–	2 min.	4 min.

Temperature at anchoring base	Curing time [1]		
	FIS VW	FIS V	FIS VS
- 5 °C to 0 °C	3 h	24 h	–
± 0 °C to + 5 °C	3 h	3 h	6 h
> 5 °C to + 10 °C	50 min.	90 min.	3 h
> 10 °C to + 20 °C	30 min.	60 min.	2 h
> 20 °C to + 30 °C	–	45 min.	60 min.
> 30 °C to + 40 °C	–	35 min.	30 min.

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least + 5 °C.
With temperatures above + 30 °C to + 40 °C the cartridges have to be cooled down to + 15 °C or + 20 °C.
For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.

[1] For wet concrete the curing time must be doubled.

10. Mechanical characteristics of anchor rods FIS A and RG M

Anchor type			FIS V M6				FIS V M8				FIS V M10				FIS V M12			
			gvz		A4-70	C-70	gvz		A4-70	C-70	gvz		A4-70	C-70	gvz		A4-70	C-70
			5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8		
stressed cross sectional area anchor rod	A_s	[mm²]	20.1				36.6				58.0				84.3			
section modulus	W	[mm³]	12.7				31.2				62.3				109.2			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	6.4	9.6	7.1	8.8	15.2	24.0	16.7	20.8	29.6	48.0	33.3	41.6	52.0	84.0	59.0	73.6
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	700	700	500	800	700	700

Anchor type			FIS V M16				FIS V M20				FIS V M24				FIS V M30			
			gvz		A4-70	C-70	gvz		A4-70	C-70	gvz		A4-70	C-70	gvz		A4-70	C-70
			5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8		
stressed cross sectional area anchor rod	A_s	[mm²]	157.0				245.0				353.0				561.0			
section modulus	W	[mm³]	277.5				540.9				935.5				1874			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	132.8	212.8	148.7	185.6	259.2	415.2	291.0	363.2	448.0	716.8	502.6	627.2	898.4	1438	1008	1258
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	700	700	500	800	700	700

fischer Injection mortar FIS V, FIS VS and FIS VW Internal-threaded anchor RG MI

Anchor design according to fischer specification

1. Types

RG MI, M8 - M20 – Internal-threaded anchor (gvz)

RG MI A4, M8 - M20 – Internal-threaded anchor (A4)

FIS V - Injection mortar FIS V 360 S, FIS V 950 S

FIS VW 300 T

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ETA-02/0024
ETAG 001-5
Option 7 for non-cracked concrete *)

Fire resistance classification
R 120
Anchor types see test report

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

FIS VS - Injection mortar
FIS VS 300 T, FIS VS 360 S

FIS VW - Injection mortar
FIS VW 360 S

Features and Advantages

- European Technical Approval option 7*) for non-cracked concrete.
- ICC-ES Evaluation Report *) for non-cracked concrete.
- Fire resistance classifications according to test report independently proved gives the safety in case of fire.
- The Hybrid mortar gives a good combination of organic resin (high bond strength) and mineral cement (avoids corrosion and gives high compressive strength).
- Expansion stress free anchoring guarantees a save use with small spacing and edge distances.
- The approval guarantees the safe function at a large temperature range of -40 °C up to +120 °C.
- Different mortar versions and a large range of accessories gives the opportunity for different applications and a wide temperature range within the anchor base.
- Variable embedment depth enables the application in all kind of building structures.
- The resin seals the drill hole and avoids penetration of dampness and gives therefore corrosion protection for the embedded steel.
- FIS VS mortar version with lower maximum processing time and lower application pressure.
- FIS VW mortar version with accelerated curing especially during winter.

*) The conditions of use in the European Technical Approval or in the ICC-ES Evaluation Report may vary from those of the Technical Handbook.

Materials

Internal-threaded anchor and screw for internal threaded anchor:	- Carbon steel, zinc plated (5 µm) and passivated (gvz) - Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
Injection mortar:	- Vinylester resin (styrene-free), hydraulic additives, quartz sand and hardener

2. Ultimate resistances of single anchors with large spacing and large edge distance[1)]

Mean values

Anchor type	FIS V RG M8 I				FIS V RG M10 I				FIS V RG M12 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	90				90				125			
non-cracked concrete **Temperatur range (+80 °C / +50 °C)[2)]**												
tension static C 20/25 N_u [kN]	20.0	30.5	27.3	27.3	30.5	46.9	43.1	43.1	45.2	58.7	58.7	58.7
C 50/60 N_u [kN]	20.0	30.5	27.3	27.3	30.5	49.4	43.1	43.1	45.2	71.4	62.0	62.0
shear static ≧ C 20/25 V_u [kN]	10.0	15.2	13.7	13.7	15.2	24.7	21.5	21.5	22.6	35.7	31.0	31.0

Anchor type	FIS V RG M16 I				FIS V RG M20 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	160				200			
non-cracked concrete **Temperatur range (+80 °C / +50 °C)[2)]**								
tension static C 20/25 N_u [kN]	83.0	87.9	87.9	87.9	129.2	135.6	135.6	135.6
C 50/60 N_u [kN]	83.0	110.8	110.8	110.8	129.2	170.9	170.9	170.9
shear static ≧ C 20/25 V_u [kN]	41.5	56.7	57.8	57.8	64.6	94.0	90.3	90.3

1) The loads apply to fischer internal-threaded anchors with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

4

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance [1)]

Anchor type	FIS V RG M8 I				FIS V RG M10 I				FIS V RG M12 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	90				90				125			
non-cracked concrete **Temperatur range (+80 °C / +50 °C)[2)]**												
tension static C 20/25 N_{Rk} [kN]	19.0	29.0	26.0	26.0	29.0	40.0	40.0	40.0	43.0	50.0	50.0	50.0
C 50/60 N_{Rk} [kN]	19.0	29.0	26.0	26.0	29.0	47.0	41.0	41.0	43.0	63.0	59.0	59.0
shear static ≧ C 20/25 V_{Rk} [kN]	9.2	14.6	12.8	12.8	14.8	23.2	20.3	20.3	21.1	33.7	29.5	29.5

Anchor type	FIS V RG M6 I				FIS V RG M20 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	160				200			
non-cracked concrete **Temperatur range (+80 °C / +50 °C)[2)]**								
tension static C 20/25 N_{Rk} [kN]	75.0	75.0	75.0	75.0	115.0	115.0	115.0	115.0
C 50/60 N_{Rk} [kN]	79.0	94.5	94.5	94.5	123.0	144.9	144.9	144.9
shear static ≧ C 20/25 V_{Rk} [kN]	39.2	54	54.8	54.8	62	90	86	86

1) The loads apply to fischer internal-threaded anchors with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.

2) (short term temperature / long term temperature)

3.2 Design resistance [1)]

Anchor type	FIS V RG M8 I				FIS V RG M10 I				FIS V RG M12 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	90				90				125			
non-cracked concrete												
Temperatur range (+80 °C / +50 °C)[2)]												
tension static C 20/25 N_{Rd} [kN]	12.7	19.3	13.9	13.9	19.3	26.7	21.9	21.9	28.7	33.3	31.6	31.6
C 50/60 N_{Rd} [kN]	12.7	19.3	13.9	13.9	19.3	31.3	21.9	21.9	28.7	42.0	31.6	31.6
shear static ≧ C 20/25 V_{Rd} [kN]	7.4	11.7	8.2	8.2	11.8	18.6	13.0	13.0	16.9	27.0	18.9	18.9

Anchor type	FIS V RG M16 I				FIS V RG M20 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	160				200			
non-cracked concrete								
Temperatur range (+80 °C / +50 °C)[2)]								
tension static C 20/25 N_{Rd} [kN]	50.0	50.0	50.0	50.0	76.7	76.7	76.7	76.7
C 50/60 N_{Rd} [kN]	52.7	63.0	58.8	58.8	82.0	96.6	92.0	92.0
shear static ≧ C 20/25 V_{Rd} [kN]	31.4	43.2	35.1	35.1	49.6	60.0	55.1	55.1

1) The loads apply to fischer internal-threaded anchors with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)

4

3.3 Recommended resistance [1) 3)]

Anchor type	FIS V RG M8 I				FIS V RG M10 I				FIS V RG M12 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	90				90				125			
non-cracked concrete												
Temperatur range (+80 °C / +50 °C)[2)]												
tension static C 20/25 N_R [kN]	9.0	13.8	9.9	9.9	13.8	19.0	15.7	15.7	20.5	23.8	22.5	22.5
C 50/60 N_R [kN]	9.0	13.8	9.9	9.9	13.8	22.4	15.7	15.7	20.5	30.0	22.5	22.5
shear static ≧ C 20/25 V_R [kN]	5.3	8.3	5.9	5.9	8.5	13.3	9.3	9.3	12.1	19.3	13.5	13.5

Anchor type	FIS V RG M16 I				FIS V RG M20 I			
	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
h_{ef} [mm]	160				200			
non-cracked concrete								
Temperatur range (+80 °C / +50 °C)[2)]								
tension static C 20/25 N_R [kN]	35.7	35.7	35.7	35.7	54.8	54.8	54.8	54.8
C 50/60 N_R [kN]	37.6	45.0	42.0	42.0	58.6	69.0	65.7	65.7
shear static ≧ C 20/25 V_R [kN]	22.4	30.9	25.1	25.1	35.4	42.9	39.4	39.4

1) The loads apply to fischer internal-threaded anchors with hammer drilling and careful drill hole cleaning according to the approval. The anchor may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)
3) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on the failure mode of the anchor.

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure for the highest loaded anchor

Design resistance for single anchor

Anchor type			FIS V RG M8 I				FIS V RG M10 I				FIS V RG M12 I			
			gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
			90				90				125			
design resistance	$N_{Rd,s}$	[kN]	12.7	19.3	13.9	13.9	19.3	31.3	21.9	21.9	28.7	45.3	31.6	31.6

Anchor type			FIS V RG M16 I				FIS V RG M20 I			
			gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
			160				200			
design resistance	$N_{Rd,s}$	[kN]	52.7	72.0	58.8	58.8	82.0	119.3	92.0	92.0

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Anchor type			FIS V RG M8 I	FIS V RG M10 I	FIS V RG M12 I	FIS V RG M16 I	FIS V RG M20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
non-cracked concrete							
temperature range (+80°C / +50°C) [1]							
Wet and Dry Concrete Design resistance	$N^0_{Rd,p}$	[kN]	20.0	26.7	33.3	50.0	76.7
Waterfilled hole Design resistance	$N^0_{Rd,p}$	[kN]	13.9	19.4	27.8	33.3	52.8
temperature range (+120°C / +72°C) [1]							
Wet and Dry Concrete Design resistance	$N^0_{Rd,p}$	[kN]	16.7	20.0	26.7	40.0	63.3
Waterfilled hole Design resistance	$N^0_{Rd,p}$	[kN]	11.1	13.9	19.4	27.8	41.7

[1] (short term temperature / long term temperature)

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	55
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,p}$	[-]	0.88	0.95	1.00	1.05	1.10	1.15	1.19	1.22	1.26

fischer Injection mortar FIS V, FIS VS and FIS VW Internal-threaded anchor RG MI

Anchor design according to fischer specification

4.2.2 Characteristic edge distance and spacing for design of combined pull-out and concrete cone failure

Anchor type			FIS V RG M8 I	FIS V RG M10 I	FIS V RG M12 I	FIS V RG M16 I	FIS V RG M20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
temperature range (+60°C / +35°C) [1]							
Wet and Dry Concrete	$s_{cr,Np}$	[mm]	261	270	350	418	523
	$c_{cr,Np}$	[mm]	130	135	175	209	261
Waterfilled hole	$s_{cr,Np}$	[mm]	238	270	350	374	475
	$c_{cr,Np}$	[mm]	119	135	175	187	238
temperature range (+72°C / +50°C) [1]							
Wet and Dry Concrete	$s_{cr,Np}$	[mm]	238	270	313	374	475
	$c_{cr,Np}$	[mm]	119	135	156	187	238
Waterfilled hole	$s_{cr,Np}$	[mm]	213	270	293	342	422
	$c_{cr,Np}$	[mm]	106	135	146	171	211

[1] (short term temperature / long term temperature)

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

4

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\, c_{cr,sp}$

Design resistance of single anchor [1]

Anchor type			FIS V RG M8 I	FIS V RG M10 I	FIS V RG M12 I	FIS V RG M16 I	FIS V RG M20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
non-cracked concrete							
design resistance	$N^0_{Rd,c}$	[kN]	28.7	28.7	47.1	68.1	95.2

[1] For underwater installation the resistance values have to be multiplied by 0.83

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,c}$	[-]	0,77	0,89	1,00	1,10	1,22	1,34	1,41	1,48	1,55

4.3.2 Concrete cone failure
Characteristic values for design

Anchor type			FIS V RG M8 I	FIS V RG M10 I	FIS V RG M12 I	FIS V RG M16 I	FIS V RG M20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
	$s_{cr,N}$	[mm]	270	270	375	480	600
	$c_{cr,N}$	[mm]	135	135	188	240	300

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_s	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure
Characteristic values for design

Anchor type				FIS V RG M8 I	FIS V RG M10 I	FIS EM M12	FIS V RG M16 I	FIS V RG M20 I
eff. anchorage depth		h_{ef}	[mm]	90	90	125	160	200
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	180	180	250	320	400
		$c_{cr,sp}$	[mm]	90	90	125	160	200
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)				
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$				
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	407	407	565	723	904
		$c_{cr,sp}$	[mm]	203	203	283	362	452
		h_{min}	[mm]	120	125	165	205	260

$f_{scr,sp}$

h/h_{ef}	1,3	1,35	1,4	1,45	1,5	1,55	1,6	1,65	1,7	1,75	1,8	1,85	1,9	1,95	2
$f_{scr,sp}$	4,52	4,34	4,16	3,98	3,80	3,62	3,44	3,26	3,08	2,90	2,72	2,54	2,36	2,18	2,00

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

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4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≥1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\,(N_{Rd,p}\,;\,N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type			FIS V RG M8 I				FIS V RG M10 I				FIS V RG M12 I			
			gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
design resistance	$V_{Rd,s}$	[kN]	7,4	11,7	8,2	8,2	11,8	18,6	13,0	13,0	16,9	27,0	18,9	18,9

Anchor type			FIS V RG M16 I				FIS V RG M20 I			
			gvz 5.8	gvz 8.8	A4-70	C-70	gvz 5.8	gvz 8.8	A4-70	C-70
design resistance	$V_{Rd,s}$	[kN]	31,4	43,2	35,1	35,1	49,6	60,0	55,1	55,1

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\,(N_{Rd,p}\,;\,N_{Rd,c})$$

k-factor

Anchor type	FIS V RG M8 I to FIS V RG M20 I
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- $c < \max(10\ h_{ef}\ ;\ 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]				
	FIS V RG M8 I	FIS V RG M10 I	FIS V M12	FIS V RG M16 I	FIS V RG M20 I
h_{ef}	90	90	125	160	200
edge distance [mm]	non-cracked concrete	non-cracked concrete	non-cracked concrete	non-cracked concrete	non-cracked concrete
55	6.2				
60	7.0				
65	7.7	8.2			
70	8.5	9.0			
75	9.3	9.8	10.8		
80	10.1	10.6	11.8		
85	11.0	11.5	12.7		
90	11.8	12.4	13.6		
95	12.7	13.3	14.6	16.2	
100	13.6	14.2	15.6	17.2	
105	14.5	15.2	16.6	18.3	
120	17.3	18.1	19.7	21.6	
125	18.3	19.1	20.7	22.7	25.2
130	19.3	20.1	21.8	23.8	26.5
135	20.3	21.1	22.9	25.0	27.7
140	21.3	22.2	24.0	26.2	29.0
160	25.5	26.5	28.6	31.0	34.2
180	29.9	31.0	33.3	36.1	39.5
200	34.5	35.8	38.3	41.3	45.1
250	46.9	48.4	51.6	55.3	60.0
300	60.3	62.2	66.0	70.4	75.9
350	74.7	76.9	81.3	86.4	92.8
400	90.0	92.5	97.5	103.4	110.6
450	106.1	108.9	114.6	121.2	129.2
500	123.0	126.1	132.5	139.8	148.7
550	140.7	144.1	151.1	159.2	168.9
600	159.0	162.8	170.5	179.2	189.9
650	178.1	182.1	190.5	200.0	211.6
700	197.7	202.2	211.2	221.4	233.9
750	218.0	222.8	232.5	243.5	256.8
800	238.9	244.1	254.4	266.2	280.4
850	260.4	265.9	276.9	289.5	304.6
900	282.5	288.3	300.0	313.3	329.3
950	305.1	311.2	323.6	337.7	354.6
1000		334.7	347.8	362.7	380.5
1100			397.8	414.2	433.8
1200			449.7	467.7	489.2
1300			503.5	523.1	546.5
1400				580.4	605.6
1500				639.4	666.6
1600				700.2	729.3
1800				826.7	859.6
2000					996.3

5.3.1 Influence of concrete strength for shear

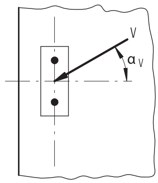
$$f_{b,V} = \sqrt{\frac{f_{ck,\,cube}}{25}} = \sqrt{\frac{f_{ck,\,cyl}}{20}}$$

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0,77	0,89	1,00	1,10	1,22	1,34	1,41	1,48	1,55

5.3.2 Influence of load direction

$f_{\alpha.V}$

	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50



For angel $\alpha \geqq 90°$ the component of the shear load acting away from the edge can be neglected and the proof can be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

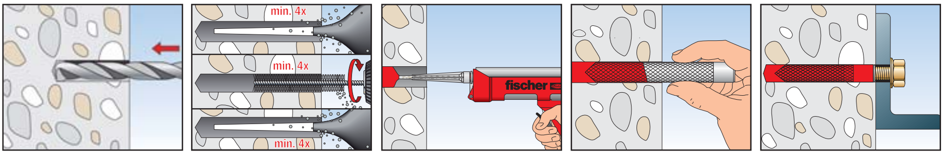
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = **tension/shear component of the design load acting on the most unfavourable single anchor**

N_{Rd} ; V_{Rd} = **tension/shear design resistance including safety factors of the most unfavourable single anchor**

7. Installation details



8. Anchor characteristics

Anchor type			FIS V RG M8 I	FIS V RG M10 I	FIS V RG M12 I	FIS V RG M16 I	FIS V RG M20 I
diameter of thread			M 8	M 10	M 12	M 16	M 20
nominal drill hole diameter	d_0	[mm]	14	18	20	24	32
drill depth	h_0	[mm]	90	90	125	160	200
effective anchorage depth	h_{ef}	[mm]	90	90	125	160	200
clearance-hole in fixture to be attached	d_f	[mm]	≦ 9	≦ 12	≦ 14	≦ 18	≦ 22
screw penetration depth	min l_s	[mm]	8	10	12	16	20
	max l_s	[mm]	18	23	26	35	45
wrench size	SW	[mm]	13	17	19	24	30
maximum torque moment	$T_{inst, max}$	[Nm]	10	20	40	80	120
minimum thickness of concrete member	h_{min}	[mm]	120	125	165	205	260
minimum spacing	s_{min}	[mm]	40	45	60	80	125
minimum edge distances	c_{min}	[mm]	40	45	60	80	125
mortar filling quantity		[scale units]	5	7	11	17	48

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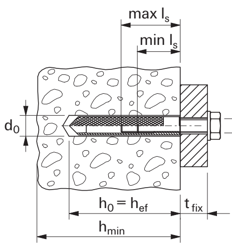


9. Gelling and curing times

System temperature	Max. processing time FIS V	Max. processing time FIS VS	Max. processing time FIS VW
± 0 °C	–	–	5 min.
+ 5 °C	13 min.	–	5 min.
+ 10 °C	9 min.	20 min.	3 min.
+ 20 °C	5 min.	10 min.	1 min.
+ 30 °C	4 min.	6 min.	–
+ 40 °C	2 min.	4 min.	–

Temperature at anchoring base	Curing time [1)] FIS V	Curing time [1)] FIS VS	Curing time [1)] FIS VW
- 5 °C to 0 °C	24 h	–	180 min.
± 0 °C to 5 °C	180 min.	6 h	180 min.
+ 5 °C to 10 °C	90 min.	180 min.	50 min.
+ 10 °C to 20 °C	60 min.	120 min.	30 min.
+ 20 °C to 30 °C	45 min.	60 min.	–
+ 30 °C to 40 °C	35 min.	30 min.	–

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least +5 °C.
With temperatures above + 30 °C to + 40 °C the cartridges have to be cooled down to + 15 °C or + 20 °C.
For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.
1) For wet concrete the curing time must be doubled.

10. Mechanical characteristics of RG MI

Anchor type			FIS V RG M8 I				FIS V RG M10 I				FIS V RG M12 I			
screw property class			**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**
stressed cross sectional area - screw	A_s	[mm²]	36.6				58.0				84.3			
resisting moment - screw	W	[mm³]	31.2				62.3				109.2			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	16.0	24.0	16.7	20.8	31.2	48.0	33.3	41.6	54.4	84.0	59.0	73.6
yield strength - screw	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength - screw	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	700	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm²]	72.5				137.1				161.8			
resisting moment - internal-threaded anchor	W	[mm³]	147.8				361.4				496.6			
yield strength - internal-threaded anchor	f_{yk}	[N/mm²]	420		450	560	420		450	560	420		450	560
tensile strength - internal-threaded anchor	f_{uk}	[N/mm²]	525		700	700	525		700	700	525		700	700

Anchor type			FIS V RG M16 I				FIS V RG M20 I			
screw property class			**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**
stressed cross sectional area - screw	A_s	[mm²]	157.0				245.0			
resisting moment - screw	W	[mm³]	277.5				540.9			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	138.4	212.8	148.7	185.6	269.6	415.2	291.0	363.2
yield strength - screw	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560
tensile strength - screw	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm²]	210.4				350.5			
resisting moment - internal-threaded anchor	W	[mm³]	836.9				1755.3			
yield strength - internal-threaded anchor	f_{yk}	[N/mm²]	420		450	560	420		450	560
tensile strength - internal-threaded anchor	f_{uk}	[N/mm²]	525		700	700	525		700	700

fischer Injection mortar FIS V, FIS VS and FIS VW with rebars

Anchor design according to fischer specification

1. Types

Reinforcement bars Ø 8 - Ø 28 mm

FIS V - Injection mortar FIS V 360 S, FIS V 950 S

FIS VW 300 T

FIS VS - Injection mortar
FIS VS 300 T, FIS VS 360 S

FIS VW - Injection mortar
FIS VW 360 S

Features and Advantages

- Suitable for non-cracked concrete.
- High-performance hybrid resin for high loads in almost all building materials.
- The Hybrid mortar gives a good combination of organic resin (high bond strength) and mineral cement (avoids corrosion and gives high compressive strength).
- Expansion stress free anchoring guarantees a save use with small spacing and edge distances.
- Different mortar versions and a large range of accessories gives the opportunity for different applications and a wide temperature range within the anchor base.
- Variable embedment depth enables the application in all kind of building structures.
- The resin seals the drill hole and avoids penetration of dampness and gives therefore corrosion protection for the embedded steel.
- FIS VS mortar version with longer maximum processing time and lower application pressure.
- FIS VW mortar version with accelerated curing especially during winter.

