Technical Handbook - Europe

fischer
FIXING SYSTEMS

Introduction

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Introduction

Dear Readers,

Our fixing technology aims to develop and offer you the best solutions for your respective problems. This means that we not only offer you new, innovative products but also a high level of customer service: consulting, measuring, information. „Quality, service and user-friendliness apply equally to products and services," as it says in our mission statement.

We work all over the world in a results-oriented manner for the benefit of our customers and users. Thanks to a process of continuous improvement – what we call the fischer process system (fPS) – we are able to respond quickly and flexibly in order to meet the requirements of our customers in the best possible way.

One example of this is our Technical Manual Europe. It covers a broad range of topics relating to fixing technology which are geared to practical applications. The Technical Manual from fischer is a valuable tool for planners and structural engineers in their day-to-day work which enables them to respond quickly and professionally to enquiries and derive maximum benefit from our service.

Yours sincerely,

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. 14.41 patent applications per year and per 1,000 employees (German industry average: 0.57) are proof of our innovative strength in the business segments of fixing systems, automotive systems and fischer technology. Around 35 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.

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

fischer process 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. In 2009, fischer launches a complete range with wood screws on the market for the first time. The best bolt tie suitable for tensile zones on the market, the FAZ II, has also been available in stainless steel since the beginning of the year and the world's first undercut anchor for glass, the FZP G, holds the slanting glass facade of the new Porsche museum in Stuttgart, one of the most demanding museum buildings in the world with regard to technology and statics.

The unique, flexible and successful highbond system for fixings in cracked concrete is now even more comprehensive. The new mortar cartridge FHB II-PF hardens up to 90% faster than the best competitor system. Only an extra two minutes are enough for the mortar to fully harden at a temperature of 21°C.

And as early as 2008, fischer presented a new innovative universal solution for the fixing of different objects in virtually all load-bearing construction materials. The long-shaft fixing SXR 10 was the first plastic anchor ever (Ø10 mm) to receive the European Technical Approval (ETA).

We offer comprehensive and continuative services for our customers for all our products. The measurement software Compufix supports planners and structural designers in the calculation of reliable and economic anchors for all applications. The measurement software SaMontec provides support in the installation of pipeline sections and the fixing elements required for this purpose.

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 2,000 planners, construction engineers, architects and skilled tradesmen are trained every year.

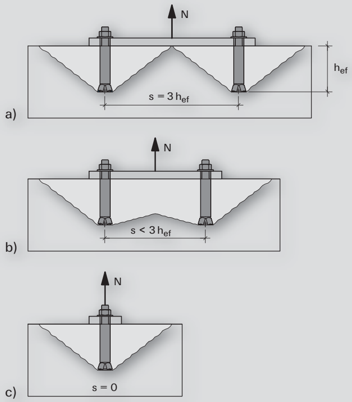
Technical manual

The 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 measurement values indicated. The measurement model used in the manual is based primarily on a simplified CC procedure.

Chapters on the topics of corrosion and fire stress conclude the comprehensive standard work, supplemented by a section on subsequently embedded reinforcing rods.

The handy Technical Manual, bound in DIN A5 format, is an essential companion on the building site and during preliminary planning. With the technical details, the Europe version is based primarily on the European Technical Approvals (ETA). It has around 370 pages in A5 format.



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 fixing elements, installed after completion of the main structure. 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 load bearing capacity of an anchor, axial spacings, edge distances and also structural component dimensions. The condition of the concrete (cracked or non-cracked) requires also thought 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 Building materials (substrate)

In the building process, many various materials are used. A variety of different masonry, concrete 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 a perforated one.

2.2.1 Concrete

A certain distinction is made 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. However, the compressive strength of normal concrete is greater than that of lightweight concrete.

Normal concrete in the fischer Technical Handbook, is identified based on the ENV 206 (Eurocode 2) by a capital letter C and a two further numbers (e.g. 20/25). The first number gives the compressive strength measured in cylinders with a diameter of 150 mm and a height of 300 mm and the second number gives the compressive strength measured in cubes with dimensions 150x150x150 mm³. Table 2.1 gives the concrete strength classifications and Table 2.2 informs about the concrete strength classes used in different countries.

In concrete mainly steel anchors (undercut, expansion or resin anchors) are used, however, with smaller load requirements nylon fixings may also be installed.

Table 2.1:
Concrete strength classes according to 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 Lightweight concrete

With applications for lightweight concrete, fischer have various approvals and recommendations available. Furthermore, the option to conduct site testing to establish the anchor performance can also be considered. Further advice may be obtained from your local, fischer Technical Service Department.

2.2.3 Board materials

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 function by collapsing into a cavity or against the rear side of the board material.

2.3 Installation

2.3.1 Drill hole depth

The drill hole depth h_0 is dependent upon the type and size of the fixing. In most cases, the hole depth is greater 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 produces the hole to the required depth. In all other cases refer to the respective part of the fischer Technical Handbook, tables "Anchor characteristics".

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 measured by the distance from the load bearing surface to the fixing's expansion surface end (see figure 2.1a).

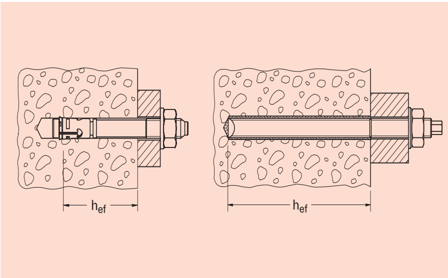
Table 2.2:
Concrete strength classes in different countries

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

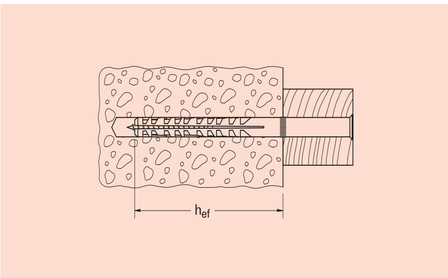
[1] Conversion: $f_{Cylinder} = 0.85 \times f_{Cubes,\ 20x20x20}$; $f_{Cubes,\ 15x15x15} = 1.05 \times f_{Cubes,\ 20x20x20}$

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 nylon sleeve (see figure 2.1c). The anchorage depths for different fixings can be found in the respective part of the fischer Technical Handbook design tables 4.3: "Concrete cone failure and splitting for the most unfavourable anchor."

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



a) Steel anchor b) Resin anchor

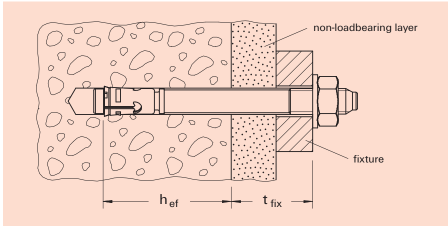


c) Nylon anchor

2.3.3 Fixture thickness

The fixture thickness (clamping thickness) t_{fix} refers to the maximum thickness of the attachment. When a non-loadbearing layer exists, this must be included in the fixture thickness (see figure 2.2). For internally threaded anchors the fixture thickness is determined by a suitable length screw, however, this is generally restricted with all other types of anchors.

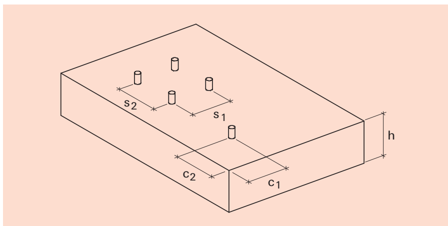
Figure 2.2:
Fixture thickness with non-loadbearing layer (e. g. plaster, tiling)



2.3.4 Edge and axial spacing, component thickness

The axial spacing s and respectively edge distance c for fixings are defined by the spacing of the fixing's axis to the adjacent fixing respectively to a free edge. The components thickness h is defined by the thickness of the structural element as shown in figure 2.3.

Figure 2.3:
Definition of axial (s_1, s_2) and edge distances (c_1, c_2) and of the component thickness h



In order that the fixing carries the maximum possible load, defined axial $s_{cr,N}$, $s_{cr,sp}$ and edge distances $c_{cr,N}$, $c_{cr,sp}$ are necessary. To prevent spalling, cracking and splitting of the base material during installation, minimum values s_{min}, c_{min} and h_{min} must be observed. The necessary spacings are given in the respective part of the fischer Technical Handbook, tables "Anchor characteristics". The values $s_{cr,N}$, $c_{cr,N}$, $s_{cr,sp}$ and $c_{cr,sp}$ are given in the respective part of the fischer Technical Handbook, tables 4.3.1 "Concrete cone failure" and 4.3.2 "Concrete splitting".

2.3.5 Type of installation

The three different types of installation are as follows:

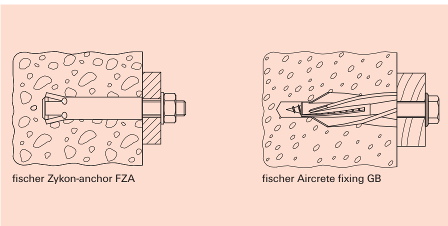
- Pre-positioned fixing
- Push-through fixing
- Stand-off fixing

A pre-positioned fixing can be seen in figure 2.4a, whereby the drill hole is made before the attachment is put in position. The drill hole is generally larger than the hole in the attachment.

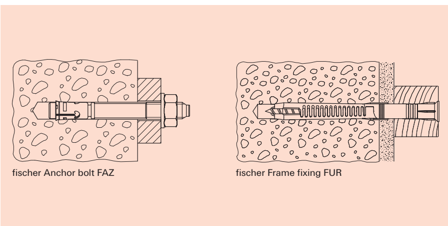
With push-through fixings the hole is drilled through the attachment into the substrate and thereafter the fixing is pushed through the hole into position (see figure 2.4b). Thus the drill hole in the attachement has at least the same size as the drill hole in the substrate.

Stand-off fixing provides support of the attachment by a pre-determined distance away from the surface of the substrate (see figure 2.4c). Often steel anchors with internal threads are used for these applications.

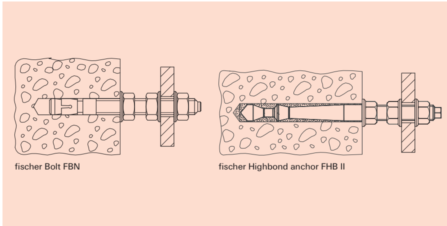
Figure 2.4:
Type of installation



a) Pre-positioned fixing



b) Push-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 the fischer Technical Handbook.

2.4 Type and direction of the load actions

The application of a load (force) in the construction industry terminology is currently referred to as the ‚action´. The following compilation (Table 2.3) of local actions is taken from /10/. Their duration and frequency consider the actions. Further distinction is made between action with or without forces of gravity.

Forces of gravity are caused either through impact, earthquake or machines with high 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. This is also known as mainly static or predominantly static actions. Where, however the load constantly alternates with no mass to consider, then this is known as a constantly changing load, due in some cases to fatigue. Should a mass however act, regardless of the number of load changes then it is considered as being dynamic.

Static loads are the sum of dead loads and slowly alternating loads. The unchanging loads are the results of the weight of the attachment (for fixing) and permanently static loads such as floor screeds or plaster. Slowly, alternating loads are due to human traffic, furniture, non-loadbearing partition walls, warehouse materials, wind and snow. The extent of these loads must be taken from each respective country standards for loading of buildings.

Deformations of the attachment may also take place due to creep or movement in concrete and temperature changes. Temperature changes leading to deformations of the attachments may take place with facades or other situations such as chimneys, silos hot and cold storage rooms. By preventing movements of this kind, additional forces may be applied to the anchors, whose geometry, position and the material in which the anchor is installed can have a further influence. 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 useful life of 50 years one load alternation per day in average.

Constantly changing loads (fatigue) are such as those found on craneways, bridge traffic, machines and lifts. The magnitude of the actions must be considered in accordance to each countries own relevant standard. In general, standards regulate whether the action is either static, changeable or fatigue. In accordance to EN 1991-1-4 (Eurocde 1) or 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.

2.5 Principles of function

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

Table 2.3:
Definition of respective actions /10/

Number of load changes				
None	Low		High	
	without forces of gravity	with forces of gravity	without forces of gravity	with forces of gravity
• dead load • partition walls • human trafffic • furniture • warehouse materials • snow • water • wind • restraint	• restraint	• impact • earthquake • explosion	• traffic on bridges and cellar roofs • craneways • lifts • machines without mass accelerations	• machines with high mass accelerations such as presses, stamping machines and rams
• mainly static actions		• dynamic actions	• alternating actions	• dynamic actions

fischer FIXING SYSTEMS

Basic principles of fixing technology

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 substrate. An undercut hole is formed using a special drill bit (FZUB). The anchor locks into the undercut hole.

Friction is the 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). Displace-

Figure 2.5:
Type of loads

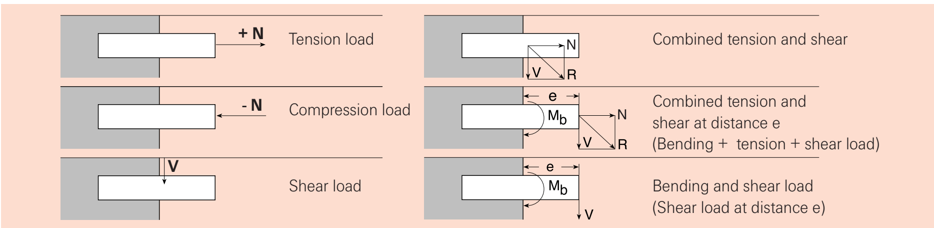
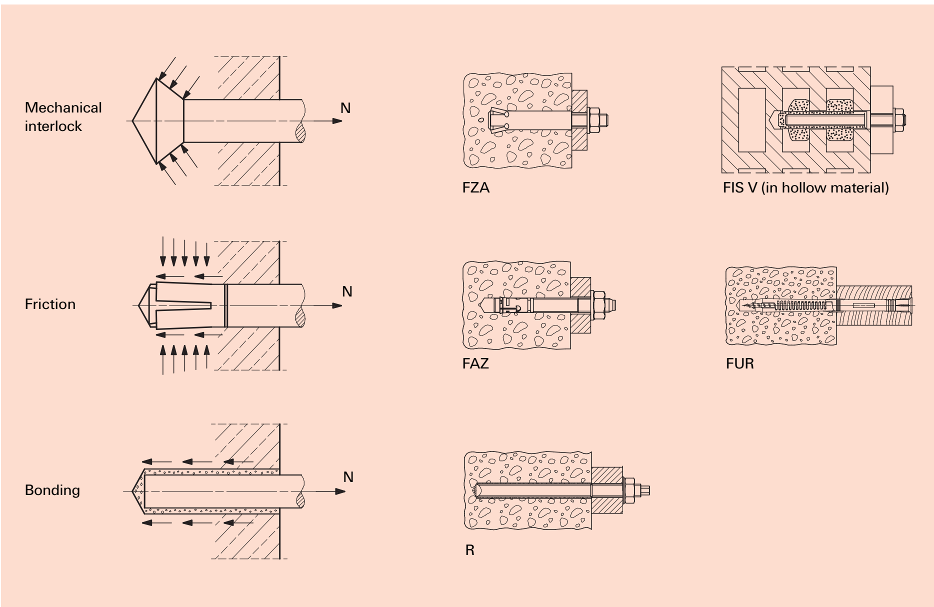


Figure 2.6:
Principles of function



ment-controlled anchors are expanded by hammering a cone into a sleeve. The necessary displacement is defined (displacement-controlled). Examples for expansion anchors are the fischer high performance anchor (FH II-H, FH II-B, FH II-S, FH II-SK), fischer anchor bolt (FAZ II), fischer bolt (FBN) and fischer hammerset anchor (EA II). In addition the nylon fixings fischer universal frame fixing FUR or fischer frame fixing (SXS and SXR) and also the fischer hammerfix (N) are further examples.