Materials

Reinforcing steel :	f_{yk} = 400 - 600 N/mm². Static values based on f_{yk} = 500 N/mm²
Injection mortar:	Vinylester resin (styrene-free), hydraulic additives, quartz sand and hardener

2. Ultimate resistances of single anchors with large spacing and large edge distance[1)]

Mean values

Anchor type				FIS V ⌀ 8	FIS V ⌀ 10	FIS V ⌀ 12	FIS V ⌀ 14	FIS V ⌀ 16	FIS V ⌀ 20	FIS V ⌀ 25	FIS V ⌀ 28
h_{ef}			[mm]	80	90	110	120	125	170	250	250
non-cracked concrete temperature range (+80 °C / +50 °C)[2)]											
tension static	C 20/25	N_u	[kN]	26.6	37.5	54.9	63.6	75.7	122.3	201.1	225.2
	C 50/60	N_u	[kN]	29.4	46.2	66.2	80.1	95.4	154.1	253.3	283.7
shear static	≧ C 20/25	V_u	[kN]	17.6	27.7	39.7	53.6	69.9	109.0	170.1	213.6

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² and careful drill hole cleaning according to the approval. The rebar may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance[1)]

Anchor type				FIS V ⌀ 8	FIS V ⌀ 10	FIS V ⌀ 12	FIS V ⌀ 14	FIS V ⌀ 16	FIS V ⌀ 20	FIS V ⌀ 25	FIS V ⌀ 28
h_{ef}			[mm]	80	90	110	120	125	170	250	250
non-cracked concrete temperature range (+80 °C / +50 °C)[2)]											
tension static	C 20/25	N_{Rk}	[kN]	22.1	31.1	45.6	52.8	62.8	101.5	176.7	186.9
	C 50/60	N_{Rk}	[kN]	27.9	39.2	57.5	66.5	79.2	127.9	222.7	235.5
shear static	≧ C 20/25	V_{Rk}	[kN]	13.8	21.6	31.1	42.4	55.3	87.0	135.0	170.0

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² and careful drill hole cleaning according to the approval. The rebar may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)

3.2 Design resistance[1)]

Anchor type				FIS V ⌀ 8	FIS V ⌀ 10	FIS V ⌀ 12	FIS V ⌀ 14	FIS V ⌀ 16	FIS V ⌀ 20	FIS V ⌀ 25	FIS V ⌀ 28
h_{ef}			[mm]	80	90	110	120	125	170	250	250
non-cracked concrete temperature range (+80 °C / +50 °C)[2)]											
tension static	C 20/25	N_{Rd}	[kN]	14.7	20.7	30.4	35.2	41.9	67.6	117.8	124.6
	C 50/60	N_{Rd}	[kN]	18.6	26.1	38.3	44.3	52.8	85.2	148.4	157.0
shear static	≧ C 20/25	V_{Rd}	[kN]	9.2	14.4	20.7	28.3	36.9	58.0	90.0	113.3

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² and careful drill hole cleaning according to the approval. The rebar may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)

3.3 Recommended resistance[1) 2)]

Anchor type				FIS V ⌀ 8	FIS V ⌀ 10	FIS V ⌀ 12	FIS V ⌀ 14	FIS V ⌀ 16	FIS V ⌀ 20	FIS V ⌀ 25	FIS V ⌀ 28
h_{ef}			[mm]	80	90	110	120	125	170	250	250
non-cracked concrete temperature range (+80 °C / +50 °C)[3)]											
tension static	C 20/25	N_R	[kN]	10.5	14.8	21.7	25.1	29.9	48.3	84.1	89.0
	C 50/60	N_R	[kN]	13.3	18.7	27.4	31.7	37.7	60.9	106.0	112.2
shear static	≧ C 20/25	V_R	[kN]	6.6	10.3	14.8	20.2	26.3	41.4	64.3	81.0

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² and careful drill hole cleaning according to the approval. The rebar may be installed in dry or wet concrete.
2) (short term temperature / long term temperature)
3) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on the failure mode of the anchor.

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^{0}_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^{0}_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^{0}_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FIS V ∅ 8	FIS V ∅ 10	FIS V ∅ 12	FIS V ∅ 14	FIS V ∅ 16	FIS V ∅ 20	FIS V ∅ 25	FIS V ∅ 28
design resistance	$N_{Rd,s}$	[kN]	20.0	31.4	45.0	60.7	79.3	123.6	192.9	242.1

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^{0}_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Anchor type		FIS V ∅ 8			FIS V ∅ 10			FIS V ∅ 12			FIS V ∅ 14		
eff. anchorage depth h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280
non-cracked concrete													
temperature range (+80 °C / +50 °C) [1]													
$N^0_{Rd,p}$	[kN]	11.1	14.7	29.5	13.8	20.7	46.1	19.4	30.4	66.4	22.0	35.2	82.1
temperature range (+120 °C / +72 °C) [1]													
$N^0_{Rd,p}$	[kN]	9.6	12.7	25.5	11.9	17.9	39.8	15.8	24.9	54.3	18.7	29.9	69.8

Anchor type		FIS V ∅ 16			FIS V ∅ 20			FIS V ∅ 25			FIS V ∅ 28		
eff. anchorage depth h_{ef}	[mm]	80	125	320	90	170	400	100	250	500	112	250	560
non-cracked concrete													
temperature range (+80 °C / +50 °C) [1]													
$N^0_{Rd,p}$	[kN]	26.8	41.9	107.2	35.8	67.6	159.2	47.1	117.8	235.6	55.8	124.6	279.1
temperature range (+120 °C / +72 °C) [1]													
$N^0_{Rd,p}$	[kN]	22.8	35.6	91.1	30.2	57.0	134.0	39.3	98.2	196.3	46.0	102.6	229.9

[1] (short term temperature / long term temperature)

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	55
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,p}$	[-]	0.88	0.95	1.00	1.05	1.10	1.15	1.19	1.22	1.26

fischer Injection mortar FIS V, FIS VS and FIS VW with rebars

Anchor design according to fischer specification

4.2.2 Characteristic edge distance and spacing for design of combined pull-out and concrete cone failure

Anchor type		FIS V ⌀ 8			FIS V ⌀ 10			FIS V ⌀ 12			FIS V ⌀ 14	
eff. anchorage depth h_{ef} [mm]	60	80	160	60	90	200	70	110	240	75	120	280
temperature range (+80 °C / +50 °C) [1]												
$s_{cr,Np}$ [mm]	180	194	194	180	242	242	210	291	291	225	323	323
$c_{cr,Np}$ [mm]	90	97	97	90	121	121	105	145	145	113	162	162
temperature range (+120 °C / +72 °C) [1]												
$s_{cr,Np}$ [mm]	180	180	180	180	225	225	210	263	263	225	298	298
$c_{cr,Np}$ [mm]	90	90	90	90	113	113	105	131	131	113	149	149

Anchor type		FIS V ⌀ 16			FIS V ⌀ 20			FIS V ⌀ 25			FIS V ⌀ 28	
eff. anchorage depth h_{ef} [mm]	80	125	320	90	170	400	100	250	500	112	250	560
temperature range (+80 °C / +50 °C) [1]												
$s_{cr,Np}$ [mm]	240	370	370	270	450	450	300	548	548	336	596	596
$c_{cr,Np}$ [mm]	120	185	185	135	225	225	150	274	274	168	298	298
temperature range (+120 °C / +72 °C) [1]												
$s_{cr,Np}$ [mm]	240	341	341	270	413	413	300	500	500	336	541	541
$c_{cr,Np}$ [mm]	120	170	170	135	207	207	150	250	250	168	271	271

[1] (short term temperature / long term temperature)

4

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type			FIS V ⌀ 8			FIS V ⌀ 10			FIS V ⌀ 12			FIS V ⌀ 14	
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280
non-cracked concrete													
design resistance	$N^0_{Rd,c}$	[kN]	15.6	24.1	68.1	15.6	28.7	95.2	19.7	38.8	125.2	21.9	44.3	157.7

Anchor type			FIS V ⌀ 16			FIS V ⌀ 20			FIS V ⌀ 25			FIS V ⌀ 28	
eff. anchorage depth	h_{ef}	[mm]	80	125	320	90	170	400	100	250	500	112	250	560
non-cracked concrete													
design resistance	$N^0_{Rd,c}$	[kN]	24.1	47.1	192.7	28.7	74.6	269.3	33.7	133.1	376.4	39.9	133.1	446.2

4

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,c}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type			FIS V ⌀ 8			FIS V ⌀ 10			FIS V ⌀ 12			FIS V ⌀ 14	
eff. anchorage depth	h_{ef}	[mm]	60	80	160	60	90	200	70	110	240	75	120	280
	$s_{cr,N}$	[mm]	180	240	480	180	270	600	210	330	720	225	360	840
	$c_{cr,N}$	[mm]	90	120	240	90	135	300	105	165	360	113	180	420

Anchor type			FIS V ⌀ 16			FIS V ⌀ 20			FIS V ⌀ 25			FIS V ⌀ 28	
eff. anchorage depth	h_{ef}	[mm]	80	125	320	90	170	400	100	250	500	112	250	560
	$s_{cr,N}$	[mm]	240	375	960	270	510	1200	300	750	1500	336	750	1680
	$c_{cr,N}$	[mm]	120	188	480	135	255	600	150	375	750	168	375	840

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_s	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type				**FIS V ⌀ 8**			**FIS V ⌀ 10**			**FIS V ⌀ 12**			**FIS V ⌀ 14**		
eff. anchorage depth		h_{ef}	**[mm]**	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**75**	**120**	**280**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	120	160	320	120	180	400	140	220	480	150	240	560
		$c_{cr,sp}$	[mm]	60	80	160	60	90	200	70	110	240	75	120	280
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see table below)											
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$											
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	271	362	723	271	407	904	316	497	1085	339	542	1266
		$c_{cr,sp}$	[mm]	136	181	362	136	203	452	158	249	542	170	271	633
		h_{min}	[mm]	100	110	190	100	120	230	100 / 102[1]	140 / 142[1]	270 / 272[1]	111	156	316

Anchor type				**FIS V ⌀ 16**			**FIS V ⌀ 20**			**FIS V ⌀ 25**			**FIS V ⌀ 28**		
eff. anchorage depth		h_{ef}	**[mm]**	**80**	**125**	**320**	**90**	**170**	**400**	**100**	**250**	**500**	**112**	**250**	**560**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	160	250	640	180	340	800	200	500	1000	224	500	1120
		$c_{cr,sp}$	[mm]	80	125	320	90	170	400	100	250	500	112	250	560
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see below)											
		$c_{cr,sp}$	[mm]	$= s_{cr,sp}/2$											
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	362	565	1446	407	768	1808	452	1130	2260	506	1130	2531
		$c_{cr,sp}$	[mm]	181	283	723	203	384	904	226	565	1130	253	565	1266
		h_{min}	[mm]	120	165	360	140	220	450	160	310	560	182	320	630

[1] (d_0 = 14 mm / d_0 = 16 mm)

$f_{scr,sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.80	3.62	3.44	3.26	3.08	2.90	2.72	2.54	2.36	2.18	2.00

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

fischer Injection mortar FIS V, FIS VS and FIS VW with rebars

Anchor design according to fischer specification

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≥1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\ (N_{Rd,p}\ ;\ N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type	**FIS V ∅ 8**	**FIS V ∅ 10**	**FIS V ∅ 12**	**FIS V ∅ 14**	**FIS V ∅ 16**	**FIS V ∅ 20**	**FIS V ∅ 25**	**FIS V ∅ 28**
design resistance $V_{Rd,s}$ [kN]	9.2	14.4	20.7	28.3	36.9	58.0	90.0	113.3

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\ (\ N_{Rd,p}\ ;\ N_{Rd,c}\ )$$

k-factor

Anchor type	**FIS V ∅ 8 to FIS V ∅ 28**
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- $c < \max(10\ h_{ef}\ ;\ 60\ d)$ with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]											
	FIS V ⌀8			FIS V ⌀10			FIS V ⌀12			FIS V ⌀14		
h_{ef}	60	80	160	60	90	200	70	110	240	75	120	280
edge distance [mm]	non-cracked concrete			non-cracked concrete			non-cracked concrete			non-cracked concrete		
40	3.5	3.7	4.4									
45	4.1	4.3	5.1	4.3	4.7	5.8						
50	4.7	5.0	5.8	4.9	5.3	6.6						
55	5.4	5.6	6.6	5.6	6.0	7.4	5.9	6.6	8.2			
60	6.0	6.3	7.3	6.2	6.8	8.2	6.6	7.3	9.1	6.9	7.7	10.0
65	6.7	7.0	8.1	6.9	7.5	9.0	7.3	8.1	10.0	7.6	8.5	11.0
70	7.4	7.8	8.9	7.7	8.3	9.9	8.1	8.9	10.9	8.4	9.4	11.9
75	8.1	8.5	9.7	8.4	9.0	10.8	8.9	9.7	11.8	9.2	10.2	12.9
80	8.9	9.3	10.6	9.2	9.8	11.7	9.7	10.6	12.8	10.0	11.1	14.0
85	9.6	10.1	11.4	9.9	10.7	12.6	10.5	11.4	13.8	10.9	12.0	15.0
90	10.4	10.9	12.3	10.7	11.5	13.5	11.3	12.3	14.8	11.7	12.9	16.0
95	11.2	11.7	13.2	11.5	12.3	14.5	12.1	13.2	15.8	12.6	13.8	17.1
100	12.0	12.6	14.1	12.4	13.2	15.5	13.0	14.1	16.8	13.5	14.8	18.2
105	12.9	13.4	15.1	13.2	14.1	16.5	13.9	15.1	17.9	14.4	15.7	19.3
110	13.7	14.3	16.0	14.1	15.0	17.5	14.8	16.0	18.9	15.3	16.7	20.4
120	15.5	16.1	18.0	15.9	16.9	19.5	16.6	17.9	21.1	17.2	18.7	22.7
125	16.4	17.0	19.0	16.8	17.8	20.6	17.6	18.9	22.2	18.1	19.7	23.9
130	17.3	17.9	20.0	17.7	18.8	21.7	18.5	20.0	23.4	19.1	20.8	25.1
135	18.2	18.9	21.0	18.7	19.8	22.8	19.5	21.0	24.5	20.1	21.8	26.3
140	19.1	19.9	22.0	19.6	20.8	23.9	20.5	22.0	25.7	21.1	22.9	27.5
160	23.0	23.9	26.3	23.6	24.9	28.4	24.6	26.3	30.4	25.3	27.3	32.5
170	25.1	25.9	28.6	25.6	27.1	30.7	26.7	28.6	32.9	27.5	29.6	35.0
180	27.1	28.1	30.9	27.8	29.3	33.2	28.9	30.8	35.4	29.7	31.9	37.7
200	31.4	32.5	35.6	32.1	33.8	38.1	33.4	35.6	40.6	34.3	36.8	43.1
250	43.0	44.3	48.2	43.9	46.0	51.3	45.5	48.2	54.4	46.6	49.7	57.4
300	55.6	57.2	61.9	56.7	59.2	65.6	58.6	61.9	69.2	59.9	63.7	72.8
350	69.2	71.1	76.5	70.5	73.4	80.9	72.7	76.5	85.1	74.3	78.6	89.2
400	83.7	85.8	92.1	85.1	88.5	97.0	87.7	92.0	101.8	89.5	94.5	106.5
450	98.9	101.4	108.4	100.6	104.4	114.0	103.5	108.4	119.4	105.5	111.2	124.6
500	115.0	117.7	125.6	116.8	121.2	131.8	120.1	125.6	137.8	122.4	128.6	143.6
550	131.8	134.8	143.5	133.8	138.6	150.4	137.4	143.5	156.9	139.9	146.9	163.2
600	149.2	152.6	162.1	151.5	156.8	169.6	155.4	162.1	176.8	158.2	165.8	183.7
650	167.4	171.0	181.4	169.8	175.6	189.6	174.1	181.4	197.3	177.2	185.4	204.8
700		190.1	201.4		195.1	210.2	193.5	201.4	218.5	196.8	205.7	226.5
750		209.9	222.0		215.1	231.4	213.5	222.0	240.3	217.0	226.6	248.9
800		230.2	243.1		235.8	253.2		243.2	262.8	237.9	248.1	272.0
850		251.1	264.9		257.1	275.6		264.9	285.8	259.3	270.2	295.6
900			287.2		279.0	298.6		287.3	309.4		292.9	319.7
1000			333.5			346.3		333.6	358.3		339.9	369.8
1200			432.3			447.7		432.3	462.3		440.0	476.1
1300			484.5			501.4			517.2		493.0	532.2
1500			594.4			614.1			632.4			649.9
1800			771.9			795.8			818.1			839.2
2000						924.7			949.7			973.3
2200						1059.5			1087.2			1113.3
2600									1378.9			1410.1
3000												1727.6

continued next page

fischer Injection mortar FIS V, FIS VS and FIS VW with rebars

Anchor design according to fischer specification

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

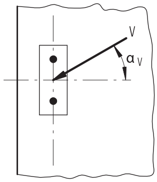
	$V^0_{Rd,c}$ [kN]											
	FIS V ⌀16			FIS V ⌀20			FIS V 25			FIS V 28		
h_{ef}	80	125	320	90	170	400	100	250	500	112	250	560
edge distance [mm]	non-cracked concrete			non-cracked concrete			non-cracked concrete			non-cracked concrete		
65	7.9	8.9	12.0									
70	8.7	9.7	13.0									
75	9.5	10.6	14.1									
80	10.4	11.5	15.1									
85	11.2	12.4	16.2	12.0	14.1	18.8						
90	12.1	13.3	17.3	12.9	15.1	20.0						
95	13.0	14.3	18.5	13.8	16.1	21.2						
100	13.9	15.2	19.6	14.7	17.2	22.5						
105	14.8	16.2	20.8	15.7	18.2	23.7						
110	15.8	17.2	21.9	16.7	19.3	25.0	17.7	22.6	29.1			
120	17.7	19.3	24.3	18.7	21.5	27.6	19.8	25.1	31.9			
125	18.7	20.3	25.5	19.7	22.6	28.9	20.8	26.3	33.4			
130	19.7	21.4	26.8	20.7	23.8	30.3	21.9	27.6	34.9	22.9	28.3	37.7
135	20.7	22.5	28.0	21.8	24.9	31.6	23.0	28.8	36.3	24.0	29.6	39.3
140	21.7	23.5	29.3	22.9	26.1	33.0	24.1	30.1	37.8	25.1	30.9	40.8
160	26.0	28.1	34.5	27.3	30.9	38.6	28.7	35.4	43.9	29.9	36.3	47.2
170	28.2	30.4	37.2	29.6	33.4	41.5	31.1	38.2	47.0	32.3	39.0	50.5
180	30.4	32.8	39.9	31.9	36.0	44.4	33.5	41.0	50.2	34.8	41.9	53.8
200	35.1	37.7	45.5	36.7	41.2	50.4	38.5	46.7	56.7	39.9	47.7	60.6
250	47.6	50.8	60.4	49.7	55.2	66.3	51.8	61.8	73.8	53.6	63.0	78.3
300	61.2	65.0	76.3	63.6	70.2	83.3	66.2	78.0	91.9	68.3	79.5	97.2
350	75.8	80.2	93.2	78.6	86.2	101.2	81.6	95.2	111.0	84.1	96.9	117.0
400	91.2	96.3	111.0	94.5	103.2	120.0	97.9	113.4	131.1	100.7	115.2	137.7
450	107.5	113.2	129.7	111.2	120.9	139.7	115.1	132.3	151.9	118.2	134.4	159.2
500	124.5	130.9	149.2	128.6	139.5	160.2	133.0	152.1	173.6	136.5	154.4	181.6
550	142.4	149.4	169.4	146.9	158.8	181.4	151.7	172.6	196.1	155.6	175.1	204.7
600	160.9	168.6	190.4	165.8	178.9	203.4	171.1	193.9	219.2	175.3	196.6	228.6
650	180.1	188.5	212.0	185.5	199.6	226.1	191.2	215.8	243.1	195.8	218.8	253.1
700	199.9	209.0	234.3	205.8	221.0	249.4	212.0	238.5	267.6	216.9	241.6	278.3
750	220.4	230.1	257.3	226.7	243.0	273.4	233.4	261.7	292.8	238.7	265.1	304.2
800	241.5	251.9	280.8	248.2	265.7	298.0	255.4	285.6	318.6	261.0	289.2	330.6
850	263.1	274.2	305.0	270.3	288.9	323.1	277.9	310.1	345.0	284.0	314.0	357.7
900	285.3	297.2	329.7	293.0	312.7	348.9	301.1	335.1	371.9	307.5	339.2	385.4
950	308.1	320.6	355.0	316.2	337.1	375.2	324.8	360.8	399.5	331.6	365.1	413.6
1000	331.4	344.6	380.9	340.0	362.0	402.1	349.1	386.9	427.6	356.3	391.5	442.4
1100		394.2	434.1	389.1	413.4	457.5	399.2	440.9	485.3	407.1	445.9	501.6
1200		445.8	489.4	440.2	466.9	514.9	451.3	496.9	545.2	460.0	502.4	562.8
1300		499.3	546.6	493.2	522.2	574.2	505.3	554.8	607.0	514.7	560.7	625.9
1400			605.7		579.4	635.4	561.1	614.6	670.6	571.4	621.0	691.0
1500			666.6		638.4	698.5	618.7	676.1	736.1	629.8	683.1	757.9
1600			729.2		699.1	763.2	678.1	739.4	803.3	689.9	746.9	826.5
1800			859.4		825.4	897.7		871.1	942.8	815.1	879.5	968.8
2000			995.8			1038.5		1009.0	1088.6		1018.4	1117.5
2200			1138.2			1185.3		1152.9	1240.5		1163.3	1272.2
2400			1286.3			1337.8		1302.5	1398.1		1313.9	1432.7
2600			1439.8			1495.8		1457.5	1561.2		1470.0	1598.6
2800			1598.5			1659.0			1729.6			1769.9
3000			1762.2			1827.3			1903.0			1946.3
3200			1930.7			2000.4			2081.4			2127.5
3600						2360.5			2452.1			2504.2
4000						2738.4			2840.6			2898.7
4500						3234.3			3349.9			3415.6
5000									3884.1			3957.3
5500									4441.8			4522.7
6000												5110.6

5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50	C45/55	C50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction



$f_{\alpha.V}$

	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angel $\alpha \geqq 90°$ the component of the shear load acting away from the edge can be neglected and the proof can be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = lowest value of $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

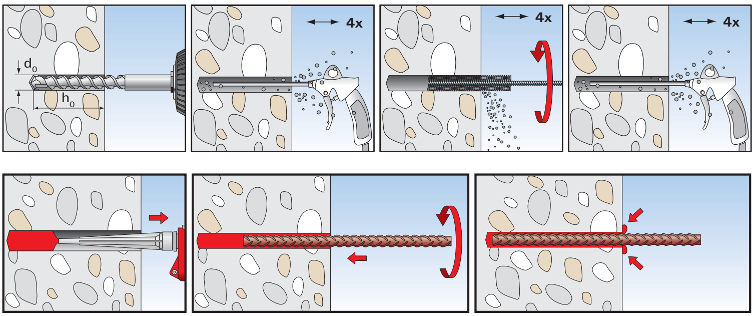
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details



d_0 ≧ 18 mm with oil free compressed air (P > 6 bar)

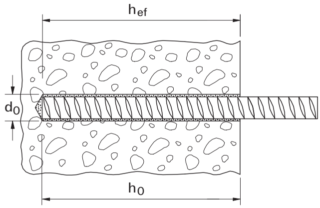
fischer Injection mortar FIS V, FIS VS and FIS VW with rebars

Anchor design according to fischer specification

8. Anchor characteristics FIS V with rebars

Anchor type			FIS V ⌀ 8			FIS V ⌀ 10			FIS V ⌀ 12			FIS V ⌀ 14		
eff. anchorage depth	h_{ef}	**[mm]**	**60**	**80**	**160**	**60**	**90**	**200**	**70**	**110**	**240**	**75**	**120**	**280**
diameter of rebar		[mm]		8			10			12			14	
nominal drill hole diameter	d_0	[mm]		12			14			16			18	
drill depth	h_0	[mm]	60	80	160	60	90	200	70	110	240	75	120	280
minimum thickness of concrete member	h_{min}	[mm]	100	110	190	100	120	230	100	140	270	105	150	310
minimum spacing	s_{min}	[mm]		40			45			55			60	
minimum edge distances	c_{min}	[mm]		40			45			55			60	
mortar filling quantity		[scale units]	3	4	7	3	5	10	4	6	13	5	8	18

Anchor type			FIS V ⌀ 16			FIS V ⌀ 20			FIS V ⌀ 25			FIS V ⌀ 28		
eff. anchorage depth	h_{ef}	**[mm]**	**80**	**160**	**320**	**90**	**200**	**400**	**100**	**230**	**500**	**112**	**260**	**560**
diameter of rebar		[mm]		16			20			25			28	
nominal drill hole diameter	d_0	[mm]		20			25			30			35	
drill depth	h_0	[mm]	80	160	320	90	200	400	100	230	500	112	260	560
minimum thickness of concrete member	h_{min}	[mm]	120	200	360	140	250	450	160	290	560	182	330	630
minimum spacing	s_{min}	[mm]		65			85			110			130	
minimum edge distances	c_{min}	[mm]		65			85			110			130	
mortar filling quantity		[scale units]	6	9	25	10	19	43	13	33	45	24	52	116



9. Gelling and curing times

System temperature	Max. processing time		
	FIS VW	FIS V	FIS VS
± 0 °C	5 min.	–	–
+ 5 °C	5 min.	13 min.	–
+ 10 °C	3 min.	9 min.	20 min.
+ 20 °C	1 min.	5 min.	10 min.
+ 30 °C	–	4 min.	6 min.
+ 40 °C	–	2 min.	4 min.