The third principle of function is bonding. In this case, the load is transferred from the anchor to the substrate by the bonding material e.g. hardened resin mortar. Examples are the fischer resin bonded anchor (type R) and the fischer Injection mortar FIS V.

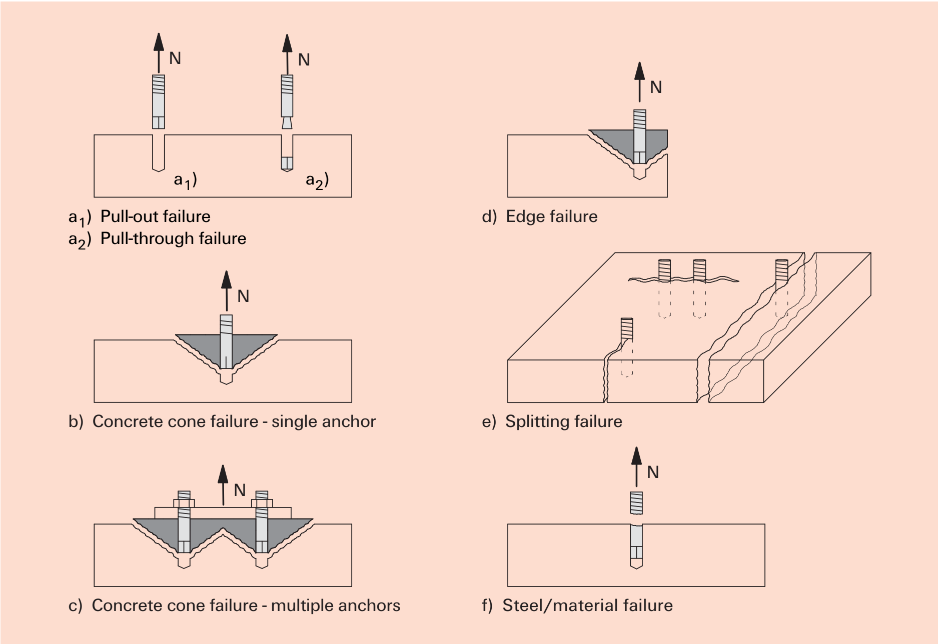
2.6 Modes of failure

Fixings can fail due to a number of circumstances. Importance is given to the understanding of the various load directions.

2.6.1 Axial 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 2.7a_1), the anchor is withdrawn from the substrate without significant damage to the concrete. Insignificant spalling may occur close to the substrate‘s surface but this does, however, have no effect upon the anchor‘s load bearing capacity. Pull-out may occur with expansion anchors whereby the expan-

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



sion force is too low to keep the anchor in its required position until concrete failure occurs.

With pull-through (figure 2.7a_2) the cone or cone bolt is pulled through the expansion sleeves or segments, which remain in the hole. Pull-through may also occur with expansion anchors, where the expansion forces are high.

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 spacings 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 spalling effect (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 axial respectively edge distances are too small.

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

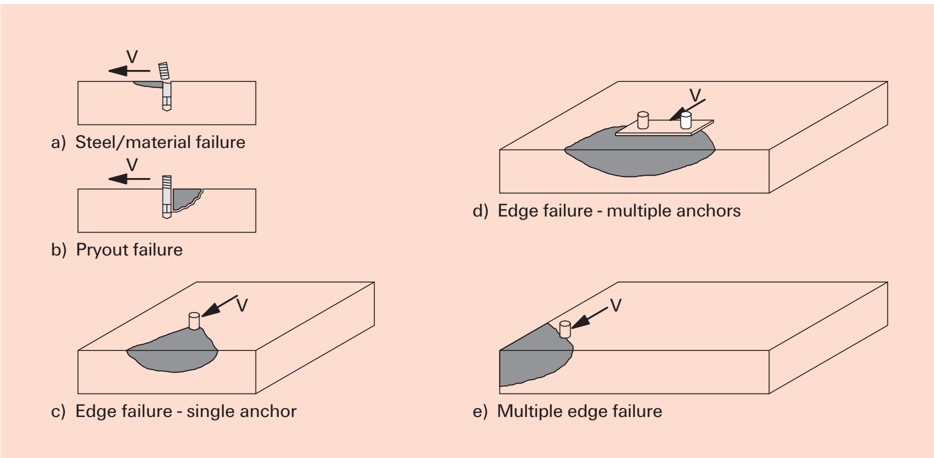
Similar types of failure as with undercut and expansion anchors can also occur with resin bonded anchors. Pull-out occurs when the bond between the drill hole and the mortar or between the threaded rod and the mortar fails. Normally a mixed failure (pull-out and concrete failure) occurs where the break-out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

In masonry the maximum load bearing capacity is 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.

2.6.2 Shear load

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

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



For anchors with large edge distances 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 axial tension, this mode of failure gives the highest possible load bearing capacity.

Short and stiff anchors or groups with small axial spacings can under shear load fail due to concrete break-out on the opposing side of the load application (pryout failure) (see figure 2.8b).

Anchors with small edge distance can lead to the failure of the concrete's edge (see figure 2.8c). Anchors near an edge with reduced axial spacings can lead to a combined break-out body (see figure 2.8d) also anchors positioned close to a corner, can result in the complete failure of the corner (see figure 2.8e).

Again for the failure mode concrete edge failure shear loads which act straigth to the edge are only to be considered on the first anchor row which is nearest to the edge if the group of anchors has more than one row of anchors parallel to the edge.

Only when it is guaranteed that the shear load acts on all anchors right for the beginning without displacement it is allowed to consider the full number of anchors. To ensure that no displacement appears the annular gap between bolt and anchor plate has to be filled with a pressure-resistant material (e. g. fischer Injection mortar FIS V or FIS EM).

Fixings in masonry fail due to steel or masonry failure.

2.7 Influencing parameters

2.7.1 Base material strength

The main failure mode of undercut anchors and expansion anchors with sufficient expansion force under axial tension load is conical concrete break-out. The magnitude of the failure is greatly influenced by the strength of the concrete. Figure 2.9 shows the failure load N_u of fischer Zykon anchors (bolt projecting) in non-cracked concrete as a function of the concrete cube strength $f_{cc,\ 200}$ (dimensions 200 x 200 x 200 mm³). Recognition is given to the fact that with an increase in concrete strength, an increase in failure load can be expected. This increase is non-linear but proportional to the square root of the concrete strength.