Temperature at anchoring base	Curing time [1)]		
	FIS VW	FIS V	FIS VS
- 5 °C to 0 °C	3 h	24 h	–
± 0 °C to + 5 °C	3 h	3 h	6 h
> 5 °C to + 10 °C	50 min.	90 min.	3 h
> 10 °C to + 20 °C	30 min.	60 min.	2 h
> 20 °C to + 30 °C	–	45 min.	60 min.
> 30 °C to + 40 °C	–	35 min.	30 min.

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least + 5 °C.
With temperatures above + 30 °C to + 40 °C the cartridges have to be cooled down to + 15 °C or + 20 °C.
For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.

1) For wet concrete the curing time must be doubled.

10. Mechanical characteristics of rebars B 500 B

Anchor type			FIS V ⌀ 8	FIS V ⌀ 10	FIS V ⌀ 12	FIS V ⌀ 14	FIS V ⌀ 16	FIS V ⌀ 20	FIS V ⌀ 25	FIS V ⌀ 28
stressed cross sectional area reinforcing steel	A_S	[mm^2]	50	79	113	154	201	314	491	616
resisting moment reinforcing steel	W	[mm^3]	50	98	170	269	402	785	1534	2155
yield strength reinforcing steel	f_{yk}	[N/mm^2]					500			
tensile strength reinforcing steel	f_{uk}	[N/mm^2]					550			

fischer Resin anchor R

Anchor design according to fischer specification

1. Types

RG M8 - M20 - threaded rod (gvz, A4 and C)
with external hexagon head

RG M24 - M30 - threaded rod (gvz, A4 and C)
straight cut

R M - Resin capsule R M8 - M30

ETA-08/0010
ETAG 001-5
Option 7 for non-cracked concrete *)

Fire resistance classification
R 120
Anchor types see test report

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Features and Advantages

- European Technical Approval option 7*) for non-cracked concrete.
- The expansion stress free anchoring allows minimal spacing and edge distances and guarantees a save use with small anchor plates and edge distances.
- The included setting tool guarantees save anchoring of threaded rods (M8 - M20).
- The resin capsule is approved for water filled drill holes and enables the use independently of weather conditions.
- The resin seals the drill hole and avoids penetration of dampness and gives therefore corrosion protection for the embedded steel.
- Large range of available fixing length gives perfect allocation to the given fixture.
- Threaded rods don't need a torque moment because of that a stand-off installation is easy to realise.

*) The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Threaded rod :	- Carbon steel, zinc plated (5 µm) and passivated (gvz) - Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316 - Highly corrosion-resistant steel of the corrosion resistance class IV, e.g. 1.4529.
Resin capsule:	- Vinylester resin (styrene-free), quartz sand and hardener

2. Ultimate resistance of single anchors with large spacing and large edge distance

Mean values

Anchor type	R M8 RG M8			R M10 RG M10			R M12 RG M12			R M16 RG M16			R M20 RG M20			R M24 RG M24			R M27 RG M27			R M30 RG M30		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+ 80 °C / + 50 °C) 2)																								
tension C 20/25 N_u [kN]	20.0	27.3		31.5	42.6		46.2	56.8			81.8			131.7			184.4			246.9			289.2	
shear ≧ C 20/25 V_u [kN]	12.0	16.1		19.0	25.6		27.6	37.2		51.4	69.2		80.3	108.0		115.6	155.7		150.4	202.4		183.8	247.4	

1) The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7“).
2) (short term temperature / long term temperature)

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance [1]

Anchor type	R M8 RG M8			R M10 RG M10			R M12 RG M12			R M16 RG M16		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+ 80 °C / + 50 °C) [2]												
tension C 20/25 N_{Rk} [kN]	22.1			31.1			41.5			59.7		
shear ≥ C 20/25 V_{Rk} [kN]	7.4	12.8		13.3	20.3		19.3	29.5		35.9	54.8	

Anchor type	R M20 RG M20			R M24 RG M24			R M27 RG M27			R M30 RG M30		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+ 80 °C / + 50 °C) [2]												
tension C 20/25 N_{Rk} [kN]	96.1			134.6			180.2			211.1		
shear ≥ C 20/25 V_{Rk} [kN]	56.0	85.7		80.7	123.4		105.1	160.8		128.3	196.2	

[1] The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7").

[2] (short term temperature / long term temperature)

3.2 Design resistance [1]

Anchor type	R M8 RG M8			R M10 RG M10			R M12 RG M12			R M16 RG M16		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+ 80 °C / + 50 °C) [2]												
tension C 20/25 N_{Rd} [kN]	12.3			17.3			27.6			39.8		
shear ≥ C 20/25 V_{Rd} [kN]	5.9	8.2	10.2	10.6	13.0	16.2	15.4	18.9	23.6	28.7	35.1	43.8

Anchor type	R M20 RG M20			R M24 RG M24			R M27 RG M27			R M30 RG M30		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+ 80 °C / + 50 °C) [2]												
tension C 20/25 N_{Rd} [kN]	64.1			89.7			120.2			140.7		
shear ≥ C 20/25 V_{Rd} [kN]	44.8	54.9	68.6	64.6	79.1	98.7	84.1	103.1	128.6	102.6	125.8	157.0

[1] The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7").

[2] (short term temperature / long term temperature)

3.3 Recommended resistance [1] [2]

Anchor type	R M8 RG M8			R M10 RG M10			R M12 RG M12			R M16 RG M16		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+ 80 °C / + 50 °C) [3]												
tension C 20/25 N_R [kN]	8.8			12.3			19.7			28.4		
shear ≥ C 20/25 V_R [kN]	4.2	5.9	7.3	7.6	9.3	11.6	11.0	13.5	16.9	20.5	25.1	31.3

Anchor type	R M20 RG M20			R M24 RG M24			R M27 RG M27			R M30 RG M30		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete temperature range (+ 80 °C / + 50 °C) [3]												
tension C 20/25 N_R [kN]	45.8			64.1			85.8			100.5		
shear ≥ C 20/25 V_R [kN]	32.0	39.2	49.0	46.1	56.5	70.5	60.1	73.6	91.9	73.3	89.8	112.1

[1] The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7").

[2] Material safety factors γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on failure mode of the anchor.

[3] (short term temperature / long term temperature)

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			R M8 RG M8			R M10 RG M10			R M12 RG M12			R M16 RG M16			R M20 RG M20			R M24 RG M24			R M27 RG M27			R M30 RG M30		
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
design resistance	$N_{Rd,s}$	[kN]	12.8	13.9	17.3	20.1	21.9	27.3	29.5	31.6	39.3	55.0	58.8	73.3	85.2	92.0	115	123	132	165	160	172	215	196	210	262

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4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Anchor type			R M8 RG M8	R M10 RG M10	R M12 RG M12	R M16 RG M16	R M20 RG M20	R M24 RG M24	R M27 RG M27	R M30 RG M30
eff. anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	250	280
non-cracked concrete										
temperature range (+ 80 °C / + 50 °C) [1)]										
	$N^0_{Rd,p}$	[kN]	12.3	17.3	27.6	39.8	64.1	89.7	120.2	140.7
temperature range (+ 120 °C / + 72 °C) [1)]										
	$N^0_{Rd,p}$	[kN]	11.2	14.9	22.1	31.4	49.8	68.6	127.2	149.5

[1)] (short term temperature / long term temperature)

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,p}$	[-]	0.85	0.9	1.00	1.06	1.14	1.22	1.27	1.31	1.35

4.2.2 Characteristic edge distance and spacing for design of combined pull-out and concrete cone failure

Anchor type			R M8 RG M8	R M10 RG M10	R M12 RG M12	R M16 RG M16	R M20 RG M20	R M24 RG M24	R M27 RG M27	R M30 RG M30
eff. anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	250	280
temperature range (+ 80 °C / + 50 °C) [1)]										
	$s_{cr,Np}$	[mm]	194	242	277	360	438	511	575	620
	$c_{cr,Np}$	[mm]	97	121	139	180	219	255	287	310
temperature range (+ 120 °C / + 72 °C) [1)]										
	$s_{cr,Np}$	[mm]	185	225	248	320	386	447	592	639
	$c_{cr,Np}$	[mm]	92	113	124	160	193	223	296	319

[1)] (short term temperature / long term temperature)

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

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4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type	R M8 RG M8	R M10 RG M10	R M12 RG M12	R M16 RG M16	R M20 RG M20	R M24 RG M24	R M27 RG M27	R M30 RG M30
non-cracked concrete								
Design resistance $N^0_{Rd,c}$ [kN]	24.1	28.7	38.8	47.1	74.6	102.5	133.1	157.7

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,c}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type			R M8 RG M8	R M10 RG M10	R M12 RG M12	R M16 RG M16	R M20 RG M20	R M24 RG M24	R M27 RG M27	R M30 RG M30
eff. anchorage depth	h_{ef}	[mm]	**80**	**90**	**110**	**125**	**170**	**210**	**250**	**280**
	$s_{cr,N}$	[mm]	240	270	330	375	510	630	750	840
	$c_{cr,N}$	[mm]	120	135	165	188	255	315	375	420

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
f_s	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type				**R M8 RG M8**	**R M10 RG M10**	**R M12 RG M12**	**R M16 RG M16**	**R M20 RG M20**	**R M24 RG M24**	**R M27 RG M27**	**R M30 RG M30**
eff. anchorage depth		h_{ef}	**[mm]**	**80**	**90**	**110**	**125**	**170**	**210**	**250**	**280**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	160	180	220	250	340	420	500	560
		$c_{cr,sp}$	[mm]	80	90	110	125	170	210	250	280
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see below)							
		$c_{cr,sp}$	[mm]	$s_{cr,sp}/2$							
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	362	407	497	565	768	949	1130	1266
		$c_{cr,sp}$	[mm]	181	203	249	283	384	475	565	633
		h_{min}	[mm]	110	120	150	160	220	280	330	370

$$f_{scr,sp}$$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2.0
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.8	3.62	3.44	3.26	3.08	2.9	2.72	2.54	2.36	2.18	2.0

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≥1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\ (N_{Rd,p}\ ;\ N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type	R M8 RG M8			R M10 RG M10			R M12 RG M12			R M16 RG M16			R M20 RG M20			R M24 RG M24			R M27 RG M27			R M30 RG M30		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
design resistance $V_{Rd,s}$ [kN]	5.9	8.2	10.2	10.6	13.0	16.2	15.4	18.9	23.6	28.7	35.1	43.8	44.8	54.9	68.6	64.6	79.1	98.7	84.1	103	129	103	126	157

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\ (\ N_{Rd,p}\ ;\ N_{Rd,c}\ )$$

k-factor

Anchor type	R M8 to R M30 RG M8 to RG M30
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

edge distance [mm]	$V^0_{Rd,c}$ [kN]							
	R M8 RG M8	R M10 RG M10	R M12 RG M12	R M16 RG M16	R M20 RG M20	R M24 RG M24	R M27 RG M27	R M30 RG M30
40	3.7							
45	4.3	4.7						
50	5.0	5.3						
55	5.6	6.0	6.6					
60	6.3	6.8	7.3					
65	7.0	7.5	8.1	8.9				
70	7.8	8.3	8.9	9.7				
75	8.5	9.0	9.7	10.6				
80	9.3	9.8	10.6	11.5				
85	10.1	10.7	11.4	12.4	14.1			
90	10.9	11.5	12.3	13.3	15.1			
95	11.7	12.3	13.2	14.3	16.1			
100	12.6	13.2	14.1	15.2	17.2	19.0		
110	14.3	15.0	16.0	17.2	19.3	21.2		
120	16.1	16.9	17.9	19.3	21.5	23.6		
130	17.9	18.8	20.0	21.4	23.8	26.0	28.0	
140	19.9	20.8	22.0	23.5	26.1	28.5	30.6	32.4
150	21.8	22.8	24.1	25.8	28.5	31.0	33.3	35.2
160	23.9	24.9	26.3	28.1	30.9	33.6	36.0	38.0
170	25.9	27.1	28.6	30.4	33.4	36.2	38.8	40.9
180	28.1	29.3	30.8	32.8	36.0	38.9	41.6	43.8
190	30.3	31.5	33.2	35.2	38.6	41.7	44.4	46.7
200	32.5	33.8	35.6	37.7	41.2	44.5	47.4	49.8
250	44.3	46.0	48.2	50.8	55.2	59.1	62.6	65.5
300	57.2	59.2	61.9	65.0	70.2	74.9	79.0	82.4
350	71.1	73.4	76.5	80.2	86.2	91.6	96.3	100.2
400	85.8	88.5	92.0	96.3	103.2	109.3	114.6	119.0
500	117.7	121.2	125.6	130.9	139.5	147.1	153.6	159.0
600	152.6	156.8	162.1	168.6	178.9	187.9	195.7	202.1
700	190.1	195.1	201.4	209.0	221.0	231.5	240.6	248.0
800	230.2	235.8	243.2	251.9	265.7	277.7	288.1	296.5
900		279.0	287.3	297.2	312.7	326.3	337.9	347.4
1000			333.6	344.6	362.0	377.1	390.0	400.5
1200			432.3	445.8	466.9	485.1	500.6	513.1
1400				554.6	579.4	600.8	618.9	633.6
1600					699.1	723.7	744.5	761.3
1800					825.4	853.2	876.7	895.7
2000						989.1	1015.3	1036.5
2200						1130.9	1159.9	1183.3
2400							1310.2	1335.8
2600							1466.0	1493.7
2800								1657.0

5.3.1 Influence of cracked concrete

f_{cr}

	Non-cracked concrete
f_{cr}	1.0

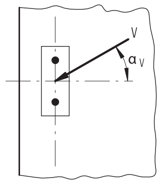
5.3.2 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.3 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.4 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.5 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.6 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.7 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

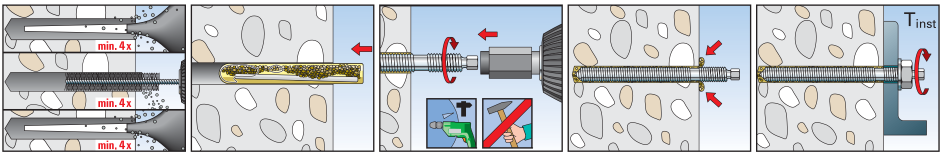
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = **tension/shear component of the design load acting on the most unfavourable single anchor**

N_{Rd} ; V_{Rd} = **tension/shear design resistance including safety factors of the most unfavourable single anchor**

7. Installation details

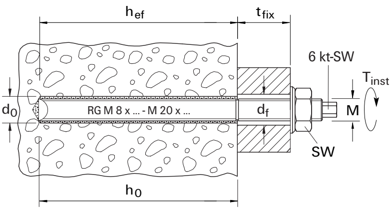


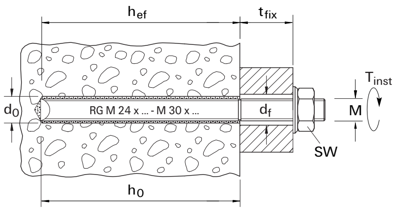
fischer Resin anchor R

Anchor design according to fischer specification

8. Anchor installation data

Anchor type			R M 8 RG M 8	R M 10 RG M 10	R M 12 RG M 12	R M 16 RG M 16	R M 20 RG M 20	R M 24 RG M 24	R M 27 RG M 27	R M 30 RG M 30
diameter of thread			M 8	M 10	M 12	M 16	M 20	M 24	M 27	M 30
nominal drill hole diameter	d_0	[mm]	10	12	14	18	25	28	32	35
drill depth	h_0	[mm]	80	90	110	125	170	210	250	280
effective anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	250	280
clearance-hole in fixture to be attached	d_f	[mm]	≦ 9	≦ 12	≦ 14	≦ 18	≦ 22	≦ 26	≦ 30	≦ 33
wrench size	SW	[mm]	13	17	19	24	30	36	41	46
required torque	T_{inst}	[Nm]	10	20	40	60	120	150	200	300
minimum thickness of concrete member	h_{min}	[mm]	110	120	150	160	220	280	330	370
minimum spacing	s_{min}	[mm]	40	45	55	65	85	105	125	140
minimum edge distances	c_{min}	[mm]	40	45	55	65	85	105	125	140





9. Curing times

Temperature at anchoring base	Curing time in [1] dry concrete	 wet concrete
- 5 °C to - 1 °C	4 h	8 h
± 0 °C to + 9 °C	45 min.	90 min.
+ 10 °C to + 20 °C	20 min.	40 min.
> + 20 °C	10 min.	20 min.

The anchor may be installed in dry or wet concrete or in flooded holes excepting sea water (premium-cleaning acc. to ETA-approval).

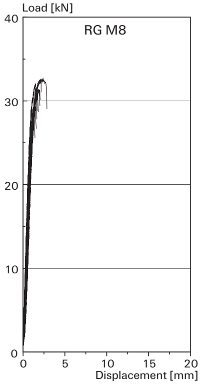
[1] In wet concrete and flooded holes the curing time has to be doubled.

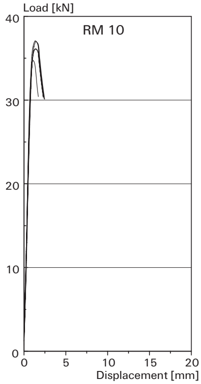
10. Mechanical characteristics of anchor rod RGM

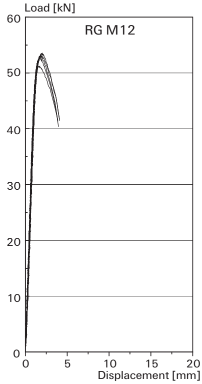
Anchor type				R M 8 RG M 8			R M 10 RG M 10			R M 12 RG M 12			R M 16 RG M 16	
property class			gvz	A4-70	C-70	gvz	A4-70	C-70	gvz	A4-70	C-70	gvz	A4-70	C-70
stressed cross sectional area anchor rod	A_s	[mm²]		36.6			58.0			84.3			157.0	
resisting moment anchor rod	W	[mm³]		31.2			62.3			109.2			277.5	
design value of bending moment	$M^0_{Rd,s}$	[Nm]	15.6	16.8	21.0	31.1	33.5	41.8	54.5	58.7	73.3	138.1	149.0	185.9
yield strength anchor rod	f_{yk}	[N/mm²]	420	450	560	420	450	560	420	450	560	420	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	520	700		520	700		520	700		520	700	

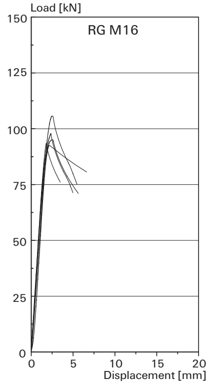
Anchor type				R M 20 RG M 20			R M 24 RG M 24			R M 27 RG M 27			R M 30 RG M 30	
property class			gvz	A4-70	C-70	gvz	A4-70	C-70	gvz	A4-70	C-70	gvz	A4-70	C-70
stressed cross sectional area anchor rod	A_s	[mm²]		245.0			353.0			459.0			561.0	
resisting moment anchor rod	W	[mm³]		540.9			935.5			1387			1874	
design value of bending moment	$M^0_{Rd,s}$	[Nm]	269.7	290.9	363.0	466.0	502.6	627.3	693.3	748.1	933.6	934.4	1008	1258
yield strength anchor rod	f_{yk}	[N/mm²]	420	450	560	420	450	560	420	450	560	420	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	520	700		520	700		520	700		520	700	

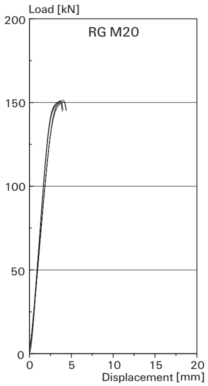
11. Load displacement curves for tension in non-cracked concrete ($f_{ck,cube\,(200)}$ = 30 N/mm^2)

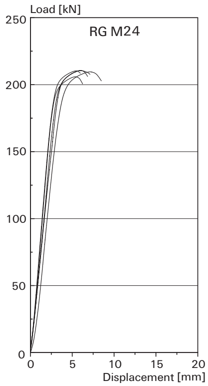


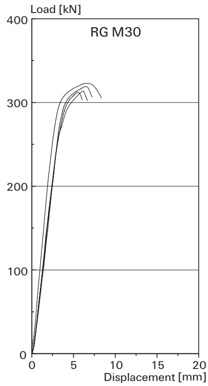












4

Notes

fischer Resin anchor R with Internal-threaded anchor RG MI

Anchor design according to fischer specification

1. Types

RG MI M8 - M20 – Internal-threaded anchor (gvz)

RG MI M8 - M20 A4 – Internal-threaded anchor (A4)

R M - Resin capsule

ETA-08/0010
ETAG 001-5
Option 7 for non-cracked concrete *)

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

4

Features and Advantages

- European Technical Approval option 7*) for non-cracked concrete.
- Resin capsule is approved for water filled drill holes and enables you the use independently of weather condidions.
- The resin seals the drill hole and avoids penetration of dampness and gives you therefore corrosion protection for the embedded steel.
- The quick curing resin in the capsule (R M) saves time.
- The resin capsule with its defined mortar quantity gaurantees a safe function.
- The glass capsule provides an optimal mortar volume and avoids overconsumption and therefore reduces costs of material.
- The included setting tool guarantees save anchoring of threaded rods and internal threaded anchors.
- The expansion stress free anchoring allows minimal spacing and edge distances, smaller anchor plates and reduces costs.
- The toned glass capsule gives you, by visual check, the safety of the mortar quality and protects the mortatr against aging effects.

*) The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Internal-threaded anchor and screw for internal threaded anchor:	- Carbon steel, zinc plated (5 µm) and passivated (gvz) - Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316
Resin capsule:	- Vinylester resin (styrene-free), quartz sand and hardener

2. Ultimate loads of single anchors with large spacing and large edge distance [1)]

Mean values

Anchor type				RG M8 I		RG M10 I		RG M12 I		RG M16 I		RG M20 I	
				5.8	A4	5.8	A4	5.8	A4	5.8	A4	5.8	A4
h_{ef}			[mm]	90		90		125		160		200	
non-cracked concrete temperature range (+80 °C / +50 °C) [2)]													
tension	C 20/25	N_u	[kN]	20.0	27.3	30.5	43.1	45.2	62.0	83.0	102.3	129.2	157.0
shear	≧ C 20/25	V_u	[kN]	9.7	13.4	15.2	21.3	22.2	31.0	41.2	57.5	65.1	90.3

1) The loads apply to fischer fischer internal threaded anchors and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ 80 °C and long term temperature T ≦ 50 °C (see also "Installation details, section 7").

2) (short term temperature / long term temperature)

fischer Resin anchor R with Internal-threaded anchor RG MI

Anchor design according to fischer specification

3. Characteristic, design and recommended resistances of single anchors with large spacing and large edge distance

3.1 Characteristic resistance [1)]

Anchor type				RG M8 I		RG M10 I		RG M12 I		RG M16 I		RG M20 I	
				5.8	A4	5.8	A4	5.8	A4	5.8	A4	5.8	A4
h_{ef}			[mm]	90		90		125		160		200	
non-cracked concrete													
temperature range (+80 °C / +50 °C) [2)]													
tension	C 20/25	N_{Rk}	[kN]	19.0	26.0	29.0	41.0	43.0	59.0	74.6	74.6	114.6	114.6
shear	≧ C 20/25	V_{Rk}	[kN]	9.2	12.8	14.5	20.3	21.1	29.5	39.2	54.8	62.0	86.0

1) The loads apply to fischer fischer internal threaded anchors and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ 80 °C and long term temperature T ≦ 50 °C (see also "Installation details, section 7").

2) (short term temperature / long term temperature)

3.2 Design resistance [1)]

Anchor type				RG M8 I		RG M10 I		RG M12 I		RG M16 I		RG M20 I	
				5.8	A4	5.8	A4	5.8	A4	5.8	A4	5.8	A4
h_{ef}			[mm]	90		90		125		160		200	
non-cracked concrete													
temperature range (+80 °C / +50 °C) [2)]													
tension	C 20/25	N_{Rd}	[kN]	12.7	13.9	19.3	21.9	28.7	31.6	49.8	49.8	76.4	76.4
shear	≧ C 20/25	V_{Rd}	[kN]	7.4	8.2	11.6	13.0	16.9	18.9	31.4	35.1	49.6	55.1

1) The loads apply to fischer fischer internal threaded anchors and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ 80 °C and long term temperature T ≦ 50 °C (see also "Installation details, section 7").

2) (short term temperature / long term temperature)

4

3.3 Recommended resistance [1) 2)]

Anchor type				RG M8 I		RG M10 I		RG M12 I		RG M16 I		RG M20 I	
				5.8	A4	5.8	A4	5.8	A4	5.8	A4	5.8	A4
h_{ef}			[mm]	90		90		125		160		200	
non-cracked concrete													
temperature range (+80 °C / +50 °C) [3)]													
tension	C 20/25	N_R	[kN]	9.0	9.9	13.8	15.7	20.5	22.5	35.5	35.5	54.6	54.6
shear	≧ C 20/25	V_R	[kN]	5.3	5.9	8.3	9.3	12.1	13.5	22.4	25.1	35.4	39.4

1) The loads apply to fischer fischer internal threaded anchors and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ 80 °C and long term temperature T ≦ 50 °C (see also "Installation details, section 7").

2) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on failure mode of the anchor.

3) (short term temperature / long term temperature)

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			RG M 8 I				RG M 10 I				RG M 12 I			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
design resistance	$N_{Rd,s}$	[kN]	12.7	19.3	13.9	17.3	19.3	31.3	21.9	27.3	28.7	45.3	31.6	39.3

Anchor type			RG M 16 I				RG M 20 I			
			5.8	8.8	A4	C	5.8	8.8	A4	C
design resistance	$N_{Rd,s}$	[kN]	52.7	72.0	58.8	73.3	82.0	119.3	92.0	114.7

4

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Anchor type			RG M 8 I	RG M 10 I	RG M 12 I	RG M 16 I	RG M 20 I
non-cracked concrete							
temperature range (+80 °C / +50 °C) [1)]							
Design resistance	$N^0_{Rd,p}$	[kN]	20.1	23.4	33.5	49.9	76.4
temperature range (+120 °C / +72 °C) [1)]							
Design resistance	$N^0_{Rd,p}$	[kN]	13.5	20.0	26.7	40.2	63.0

1) (short term temperature / long term temperature)

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,p}$	[-]	0.70	0.85	1.00	1.06	1.14	1.20	1.27	1.31	1.35

4.2.2 Characteristic edge distance and spacing for design of combined pull-out and concrete cone failure

Anchor type			RG M 8 I	RG M 10 I	RG M 12 I	RG M 16 I	RG M 20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
temperature range (+80 °C / +50 °C) [1)]							
	$s_{cr,Np}$	[mm]	270	270	370	436	558
	$c_{cr,Np}$	[mm]	135	135	185	218	279
temperature range (+120 °C / +72 °C) [1)]							
	$s_{cr,Np}$	[mm]	231	270	330	392	507
	$c_{cr,Np}$	[mm]	115	135	165	196	253

1) (short term temperature / long term temperature)

fischer Resin anchor R with Internal-threaded anchor RG MI

Anchor design according to fischer specification

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\, c_{cr,sp}$

Design resistance of single anchor

Anchor type	RG M 8 I	RG M 10 I	RG M 12 I	RG M 16 I	RG M 20 I
eff. anchorage depth h_{ef} [mm]	90	90	125	160	200
non-cracked concrete					
design resistance $N^0_{Rd,c}$ [kN]	28.7	28.7	47.1	68.1	95.2

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,c}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type	RG M 8 I	RG M 10 I	RG M 12 I	RG M 16 I	RG M 20 I
eff. anchorage depth h_{ef} [mm]	90	90	125	160	200
$s_{cr,N}$ [mm]	270	270	375	480	600
$c_{cr,N}$ [mm]	135	135	188	240	300

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
f_s	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0$$

$$f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

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4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type				**RG M8 I**	**RG M10 I**	**RG M12 I**	**RG M16 I**	**RG M20 I**
eff. anchorage depth		h_{ef}	[mm]	**90**	**90**	**125**	**160**	**200**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	180	180	250	320	400
		$c_{cr,sp}$	[mm]	90	90	125	160	200
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see below)				
		$c_{cr,sp}$	[mm]	$s_{cr,sp}/2$				
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	407	407	565	723	904
		$c_{cr,sp}$	[mm]	203	203	283	362	452
		h_{min}	[mm]	120	120	170	220	270

$f_{scr,sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2.0
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.8	3.62	3.44	3.26	3.08	2.9	2.72	2.54	2.36	2.18	2.0

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≥1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

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5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\ (N_{Rd,p}\ ;\ N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type			RG M 8 I					RG M 10 I					RG M 12 I				
			5.8	8.8	10.9	A4	C	5.8	8.8	10.9	A4	C	5.8	8.8	10.9	A4	C
design resistance	$V_{Rd,s}$	[kN]	7.4	11.7	10.2	8.2	10.2	11.6	18.6	16.2	13.0	16.2	16.9	27.0	23.6	18.9	23.6

Anchor type			RG M 16 I					RG M 20 I				
			5.8	8.8	10.9	A4	C	5.8	8.8	10.9	A4	C
design resistance	$V_{Rd,s}$	[kN]	31.4	43.2	41.8	35.1	43.8	49.6	60.0	60.7	55.1	68.8

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\ (\ N_{Rd,p}\ ;\ N_{Rd,c}\ )$$

k-factor

Anchor type	RG M 8 I	RG M 10 I	RG M 12 I	RG M 16 I	RG M 20 I
k	2.0	2.0	2.0	2.0	2.0

fischer Resin anchor R with Internal-threaded anchor RG MI

Anchor design according to fischer specification

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

edge distance [mm]	$V^0_{Rd,c}$ [kN]				
	RG M 8 I	RG M 10 I	RG M 12 I	RG M 16 I	RG M 20 I
45	4.8	5.2			
50	5.5	5.9			
55	6.2	6.6			
60	7.0	7.4	8.2		
65	7.7	8.2	9.1		
70	8.5	9.0	10.0		
75	9.3	9.8	10.8		
80	10.1	10.6	11.8	13.1	
85	11.0	11.5	12.7	14.1	
90	11.8	12.4	13.6	15.1	
95	12.7	13.3	14.6	16.2	
100	13.6	14.2	15.6	17.2	19.3
105	14.5	15.2	16.6	18.3	20.5
110	15.4	16.1	17.6	19.4	21.6
115	16.4	17.1	18.6	20.5	22.8
120	17.3	18.1	19.7	21.6	24.0
125	18.3	19.1	20.7	22.7	25.2
130	19.3	20.1	21.8	23.8	26.5
135	20.3	21.1	22.9	25.0	27.7
140	21.3	22.2	24.0	26.2	29.0
150	23.4	24.3	26.2	28.6	31.5
160	25.5	26.5	28.6	31.0	34.2
170	27.7	28.7	30.9	33.5	36.8
180	29.9	31.0	33.3	36.1	39.5
190	32.2	33.4	35.8	38.7	42.3
200	34.5	35.8	38.3	41.3	45.1
250	46.9	48.4	51.6	55.3	60.0
300	60.3	62.2	66.0	70.4	75.9
350	74.7	76.9	81.3	86.4	92.8
400	90.0	92.5	97.5	103.4	110.6
450	106.1	108.9	114.6	121.2	129.2
500	123.0	126.1	132.5	139.8	148.7
600	159.0	162.8	170.5	179.2	189.9
700	197.7	202.2	211.2	221.4	233.9
800	238.9	244.1	254.4	266.2	280.4
900	282.5	288.3	300.0	313.3	329.3
1000		334.7	347.8	362.7	380.5
1100			397.8	414.2	433.8
1200			449.7	467.7	489.2
1300			503.5	523.1	546.5
1400				580.4	605.6
1500				639.4	666.6
1600				700.2	729.3
1700					793.6
1800					859.6
1900					927.2
2000					996.3

5.3.1 Influence of cracked concrete

f_{cr}

	Non-cracked concrete
f_{cr}	1.0

5.3.2 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

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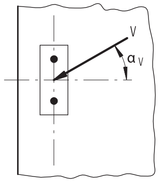
5.3.3 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.4 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≥3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.5 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≥1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.6 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.7 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

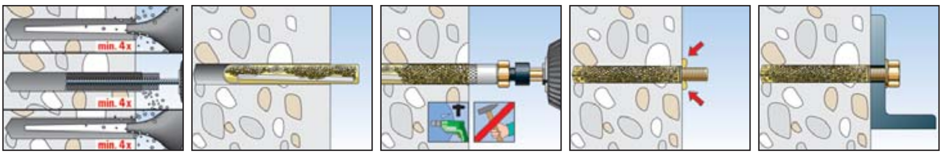
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd}; V_{Sd} = **tension/shear component of the design load acting on the most unfavourable single anchor**

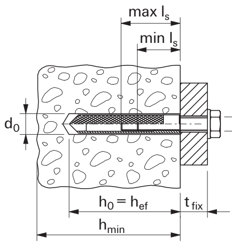
N_{Rd}; V_{Rd} = **tension/shear design resistance including safety factors of the most unfavourable single anchor**

7. Installation details



8. Anchor characteristics

Anchor type			RG M 8 I	RG M 10 I	RG M 12 I	RG M 16 I	RG M 20 I
diameter of thread			M 8	M 10	M 12	M 16	M 20
nominal drill hole diameter	d_0	[mm]	14	18	20	24	32
drill depth	h_0	[mm]	90	90	125	160	200
effective anchorage depth	h_{ef}	[mm]	90	90	125	160	200
clearance-hole in fixture to be attached	d_f	[mm]	≦ 9	≦ 12	≦ 14	≦ 18	≦ 22
screw penetration depth	min l_s	[mm]	8	10	12	16	20
	max l_s	[mm]	18	23	26	35	45
wrench size	SW	[mm]	13	17	19	24	30
required torque	T_{inst}	[Nm]	10	20	40	60	120
minimum thickness of concrete member	h_{min}	[mm]	120	120	170	220	270
minimum spacing	s_{min}	[mm]	45	45	60	80	100
minimum edge distances	c_{min}	[mm]	45	45	60	80	100
corresponding mortar capsule			FEB RM 12	FEB RM 14	FEB RM 16E	FEB RM 16E	FEB RM 20



9. Curing times

Temperature at anchoring base	Curing time in dry concrete	Curing time in wet concrete
- 5 °C to - 1 °C	4 h	8 h
± 0 °C to + 9 °C	45 min.	90 min.
+ 10 °C to + 20 °C	20 min.	40 min.
> + 20 °C	10 min.	20 min.

The anchor may be installed in dry or wet concrete or in flooded holes excepting sea water (premium-cleaning acc. to ETA-approval).
In wet concrete and flooded holes the curing time has to be doubled.

fischer Resin anchor R with Internal-threaded anchor RG MI

Anchor design according to fischer specification

10. Mechanical characteristics of RG MI

Anchor type			R M RG M8 I				R M RG M10 I				R M RG M12 I			
screw property class			**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**
stressed cross sectional area - screw	A_s	[mm²]	36.6				58.0				84.3			
resisting moment - screw	W	[mm³]	31.2				62.3				109.2			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	16.0	24.0	16.7	20.8	31.2	48.0	33.3	41.6	54.4	84.0	59.0	73.6
yield strength - screw	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength - screw	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	700	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm²]	72.5				137.1				161.8			
resisting moment - internal-threaded anchor	W	[mm³]	147.8				361.4				496.6			
yield strength - internal-threaded anchor	f_{yk}	[N/mm²]	420		450	560	420		450	560	420		450	560
tensile strength - internal-threaded anchor	f_{uk}	[N/mm²]	525		700	700	525		700	700	525		700	700

Anchor type			R M RG M16 I				R M RG M20 I			
screw property class			**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**
stressed cross sectional area - screw	A_s	[mm²]	157.0				245.0			
resisting moment - screw	W	[mm³]	277.5				540.9			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	138.4	212.8	148.7	185.6	269.6	415.2	291.0	363.2
yield strength - screw	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560
tensile strength - screw	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm²]	210.4				350.5			
resisting moment - internal-threaded anchor	W	[mm³]	836.9				1755.3			
yield strength - internal-threaded anchor	f_{yk}	[N/mm²]	420		450	560	420		450	560
tensile strength - internal-threaded anchor	f_{uk}	[N/mm²]	525		700	700	525		700	700

Notes

fischer Injection mortar FIS VT

Anchor design according to fischer specification

1. Types

FIS A M8 - M30 – threaded rod (gvz, A4 and C)
straight cut

RG M8 - M30 - threaded rod (gvz, A4 and C)
with external hexagon head

Injection mortar FIS VT 380 C

ETA
ETA-08/0061
ETAG 001-5
Option 7 for non-cracked concrete *)

Features and Advantages

- European Technical Approval option 7 for non-cracked concrete*).
- The Hybrid mortar gives a good combination of organic resin (high bond strength) and mineral cement (avoids corrosion and gives high compressive strength).
- Expansion stress free anchoring guarantees a save use with small spacing and edge distances.
- The approval guarantees the safe function at a large temperature range of -40 °C up to +120 °C.
- A large range of accessories gives the opportunity for different applications and a wide temperature range of the anchor base.
- Variable embedment depth enables the application in all kind of building structures.
- The resin seals the drill hole and avoids penetration of dampness and gives therefore corrosion protection for the embedded steel.
- A stand-off installation is easier to realize because threaded rods didn't need a torque moment

*) The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Threaded rod :	- Carbon steel, zinc plated (5 µm) and passivated (gvz) - Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316 - Highly corrosion-resistant steel of the corrosion resistance class IV, e.g. 1.4529.
Injection mortar:	- Vinylester resin (styrene-free), hydraulic additives, quartz sand and hardener

2. Ultimate resistances of single anchors with large spacing and large edge distance[1)]

Mean values

Anchor type	FIS VT M8				FIS VT M10				FIS VT M12				FIS VT M16			
	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef} [mm]	80				90				110				125			
non-cracked concrete temperature range (+80 °C / +50 °C)[2)]																
tension C 20/25 N_u [kN]	20.0	23.0	23.0	23.0	30.5	32.4	32.4	32.4	45.2	47.5	47.5	47.5	82.4	82.4	82.4	82.4
shear ≧ C 20/25 V_u [kN]	11.5	18.4	16.1	16.1	18.3	29.2	25.6	25.6	26.6	42.5	37.2	37.2	49.5	79.1	69.2	69.2

Anchor type	FIS VT M20				FIS VT M24				FIS VT M30			
	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef} [mm]	170				210				280			
non-cracked concrete temperature range (+80 °C / +50 °C)[2)]												
tension C 20/25 N_u [kN]	103.0	103.0	103.0	103.0	143.1	143.1	143.1	143.1	222.6	222.6	222.6	222.6
shear ≧ C 20/25 V_u [kN]	77.2	123.5	108.0	108.0	111.2	177.9	155.7	155.7	176.7	282.7	247.4	247.4

1) The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7").

2) (short term temperature / long term temperature)

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance [1)]

Anchor type	FIS VT M8				FIS VT M10				FIS VT M 12				FIS VT M16			
	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef} [mm]	80				90				110				160			
non-cracked concrete temperature range (+80 °C / +50 °C)[2)]																
tension C 20/25 N_{Rk} [kN]	19.1				26.9				39.4				68.4			
shear C 20/25 V_{Rk} [kN]	9.0	15.0	13.0		15.0	23.0	20.0		21.0	34.0	30.0		39.0	63.0	55.0	

Anchor type	FIS VT M20				FIS VT M24				FIS VT M30			
	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef} [mm]	170				210				280			
non-cracked concrete temperature range (+80 °C / +50 °C)[2)]												
tension C 20/25 N_{Rk} [kN]	85.5				118.8				184.7			
shear C 20/25 V_{Rk} [kN]	61.0	98.0	86.0		89.0	141.0	124.0		141.0	225.0	197.0	

1) The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7").

2) (short term temperature / long term temperature)

fischer Injection mortar FIS VT

Anchor design according to fischer specification

3.2 Design resistance [1)]

Anchor type	FIS VT M8				FIS VT M10				FIS VT M12				FIS VT M16			
	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef} [mm]	80				90				110				160			
non-cracked concrete																
temperature range (+80 °C / +50 °C) [2)]																
tension C 20/25 N_{Rd} [kN]	10.6				14.9				21.9				38.0			
shear C 20/25 V_{Rd} [kN]	7.2	12.0	8.3	10.4	12.0	18.4	12.8	16.0	16.8	27.2	19.2	24.0	31.2	50.4	35.7	44.0

Anchor type	FIS VT M20				FIS VT M24				FIS VT M30			
	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef} [mm]	170				210				280			
non-cracked concrete												
temperature range (+80 °C / +50 °C) [2)]												
tension C 20/25 N_{Rd} [kN]	47.5				66.0				102.6			
shear C 20/25 V_{Rd} [kN]	48.8	78.4	55.1	68.8	71.2	112.8	79.5	99.2	112.8	180.0	126.3	157.6

[1)] The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7").

[2)] (short term temperature / long term temperature)

3.3 Recommended resistance [1) 2)]

Anchor type	FIS VT M8				FIS VT M10				FIS VT M12				FIS VT M16			
	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef} [mm]	80				90				110				160			
non-cracked concrete																
temperature range (+80 °C / +50 °C) [3)]																
tension C 20/25 N_R [kN]	7.6				10.7				15.6				27.1			
shear C 20/25 V_R [kN]	5.1	8.6	6.0	7.4	8.6	13.1	9.2	11.4	12.0	19.4	13.7	17.1	22.3	36.0	25.2	31.4

Anchor type	FIS VT M20				FIS VT M24				FIS VT M30			
	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef} [mm]	170				210				280			
non-cracked concrete												
temperature range (+80 °C / +50 °C) [3)]												
tension C 20/25 N_R [kN]	33.9				47.1				73.3			
shear C 20/25 V_R [kN]	34.9	56.0	39.4	49.1	50.9	80.6	56.8	70.9	80.6	128.6	90.2	112.6

[1)] The loads apply to fischer threaded rods and careful drill hole cleaning, carried out with a brush and blow-out tool and temperature in the substrate in the area of the mortar with short term temperature T ≤ + 80 °C and long term temperature T ≤ + 50 °C (see also „Installation details, section 7").

[2)] Material safety factors γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on failure mode of the anchor.

[3)] (short term temperature / long term temperature)

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^{0}_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^{0}_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^{0}_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_{h}$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FIS VT M8				FIS VT M10				FIS VT M12				FIS VT M16			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef}		[mm]	80				90				110				125			
design resistance	$N_{Rd,s}$	[kN]	12.7	20.0	13.9	17.3	19.3	31.3	21.9	27.3	28.7	45.3	31.6	39.3	52.7	84.0	58.8	73.3

Anchor type			FIS VT M20				FIS VT M24				FIS VT M30			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
h_{ef}		[mm]	170				210				280			
design resistance	$N_{Rd,s}$	[kN]	82.0	130.7	92.0	114.7	118.0	188.0	132.1	164.7	187.3	299.3	210.2	262.0

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^{0}_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Anchor type			FIS VT M8			FIS VT M10			FIS VT M12			FIS VT M16			FIS VT M20			FIS VT M24			FIS VT M30		
eff. anchorage depth	h_{ef}	[mm]	64	80	96	80	90	120	96	110	144	125	160	192	160	170	240	192	210	288	240	280	360
non-cracked concrete																							
temperature range (+80 °C / +50 °C) [1)]																							
	$N^{0}_{Rd,p}$	[kN]	8.5	10.6	12.7	13.3	14.9	19.9	19.1	21.9	28.7	29.7	38.0	45.6	44.7	47.5	67.0	60.3	66.0	90.5	88.0	102.6	131.9
temperature range (+120 °C / +72 °C) [1)]																							
	$N^{0}_{Rd,p}$	[kN]	7.1	8.9	10.7	11.2	12.6	16.8	15.1	17.3	22.6	24.4	31.3	37.5	36.3	38.6	54.5	48.3	52.8	72.4	75.4	88.0	113.1

[1)] (short term temperature / long term temperature)

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,p}$	[-]	0.8	0.9	1.00	1.05	1.10	1.15	1.19	1.22	1.26

4.2.2 Characteristic edge distance and spacing for design of combined pull-out and concrete cone failure

Anchor type			FIS VT M8			FIS VT M10			FIS VT M12			FIS VT M16			FIS VT M20			FIS VT M24			FIS VT M30		
eff. anchorage depth	h_{ef}	[mm]	64	80	96	80	90	120	96	110	144	125	160	192	160	170	240	196	210	288	240	280	360
temperature range (+80 °C / +50 °C) [1)]																							
	$s_{cr,Np}$	[mm]	180			225			270			340			413			480			580		
	$c_{cr,Np}$	[mm]	90			113			135			170			207			240			290		
temperature range (+120 °C / +72 °C) [1)]																							
	$s_{cr,Np}$	[mm]	165			207			240			309			372			429			537		
	$c_{cr,Np}$	[mm]	83			103			120			155			186			215			268		

[1)] (short term temperature / long term temperature)

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type			**FIS VT M8**			**FIS VT M10**			**FIS VT M12**			**FIS VT M16**			**FIS VT M20**			**FIS VT M24**			**FIS VT M30**		
eff. anchorage depth	h_{ef}	[mm]	**64**	**80**	**96**	**80**	**90**	**120**	**96**	**110**	**144**	**125**	**160**	**192**	**160**	**170**	**240**	**192**	**210**	**288**	**240**	**280**	**360**
non-cracked concrete																								
design resistance	$N^0_{Rd,c}$	[kN]	17.2	24.1	31.7	24.1	28.7	44.3	31.7	38.8	58.2	47.1	68.1	89.6	68.1	74.6	125.2	89.6	102.5	164.5	125.2	157.7	230.0

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			**C 12/15**	**C 16/20**	**C 20/25**	**C 25/30**	**C 30/37**	**C 35/45**	**C 40/50**	**C 45/55**	**C 50/60**
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,c}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type			FIS VT M8			FIS VT M10			FIS VT M12			FIS VT M16			FIS VT M20			FIS VT M24			FIS VT M30		
eff. anchorage depth	h_{ef}	[mm]	64	80	96	80	90	120	96	110	144	125	160	192	160	170	240	192	210	288	240	280	360
	$s_{cr,N}$	[mm]	192	240	288	240	270	360	288	330	432	375	480	576	480	510	720	576	630	864	720	840	1080
	$c_{cr,N}$	[mm]	96	120	144	120	135	180	144	165	216	188	240	288	240	255	360	288	315	432	360	420	540

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
f_s	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type				FIS VT M8			FIS VT M10			FIS VT M12			FIS VT M16			FIS VT M20			FIS VT M24			FIS VT M30		
eff. anchorage depth		h_{ef}	[mm]	64	80	96	80	90	120	96	110	144	125	160	192	160	170	240	192	210	288	240	280	360
application with concrete member thickness	$h/h_{ef} \geq 2.0$	$s_{cr,sp}$	[mm]	128	160	192	160	180	240	192	220	288	250	320	384	320	340	480	384	420	576	480	560	720
		$c_{cr,sp}$	[mm]	64	80	96	80	90	120	96	110	144	125	160	192	160	170	240	192	210	288	240	280	360
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see below)																				
		$c_{cr,sp}$	[mm]	$s_{cr,sp}/2$																				
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	289	362	434	362	407	542	434	497	651	565	723	868	723	768	1085	886	949	1302	1085	1266	1627
		$c_{cr,sp}$	[mm]	145	181	217	181	203	271	217	249	325	283	362	434	362	384	542	443	475	651	542	633	814
		h_{min}	[mm]	100	110	126	110	120	150	126	140	174	161	196	228	208	218	288	248	266	344	310	350	430

$f_{scr,sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2.0
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.8	3.62	3.44	3.26	3.08	2.9	2.72	2.54	2.36	2.18	2.0

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

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5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\ (N_{Rd,p}\ ;\ N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type			FIS VT M8				FIS VT M10				FIS VT M12				FIS VT M16			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
design resistance	$V_{Rd,s}$	[kN]	7.2	12.0	8.3	10.4	12.0	18.4	12.8	16.0	16.8	27.2	19.2	24.0	31.2	50.4	35.3	44.0

Anchor type			FIS VT M20				FIS VT M24				FIS VT M30			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
design resistance	$V_{Rd,s}$	[kN]	48.8	78.4	55.1	68.8	71.2	112.8	79.5	99.2	112.8	180.0	126.3	157.6