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

Figure 2.9:
Ultimate load N_u of fischer Zykon anchors (bolt projecting) subject to tensile load in non-cracked concrete in relation to the concrete compressive strength $f_{cc,\ 200}$

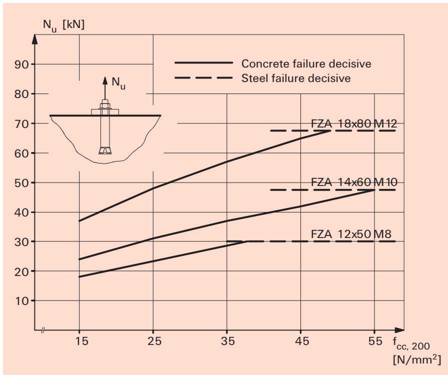
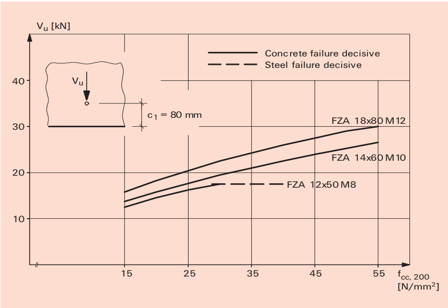


Figure 2.10 shows the relationship of the concrete failure load of fischer Zykon anchors (bolt projecting) in non-cracked concrete under shear load and the concrete cube strength $f_{cc,\ 200}$. This illustration is valid for anchors that have an edge distance c_1 = 80mm which are loaded towards a free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

Figure 2.10:
Ultimate load V_u of fischer Zykon anchors (bolt projecting) subject to shear load in non-cracked concrete in relation to the concrete compressive strength $f_{cc, 200}$



As with axial tension load recognition is given to the fact that the failure load is dependent upon the strength of the concrete. The failure load increases proportionally to the square root of the concrete strength and is limited by the anchor's steel strength.

The concrete failure loads under both, axial tension as well as shear load are influenced by the square root of the concrete strength. This is because in both cases use is made of the concrete's tensile strength which can be described by the square root of the concrete compressive 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 substrates, however, the relationship cannot be measured as accurately as with concrete. A greater number of parameters such as the type, size and structure of the materials need further consideration.

2.7.2 Anchorage depth

The failure load of an anchor under axial tension load is influenced by its anchorage depth. Figure 2.11 illustrates the concrete failure load N_u of fischer Zykon anchors (bolt projecting) due to a tensile load in non-cracked concrete in relation to the anchorage depth h_{ef}. The increase follows by a superproportional relationship to the anchorage depth and is proportional to anchorage depth to the power of 1.5. The ultimate load is restricted again by the anchor's steel strength.

Figure 2.11:
Ultimate load N_u of fischer Zykon anchors (bolt projecting) subject to tensile load in non-cracked concrete in relation to the anchorage depth h_{ef}

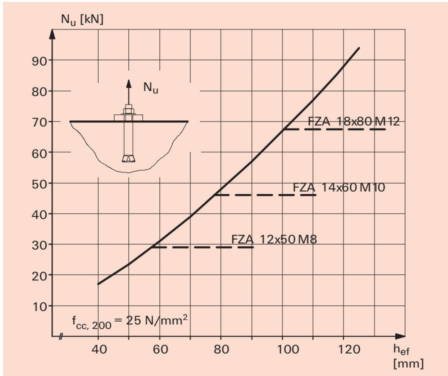
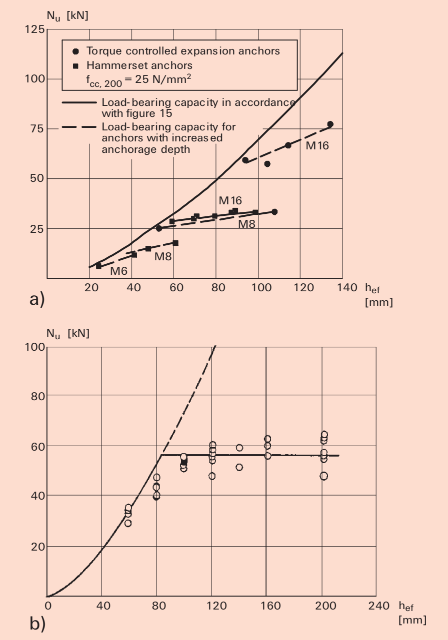


Figure 2.11 is valid only when the undercut or the expansion force is sufficiently large to create concrete failure for the given anchorage depth. Should the anchor's embedment depth be increased, then the undercut or expansion force is often insufficient to cause concrete failure. Then the anchor displaces and in doing so reduces its anchorage depth which then leads to concrete failure or to pull-through failure (compare figure 2.7a$_2$) This means that the ultimate loads of anchors with an increased embedment depth, show only a small increase in load. The figures 2.12a and 2.12b show this relationship /1, 9/. The figures are valid for hammerset anchors (figure 2.12a) and torque-controlled expansion anchors respectively (figures 2.12a and 2.12b). The failure load increases insignificantly (figure 2.12a), because the expansion force is not optimised in accordance to the anchorage depth.

Figure 2.12:
Failure load of anchors due to an inrease in the anchorage depth for anchors subject to axial tension load /1, 9/
a) Torque-controlled and displacement-controlled anchors with different sizes /1/
b) Torque-controlled anchors M 16 /9/



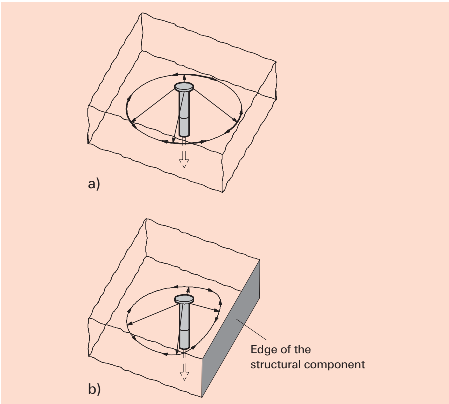
With shear loads the influence of the anchorage depth on concrete failure is only indirectly due to the stiffness of the anchor. However, this influence is only small and requires no further examination.

2.7.3 Edge distance

Anchors with sufficient undercut and expansion capacity fail due to axial tension load in consequence of conical concrete break-out. The break-out body develops from the area of undercut or expansion at an angle of approximately 35° in relation to the concrete surface. This results in the 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 restriction by edges. 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, a reduction in the ultimate load has to be expected.

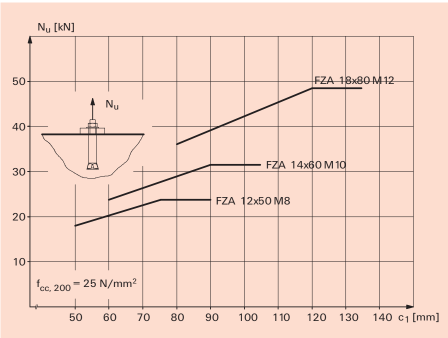
For anchors with sufficient edge distance the balance between external and internal forces is guaranteed by tensile hoop stresses, that means the stresses in the concrete are radially symmetric to the anchor (see figure 2.13a) /10/. A reduction of the edge distance causes a change of the radially symmetric stress distribution and thus a reduction of the concrete failure load (see figure 2.13b). Both parameters, the truncation of the break-out body as well as the disturbance of the stress distribution are self-super-imposing. Figure 2.14 shows the ultimate load N_u of fischer Zykon anchors (bolt projecting) subject to axial 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 2.13:
Distribution of forces in the area of a cast-in headed stud subject to axial tension /10/



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 and is not restricted by the edge.

Figure 2.14:
Ultimate load N_u of fischer Zykon anchors (bolt projecting) subject to tensile 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 spalling-off of the edge (compare section 2.6.2, figure 2.8c). 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 2.15). The height of the break-out body is in accordance with test results approximately 1.5 times the edge distance c_1.

Figure 2.15:
Form and dimensions of the concrete break-out body for a single anchor under shear loading close to an edge.

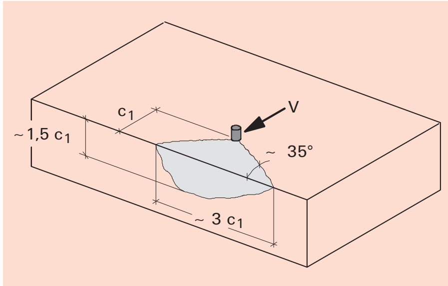


Figure 2.16:
Ultimate load V_u of fischer Zykon anchors (bolt projecting) subject to shear load in non-cracked concrete in relation to the edge distance c_1.

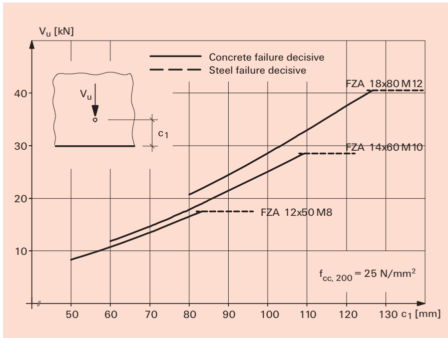


Figure 2.16 shows the concrete failure load V_u of fischer Zykon anchors (bolt projecting) due to shear load in non-cracked concrete in relation to the edge distance c_1. The increase follows by a superproportional relationship to the edge distance and is proportional to edge distance to the power of 1.5. The ultimate load is restricted again by the anchor's steel strength.

2.7.4 Axial spacing

The axial spacing has also a tremendous influence upon the concrete load bearing capacity. The maximum failure load of anchors subjected to axial tension load is only achieved when the complete break-out cone can develop unrestricted. Figure 2.17 should make this clear with the example of a pair of anchors subject to tension load.

Figure 2.17a shows a pair of anchors with an axial 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 thereby the two anchors achieve the maximum capacity. This means the ultimate load for the pair of anchors is equal to two times the maximum load for a single anchor.

In figure 2.17b, the axial spacing of the anchors is less than the diameter of the expected failure cone. The failure cones intersect each other and therefore resulting 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 2.17c), only one break-out 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 2.17a. To simplify matters, a linear relationship is taken between the extreme values illustrated in figures 2.17a and 2.17c.

Figure 2.18 demonstrates the effect of the axial spacing for a pair of fischer Zykon anchors (bolt projecting) subject to axial tension load in non-cracked concrete with a strength of $f_{cc,\ 200} = 25\ N/mm^2$. The horizontal axis shows not the absolute values of the spacing but those of the ratios of the axial spacing to the anchorage depth.

An increasing axial spacing to the point where the break-out cone's diameter is achieved ($s = 3 \cdot h_{ef}$) causes an increase of failure load. For larger axial spacings it is natural not to expect a larger failure load because the maximum capacity of a pair has been reached.

Figure 2.17:
Intersection of the break-out bodies for anchors subject to axial tension load

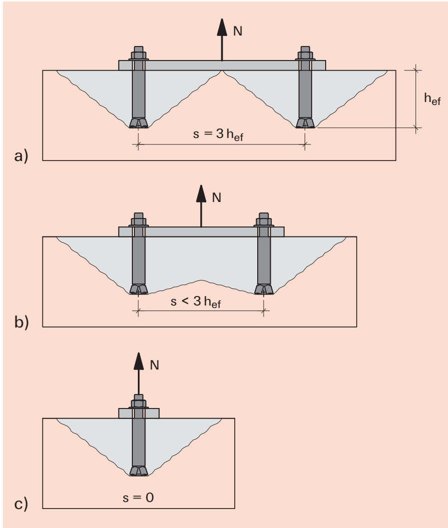
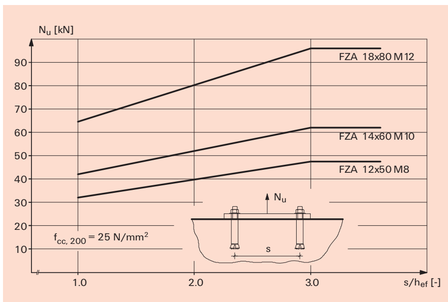


Figure 2.18:
Ultimate load N_u of a pair of fischer Zykon anchors (bolt projecting) subject to tensile load in non-cracked concrete in relation to the ratio of the axial spacing s and the anchorage depth h_{ef}



When a group of anchors with a large edge distance is loaded by a shear force, normally steel failure will occur, even with small axial spacings. With short and stiff anchors and/or groups with small axial spacings within the group concrete failure may occur due to break-out on the opposing side of the load application (pryout failure) (compare section 2.6.2,

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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 axial spacing of the anchors has an overwhelming influence. This can be seen in figure 2.19.

In accordance with Figure 2.15 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 axial spacing of the anchors has a minimum value of 3 times the edge distance, in this situation the break-out bodies do not intersect and thereby the two anchors achieve the maximum capacity (compare figure 2.19a). This means the ultimate load for the pair of anchors is equal to 2 times the maximum load for a single anchor. If the axial spacing of the anchors is reduced (see figure 2.19b) then the expected failure bodies intersect each other and therefore 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 2.19c), 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 2.19a. To simplify matters, a linear relationship is taken between the extreme values illustrated in figures 2.19a and 2.19c.

Figure 2.20 illustrates this relationship for a pair of fischer Zykon anchors (bolt projecting) 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 component with a sufficient thickness. The thickness is sufficient if the break-out body can develop completely on the side face of the structural component ($h \geqq 1.5\ c_1$) (compare figure 2.15).

The failure load of a pair increases with increasing axial spacings until the spacing reaches 3 times the edge distance. For larger axial spacings no further increase in ultimate load can be expected because the maximum capacity of the pair cannot exceed 2 times 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 pair is limited by the steel failure load.

Figure 2.19:
Intersecting of the break-out bodies of anchors under shear load close to an edge

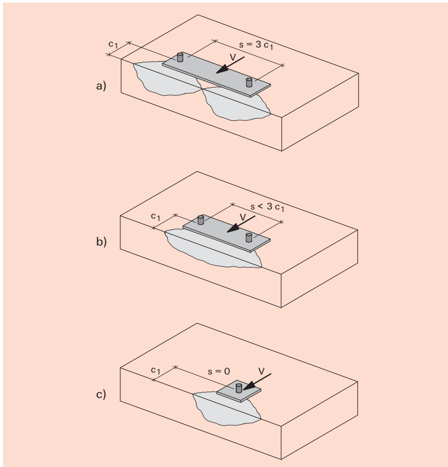
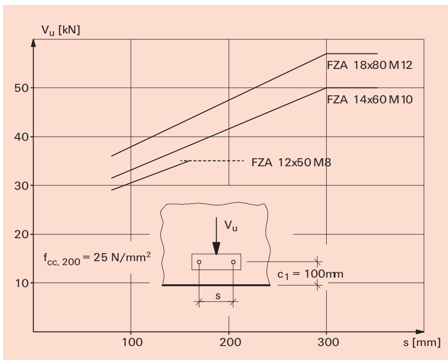