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\ (\ N_{Rd,p}\ ;\ \ N_{Rd,c}\ )$$

k-factor

Anchor type	FIS VT M8 to FIS VT M30
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]											
	FIS VT M8			FIS VT M10			FIS VT M12			FIS VT M16		
h_{ef}	64	80	96	80	90	120	96	110	144	125	160	192
edge distance [mm]												
40	3.6	3.7	3.9									
45	4.2	4.3	4.5	4.5	4.7	5.0						
50	4.8	5.0	5.2	5.2	5.3	5.7						
55	5.4	5.6	5.9	5.9	6.0	6.4	6.3	6.6	7.0			
60	6.1	6.3	6.6	6.6	6.8	7.2	7.1	7.3	7.8			
65	6.8	7.0	7.3	7.3	7.5	8.0	7.9	8.1	8.7	8.9	9.5	10.0
70	7.5	7.8	8.0	8.1	8.3	8.8	8.6	8.9	9.5	9.7	10.4	11.0
75	8.2	8.5	8.8	8.8	9.0	9.6	9.4	9.7	10.3	10.6	11.3	11.9
80	9.0	9.3	9.6	9.6	9.8	10.4	10.3	10.6	11.2	11.5	12.2	12.9
85	9.7	10.1	10.4	10.4	10.7	11.3	11.1	11.4	12.1	12.4	13.2	13.9
90	10.5	10.9	11.2	11.3	11.5	12.1	12.0	12.3	13.0	13.3	14.2	14.9
95	11.3	11.7	12.1	12.1	12.3	13.0	12.9	13.2	14.0	14.3	15.1	15.9
100	12.1	12.6	12.9	13.0	13.2	13.9	13.8	14.1	14.9	15.2	16.2	16.9
105	13.0	13.4	13.8	13.8	14.1	14.8	14.7	15.1	15.9	16.2	17.2	18.0
120	15.6	16.1	16.5	16.6	16.9	17.7	17.5	17.9	18.9	19.3	20.3	21.2
140	19.3	19.9	20.4	20.4	20.8	21.8	21.5	22.0	23.1	23.5	24.8	25.8
160	23.2	23.9	24.4	24.5	24.9	26.0	25.8	26.3	27.6	28.1	29.4	30.6
180	27.3	28.1	28.7	28.8	29.3	30.5	30.2	30.8	32.2	32.8	34.3	35.6
200	31.7	32.5	33.2	33.3	33.8	35.2	34.9	35.6	37.1	37.7	39.4	40.8
250	43.3	44.3	45.2	45.3	46.0	47.7	47.3	48.2	50.1	50.8	52.9	54.6
300	56.0	57.2	58.3	58.5	59.2	61.3	60.8	61.9	64.1	65.0	67.5	69.5
350	69.6	71.1	72.4	72.5	73.4	75.8	75.3	76.5	79.1	80.2	83.1	85.4
400	84.1	85.8	87.3	87.5	88.5	91.3	90.6	92.0	95.1	96.3	99.6	102.2
450	99.5	101.4	103.1	103.3	104.4	107.6	106.8	108.4	111.8	113.2	116.9	119.9
500	115.6	117.7	119.6	119.8	121.2	124.6	123.8	125.6	129.4	130.9	135.0	138.3
550	132.4	134.8	136.9	137.1	138.6	142.4	141.6	143.5	147.7	149.4	153.9	157.5
600	150.0	152.6	154.9	155.1	156.8	161.0	160.0	162.1	166.7	168.6	173.5	177.4
650	168.2	171.0	173.6	173.8	175.6	180.2	179.1	181.4	186.4	188.5	193.8	198.0
700		190.1	192.9	193.2	195.1	200.0	198.9	201.4	206.7	209.0	214.7	219.3
750		209.9	212.8	213.1	215.1	220.5	219.3	222.0	227.7	230.1	236.3	241.2
800		230.2	233.3	233.7	235.8	241.5	240.3	243.2	249.3	251.9	258.4	263.7
900			276.1		279.0	285.4	284.0	287.3	294.2	297.2	304.6	310.5
1000			321.0			331.5	329.9	333.6	341.3	344.6	352.9	359.5
1100						379.7		381.9	390.5	394.2	403.3	410.6
1200						429.8			441.7	445.8	455.8	463.8
1300									494.9	499.3	510.2	518.8
1400									549.8		566.4	575.8
1500									606.5		624.4	634.4
1600											684.1	694.8
1700												756.9
1800												820.6
1900												885.8

continued next page

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Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]								
	FIS VT M20			FIS VT M24			FIS VT M30		
h_{ef}	160	170	240	192	210	288	240	280	360
edge distance [mm]									
85	13.8	14.1	15.6						
90	14.8	15.1	16.7						
95	15.8	16.1	17.8						
100	16.9	17.2	18.9						
105	17.9	18.2	20.1	19.6	20.1	22.2			
120	21.2	21.5	23.6	23.0	23.6	25.9			
140	25.7	26.1	28.4	27.8	28.5	31.1	30.9	32.4	35.2
160	30.5	30.9	33.5	32.9	33.6	36.5	36.3	38.0	41.1
180	35.5	36.0	38.9	38.1	38.9	42.2	42.0	43.8	47.2
200	40.7	41.2	44.4	43.6	44.5	48.0	47.8	49.8	53.4
250	54.6	55.2	59.0	58.1	59.1	63.4	63.2	65.5	69.9
300	69.5	70.2	74.8	73.6	74.9	79.9	79.6	82.4	87.5
350	85.4	86.2	91.5	90.2	91.6	97.3	97.1	100.2	106.0
400	102.2	103.2	109.1	107.6	109.3	115.7	115.4	119.0	125.5
450	119.9	120.9	127.5	125.9	127.8	134.9	134.7	138.6	145.8
500	138.3	139.5	146.8	145.0	147.1	155.0	154.7	159.0	166.9
550	157.5	158.8	166.8	164.9	167.1	175.8	175.5	180.2	188.8
600	177.5	178.9	187.6	185.5	187.9	197.3	197.0	202.1	211.4
650	198.1	199.6	209.0	206.8	209.4	219.5	219.2	224.7	234.7
700	219.4	221.0	231.1	228.7	231.5	242.4	242.1	248.0	258.7
750	241.3	243.0	253.8	251.3	254.3	265.9	265.6	271.9	283.3
800	263.8	265.7	277.2	274.5	277.7	290.1	289.8	296.5	308.6
900	310.6	312.7	325.7	322.7	326.3	340.1	339.9	347.4	360.9
1000	359.7	362.0	376.4	373.1	377.1	392.5	392.2	400.5	415.4
1100	410.9	413.4	429.3	425.7	430.1	446.9	446.7	455.8	472.1
1200	464.0	466.9	484.2	480.3	485.1	503.4	503.2	513.1	530.9
1300	519.1	522.2	541.0	536.8	542.0	561.9	561.7	572.4	591.6
1400	576.1	579.4	599.7	595.2	600.8	622.2	622.0	633.6	654.2
1500	634.8	638.4	660.1	655.3	661.3	684.3	684.2	696.6	718.6
1600	695.3	699.1	722.3	717.2	723.7	748.2	748.1	761.3	784.8
1700		761.4	786.2	780.8	787.6	813.7	813.6	827.7	852.6
1800			851.7	846.0	853.2	880.9	880.8	895.7	922.1
1900			918.7	912.7	920.4	949.6	949.6	965.3	993.2
2000			987.3		989.1	1019.9	1019.9	1036.5	1065.8
2200			1128.9		1130.9	1164.9	1165.0	1183.3	1215.5
2400			1276.2			1315.6	1315.8	1335.8	1371.0
2600						1471.8		1493.7	1531.9
2800						1633.2		1657.0	1698.1
3000						1799.6			1869.4
3200									2045.6
3400									2226.5
3600									2412.0

5.3.1 Influence of cracked concrete

f_{cr}

	Non-cracked concrete
f_{cr}	1.0

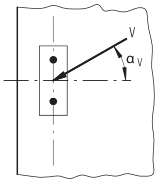
5.3.2 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.3 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.4 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.5 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.6 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.7 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

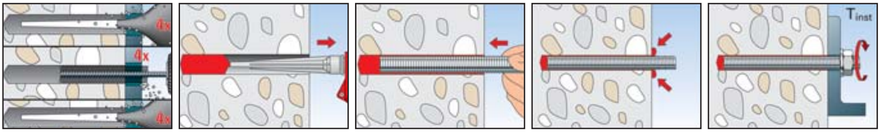
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = **tension/shear component of the design load acting on the most unfavourable single anchor**

N_{Rd} ; V_{Rd} = **tension/shear design resistance including safety factors of the most unfavourable single anchor**

7. Installation details



$d_0 \geq 18$ mm with oil free compressed air (P > 6 bar)

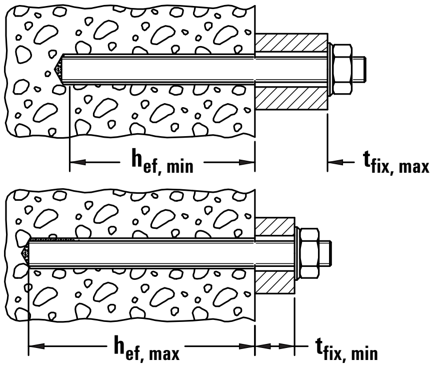
fischer Injection mortar FIS VT

Anchor design according to fischer specification

8. Anchor installation data

Anchor type			FIS VT M8			FIS VT M10			FIS VT M12			FIS VT M16		
	h_{ef}	[mm]	64	80	96	80	90	120	96	110	144	125	160	192
diameter of thread			M 8			M 10			M 12			M 16		
nominal drill hole diameter	d_0	[mm]	10			12			14			18		
drill depth	h_0	[mm]	64	80	96	80	90	120	96	110	144	125	160	192
clearance-hole in fixture to be attached pre-positioned installation	d_f	[mm]	≦ 9			≦ 12			≦ 14			≦ 18		
wrench size	SW	[mm]	13			17			19			24		
required torque	T_{inst}	[Nm]	10			20			40			60		
minimum thickness of concrete member	h_{min}	[mm]	100	110	126	110	120	150	126	140	174	161	196	228
minimum spacing	s_{min}	[mm]	40			45			55			65		
minimum edge distances	c_{min}	[mm]	40			45			55			65		
mortar filling quantity		[scale units]	3	4	4	4	5	5	5	6	7	7	9	11

Anchor type			FIS VT M20			FIS VT M24			FIS VT M30		
	h_{ef}	[mm]	160	170	240	192	210	288	240	280	360
diameter of thread			M 20			M 24			M 30		
nominal drill hole diameter	d_0	[mm]	24			28			35		
drill depth	h_0	[mm]	160	170	240	192	210	288	240	280	360
clearance-hole in fixture to be attached pre-positioned installation	d_f	[mm]	≦ 22			≦ 26			≦ 33		
wrench size	SW	[mm]	30			36			46		
required torque	T_{inst}	[Nm]	120			150			300		
minimum thickness of concrete member	h_{min}	[mm]	208	218	288	248	266	344	310	350	430
minimum spacing	s_{min}	[mm]	85			105			140		
minimum edge distances	c_{min}	[mm]	85			105			140		
mortar filling quantity		[scale units]	20	23	30	30	34	45	55	65	85



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fischer Injection mortar FIS VT

Anchor design according to fischer specification

9. Gelling and curing times

System temperature (minimum + 5 °C)	**Max. processing time** FIS VT	**Temperature at anchoring base**	**Curing time** [1)] FIS VT
		- 5 °C	24 h
		± 0 °C	180 min.
+ 5 °C	13 min.	+ 5 °C	90 min.
+ 10 °C	9 min.	+ 10 °C	60 min.
+ 20 °C	5 min.	+ 20 °C	45 min.
+ 30 °C	4 min.	+ 30 °C	35 min.
+ 40 °C	2 min.	+ 40 °C	35 min.

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least + 5 °C.
With temperatures above + 30 °C to + 40 °C the cartridges have to be cooled down to + 15 °C or + 20 °C.
For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.

1) In wet concrete the curing time has to be doubled.

10. Mechanical characteristics of anchor rods FIS A and RGM

Anchor type			**FIS VT M8**				**FIS VT M10**				**FIS VT M12**					**FIS VT M16**				
property class			**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**10.9**	**A4-70**	**C-70**	**5.8**	**8.8**	**10.9**	**A4-70**	**C-70**
stressed cross sectional area anchor rod	A_S	[mm²]	36.6				58.0				84.3					157.0				
section modolus	W	[mm³]	31.2				62.3				109.2					277.5				
design value of bending moment	$M^0_{Rd,s}$	[Nm]	15.2	24.0	16.7	20.8	29.6	48.0	33.3	41.6	52.0	84.0	98.0	59.0	73.6	133	213	249	149	186
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	900	450	560	400	640	900	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	1000	700	700	500	800	1000	700	700

Anchor type			**FIS VT M20**					**FIS VT M24**					**FIS VT M30**				
property class			**5.8**	**8.8**	**10.9**	**A4-70**	**C-70**	**5.8**	**8.8**	**10.9**	**A4-70**	**C-70**	**5.8**	**8.8**	**10.9**	**A4-70**	**C-70**
stressed cross sectional area anchor rod	A_S	[mm²]	245.0					353.0					561.0				
section modolus	W	[mm³]	540.9					935.5					1874				
design value of bending moment	$M^0_{Rd,s}$	[Nm]	259	415	487	291	363	448	717	841	503	627	898	1438	1687	1008	1258
yield strength anchor rod	f_{yk}	[N/mm²]	400	640	900	450	560	400	640	900	450	560	400	640	900	450	560
tensile strength anchor rod	f_{uk}	[N/mm²]	500	800	1000	700	700	500	800	1000	700	700	500	800	1000	700	700

Notes

fischer Injection mortar FIS VT with Internal-threaded anchor RG MI

Anchor design according to fischer specification

1. Types

RG MI, M8 - M20 – Internal-threaded anchor (gvz)

RG MI A4, M8 - M20 – Internal-threaded anchor (A4)

Injection mortar FIS VT 380 C

ETA-08/0061
ETAG 001-5
Option 7 for non-cracked concrete *)

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

4

Features and Advantages

- European Technical Approval option 7*) for non-cracked concrete.
- The mortar gives a good combination of organic resin (high bond strength) and mineral cement (avoids corrosion and gives high compressive strength).
- Expansion stress free anchoring guarantees a save use with small spacing and edge distances.
- The approval guarantees the safe function at a large temperature range of -40 °C up to +120 °C.
- The resin seals the drill hole and avoids penetration of dampness and gives therefore corrosion protection for the embedded steel.
- Internal thread for all kind of screws and rods.

*) The conditions of use in the European Technical Approval may vary from those of the Technical Handbook.

Materials

Internal-threaded anchor and screw for internal threaded anchor:
- Carbon steel, zinc plated (5 µm) and passivated (gvz)
- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4362) and according to ASTM/AISI steel grade 316

Injection mortar:
- Vinylester resin (styrene-free), quartz sand and hardener

2. Ultimate loads of single anchors with large spacing and large edge distance [1)]

Mean values

Anchor type	FIS VT RG M8 I		FIS VT RG M10 I		FIS VT RG M12 I		FIS VT RG M16 I		FIS VT RG M20 I	
	5.8	A4	5.8	A4	5.8	A4	5.8	A4	5.8	A4
h_{ef} [mm]	90		90		125		160		200	
non-cracked concrete **Temperatur range (+ 80 °C / + 50 °C) [2)]**										
tension C 20/25 N_u [kN]	20.0	27.3	31.5	42.2	46.2	60.4	72.3	72.3	114.5	114.5
shear ≧ C 20/25 V_u [kN]	9.7	13.4	15.2	21.3	22.2	31.0	41.2	57.5	65.1	90.3

1) The loads apply to fischer internal threaded anchors and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ + 80 °C and long term temperature T ≦ + 50 °C (see also „Installation details, section 7").

2) (short term temperature / long term temperature)

3. Characteristic. design and recommended loads of single anchors with large spacing and large edge distance

3.1 Characteristic resistance [1)]

Anchor type			FIS VT RG M8 I		FIS VT RG M10 I		FIS VT RG M12 I		FIS VT RG M16 I		FIS VT RG M20 I	
			5.8	A4	5.8	A4	5.8	A4	5.8	A4	5.8	A4
h_{ef}		[mm]	90		90		125		165		200	
non-cracked concrete												
Temperatur range (+ 80 °C / + 50 °C) [2)]												
tension	C 20/25 N_{Rk}	[kN]	19.0	26.0	35.0	35.0	50.1	50.1	60.0	60.0	95.0	95.0
shear	≧ C 20/25 V_{Rk}	[kN]	9.2	12.8	14.5	20.3	21.1	29.5	39.2	54.8	62.0	86.0

1) The loads apply to fischer internal threaded anchors and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ + 80 °C and long term temperature T ≦ + 50 °C (see also „Installation details, section 7").

2) (short term temperature / long term temperature)

3.2 Design resistance [1)]

Anchor type			FIS VT RG M8 I		FIS VT RG M10 I		FIS VT RG M12 I		FIS VT RG M16 I		FIS VT RG M20 I	
			5.8	A4	5.8	A4	5.8	A4	5.8	A4	5.8	A4
h_{ef}		[mm]	90		90		125		165		200	
non-cracked concrete												
Temperatur range (+ 80 °C / + 50 °C) [2)]												
tension	C 20/25 N_{Rd}	[kN]	12.7	13.9	19.4	19.4	27.8	27.8	33.3	33.3	52.8	52.8
shear	≧ C 20/25 V_{Rd}	[kN]	7.4	8.2	11.6	13.0	16.9	18.9	31.4	35.1	49.6	55.1

1) The loads apply to fischer internal threaded anchors and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ + 80 °C and long term temperature T ≦ + 50 °C (see also „Installation details, section 7").

2) (short term temperature / long term temperature)

3.3 Recommended resistance [1) 2)]

Anchor type			FIS VT RG M8 I		FIS VT RG M10 I		FIS VT RG M12 I		FIS VT RG M16 I		FIS VT RG M20 I	
			5.8	A4	5.8	A4	5.8	A4	5.8	A4	5.8	A4
h_{ef}		[mm]	90		90		125		165		200	
non-cracked concrete												
Temperatur range (+ 80 °C / + 50 °C) [3)]												
tension	C 20/25 N_R	[kN]	9.0	9.9	13.9	13.9	19.9	19.9	23.8	23.8	37.7	37.7
shear	≧ C 20/25 V_R	[kN]	5.3	5.9	8.3	9.3	12.1	13.5	22.4	25.1	35.4	39.4

1) The loads apply to fischer internal threaded anchors and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ + 80 °C and long term temperature T ≦ + 50 °C (see also „Installation details, section 7").

2) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on failure mode of the anchor.

3) (short term temperature / long term temperature)

fischer Injection mortar FIS VT with Internal-threaded anchor RG MI

Anchor design according to fischer specification

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure for the highest loaded anchor

Design resistance for single anchor

Anchor type	FIS VT RG M8 I				FIS VT RG M10 I				FIS VT RG M12 I			
	5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
design resistance $N_{Rd,s}$ [kN]	12.7	19.3	13.9	17.3	20.0	30.7	21.9	27.3	29.3	44.7	31.6	39.3

Anchor type	FIS VT RG M16 I				FIS VT RG M20 I			
	5.8	8.8	A4	C	5.8	8.8	A4	C
design resistance $N_{Rd,s}$ [kN]	54.7	72.7	58.8	73.3	84.7	121.3	91.4	114.0

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4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Anchor type	FIS V RG M8 I	FIS V RG M10 I	FIS V RG M12 I	FIS V RG M16 I	FIS V RG M20 I
eff. anchorage depth h_{ef} [mm]	90	90	125	160	200
non-cracked concrete					
temperature range (+80°C / +50°C) 1)					
$N^0_{Rd,p}$ [kN]	13.9	19.4	27.8	33.3	52.8
temperature range (+120°C / +72°C) 1)					
$N^0_{Rd,p}$ [kN]	11.2	14.0	19.4	27.8	41.7

1) (short term temperature / long term temperature)

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class	C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength $f_{ck,cube}$ [N/mm²]	15	20	25	30	37	45	50	55	60
influence factor $f_{b,N,p}$ [-]	0.80	0.90	1.00	1.05	1.10	1.14	1.19	1.22	1.26

4.2.2 Characteristic edge distance and spacing for design of combined pull-out and concrete cone failure

Anchor type	FIS V RG M8 I	FIS V RG M10 I	FIS V RG M12 I	FIS V RG M16 I	FIS V RG M20 I
eff. anchorage depth h_{ef} [mm]	90	90	125	160	200
temperature range (+80°C / +50°C) 1)					
$s_{cr,Np}$ [mm]	243	270	355	378	479
$c_{cr,Np}$ [mm]	122	135	177	189	240
temperature range (+120 °C / +72 °C) 1)					
$s_{cr,Np}$ [mm]	218	270	296	345	426
$c_{cr,Np}$ [mm]	109	135	148	173	213

1) (short term temperature / long term temperature)

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

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4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type	FIS V RG M8 I	FIS V RG M10 I	FIS V RG M12 I	FIS V RG M16 I	FIS V RG M20 I
eff. anchorage depth h_{ef} [mm]	90	90	125	160	200
non-cracked concrete					
design resistance $N^0_{Rd,c}$ [kN]	28.7	28.7	47.1	68.1	95.2

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,c}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type	FIS V RG M8 I	FIS V RG M10 I	FIS V RG M12 I	FIS V RG M16 I	FIS V RG M20 I
eff. anchorage depth h_{ef} [mm]	90	90	125	160	200
$s_{cr,N}$ [mm]	270	270	375	480	600
$c_{cr,N}$ [mm]	135	135	188	240	300

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4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
f_s	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0$$

$$f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type				**FIS V RG M8 I**	**FIS V RG M10 I**	**FIS V RG M12 I**	**FIS V RG M16 I**	**FIS V RG M20 I**
eff. anchorage depth		h_{ef}	**[mm]**	**90**	**90**	**125**	**160**	**200**
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	180	180	250	320	400
		$c_{cr,sp}$	[mm]	90	90	125	160	200
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see below)				
		$c_{cr,sp}$	[mm]	$s_{cr,sp}/2$				
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	407	407	565	723	904
		$c_{cr,sp}$	[mm]	203	203	283	362	452
		h_{min}	[mm]	120	125	165	205	260

$f_{scr,sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2.0
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.8	3.62	3.44	3.26	3.08	2.9	2.72	2.54	2.36	2.18	2.0

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≥1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

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5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot min\ (N_{Rd,p}\ ;\ N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type			FIS VT RG M8 I				FIS VT RG M10 I				FIS VT RG M 12 I			
			5.8	8.8	A4	C	5.8	8.8	A4	C	5.8	8.8	A4	C
design resistance	$V_{Rd,s}$	[kN]	7.4	11.7	8.2	10.2	11.6	18.6	13.0	16.2	16.9	27.0	18.9	23.6

Anchor type			FIS VT RG M16 I				FIS VT RG M20 I			
			5.8	8.8	A4	C	5.8	8.8	A4	C
design resistance	$V_{Rd,s}$	[kN]	31.4	43.2	35.1	43.8	49.6	60.0	55.1	68.8

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot min\ (N_{Rd,p}\ ;\ N_{Rd,c})$$

k-factor

Anchor type	FIS VT M8 I to FIS VT M20 I
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:
- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]				
	FIS VT RG M8 I	FIS VT RG M10 I	FIS VT RG M12 I	FIS VT RG M16 I	FIS VT RG M20 I
h_{ef}	90	90	125	160	200
edge distance [mm]					
40	4.2				
45	4.9	5.2			
50	5.6	5.9			
55	6.3	6.7			
60	7.0	7.4	8.3		
65	7.8	8.2	9.1		
70	8.6	9.0	10.0		
75	9.4	9.8	10.9		
80	10.2	10.7	11.8	13.2	
85	11.0	11.6	12.7	14.2	
90	11.9	12.5	13.7	15.2	
95	12.8	13.4	14.7	16.2	
100	13.7	14.3	15.6	17.3	
120	17.4	18.1	19.7	21.7	
125	18.4	19.1	20.8	22.8	25.3
140	21.4	22.2	24.1	26.3	29.1
160	25.6	26.6	28.7	31.1	34.3
180	30.1	31.1	33.5	36.2	39.7
200	34.7	35.9	38.5	41.5	45.3
250	47.1	48.6	51.8	55.5	60.1
300	60.6	62.4	66.2	70.6	76.1
350	75.0	77.1	81.5	86.7	93.0
400	90.3	92.7	97.8	103.7	110.8
450	106.5	109.2	114.9	121.5	129.5
500	123.5	126.5	132.8	140.1	149.0
550	141.2	144.5	151.5	159.5	169.3
600	159.6	163.2	170.9	179.7	190.3
650	178.6	182.6	191.0	200.5	212.0
700	198.4	202.6	211.7	221.9	234.3
750	218.7	223.3	233.0	244.0	257.3
800	239.7	244.6	255.0	266.8	280.9
900	283.3	288.9	300.7	314.0	329.9
1000		335.4	348.6	363.4	381.2
1100			398.6	415.0	434.5
1200			450.6	468.5	490.0
1300			504.5	524.0	547.3
1400				581.4	606.6
1500				640.5	667.6
1600				701.4	730.3
1800					860.8
2000					997.6

5.3.1 Influence of cracked concrete

f_{cr}

	Non-cracked concrete
f_{cr}	1.0

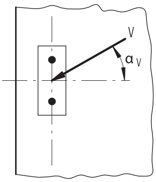
5.3.2 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.3 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.4 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.5 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.6 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.7 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

Anchor design according to fischer specification

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}; N_{Rd,p}; N_{Rd,c}; N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}; V_{Rd,cp}; V_{Rd,c}$

6.3 Combined tension and shear load:

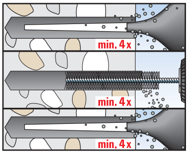
$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

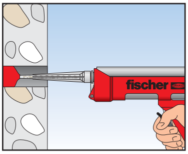
$N_{Sd}; V_{Sd}$ = tension/shear component of the design load acting on the most unfavourable single anchor

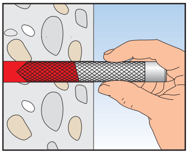
$N_{Rd}; V_{Rd}$ = tension/shear design resistance including safety factors of the most unfavourable single anchor

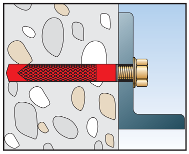
4

7. Installation details





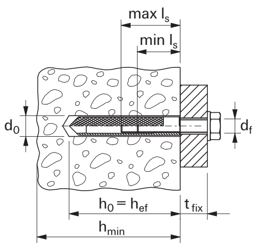




$d_0 \geqq 18$ mm with oil free compressed air (P > 6 bar)

8. Anchor characteristics

Anchor type			FIS VT RG M 8 I	FIS VT RG M 10 I	FIS VT RG M 12 I	FIS VT RG M 16 I	FIS VT RG M 20 I
diameter of thread			M 8	M 10	M 12	M 16	M 20
nominal drill hole diameter	d_0	[mm]	14	18	20	24	32
drill depth	h_0	[mm]	90	90	125	160	200
effective anchorage depth	h_{ef}	[mm]	90	90	125	160	200
clearance-hole in fixture to be attached	d_f	[mm]	≦ 9	≦ 12	≦ 14	≦ 18	≦ 22
screw penetration depth	min l_s	[mm]	8	10	12	16	20
	max l_s	[mm]	18	23	26	35	45
wrench size	SW	[mm]	13	17	19	24	30
required torque	T_{inst}	[Nm]	10	20	40	80	120
minimum thickness of concrete member	h_{min}	[mm]	120	125	165	205	260
minimum spacing	s_{min}	[mm]	40	45	60	80	125
minimum edge distances	c_{min}	[mm]	40	45	60	80	125
mortar filling quantity		[scale units]	5	7	11	17	48



fischer Injection mortar FIS VT with Internal-threaded anchor RG MI

Anchor design according to fischer specification

9. Gelling and curing times

System temperature	Max. processing time FIS VT
+ 5 °C	13 min.
+ 10 °C	9 min.
+ 20 °C	5 min.
+ 30 °C	4 min.
+ 40 °C	2 min.