Figure 2.20:
Ultimate load V_u of pairs of fischer Zykon anchors (bolt projecting) in non-cracked concrete subject to shear load in relation to the axial spacing s (edge distance c1 = 100 mm)



2.7.5 Concrete component thickness

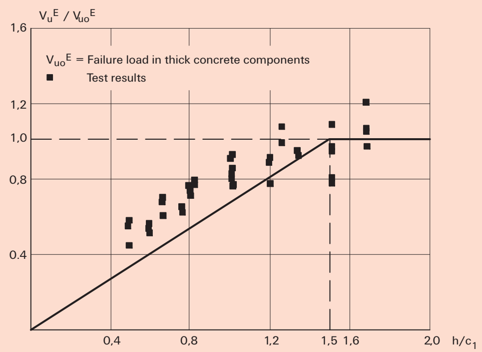
With axial tension load the concrete component thickness has only an indirect influence on the load bearing capacity of the anchor. Should the thickness, however, be insufficient problems may arise during installation or also due to the load of the anchor. In the case of splitting the maximum concrete 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 component with at least the minimum thickness h_{min}. The minimum values of the structural component thickness are given in the respective part of the fischer Technical Handbook, tables "Anchor characteristics".

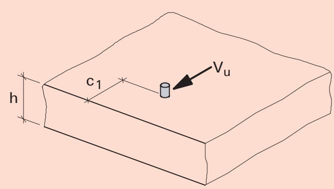
In comparison to the behaviour of anchors under axial tension load, the load bearing capacity of anchors close to an edge under shear load is greatly affected by the structure component thickness. This can be seen in figure 2.21. The diagram shows on the horizontal axis the ratio between the component thickness and the edge distance, and on the vertical axis the ratio of the ultimate load from testing and the calculated value for anchors in thick structural components. It shows that the ultimate load increases when the structural component also increases in thickness, until approximately 1.5 times the edge distance is reached. This can be explained in accordance with figure 2.15. It shows that the height of the concrete failure body on the side surface of the structural element is about 1.5 times the edge distance c_1. Should the thickness be less than 1.5 times the edge distance, the break-out body is truncated on its lower edge and therefore, the load bearing capacity is reduced (see figure 2.21).

2.7.6 Cracks

Concrete demonstrates a relatively low tensile strength which may be totally or partially consumed by induced deformations due to shrinkage or temperature. For these reasons during the design of reinforced concrete elements, the tensile strength of the concrete must not be taken into consideration. Therefore, 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 will not exceed the values of w ~ 0.3 to 0.4mm /2/, /3/, /4/. Under permissable design loads larger cracks

Figure 2.21:
Influence of the component thickness h upon the load bearing capacity of steel anchors subjected to shear load close to an edge





can be expected, whereby, the 95%-fractile may reach values up to $w_{95\%}$ ~ 0.5 to 0.6mm /3/. The 95% fractile is the value which is not exceeded by 95% and exceeded by 5% of all cracks in the structural element. Most national standards limit the crack width in the serviceability limit state.

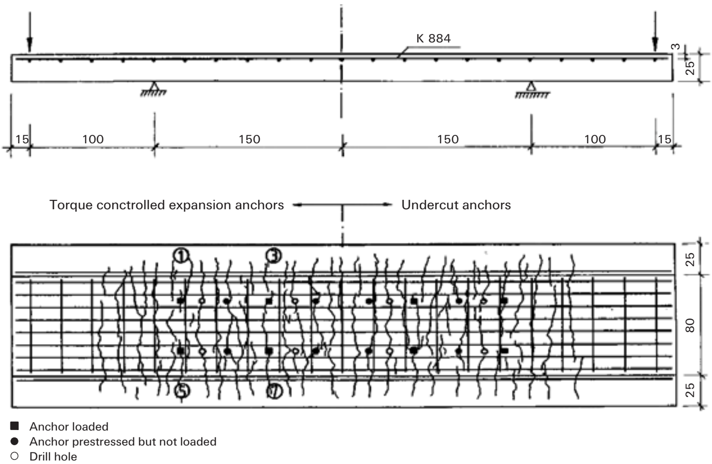
When cracks occur there is a high probability that they either are attracted directly to the anchor or tangentially pass by. In the immediate area of the anchor increased tensile forces are present. These are caused by resulting splitting forces due to the anchor's pre-tension and applied load, the peak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

In order to confirm this, tests were conducted with concrete samples with a thickness of h = 250 mm /11/.The samples were reinforced with bars or welded reinforcement mesh. The spacing of the transverse reinforcement was 250 mm. Undercut and torque controlled expansion anchors were installed into the concrete (M12, h_{ef} = 80 mm). The anchors were loaded to either the recommended torque or 1.3 times the permissible load and the spacing to the transverse reinforcement varied between 40 and 80 mm. Some of the drill holes are left free with no anchors installed. The anchors were installed in non-cracked concrete and loaded. Finally, the concrete samples were loaded in steps until their permissible load was reached.

At approximately 40% of the permissible load, bending cracks started to appear in the concrete. Under the permissible load, almost all of the anchors and drill holes were seen to be affected by the cracks, regardless of the spacing between the anchors and the transverse reinforcement and type of load (see figure 2.22). The cracks went directly through the anchorage zone. Similar results are described in /2,12,13/.

Figure 2.23 shows for the simple example of a structure with a uniformly distributed load in which areas of the structure cracks may occur. 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

Figure 2.22:
Crack pattern in a reinforced concrete sample at service load subjected to bending (measures in [cm]) /11/



cracks and their location. In the worst case the compressive zones may become tensile zones with changing loads. This very simple example highlights the difficulty in determining the position of cracks. This applies particularly to complicated multi-framework type structures.

Should the designer, or user, be unable to determine both tensile and compressive zones in the structure, we would recommend a range of anchors that are suitable for applications in cracks, such as:

- fischer Zykon anchor FZA (bolt projecting)
- fischer Zykon anchor FZA-D (through bolt)
- fischer Zykon anchor FZA-I (internal thread)
- fischer Zykon hammerset anchor FZEA
- fischer anchor bolt FAZ
- fischer high performance anchor FH II-H, FH II-B, FH II-S, FH II-SK
- fischer Long-shaft fixing SXS and SXR
- fischer Highbond FHB II

How do anchors behave in cracked concrete?

Figure 2.24a 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, an anchor, which has been designed for use in non-cracked concrete, be used for cracked concrete, then the behavior of the anchor in cracks is altered significantly. Figure 2.24b shows test measured load displacement curves for torque-controlled expansion anchors which are only suitable for applications in non-cracked concrete, rather than cracked concrete. It can be seen that the anchors only in non-cracked concrete have a continuous increase in load displacement behavior. However, in cracked concrete the load displacement behavior and maximum load have a large scatter of results with no indication of when failure is likely to occur. In extreme cases with relatively low increase in load, the anchor is pulled out of the concrete (see figure 2.24b, lower curve).