Temperature at anchoring base	Curing time [1)] FIS VT
- 5 °C	24 h
± 0 °C	180 min.
+ 5 °C	90 min.
+ 10 °C	60 min.
+ 20 °C	45 min.
+ 30 °C	35 min.
+ 40 °C	35 min.

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least + 5 °C. With temperatures above + 30 °C to + 40 °C the cartridges have to be cooled down to + 15 °C or + 20 °C. In wet concrete the curing time has to be doubled.
For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.
[1)] In wet concrete the curing time has to be doubled.

10. Mechanical characteristics of RG MI

Anchor type			FIS VT RG M8 I				FIS VT RG M10 I				FIS VT RG M12 I			
screw property class			**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C70**	**5.8**	**8.8**	**A4-70**	**C-70**
stressed cross sectional area - screw	A_s	[mm²]	36.6				58.0				84.3			
resisting moment - screw	W	[mm³]	31.2				62.3				109.2			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	16.0	24.0	16.7	20.8	31.2	48.0	33.3	41.6	54.4	84.0	59.0	73.6
yield strength - screw	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560	400	640	450	560
tensile strength - screw	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700	500	800	700	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm²]	72.5				137.1				161.8			
resisting moment - internal-threaded anchor	W	[mm³]	147.8				361.4				496.6			
yield strength - internal-threaded anchor	f_{yk}	[N/mm²]	420		450	560	420		450	560	420		450	560
tensile strength - internal-threaded anchor	f_{uk}	[N/mm²]	525		700	700	525		700	700	525		700	700

Anchor type			FIS VT RG M16 I				FIS VT RG M20 I			
screw property class			**5.8**	**8.8**	**A4-70**	**C-70**	**5.8**	**8.8**	**A4-70**	**C-70**
stressed cross sectional area - screw	A_s	[mm²]	157.0				245.0			
resisting moment - screw	W	[mm³]	277.5				540.9			
design value of bending moment	$M^0_{Rd,s}$	[Nm]	138.4	212.8	148.7	185.6	269.6	415.2	291.0	363.2
yield strength - screw	f_{yk}	[N/mm²]	400	640	450	560	400	640	450	560
tensile strength - screw	f_{uk}	[N/mm²]	500	800	700	700	500	800	700	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm²]	210.4				350.5			
resisting moment - internal-threaded anchor	W	[mm³]	836.9				1755.3			
yield strength - internal-threaded anchor	f_{yk}	[N/mm²]	420		450	560	420		450	560
tensile strength - internal-threaded anchor	f_{uk}	[N/mm²]	525		700	700	525		700	700

fischer Injection mortar FIS VT with rebars

Anchor design according to fischer specification

1. Types

Reinforcement bars Ø 8 - Ø 30 mm

Static mixer FIS S

Injection mortar
FIS VT 380 C

Features and Advantages

- Suitable for non-cracked concrete.
- The Hybrid mortar gives a good combination of organic resin (high bond strength) and mineral cement (avoids corrosion and gives high compressive strength).
- Expansion stress free anchoring guarantees a save use with small spacing and edge distances.
- Variable embedment depth enables the application in all kind of building structures.
- The resin seals the drill hole and avoids penetration of dampness and gives therefore corrosion protection for the embedded steel.

Materials

Reinforcing steel : f_{yk} = 400 - 600 N/mm². Static values based on f_{yk} = 500 N/mm²

Injection mortar: Vinylester resin (styrene-free), hydraulic additives, quartz sand and hardener

2. Ultimate resistances of single anchors with large spacing and large edge distance[1)]

Mean values

Anchor type				FIS VT Ø 8	FIS VT Ø 10	FIS VT Ø 12	FIS VT Ø 14	FIS VT Ø 16	FIS VT Ø 18	FIS VT Ø 20	FIS VT Ø 22	FIS VT Ø 24	FIS VT Ø 25	FIS VT Ø 26	FIS VT Ø 28	FIS VT Ø 30
h_{ef}			[mm]	80	90	110	120	160	180	200	220	210	230	240	260	280
non-cracked concrete temperature range (+80 °C / +50 °C)[2)]																
tension	C 20/25	N_u	[kN]	23.0	32.4	47.5	54.1	82.4	98.1	121.1	137.4	143.1	152.3	165.3	192.9	222.6
shear	≧ C 20/25	V_u	[kN]	17.3	27.4	39.2	53.4	69.6	88.0	108.8	131.7	156.6	170.1	184.0	213.4	245.0

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ + 80 °C and long term temperature T ≦ + 50 °C (see also „Installation details, section 7").

2) (short term temperature / long term temperature)

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance [1)]

Anchor type			FIS VT ⌀ 8	FIS VT ⌀ 10	FIS VT ⌀ 12	FIS VT ⌀ 14	FIS VT ⌀ 16	FIS VT ⌀ 18	FIS VT ⌀ 20	FIS VT ⌀ 22	FIS VT ⌀ 24	FIS VT ⌀ 25	FIS VT ⌀ 26	FIS VT ⌀ 28	FIS VT ⌀ 30
h_{ef}		[mm]	80	90	110	120	160	180	200	220	210	230	240	260	280
non-cracked concrete temperature range (+80 °C / +50 °C) [2)]															
tension	C 20/25 N_{Rk}	[kN]	19.1	26.9	39.4	44.9	68.4	81.4	100.5	114.0	118.8	126.4	137.2	160.1	184.7
shear	≧ C 20/25 V_{Rk}	[kN]	13.8	21.6	31.1	42.4	55.3	70.0	87.0	105.0	125.0	135.0	146.0	170.0	195.0

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ + 80 °C and long term temperature T ≦ + 50 °C (see also „Installation details, section 7").

2) (short term temperature / long term temperature)

3.2 Design resistance [1)]

Anchor type			FIS VT ⌀ 8	FIS VT ⌀ 10	FIS VT ⌀ 12	FIS VT ⌀ 14	FIS VT ⌀ 16	FIS VT ⌀ 18	FIS VT ⌀ 20	FIS VT ⌀ 22	FIS VT ⌀ 24	FIS VT ⌀ 25	FIS VT ⌀ 26	FIS VT ⌀ 28	FIS VT ⌀ 30
h_{ef}		[mm]	80	90	110	120	160	180	200	220	210	230	240	260	280
non-cracked concrete temperature range (+80 °C / +50 °C) [2)]															
tension	C 20/25 N_{Rd}	[kN]	10.6	14.9	21.9	24.9	38.0	45.2	55.9	63.4	66.0	70.2	76.2	88.9	102.6
shear	≧ C 20/25 V_{Rd}	[kN]	9.2	14.4	20.7	28.3	36.9	46.7	58.0	70.0	83.3	90.0	97.3	113.3	130.0

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ + 80 °C and long term temperature T ≦ + 50 °C (see also „Installation details, section 7").

2) (short term temperature / long term temperature)

3.3 Recommended resistance [1) 2)]

Anchor type			FIS VT ⌀ 8	FIS VT ⌀ 10	FIS VT ⌀ 12	FIS VT ⌀ 14	FIS VT ⌀ 16	FIS VT ⌀ 18	FIS VT ⌀ 20	FIS VT ⌀ 22	FIS VT ⌀ 24	FIS VT ⌀ 25	FIS VT ⌀ 26	FIS VT ⌀ 28	FIS VT ⌀ 30
h_{ef}		[mm]	80	90	110	120	160	180	200	220	210	230	240	260	280
non-cracked concrete temperature range (+80 °C / +50 °C) [3)]															
tension	C 20/25 N_R	[kN]	7.6	10.7	15.6	17.8	27.1	32.3	39.9	45.3	47.1	50.2	54.5	63.5	73.3
shear	≧ C 20/25 V_R	[kN]	6.6	10.3	14.8	20.2	26.3	33.3	41.4	50.0	59.5	64.3	69.5	81.0	92.9

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm² and careful drill hole cleaning, carried out with a brush and blow-out tool and temperatures in the substrate in the area of the mortar with short term temperature T ≦ + 80 °C and long term temperature T ≦ + 50 °C (see also „Installation details, section 7").

2) Material safety factor γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on failure mode of the anchor.

3) (short term temperature / long term temperature)

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Combined pull-out and concrete cone failure:

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			FIS VT ∅ 8	FIS VT ∅ 10	FIS VT ∅ 12	FIS VT ∅ 14	FIS VT ∅ 16	FIS VT ∅ 18	FIS VT ∅ 20	FIS VT ∅ 22	FIS VT ∅ 24	FIS VT ∅ 25	FIS VT ∅ 26	FIS VT ∅ 28	FIS VT ∅ 30
design resistance	$N_{Rd,s}$	[kN]	20.0	31.4	45.0	60.7	79.3	100.0	123.6	149.3	177.9	192.9	208.6	242.1	277.9

4.2 Combined pull-out and concrete cone failure

$$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,N,p} \cdot f_{s1,p} \cdot f_{s2,p} \cdot f_{s3,p} \cdot f_{c1,p,A} \cdot f_{c1,p,B} \cdot f_{c2,p}$$

Design resistance of single anchor

Anchor type			FIS VT ∅ 8			FIS VT ∅ 10			FIS VT ∅ 12			FIS VT ∅ 14			FIS VT ∅ 16			FIS VT ∅ 18			FIS VT ∅ 20		
eff. anchorage depth	h_{ef}	[mm]	64	80	96	80	90	120	96	110	144	110	120	160	125	160	192	140	180	210	160	200	240
non-cracked concrete																							
temperature range (+80 °C / +50 °C) [1)]																							
	$N^0_{Rd,p}$	[kN]	8.5	10.6	12.7	13.3	14.9	19.9	19.1	21.9	28.7	22.8	24.9	33.2	29.7	38.0	45.6	35.2	45.2	52.8	44.7	55.9	67.0
temperature range (+120 °C / +72 °C) [1)]																							
	$N^0_{Rd,p}$	[kN]	7.1	8.9	10.7	11.2	12.6	16.8	15.1	17.3	22.6	18.8	20.5	27.4	24.4	31.3	37.5	28.6	36.8	42.9	36.3	45.4	54.5

Anchor type			FIS VT ∅ 22			FIS VT ∅ 24			FIS VT ∅ 25			FIS VT ∅ 26			FIS VT ∅ 28			FIS VT ∅ 30		
eff. anchorage depth	h_{ef}	[mm]	180	220	260	192	210	288	210	230	310	220	240	320	230	260	330	240	280	360
non-cracked concrete																				
temperature range (+80 °C / +50 °C) [1)]																				
	$N^0_{Rd,p}$	[kN]	51.8	63.4	74.9	60.3	66.0	90.5	64.1	70.2	94.7	69.9	76.2	101.6	78.7	88.9	112.9	88.0	102.6	131.9
temperature range (+120 °C / +72 °C) [1)]																				
	$N^0_{Rd,p}$	[kN]	41.5	50.7	59.9	48.3	52.8	72.4	55.0	60.2	81.2	59.9	65.3	87.1	67.4	76.2	96.8	75.4	88.0	113.1

[1)] (short term temperature / long term temperature)

4.2.1 Influence of concrete strength / combined pull-out and concrete cone failure

$f_{b,N,p}$

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,p}$	[-]	0.80	0.90	1.00	1.05	1.10	1.15	1.19	1.22	1.26

4.2.2 Characteristic edge distance and spacing for design of combined pull-out and concrete cone failure

Anchor type eff. anchorage depth h_{ef} [mm]	FIS VT ø 8 ≥ 64	FIS VT ø 10 ≥ 80	FIS VT ø 12 ≥ 96	FIS VT ø 14 ≥ 110	FIS VT ø 16 ≥ 125	FIS VT ø 18 ≥ 140	FIS VT ø 20 ≥ 160
non-cracked concrete							
temperature range (+80 °C / +50 °C) [1]							
$s_{cr,Np}$ [mm]	180	225	270	298	341	372	413
$c_{cr,Np}$ [mm]	90	113	135	149	170	186	207
temperature range (+120 °C / +72 °C) [1]							
$s_{cr,Np}$ [mm]	165	207	240	271	309	335	372
$c_{cr,Np}$ [mm]	83	103	120	135	155	168	186

Anchor type eff. anchorage depth h_{ef} [mm]	FIS VT ø 22 ≥ 180	FIS VT ø 24 ≥ 192	FIS VT ø 25 ≥ 210	FIS VT ø 26 ≥ 220	FIS VT ø 28 ≥ 230	FIS VT ø 30 ≥ 240
non-cracked concrete						
temperature range (+80 °C / +50 °C) [1]						
$s_{cr,Np}$ [mm]	440	480	483	502	541	580
$c_{cr,Np}$ [mm]	220	240	242	251	271	290
temperature range (+120 °C / +72 °C) [1]						
$s_{cr,Np}$ [mm]	394	429	447	465	501	537
$c_{cr,Np}$ [mm]	197	215	224	233	250	268

[1] (short term temperature / long term temperature)

4

4.2.2.1 Influence of spacing / combined pull-out and concrete cone failure

$$f_{s1,p} = f_{s2,p} = f_{s3,p} = \left(1.0 + \frac{s}{s_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s1,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.2.2.2 Influence of edge distance / combined pull-out and concrete cone failure

$$f_{c1,p,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}} \leqq 1.0 \qquad f_{c1,p,B} = f_{c2,p} = \left(1.0 + \frac{c}{c_{cr,Np}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,Np}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,p,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,p,B}$ $f_{c2,p}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\, c_{cr,sp}$

Design resistance of single anchor

Anchor type			FIS VT Ø 8			FIS VT Ø 10			FIS VT Ø 12			FIS VT Ø 14			FIS VT Ø 16			FIS VT Ø 18			FIS VT Ø 20		
eff. anchorage depth	h_{ef}	[mm]	64	80	96	80	90	120	96	110	144	110	120	160	125	160	192	140	180	210	160	200	240
non-cracked concrete																							
design resistance	$N^0_{Rd,c}$	[kN]	17.2	24.1	31.7	24.1	28.7	44.3	31.7	38.8	58.2	38.8	44.3	68.1	47.1	68.1	89.6	55.8	81.3	102.5	68.1	95.2	125.2

Anchor type			FIS VT Ø 22			FIS VT Ø 24			FIS VT Ø 25			FIS VT Ø 26			FIS VT Ø 28			FIS VT Ø 30		
eff. anchorage depth	h_{ef}	[mm]	180	220	260	192	210	288	210	230	310	220	240	320	230	260	330	240	280	360
non-cracked concrete																				
design resistance	$N^0_{Rd,c}$	[kN]	81.3	109.9	141.1	89.6	102.5	164.5	102.5	117.4	183.8	109.9	125.2	192.7	117.4	141.1	201.8	125.2	157.7	230.0

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
influence factor	$f_{b,N,c}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic values for design

Anchor type			FIS VT Ø 8			FIS VT Ø 10			FIS VT Ø 12			FIS VT Ø 14			FIS VT Ø 16			FIS VT Ø 18			FIS VT Ø 20		
eff. anchorage depth	h_{ef}	[mm]	64	80	96	80	90	120	96	110	144	110	120	160	125	160	192	140	180	210	160	200	240
	$s_{cr,N}$	[mm]	192	240	288	240	270	360	288	330	432	330	360	480	375	480	576	420	540	630	480	600	720
	$c_{cr,N}$	[mm]	96	120	144	120	135	180	144	165	216	165	180	240	188	240	288	210	270	315	240	300	360

Anchor type			FIS VT Ø 22			FIS VT Ø 24			FIS VT Ø 25			FIS VT Ø 26			FIS VT Ø 28			FIS VT Ø 30		
eff. anchorage depth	h_{ef}	[mm]	180	220	260	192	210	288	210	230	310	220	240	320	230	260	330	240	280	360
	$s_{cr,N}$	[mm]	540	660	780	576	630	864	630	690	930	660	720	960	690	780	990	720	840	1080
	$c_{cr,N}$	[mm]	270	330	390	288	315	432	315	345	465	330	360	480	345	390	495	360	420	540

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
f_s	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic values for design

Anchor type				FIS VT Ø 8			FIS VT Ø 10			FIS VT Ø 12			FIS VT Ø 14			FIS VT Ø 16			FIS VT Ø 18			FIS VT Ø 20		
eff. anchorage depth		h_{ef}	[mm]	64	80	96	80	90	120	96	110	144	110	120	160	125	160	192	140	180	210	160	200	240
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	128	160	192	160	180	240	192	220	288	220	240	320	250	320	384	280	360	420	320	400	480
		$c_{cr,sp}$	[mm]	64	80	96	80	90	120	96	110	144	110	120	160	125	160	192	140	180	210	160	200	240
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see below)																				
		$c_{cr,sp}$	[mm]	$s_{cr,sp}/2$																				
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	289	362	434	362	407	542	434	497	651	497	542	723	565	723	868	633	814	949	723	904	1085
		$c_{cr,sp}$	[mm]	145	181	217	181	203	271	217	249	325	249	271	362	283	362	434	316	407	475	362	452	542
		h_{min}	[mm]	100	110	126	110	120	150	126	140	174	140	150	190	165	200	232	190	230	260	210	250	290

Anchor type				FIS VT Ø 22			FIS VT Ø 24			FIS VT Ø 25			FIS VT Ø 26			FIS VT Ø 28			FIS VT Ø 30		
eff. anchorage depth		h_{ef}	[mm]	180	220	260	192	210	288	210	230	310	220	240	320	230	260	330	240	280	360
application with concrete member thickness	$h/h_{ef} \geqq 2.0$	$s_{cr,sp}$	[mm]	360	440	520	384	420	576	420	460	620	440	480	640	460	520	660	480	560	720
		$c_{cr,sp}$	[mm]	180	220	260	192	210	288	210	230	310	220	240	320	230	260	330	240	280	360
	$2.0 > h/h_{ef} > 1.3$	$s_{cr,sp}$	[mm]	$f_{scr,sp} \cdot h_{ef}$ ($f_{scr,sp}$ see below)																	
		$c_{cr,sp}$	[mm]	$s_{cr,sp}/2$																	
	$h/h_{ef} \leqq 1.3$	$s_{cr,sp}$	[mm]	814	994	1175	868	949	1302	949	1040	1401	994	1085	1446	1040	1175	1492	1085	1266	1627
		$c_{cr,sp}$	[mm]	407	497	588	434	475	651	475	520	701	497	542	723	520	588	746	542	633	814
		h_{min}	[mm]	240	280	320	252	270	348	270	290	370	290	310	390	300	330	400	320	360	440

$f_{scr,sp}$

h/h_{ef}	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	1.85	1.9	1.95	2.0
$f_{scr,sp}$	4.52	4.34	4.16	3.98	3.8	3.62	3.44	3.26	3.08	2.9	2.72	2.54	2.36	2.18	2.0

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≥1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

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5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = k \cdot \min(N_{Rd,p} ; N_{Rd,c})$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure for the highest loaded anchor

Design resistance of single anchor

Anchor type	**FIS VT ⌀ 8**	**FIS VT ⌀ 10**	**FIS VT ⌀ 12**	**FIS VT ⌀ 14**	**FIS VT ⌀ 16**	**FIS VT ⌀ 18**	**FIS VT ⌀ 20**	**FIS VT ⌀ 22**	**FIS VT ⌀ 24**	**FIS VT ⌀ 25**	**FIS VT ⌀ 26**	**FIS VT ⌀ 28**	**FIS VT ⌀ 30**
design resistance $V_{Rd,s}$ [kN]	9.2	14.4	20.7	28.3	36.9	46.7	58.0	70.0	83.3	90.0	97.3	113.3	130.0

5.2 Pryout failure for the most unfavourable anchor

$$V_{Rd,cp} = k \cdot \min(N_{Rd,p} ; N_{Rd,c})$$

k-factor

Anchor type	**FIS VT ⌀ 8 to FIS VT ⌀ 30**
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{cr} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary if the following condition is met:

- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]											
	FIS VT Ø8			FIS VT Ø10			FIS VT Ø12			FIS VT Ø14		
h_{ef}	64	80	96	80	90	120	96	110	144	110	120	160
edge distance [mm]												
40	3.6	3.7	3.9									
45	4.2	4.3	4.5	4.5	4.7	5.0						
50	4.8	5.0	5.2	5.2	5.3	5.7						
55	5.4	5.6	5.9	5.9	6.0	6.4	6.3	6.6	7.0			
60	6.1	6.3	6.6	6.6	6.8	7.2	7.1	7.3	7.8	7.6	7.7	8.4
65	6.8	7.0	7.3	7.3	7.5	8.0	7.9	8.1	8.7	8.4	8.5	9.2
70	7.5	7.8	8.0	8.1	8.3	8.8	8.6	8.9	9.5	9.2	9.4	10.1
75	8.2	8.5	8.8	8.8	9.0	9.6	9.4	9.7	10.3	10.0	10.2	11.0
80	9.0	9.3	9.6	9.6	9.8	10.4	10.3	10.6	11.2	10.9	11.1	11.9
85	9.7	10.1	10.4	10.4	10.7	11.3	11.1	11.4	12.1	11.7	12.0	12.8
90	10.5	10.9	11.2	11.3	11.5	12.1	12.0	12.3	13.0	12.6	12.9	13.8
95	11.3	11.7	12.1	12.1	12.3	13.0	12.9	13.2	14.0	13.6	13.8	14.7
100	12.1	12.6	12.9	13.0	13.2	13.9	13.8	14.1	14.9	14.5	14.8	15.7
120	15.6	16.1	16.5	16.6	16.9	17.7	17.5	17.9	18.9	18.4	18.7	19.8
140	19.3	19.9	20.4	20.4	20.8	21.8	21.5	22.0	23.1	22.5	22.9	24.2
160	23.2	23.9	24.4	24.5	24.9	26.0	25.8	26.3	27.6	26.9	27.3	28.8
180	27.3	28.1	28.7	28.8	29.3	30.5	30.2	30.8	32.2	31.5	31.9	33.6
200	31.7	32.5	33.2	33.3	33.8	35.2	34.9	35.6	37.1	36.3	36.8	38.6
250	43.3	44.3	45.2	45.3	46.0	47.7	47.3	48.2	50.1	49.1	49.7	51.9
300	56.0	57.2	58.3	58.5	59.2	61.3	60.8	61.9	64.1	62.9	63.7	66.4
350	69.6	71.1	72.4	72.5	73.4	75.8	75.3	76.5	79.1	77.7	78.6	81.7
400	84.1	85.8	87.3	87.5	88.5	91.3	90.6	92.0	95.1	93.5	94.5	98.0
450	99.5	101.4	103.1	103.3	104.4	107.6	106.8	108.4	111.8	110.0	111.2	115.2
500	115.6	117.7	119.6	119.8	121.2	124.6	123.8	125.6	129.4	127.4	128.6	133.1
550	132.4	134.8	136.9	137.1	138.6	142.4	141.6	143.5	147.7	145.5	146.9	151.8
600	150.0	152.6	154.9	155.1	156.8	161.0	160.0	162.1	166.7	164.3	165.8	171.2
700		190.1	192.9	193.2	195.1	200.0	198.9	201.4	206.7	204.0	205.7	212.0
800		230.2	233.3	233.7	235.8	241.5	240.3	243.2	249.3	246.1	248.1	255.3
900			276.1		279.0	285.4	284.0	287.3	294.2	290.6	292.9	301.0
1000			321.0			331.5	329.9	333.6	341.3	337.3	339.9	349.0
1200						429.8		432.3	441.7	436.9	440.0	451.0
1400									549.8		547.8	560.8
1600									664.9			677.6

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fischer Injection mortar FIS VT with rebars

Anchor design according to fischer specification

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]											
	FIS VT ∅16			FIS VT ∅18			FIS VT ∅20			FIS VT ∅22		
h_{ef}	125	160	192	140	180	210	160	200	240	180	220	260
edge distance [mm]												
65	8.9	9.5	10.0									
70	9.7	10.4	11.0									
75	10.6	11.3	11.9	11.2	12.0	12.6						
80	11.5	12.2	12.9	12.1	13.0	13.6						
85	12.4	13.2	13.9	13.1	14.0	14.6	13.8	14.8	15.6			
90	13.3	14.2	14.9	14.0	15.0	15.6	14.8	15.8	16.7			
95	14.3	15.1	15.9	15.0	16.0	16.7	15.8	16.9	17.8	16.7	17.7	18.7
100	15.2	16.2	16.9	16.0	17.0	17.8	16.9	17.9	18.9	17.8	18.8	19.9
120	19.3	20.3	21.2	20.2	21.4	22.2	21.2	22.4	23.6	22.2	23.5	24.6
140	23.5	24.8	25.8	24.6	26.0	26.9	25.7	27.1	28.4	26.9	28.3	29.6
160	28.1	29.4	30.6	29.2	30.8	31.8	30.5	32.1	33.5	31.9	33.4	34.9
180	32.8	34.3	35.6	34.0	35.8	37.0	35.5	37.3	38.9	37.0	38.7	40.4
200	37.7	39.4	40.8	39.1	41.0	42.3	40.7	42.7	44.4	42.4	44.3	46.0
250	50.8	52.9	54.6	52.6	54.9	56.5	54.6	56.9	59.0	56.6	58.9	61.0
300	65.0	67.5	69.5	67.1	69.9	71.8	69.5	72.3	74.8	71.9	74.6	77.1
350	80.2	83.1	85.4	82.6	85.9	88.0	85.4	88.6	91.5	88.1	91.3	94.1
400	96.3	99.6	102.2	99.1	102.7	105.2	102.2	105.8	109.1	105.3	108.9	112.1
450	113.2	116.9	119.9	116.3	120.4	123.2	119.9	123.9	127.5	123.3	127.3	130.9
500	130.9	135.0	138.3	134.4	139.0	142.0	138.3	142.8	146.8	142.2	146.6	150.5
550	149.4	153.9	157.5	153.2	158.2	161.6	157.5	162.4	166.8	161.8	166.6	170.9
600	168.6	173.5	177.4	172.7	178.2	181.9	177.5	182.8	187.6	182.1	187.3	192.0
700	209.0	214.7	219.3	213.8	220.2	224.5	219.4	225.6	231.1	224.8	230.8	236.3
800	251.9	258.4	263.7	257.5	264.8	269.6	263.8	270.9	277.2	270.0	276.9	283.1
900	297.2	304.6	310.5	303.5	311.7	317.2	310.6	318.6	325.7	317.6	325.3	332.3
1000	344.6	352.9	359.5	351.7	360.9	366.9	359.7	368.6	376.4	367.4	376.0	383.8
1200	445.8	455.8	463.8	454.4	465.4	472.8	464.0	474.7	484.2	473.4	483.7	493.0
1400		510.2	518.8	508.6	520.6	528.6	519.1	530.7	541.0	529.3	540.5	550.6
1600		566.4	575.8	564.7	577.7	586.3	576.1	588.6	599.7	587.1	599.2	610.1
1800		684.1	694.8		697.1	707.0	695.3	709.7	722.3	707.9	721.8	734.3
2000			820.6		823.1	834.3		837.4	851.7	835.4	851.1	865.2
2200			952.5			967.9		971.4	987.3		986.7	1002.4
2400									1351.9		1351.2	1370.9
2600												1772.8
2800												2204.9

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fischer Injection mortar FIS VT with rebars

Anchor design according to fischer specification

Design resistance of single anchor in concrete C 20/25 dependent on edge distance c_1

	$V^0_{Rd,c}$ [kN]														
	FIS VT ∅24			FIS VT ∅25			FIS VT ∅26			FIS VT ∅28			FIS VT ∅30		
h_{ef} / edge distance [mm]	192	210	288	210	230	310	220	240	320	230	260	330	240	280	360
105	19.6	20.1	22.2												
110	20.7	21.2	23.4	21.4	22.0	24.3									
120	23.0	23.6	25.9	23.8	24.4	26.8	24.3	25.0	27.4						
130	25.4	26.0	28.5	26.2	26.9	29.4	26.8	27.5	30.0	27.6	28.6	30.9			
140	27.8	28.5	31.1	28.7	29.4	32.1	29.3	30.0	32.7	30.1	31.2	33.7	30.9	32.4	35.2
160	32.9	33.6	36.5	33.9	34.7	37.6	34.5	35.3	38.3	35.4	36.7	39.3	36.3	38.0	41.1
170	35.5	36.2	39.3	36.5	37.4	40.5	37.2	38.1	41.2	38.2	39.5	42.3	39.1	40.9	44.1
180	38.1	38.9	42.2	39.2	40.1	43.4	39.9	40.8	44.1	41.0	42.3	45.2	42.0	43.8	47.2
190	40.8	41.7	45.1	42.0	42.9	46.3	42.7	43.7	47.1	43.8	45.2	48.3	44.9	46.7	50.3
200	43.6	44.5	48.0	44.8	45.7	49.3	45.6	46.5	50.1	46.7	48.2	51.3	47.8	49.8	53.4
250	58.1	59.1	63.4	59.5	60.7	65.0	60.5	61.7	66.0	61.8	63.6	67.4	63.2	65.5	69.9
300	73.6	74.9	79.9	75.3	76.7	81.7	76.5	77.9	82.9	78.1	80.1	84.6	79.6	82.4	87.5
350	90.2	91.6	97.3	92.1	93.7	99.5	93.5	95.0	100.8	95.3	97.6	102.7	97.1	100.2	106.0
400	107.6	109.3	115.7	109.9	111.6	118.1	111.4	113.1	119.6	113.4	116.1	121.8	115.4	119.0	125.5
450	125.9	127.8	134.9	128.4	130.4	137.6	130.1	132.1	139.3	132.4	135.4	141.7	134.7	138.6	145.8
500	145.0	147.1	155.0	147.8	150.0	157.9	149.7	151.8	159.7	152.2	155.5	162.4	154.7	159.0	166.9
600	185.5	187.9	197.3	188.8	191.4	200.8	191.0	193.6	202.9	194.0	197.9	206.1	197.0	202.1	211.4
700	228.7	231.5	242.4	232.6	235.6	246.4	235.1	238.1	248.9	238.6	243.1	252.6	242.1	248.0	258.7
800	274.5	277.7	290.1	278.9	282.3	294.7	281.8	285.2	297.5	285.8	290.9	301.6	289.8	296.5	308.6
900	322.7	326.3	340.1	327.6	331.5	345.3	330.9	334.7	348.4	335.4	341.1	353.1	339.9	347.4	360.9
1000	373.1	377.1	392.5	378.6	382.9	398.2	382.3	386.5	401.7	387.3	393.6	406.8	392.2	400.5	415.4
1200	480.3	485.1	503.4	486.9	492.0	510.2	491.2	496.3	514.4	497.3	504.8	520.6	503.2	513.1	530.9
1400	595.2	600.8	622.2	602.9	608.9	630.1	608.0	613.9	635.0	615.1	623.9	642.3	622.0	633.6	654.2
1600	717.2	723.7	748.2	726.1	732.9	757.3	732.0	738.7	762.9	740.1	750.1	771.1	748.1	761.3	784.8
1800	846.0	853.2	880.9	856.0	863.7	891.1	862.7	870.3	897.4	871.8	883.1	906.8	880.8	895.7	922.1
2000	981.0	989.1	1019.9	992.2	1000.8	1031.3	999.6	1008.1	1038.3	1009.9	1022.5	1048.7	1019.9	1036.5	1065.8
2200		1130.9	1164.9	1134.4	1143.9	1177.5	1142.6	1152.0	1185.2	1153.9	1167.8	1196.7	1165.0	1183.3	1215.5
2400			1315.6		1292.6	1329.4		1301.5	1337.9	1303.7	1318.8	1350.4	1315.8	1335.8	1371.0
2600			1471.8			1486.7			1496.0		1475.3	1509.6		1493.7	1531.9
2800			1633.2			1649.3			1659.3			1674.1		1657.0	1698.1
3000			1799.6			1816.9			1827.7			1843.6			1869.4
3500									2269.6			2288.3			2318.7

5.3.1 Influence of cracked concrete

f_{cr}

	non-cracked concrete
f_{cr}	1.0

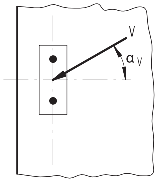
5.3.2 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.3 Influence of load direction

$f_{\alpha.V}$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angel $\alpha \geqq 90°$ the component of the shear load acting away from the edge can be neglected and the proof can be done with the component of the load acting parallel to the edge.

5.3.4 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≥3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.5 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≥1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.6 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≥1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.7 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

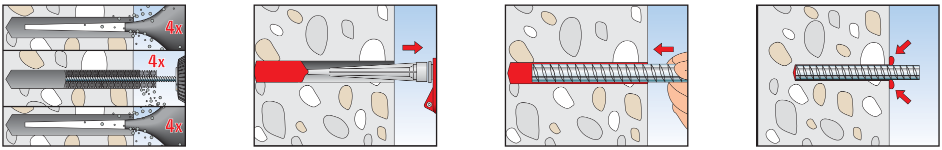
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details



d_0 ≧ 18 mm with oil free compressed air (P > 6 bar)

fischer Injection mortar FIS VT with rebars

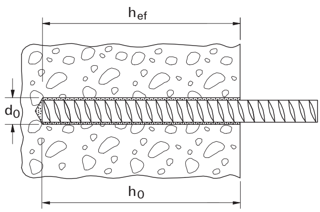
Anchor design according to fischer specification

8. Anchor characteristics

Anchor type			FIS VT ⌀ 8			FIS VT ⌀ 10			FIS VT ⌀ 12			FIS VT ⌀ 14			FIS VT ⌀ 16		
eff. anchorage depth	h_{ef}	**[mm]**	**64**	**80**	**96**	**80**	**90**	**120**	**96**	**110**	**144**	**110**	**120**	**160**	**125**	**160**	**192**
diameter of rebar		[mm]		8			10			12			14			16	
nominal drill hole diameter	d_0	[mm]		12			14			16			18			20	
drill depth	h_0	[mm]	64	80	96	80	90	120	96	110	144	110	120	160	125	160	192
effective anchorage depth	h_{ef}	[mm]	64	80	96	80	90	120	96	110	144	110	120	160	125	160	192
minimum thickness of concrete member	h_{min}	[mm]	100	110	126	110	120	150	126	140	174	140	150	190	165	200	232
minimum spacing	s_{min}	[mm]		40			45			55			60			65	
minimum edge distances	c_{min}	[mm]		40			45			55			60			65	
mortar filling quantity		[scale units]	3	4	4	4	5	6	6	7	9	8	8	11	10	12	15

Anchor type			FIS VT ⌀ 18			FIS VT ⌀ 20			FIS VT ⌀ 22			FIS VT ⌀ 24			FIS VT ⌀ 25		
eff. anchorage depth	h_{ef}	**[mm]**	**140**	**180**	**210**	**160**	**200**	**240**	**180**	**220**	**260**	**192**	**210**	**288**	**210**	**230**	**310**
diameter of rebar		[mm]		18			20			22			24			25	
nominal drill hole diameter	d_0	[mm]		25			25			30			30			30	
drill depth	h_0	[mm]	140	180	210	160	200	240	180	220	260	192	210	288	210	230	310
effective anchorage depth	h_{ef}	[mm]	140	180	210	160	200	240	180	220	260	192	210	288	210	230	310
minimum thickness of concrete member	h_{min}	[mm]	190	230	260	210	250	290	240	280	320	252	270	348	270	290	370
minimum spacing	s_{min}	[mm]		75			85			95			105			110	
minimum edge distances	c_{min}	[mm]		75			85			95			105			110	
mortar filling quantity		[scale units]	22	28	32	19	23	28	38	46	54	32	35	48	30	33	44

Anchor type			FIS VT ⌀ 26			FIS VT ⌀ 28			FIS VT ⌀ 30		
eff. anchorage depth	h_{ef}	**[mm]**	**220**	**240**	**320**	**230**	**260**	**330**	**240**	**280**	**360**
diameter of rebar		[mm]		26			28			30	
nominal drill hole diameter	d_0	[mm]		35			35			40	
drill depth	h_0	[mm]	220	240	320	230	260	330	240	280	360
effective anchorage depth	h_{ef}	[mm]	220	240	320	230	260	330	240	280	360
minimum thickness of concrete member	h_{min}	[mm]	290	310	390	300	330	400	320	360	440
minimum spacing	s_{min}	[mm]		120			130			140	
minimum edge distances	c_{min}	[mm]		120			130			140	
mortar filling quantity		[scale units]	61	66	88	52	59	74	84	98	126



4

fischer
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9. Gelling and curing times

System temperature (minimum + 5 °C)	Max. processing time FIS VT	Temperature at anchoring base	Curing time [1] FIS VT
		- 5 °C	24 h
		± 0 °C	180 min.
+ 5 °C	13 min.	+ 5 °C	90 min.
+ 10 °C	9 min.	+ 10 °C	60 min.
+ 20 °C	5 min.	+ 20 °C	45 min.
+ 30 °C	4 min.	+ 30 °C	35 min.
+ 40 °C	2 min.	+ 40 °C	35 min.

The above times apply from the moment of contact between resin and hardener in the static mixer. For installation, the cartridge temperature must be at least + 5 °C. With temperatures above + 30 °C to + 40 °C the cartridges have to be cooled down to + 15 °C or + 20 °C.

For longer installation times, i.e. when interruptions occur in work, the static mixer shall be replaced.

[1] In wet concrete the curing time has to be doubled.

10. Mechanical characteristics of rebars B 500 B

Anchor type			FIS VT ⌀ 8	FIS VT ⌀ 10	FIS VT ⌀ 12	FIS VT ⌀ 14	FIS VT ⌀ 16	FIS VT ⌀ 18	FIS VT ⌀ 20
stressed cross sectional area reinforcing steel	A_S	[mm²]	50	79	113	154	201	254	314
resisting moment reinforcing steel	W	[mm³]	50	98	170	269	402	573	785
yield strength reinforcing steel	f_{yk}	[N/mm²]	500						
tensile strength reinforcing steel	f_{uk}	[N/mm²]	550						

Anchor type			FIS VT ⌀ 22	FIS VT ⌀ 24	FIS VT ⌀ 25	FIS VT ⌀ 26	FIS VT ⌀ 28	FIS VT ⌀ 30
stressed cross sectional area reinforcing steel	A_S	[mm²]	380	452	491	531	616	707
resisting moment reinforcing steel	W	[mm³]	1045	1357	1534	1726	2155	2651
yield strength reinforcing steel	f_{yk}	[N/mm²]	500					
tensile strength reinforcing steel	f_{uk}	[N/mm²]	550					

fischer Long-shaft fixing SXS

Anchor design according to fischer specification

1. Types

SXS-T – with CO-NA countersunk head screw
(gvz, A4)

SXS-F US – with CO-NA hexagon-head screw with integrated washer
(gvz, A4)

SXS-SS – with CO-NA hexagon-head screw
(gvz, A4)

Features and Advantages

- German General Approval design according to Annex C of the ETAG 001*) for cracked and non-cracked concrete.
- European Technical Approval ETA for redundant systems / multiple fixings.
- Specially developed fischer CO-NA screw ensures high loads and bending moments.
- Expansion in 4 directions gives highest loads and highest safety.
- High bending moment of the CO-NA screw reduces the costs of anchors for all applications with high shear loads with or without lever arm.
- Polyamide/Nylon guarantees non-reduced loads for a period of 50 years and guarantees the safe function at a large temperature range of -40 °C up to +80 °C
- Hammer-in stop enables quick and failure resistant installation because the screw will not slip into the sleeve during tap-in.
- Anti-rotation lock prevents safely the sleeve from rotating in the base material when screwing in.
- Large range of available fixing lengths gives perfect allocation to the given fixture.
- The SXS-F US version does not require additional washers and prevents contact corrosion.

*) The conditions of use in the German General Approval may vary from those of the Technical Handbook.

Materials

Screw:	- Carbon steel, zinc plated (5 µm) and passivated (gvz)
	- Stainless steel of corrosion resistance class III, e.g. A4 (1.4401 optional 1.4571, 1.4404, 1.4578) and according to ASTM/AISI steel grade 316
Anchor sleeve:	- Polyamide

fischer Long-shaft fixing SXS

Anchor design according to fischer specification

2. Ultimate resistance of single anchors with large spacing and large edge distance

Mean values

Anchor type				SXS 10 gvz		SXS 10 A4	
temperature range: short term / long term			[°C]	(+ 50 °C / + 30 °C) [1]	(+ 80 °C / + 50 °C) [1]	(+ 50 °C / + 30 °C) [1]	(+ 80 °C / + 50 °C) [1]
non-cracked concrete							
tension	C 20/25	N_u	[kN]	12.8	8.3	12.8	8.3
shear	≥ C 20/25	V_u	[kN]	13.5	13.1	13.5	13.1
cracked concrete							
tension	C 20/25	N_u	[kN]	10.4	6.7	10.4	6.7
shear	≥ C 20/25	V_u	[kN]	13.5	13.1	13.5	13.1

[1] (short term temperature / long term temperature)

3. Characteristic, design and recommended resistance of single anchors with large spacing and large edge distance

3.1 Characteristic resistance

Anchor type				SXS 10 gvz		SXS 10 A4	
temperature range: short term / long term			[°C]	(+ 50 °C / + 30 °C) [1]	(+ 80 °C / + 50 °C) [1]	(+ 50 °C / + 30 °C) [1]	(+ 80 °C / + 50 °C) [1]
non-cracked concrete							
tension	C 20/25	N_{Rk}	[kN]	9.5	6.5	9.5	6.5
shear	≥ C 20/25	V_{Rk}	[kN]	12.9	12.9	12.5	12.5
cracked concrete							
tension	C 20/25	N_{Rk}	[kN]	5.0	3.0	5.0	3.0
shear	≥ C 20/25	V_{Rk}	[kN]	9.0	7.5	9.0	7.5

[1] (short term temperature / long term temperature)

3.2 Design resistance

Anchor type				SXS 10 gvz		SXS 10 A4	
temperature range: short term / long term			[°C]	(+ 50 °C / + 30 °C) [1]	(+ 80 °C / + 50 °C) [1]	(+ 50 °C / + 30 °C) [1]	(+ 80 °C / + 50 °C) [1]
non-cracked concrete							
tension	C 20/25	N_{Rd}	[kN]	5.3	3.6	5.3	3.6
shear	≥ C 20/25	V_{Rd}	[kN]	10.3	10.3	10.0	10.0
cracked concrete							
tension	C 20/25	N_{Rd}	[kN]	2.8	1.7	2.8	1.7
shear	≥ C 20/25	V_{Rd}	[kN]	5.0	4.2	5.0	4.2

[1] (short term temperature / long term temperature)

3.3 Recommended resistance [1]

Anchor type				SXS 10 gvz		SXS 10 A4	
temperature range: short term / long term			[°C]	(+ 50 °C / + 30 °C) [1]	(+ 80 °C / + 50 °C) [1]	(+ 50 °C / + 30 °C) [1]	(+ 80 °C / + 50 °C) [1]
non-cracked concrete							
tension	C 20/25	N_R	[kN]	3.8	2.6	3.8	2.6
shear	≥ C 20/25	V_R	[kN]	7.4	7.4	7.1	7.1
cracked concrete							
tension	C 20/25	N_R	[kN]	2.0	1.2	2.0	1.2
shear	≥ C 20/25	V_R	[kN]	3.6	3.0	3.6	3.0

[1] Material safety factors γ_M and safety factor for action γ_L = 1.4 are included. Material safety factor γ_M depends on failure mode of the anchor.