Figure 2.23:
Typical crack pattern in a frame under uniformly distributed load

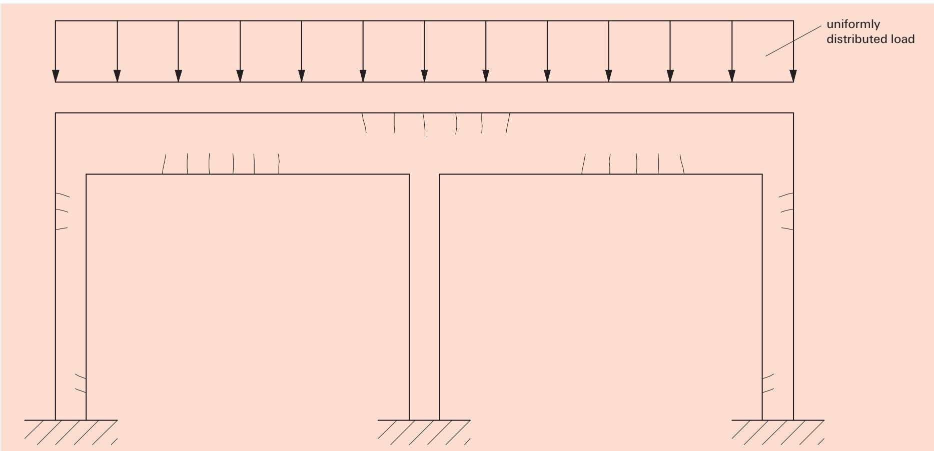
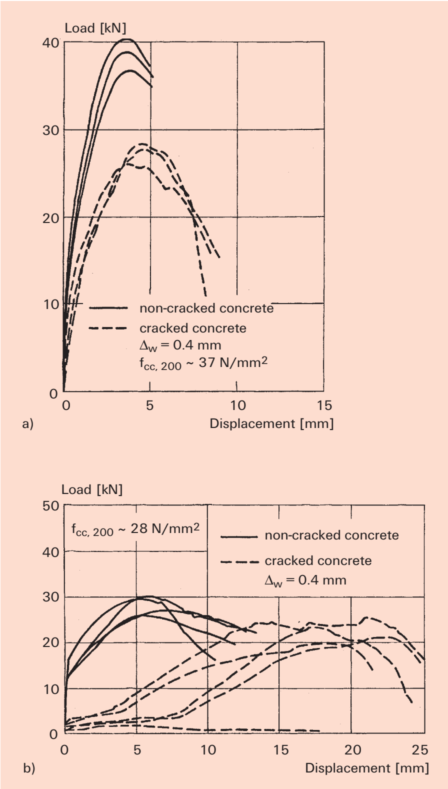


Figure 2.24:
Load-displacement curves of torque-contolled expansion anchors (M12, h_{ef} = 80 mm)

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

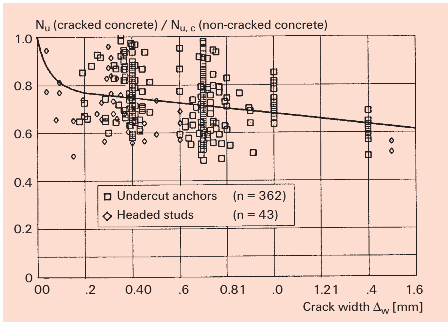


In figure 2.25 the ratio of the failure load of undercut anchors and cast-in headed studs under axial tension load in cracked concrete and the theoretical value in non-cracked concrete is shown as a function of the crack width differences Δw. The crack width differences are defined by the crack width between the installation and the loading of the anchor.

The test values are from /10/ and found as follows: In the first instance, hairline cracks appear in the reinforced element, in which the anchors are installed. Followed by the opening of the cracks by the amount of Δw and loading of the anchor to failure.

Figure 2.25 shows that undercut anchors and cast-in headed studs behave the same in cracks. The failure load is reduced considerably even with small cracks and achieves in a crack with a width of Δw = 0.4mm as an average value approximately 75% of the capacity of anchors in non-cracked concrete. For increased crack widths to the value of Δw = 1.6 mm only a small further decrease in load is to be expected. fischer Zykon anchors and cast-in headed studs behave the same in cracks because they have the same principle of function: mechanical interlock (see section 2.5, figure 2.6)

Figure 2.25:
Influence of cracks on the ultimate load of undercut anchors and headed studs under tension load /10/



A similar relationship in cracked concrete is experienced with torque-controlled expansion anchors, which are suitable for applications in cracks (see figure 2.26). The anchors must be able to develop further expansion (post expansion). As the crack opens the anchor's cone is drawn further into the sleeve, both expanding and bridging the crack at the same time. The torque-controlled expansion anchor, fischer anchor bolt (FAZ II) and fischer high performance anchor (FH II-H, FH II-B, FH II-S, FH II-SK) as well as the torque-controlled bonded anchor (FHB II) are suitable for applications in cracks.

Similar to undercut anchors and cast-in headed studs, the failure load is reduced even with small cracks (see figure 2.26). With a crack width in the region of 0.4 mm the ultimate load is reduced to approximately 65% of the value in non-cracked concrete. With ever increasing crack widths, a reduction in the ultimate load also occurs. The reduction is larger than with undercut anchors and cast-in headed studs. The cone is drawn into the expansion sleeve and thus the anchorage depth is reduced. This behaviour depends on the type of anchor.

Figure 2.26:
Influence of cracks on the ultimate load of torque-controlled anchors under tension load /10/

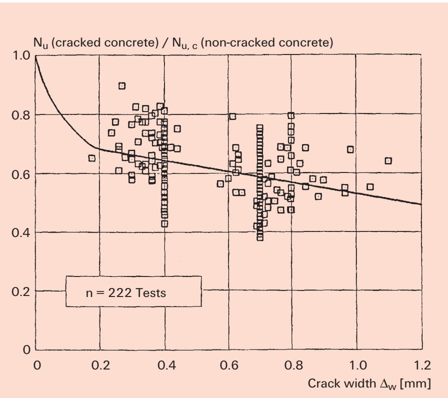
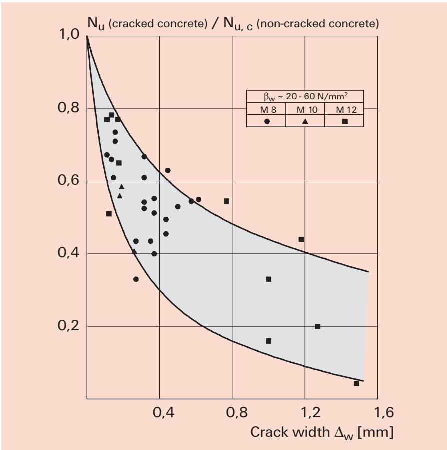


Figure 2.27 shows the influence of cracks on the load capacity of hammerset anchors under axial tension load. The capacity decreases extremely with increasing crack widths and the range of scatter of the test results is rather high. It must be pointed out that this figure is valid for fully expanded hammerset anchors. For partially expanded hammerset anchors an even higher reduction can be expected.

A similar relationship as that given in figure 2.27, is also expected for torque-controlled expansion anchors with no capacity to post-expansion and therefore, are **not suitable** for use in cracked concrete. In this situation neither the ultimate load nor the load-displacement behaviour of the anchor can be forecasted accurately. In extreme cases the capacity may be reduced to zero. That means the influence of cracks **can not** be considered by increased safety factors.

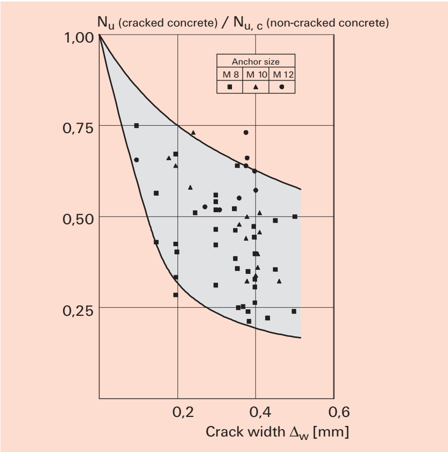
Common resin bonded anchors which consist of threaded rod and resin capsule are significantly influenced by cracks (compare figure 2.28). It is noticeable that the load in a crack with a width of 0.4 mm is as a mean value approximately 40% of the ultimate load in non-cracked concrete. In extreme cases this may be reduced to as little as 20%.