[2] (short term temperature / long term temperature)

4. Calculation of tension resistance

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

Steel failure: $N_{Rd,s}$

Pull-out / pull-through failure: $N_{Rd,p} = N^0_{Rd,p}$

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

4.1 Steel failure of the highest loaded anchor

Design resistance of single anchor

Anchor type			SXS 10 gvz	SXS 10 A4
design resistance	$N_{Rd,s}$	[kN]	10.7	10.4

4.2 Pull-out/pull-through failure of the highest loaded anchor

$$N_{Rd,p} = N^0_{Rd,p}$$

Design resistance of single anchor (pull-out resistance is the same for all concrete strength classes)

Anchor type			SXS 10	
temperature range: short term / long term		[°C]	(+ 50 °C / + 30 °C) [1]	(+ 80 °C / + 50 °C) [1]
non-cracked concrete				
design resistance	$N^0_{Rd,p}$	[kN]	5.3	3.6
cracked concrete				
design resistance	$N^0_{Rd,p}$	[kN]	2.8	1.7

[1] (short term temperature / long term temperature)

4.3 Concrete cone failure and splitting of the most unfavourable anchor

Concrete cone failure: $N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1} \cdot f_{s2} \cdot f_{s3} \cdot f_{c1,A} \cdot f_{c1,B} \cdot f_{c2}$

Concrete splitting failure: $N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,N} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{s3,sp} \cdot f_{c1,sp,A} \cdot f_{c1,sp,B} \cdot f_{c2,sp} \cdot f_h$

Proof of splitting failure is only necessary if all of the following conditions are met:
- non-cracked concrete
- $c_{cr,sp} > c_{cr,N}$
- $c < 1.2\ c_{cr,sp}$

Design resistance of single anchor

Anchor type			SXS 10
eff. anchorage depth	h_{ef}	[mm]	35
non-cracked concrete			
design resistance	$N^0_{Rd,c}$	[kN]	7.0
cracked concrete			
design resistance	$N^0_{Rd,c}$	[kN]	5.0

4.3.1 Influence of concrete strength for tension

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,N}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

4.3.2 Concrete cone failure

Characteristic edge distance and spacing for design

Anchor type		SXS 10
h_{ef}	[mm]	35
$s_{cr,N}$	[mm]	105
$c_{cr,N}$	[mm]	53

4.3.2.1 Influence of spacing / concrete cone failure

$$f_{s1} = f_{s2} = f_{s3} = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
f_{s1}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.2.2 Influence of edge distance / concrete cone failure

$$f_{c1,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}} \leqq 1.0 \qquad f_{c1,B} = f_{c2} = \left(1.0 + \frac{c}{c_{cr,N}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,N}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,B}$ f_{c2}	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3 Concrete splitting failure

Characteristic edge distance and spacing for design

Anchor type		SXS 10
h_{ef}	[mm]	35
$s_{cr,sp}$	[mm]	200
$c_{cr,sp}$	[mm]	100

4.3.3.1 Influence of spacing / concrete splitting failure

$$f_{s1,sp} = f_{s2,sp} = f_{s3,sp} = \left(1.0 + \frac{s}{s_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$s/s_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{s,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.2 Influence of edge distance / concrete splitting failure

$$f_{c1,sp,A} = 0.7 + 0.3 \cdot \frac{c}{c_{cr,sp}} \leqq 1.0 \qquad f_{c1,sp,B} = f_{c2,sp} = \left(1.0 + \frac{c}{c_{cr,sp}}\right) \cdot 0.5 \leqq 1.0$$

$c/c_{cr,sp}$	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	≧1.0
$f_{c1,sp,A}$	0.73	0.75	0.76	0.78	0.79	0.81	0.82	0.84	0.85	0.87	0.88	0.9	0.91	0.93	0.94	0.96	0.97	0.99	1.0
$f_{c1,sp,B}$ $f_{c2,sp}$	0.55	0.58	0.6	0.63	0.65	0.68	0.7	0.73	0.75	0.78	0.8	0.83	0.85	0.88	0.9	0.93	0.95	0.98	1.0

4.3.3.3 Influence of concrete thickness / concrete splitting failure

$$f_h = \left(\frac{h}{h_{min}}\right)^{2/3} \leqq 1.5$$

h/h_{min}	1.0	1.05	1.1	1.15	1.2	1.25	1.3	1.35	1.4	1.45	1.5	1.55	1.6	1.65	1.7	1.75	1.8	≧1.84
f_h	1.0	1.03	1.07	1.1	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.37	1.4	1.42	1.45	1.48	1.5

5. Calculation of shear resistance

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

Steel failure: $V_{Rd,s}$

Pryout failure: $V_{Rd,cp} = N_{Rd,c} \cdot k$

Concrete edge failure: $V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$

5.1 Steel failure / pull-out failure for the highest loaded anchor

Design resistance of single anchor

Anchor type			SXS 10 gvz		SXS 10 A4	
temperature range: short term / long term		[°C]	(+ 50 °C / + 30 °C) [1]	(+ 80 °C / + 50 °C) [1]	(+ 50 °C / + 30 °C) [1]	(+ 80 °C / + 50 °C) [1]
non-cracked concrete						
Design resistance	$V_{Rd,s}$	[kN]	10.3	10.3	10.0	10.0
cracked concrete						
Design resistance	$V_{Rd,s}$	[kN]	5.0	4.2	5.0	4.2

[1] (short term temperature / long term temperature)

5.2 Pryout failure for the most unfavourable anchor

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

k-factor

Anchor type	SXS 10
k	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{s1,V} \cdot f_{s2,V} \cdot f_{c2,V} \cdot f_{h,V} \cdot f_m$$

Proof of concrete edge failure is only necessary, if the following condition is met:

- c < max (10 h_{ef} ; 60 d) with d = nominal anchor diameter

Design resistance of single anchor in concrete C 20/25 dependent on edge distance to first edge c_1

edge distance [mm]	$V^0_{Rd,c}$ [kN] SXS	
	non-cracked concrete	cracked concrete
50		3.3
55		3.8
60	6.0	4.3
65	6.7	4.8
70	7.4	5.3
75	8.1	5.8
80	8.9	6.3
85	9.7	6.8
90	10.4	7.4
95	11.2	8.0
100	12.1	8.5
110	13.7	9.7
120	15.5	11.0
130	17.3	12.2
140	19.2	13.6
150	21.1	14.9
200	31.5	22.3
250	43.0	30.5
300	55.7	39.4
350	69.3	49.1
400	83.7	59.3
450	99.0	70.1
500	115.0	81.5
550	131.8	93.4
600	149.3	105.8

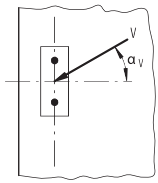
5.3.1 Influence of concrete strength for shear

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

Concrete strength class			C 12/15	C 16/20	C 20/25	C 25/30	C 30/37	C 35/45	C 40/50	C 45/55	C 50/60
Cylinder compressive strength	$f_{ck,cyl}$	[N/mm²]	12	16	20	25	30	35	40	45	50
Cube compressive strength	$f_{ck,cube}$	[N/mm²]	15	20	25	30	37	45	50	55	60
Influence factor	$f_{b,V}$	[-]	0.77	0.89	1.00	1.10	1.22	1.34	1.41	1.48	1.55

5.3.2 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \leqq 2.5$$



	0	10	20	30	40	50	60	70	80	90
$f_{\alpha,V}$	1.00	1.01	1.05	1.13	1.24	1.40	1.64	1.97	2.32	2.50

For angle $\alpha \geqq 90°$ the component of the shear load acting away from the edge may be neglected and the proof may be done with the component of the load acting parallel to the edge.

5.3.3 Influence of spacing

$$f_{s1,V} = f_{s2,V} = \frac{1}{6} \cdot \frac{s}{c_1} + \frac{1}{2} \leqq 1.0$$

s/c_1	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	≧3.0
$f_{s1,V}$	0.58	0.6	0.62	0.63	0.65	0.67	0.7	0.73	0.77	0.8	0.83	0.87	0.9	0.93	0.97	1.0

5.3.4 Influence of edge distance

Distance to second edge; $c_1 < c_2$

$$f_{c2,V} = \left(\frac{1}{2} + \frac{1}{3} \cdot \frac{c_2}{c_1}\right) \cdot \left(0.7 + 0.3 \cdot \frac{c_2}{1.5 \cdot c_1}\right) \leqq 1.0$$

c_2/c_1	1.0	1.1	1.2	1.3	1.4	≧1.5
$f_{c2,V}$	0.75	0.8	0.85	0.9	0.95	1.0

5.3.5 Influence of member thickness

$$f_{h,V} = \left(\frac{h}{1.5 \cdot c_1}\right)^{0.5} \leqq 1.0$$

h/c_1	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.3	1.4	≧1.5
$f_{h,V}$	0.26	0.37	0.45	0.52	0.58	0.63	0.68	0.73	0.77	0.82	0.89	0.93	0.97	1.0

5.3.6 Influence of group with ≧ 4 anchors in a row at the edge

f_m

s/c_1	0.25	0.5	1.0	≧2.0
f_m	0.3	0.5	0.75	1.0

6. Summary of required proof:

6.1 Tension: $N_{Sd} \leqq N_{Rd}$ = *lowest value of* $N_{Rd,s}$; $N_{Rd,p}$; $N_{Rd,c}$; $N_{Rd,sp}$

6.2 Shear: $V_{Sd} \leqq V_{Rd}$ = *lowest value of* $V_{Rd,s}$; $V_{Rd,cp}$; $V_{Rd,c}$

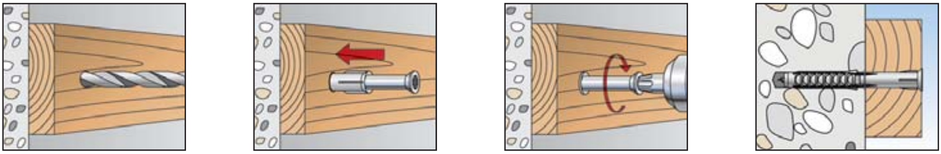
6.3 Combined tension and shear load:

$$\frac{N_{Sd}}{N_{Rd}} + \frac{V_{Sd}}{V_{Rd}} \leqq 1.2$$

N_{Sd} ; V_{Sd} = tension/shear component of the design load acting on the most unfavourable single anchor

N_{Rd} ; V_{Rd} = tension/shear design resistance including safety factors of the most unfavourable single anchor

7. Installation details



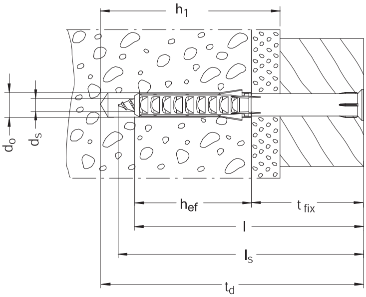
fischer Long-shaft fixing SXS

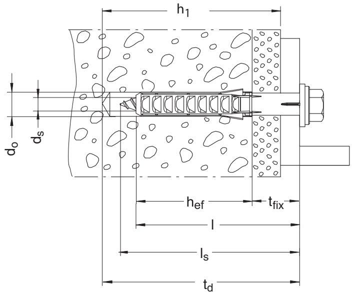
Anchor design according to fischer specification

8. Anchor installation data

Anchor type			SXS 10	
nominal drill hole diameter	d_0	[mm]	10	
drill depth	h_1	[mm]	60	
effective anchorage depth	h_{ef}	[mm]	35	
clearance-hole in fixture to be attached	d_f	[mm]	≦ 10.5	
drill hole depth for through fixing	t_d	[mm]	$t_d = h_1 + t_{fix}$	
wrench size type SXS-F US and SXS-SS	SW	[mm]	10	
torx drive type SXS-F US and SXS-T		[-]	T40	
min. thickness of concrete member	h_{min}	[mm]	100	140
non-cracked concrete				
minimum spacing	s_{min}	[mm]	55	50
for required edge distance	for c ≧	[mm]	100	100
minimum edge distance	c_{min}	[mm]	60	60
for required spacing	for s ≧	[mm]	250	200
cracked concrete				
minimum spacing	s_{min}	[mm]	55	50
for required edge distance	for c ≧	[mm]	100	90
minimum edge distance	c_{min}	[mm]	50	50
for required spacing	for s ≧	[mm]	250	200

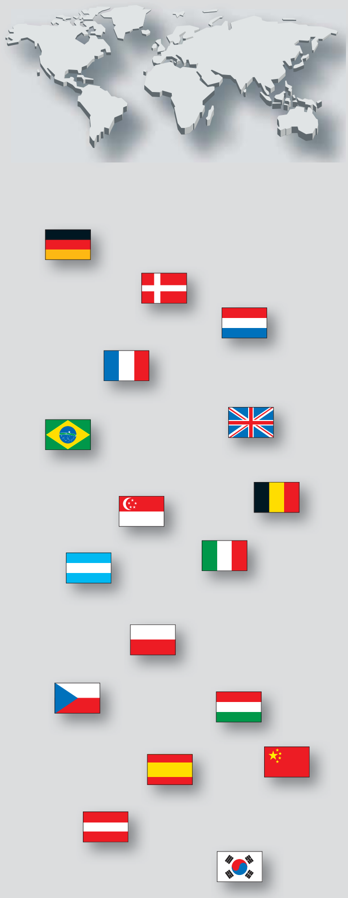
4





9. Mechanical anchor material characteristics

Anchor type			SXS 10 gvz	SXS 10 A4
stressed cross sectional area screw	A_s	[mm²]	26.9	26.9
resisting moment screw	W	[mm³]	39.8	39.8
design value of bending moment	$M^0_{Rd,s}$	[Nm]	22.9	22.2
yield strength screw	f_{yk}	[N/mm²]	480	450
tensile strength screw	f_{uk}	[N/mm²]	600	580



Service / Contact

5

International Technical Service (Support)

This Technical Manual gives you some insight into fixing engineering in general, and into the special products by fischerwerke in detail. The Technical Data will show you the efficiency of the products when selected properly and when used under the defined parameters and ambient conditions.

Besides their COMPUFIX design software, fischerwerke also offer you their world-wide application service. Our engineers will be pleased to help you to solve your special application problems. If you need support just contact our local fischer representation. In case of a special application problem please contact the International Technical Service in Germany.

We also offer training seminars which, suited to your individual needs and requirements, are designed to back your confidence in fischer products.

CC-COMPUFIX
Design Software for anchors

- For design of steel and nylon anchors based on the CC-Method according to the fischer Technical Handbook and European Technical Approvals
- For predominantly static and dynamic loads (pulsating and alternating)
- Takes into account torsion moments on anchor groups close to an edge
- Considers single anchors and groups of two to six anchors
- Allows the design of asymmetrical connections
- Permits bending of the anchors
- Covers design of zinc plated and passivated steel, stainless steel A4 (grade 316) and highly corrosion-resistant steel (material no 1.4529)
- Allows the design of the fixture (steel plate) for different steel types considering various types of profiles
- Gives information on installation details and makes the full text of European Technical Approvals available
- Generates a detailed printout including a scaled drawing of anchors and steel plate
- Offers the most up-to-date version through LifeUpdate
- Download of the fischer Design Software: www.fischer.de

SaMontec
Installationsystems

Pipe support system for the installation and mounting of pipes in commercial, industrial and residental buildings

Different kind of channels for a cost-effective installation according to the kind of application.

A big choice of pipeclamps offers a adequate fixation for all kind of pipes.

With the appropriate accessories there are hardly no limits by designing the needed rack construction.

Fit for today's and tomorrow's demands

Planning for the future means constantly being prepared to meet new requirements. That is why the **fischer Installation Grid** is the installation system for modern and future supply technology in industrial buildings. Its strengths are:

- quick installation and consequent low costs
- high flexibility and adaptability to change utilisation of buildings
- good order and organisation in media supply
- new design perspectives
- highly economical over the entire duration of utilisation
- clear calculation of time and cost thanks to modular construction
- support in planning and installation

Backed-up by the entire know-how and experience of a leading manufacturer of fixing systems.

A | C | T

Advanced **C**urtain wall **T**echnique

fischer ACT system - the key to new façade aesthetics

With its ACT System (Advanced Curtain wall Technique), fischer offers architects and specifiers an innovative, high-quality, all-inclusive system for fixing ventilated claddings of natural stone, cast stone, ceramic, fine stoneware, HPL, fibre cement and point-fixed glass facades.

Apart from technical and financial advantages, the ACT System also provides a particularly extensive scope for architectural design. For example, ACT

allows the use of facade natural stone panels from 20 mm in thickness, free positioning of the anchor anywhere on the back face of the panel and easy replacement of all or individual panels. Even reveal panels can be attached with ease and in many different ways. ACT's aesthetic highlight is its undercut technology combined with the FZP fischer zykon panel anchor, which ensures that there are no visible fixing elements at the joint. Small fixing point diameter without penetration of cladding.

Complete service from a single source

The ACT System is not restricted to innovative fixing products – this is only the start. Fixing specialists at the ACT Competence Centres offer architects, specifiers and craftsmen comprehensive support, from the planning stage and static calculations through to on-time delivery to the site. Their service also includes provision of design software and instruction for users, as well as advice in selecting the appropriate fischer drilling and setting machines.

ACT Service:

fischerwerke GmbH & Co. KG
Weinhalde 14-18
D-72178 Waldachtal · Germany
Tel.: +49 74 43 12-45 53
Fax: +49 74 43 12-49 07
act@fischer.de · www.fischer.de

GERMANY
fischerwerke GmbH & Co. KG
Weinhalde 14-18
72178 Waldachtal
Tel.: +49 7443 12 - 0
Fax: +49 7443 12 - 0
E-Mail: info@fischer.de
Web: http://www.fischer.de

ARGENTINA
fischer Argentina S.A.
Armenia 3044
1605 Munro Ra-PCIA: De Buenos Aires
Tel.: +54 1147 62 27 78
Fax: +54 1147 56 13 11
E-Mail: asistenciatecnica@fischer.com.ar
Web: http://www.fischer.com.ar

AUSTRIA
fischer Austria GmbH
Wiener Straße 95
2514 Traiskirchen
Tel.: +43 2252 53730-0
Fax: +43 2252 53730-70
E-Mail: office@fischer.at
Web: http://www.fischer.at

BELGIUM
fischer Cobemabel snc
Schaliënhoevedreef 20 D
2800 Mechelen
Tel.: +32 152 8 47 00
Fax: +32 152 8 47 10
E-Mail: info@fischer.be
Web: http://www.fischer.be

BRASIL
fischer brasil Industria e Comercio Ltda.
Rua Dr. Rafael de Barros, 209 – 5° andar – Paraiso
04003-041 São Paulo - SP
Tel.: +55 11 3178 2545
Fax: +55 11 30 48 86 07
E-Mail: fischer@fischerbrasil.com.br
Web: http://www.fischerbrasil.com.br

BULGARIA
Fischer Bulgaria EOOD
Tzar Osvoboditel Blvd. 14
1000 Sofia, Bulgaria
Mobil: +359 888 723761
gueorgui.tchotrev@fischer.at
Fax: +43 2252 53730-70

CHINA
fischer (Taicang) fixings Co. Ltd.
Shanghai Rep. Office Rm 1503-1504,
No. 63 Chifeng Road
200092 Shanghai
Tel.: +86 21 51 00 16 68
Fax: +86 21 65 97 96 69
E-Mail: ficnsh@fischer.com.cn
Web: http://www.fischer.com.cn

CHINA
fischer (Taicang) fixings Co. Ltd.
Jinzhou Road 18
215400 Taicang Jiangsu
Tel.: +86 512 53 58 89 38
Fax: +86 512 53 58 89 48
E-Mail: ficn@fischer.com.cn
Web: http://www.fischer.com.cn

CROATIA
fischer Hrvatska d.o.o.
Nadinska 29
HR-10010 Zagreb
Tel.: +385 16 235 935
Fax: +385 16 235 882
Mobil: +385(0)91 3472438
E-Mail: mirjana.zajec@fischerhrvatska.kr

CZECH REPUBLIC
fischer international s.r.o.
Prùmyslová 1833
25001 Brandýs nad Labem
Tel.: +42 03 26 90 46 01
Fax: +42 03 26 90 46 00
E-Mail: info@fischer-cz.cz
Web: http://www.fischer-cz.cz

DENMARK
fischer a/s
Sandvadsvej 17 A
4600 Køge
Tel.: +45 46 32 02 20
Fax: +45 46 32 50 52
E-Mail: fidk@fischerdanmark.dk
Web: http://www.fischerdanmark.dk

FINLAND
fischer Finland
Oluf Onsumsvei 9
0680 Oslo
Tel: +358 207 414660
Fax: +358 207 414 669

FRANCE
fischer S. A. S.
12, rue Livio, P. O. Box 10182
67022 Strasbourg-Cedex
Tel.: +33 388 39 18 67
Fax: +33 388 39 80 44
E-Mail: info@fischer.fr
Web: http://www.fischer.fr

GREAT BRITAIN
fischer fixings UK Ltd.
Whitely Road
Oxon OX10 9AT Wallingford
Tel.: +44 1491 82 79 00
Fax: +44 1491 82 79 53
E-Mail: info@fischer.co.uk
Web: http://www.fischer.co.uk

GREECE
fischer Hellas Emporiki EPE
Nat. Road Athens-Lamia (17th) & Roupel 6
14564 Kifissia, Athens

Tel.: +30 210 2838167
Fax: +30 210 2838169
E-Mail: info@fischer.gr
Web: http://www.fischer.gr

HUNGARY
fischer Hungária Bt.
Szerémi út 7.
1117 Budapest
Tel.: +36 1 347 97 55
Fax: +36 1 347 97 65
E-Mail: info@fischerhungary.hu
Web: http://www.fischerhungary.hu

ITALY
fischer italia S.R.L
Corso Stati Uniti, 25, Casella Postale 391
35127 Padova Z.I. Sud
Tel.: +39 049 8 06 31 11
Fax: +39 049 8 06 34 01
E-Mail: sercli@fischeritalia.it
Web: http://www.fischeritalia.it

JAPAN
Fischer Japan K.K.
Seishin Kudan Building 3rd Floor
3-4-15 Kudan Minami
Chiyoda-ku
Tokyo 102-0074
Tel: +81-3-3263-4491
Fax: +81-3-6272-9935
E-Mail:info@fischerjapan.co.jp
Web: http://www.fischerjapan.co.jp

KOREA
fischer Korea Co., Ltd
#503 Dae-Ryung Techno Town 8th 481-11
Gasan-dong, Geumcheon-Gu,
153-775 Seoul
Tel.: +82 1544 8955
Fax: +82 1544 8903
E-Mail: info@fischerkorea.com
Web: http://www.fischerkorea.com

MEXICO
fischer Sistemas de Fijación, S.A. de C.V.
Blvd. Manuel Avila Camacho 3130-400B
Col. Valle Dorado, Tlalnepantla 54020 Estado de Mexico
C.P. 54020
Tel.: +52 55 55 72 08 83
Fax: +52 55 55 72 15 90
E-Mail: info@fischermex.com.mx
Web: www.fischermex.com.mx

NETHERLANDS
fischer Benelux B.V.
Amsterdamsestraatweg 45 B/C
1411 AX Naarden
Tel.: +31 35 6 95 66 66
Fax: +31 35 6 95 66 99
E-Mail: info@fischer.nl
Web: http://www.fischer.nl

NORWAY
fischer Norge AS
Enebakkveien 117
0680 Oslo
Tel: +47 232 427 10
Fax: +47 232 427 13
Web: http://www.fischernorge.no/

POLAND
fischerpolska Sp.z o.o
ul. Albatrosow 2
30-716 Kraków
Tel.: +48 12 2 90 08 80
Fax: +48 12 2 90 08 88
E-Mail: info@fischerpolska.pl
Web: http://www.fischerpolska.pl

PORTUGAL
Fischerwerke Portugal , Lda
Av. Casal da Serra , Lote I-4, Sala 5
2625-085 Povoa de Santa Iria
Tel.: + 351 21 953 74 50
Fax: + 351 21 959 13 90
E-Mail: fischerportugal.info@fischer.es
Web: http://www.fischer.pt

RUSSIA
OOO fischer Befestigungssysteme Rus
I. Dokukina 16/1, Building 1
129226 Moscow
Tel.: +7 495 223-03-34
Fax: +7 495 223-03-34
E-Mail: info@fischerfixing.ru
Web: http://www.fischerfixing.ru

SINGAPORE
fischer systems Asia Pte. Ltd.
150 Kampong Ampat #04-03 KA Centre
368324 Singapore
Tel.: +65 62 85 22 07
Fax: +65 62 85 83 10
E-Mail: sales@fischer.sg
Web: http://www.fischer.sg

SLOVAKIA
fischer S.K. s.r.o.
Vajnorská 134/A
831 04 Bratislava
Tel.: +421 2 4920 6046
Fax: +421 2 4920 6044
E-Mail: info@fischerwerke.sk
Web: http://www.fischer-sk.sk

SPAIN
fischer iberica S.A.
Klaus Fischer 1
43300 Mont-Roig del Camp Tarragona
Tel.: +34 977 83 87 11
Fax: +34 977 83 87 70
E-Mail: tacos@fischer.es
Web: http://www.fischer.es

SWEDEN
fischer Sverige AB
Tenngatan 4
602 23 Norrköping
Tel.: +46 11 31 44 50
Fax: +46 11 31 19 50
ml@fischersverige.se
Web: http://www.fischersverige.se

TURKEY
FISCHER METAL SANAYI VE TICARET LTD STI
Yeni yol Sokak, ETAP Is Merkezi. A Blok No: 16/9
34722 Hasanpasa / Kadikoy Istanbul
Tel.: +90 216 326 0066
Fax: +90 216 326 0018
E-Mail: info@fischer.com.tr

UNITED ARAB EMIRATES
fischer FZE
Postfach 261738, Jebel Ali Free Zone
Dubai
Tel.: +97 14 8 83 74 77
Fax: +97 14 8 83 74 76
E-Mail: fixings@fischer.ae
Web: http://www.fischer.ae

UNITED STATES OF AMERICA
fischer fixings LLC
62 Orange Ave
Suffern, NY 10901
Tel.: +1-845-504-5098
Fax: +1-845-625-2666
E-Mail: info@fischerfixingsusa.com
www.fischerfixings.com

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fischerwerke GmbH & Co. KG
Weinhalde 14-18 · 72178 Waldachtal
P. O. Box 1152 · 72176 Waldachtal
Germany
Phone +49 7443 12-0 · Fax +49 7443 12-4222
www.fischer.de

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