Figure 2.27:
Influence of cracks on the ultimate load of fully expanded hammerset anchors under axial tension load /5/



The figures 2.25 - 2.28 are valid for the behaviour of anchors in cracks subject to axial tension load. With shear load, the difference between anchors close to an edge and without edge influence should be acknowledged. The ultimate load for anchors with no edge influence is affected only to a rather small extent by cracks. Compared with the capacity in non-cracked concrete a reduction in ultimate load of < 10% can be seen. Anchors positioned close to an edge are greatly effected by cracks. The ultimate load of an anchor located in a crack of Δw = 0.4 mm is approximately 75% of the value in non-cracked concrete. The reduction of the concrete edge failure load due to cracks is therefore of the same magnitude like the reduction of the concrete cone failure load under tension.

Figure 2.28:
Influence of cracks on the ultimate load of resin bonded anchors under axial tension load /6/



2.8 Testing of anchors
2.8.1 Requirements

Function and load bearing capacity of the steel anchors described in this Technical Handbook are based upon comprehensive testing in accordance with the guidelines and test regulations for approved testing of the German Institute for Building Technology, Berlin and more recently on the basis of the guideline of the European Organisation for Technical Approvals (EOTA) /7/.

This is based upon two different groups of tests:

- Tests to prove function (functioning tests)
- Tests to determine the permissible service conditions

Function proving tests consider whether the anchor is sensitive to un-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 hammerset anchors
- Incorrectly mixed mortar, drill hole incorrectly cleaned, drill hole filled with water, with resin bonded anchors or injection systems

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

As already mentioned functioning tests consider whether the anchor is sensitive to un-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. hammersetting instead of hammering rotating the threaded rod for resin bonded anchors) cannot be considered in these tests.

Functioning 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 upon load performance, both new and worn bits are used in tests.

Additional functioning tests are carried out with alternating loads (not dynamic loads!) as in reality, anchors are often subjected to load changes.

Anchors for use in cracked concrete have special test requirements called for. The anchor's functioning must be 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. 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. The remaining test conditions depend upon the anchor's principle of function. For example torque-controlled expansion anchors are installed in one test series to 50% of their recommended torque in order to judge the influence of a reduced torque on the anchor's performance. In further series of tests the maximum torque is applied, but in order to simulate the effect of creep and shrinkage of the concrete the torque is reduced to half its original value after a further ten minutes.

Should the anchor's base material 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 sustained load. Finally the cracks are opened and closed a thousand times by $\Delta w \sim 0.2$ mm. Once the movement of the cracks has stopped, the anchors are then pulled out from the open crack.

All functioning tests of anchors must display a suitable load displacement relationship. The load displacement curves should climb continually until about 70% of the ultimate load has been achieved with no horizontal interruptions, which would indicate that the anchor has slipped in the drill hole. The ultimate load during the functioning tests may be reduced by a pre-determined percent compared with the ultimate load of anchors which are installed in accordance with the manufacturer's instructions. For tests in opened and closed cracks, the measured displacement plotted to the logarithm of the number of crack movements must either be linear or diminishing and must not exceed required values.

In tests to determine the permissible service conditions, the permissible loads and the appropriate axial and edge distances and the structural component dimensions are stipulated. Therefore, the anchors are installed in accordance with the manufacturer's instructions. To determine the influence of the load direction upon the ultimate load, anchors are tested subjected to axial tension, shear and combined loads. For anchors that are suitable for use in cracked concrete, these tests are conducted in cracks with a width of approximately 0.3 mm.

Due to the results of these tests and in order to make this applicable to the application conditions, characteristic values for the tested anchor's resistance in non-cracked and for crack proof anchors also in cracked concrete are determined. These values are as follows:

$N_{Rk,s}$ characteristic resistance of an anchor in case of steel failure when subjected to a tension load

$N^0_{Rk,c}$ characteristic resistance of an anchor in case of concrete cone failure when subjected to a tension load

$N_{Rk,p}$ characteristic resistance of an anchor in case of pull-out/pull-through failure when subjected to a tension load

$V_{Rk,s}$ characteristic resistance of an anchor in case of steel failure when subjected to a shear load

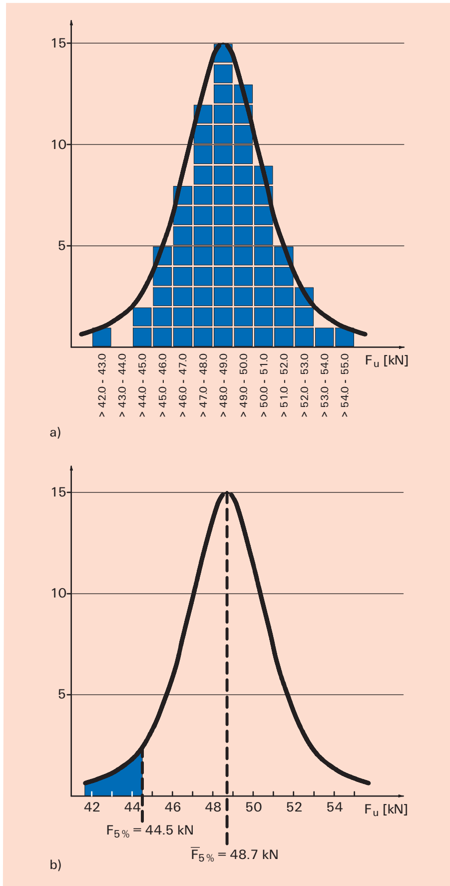
In addition the characteristic axial spacings and edge distances are determined by the maximum tensile load bearing capacity for cone failure, concrete and splitting. These values are as follows:

- $s_{cr,N}$ characteristic axial spacing for concrete cone failure when subjected to a tensile load
- $c_{cr,N}$ characteristic edge distance for concrete cone failure when subjected to a tensile load
- $s_{cr,sp}$ characteristic axial spacing for splitting when subjected to a tensile load
- $c_{cr,sp}$ characteristic edge distance for splitting when subjected to a tensile load

In order to prevent splitting during installation, the minimal axial spacings and edge distances (s_{min}, c_{min}) as well as the minimum structural component thickness (h_{min}) must be observed. These values are also established from tests.

The characteristic values of resistance for the various load directions and modes of failure are in accordance to the so-called 5% fractile obtained from ultimate load test results. The 5% fractile represents the load where 5% of the test results fall below and 95% of the results exceed this value. To determine the characteristic value, the 5% fractile is used rather than the mean value of the test results as basic value, so as to differentiate between the range of scatter of the test results for various anchor types and sizes. Figure 2.29a 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 $F_u \leq 43$ kN, and the last classification all the values between $F_u > 54$ kN and $F_u \leq 55$ kN (each square represents one result). The results are suitably evaluated by use of the Gauss curve, as shown in figure 2.29a. Figure 2.29b 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 2.29:
Frequency distribution for a series of tests with undercut anchors having failed due to concrete cone failure



The 5% fractile is determined by the eqn. (2.1). Shown on page 30 in this Technical Handbook the characteristic values for the resistance are given as the 5% fractile in accordance to Owen /14/. It is assumed that the standard deviation for both, the population as well as the sample are 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/14/
= 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

2.8.2 Anchor testing at fischerwerke

In the research and development centre at fischerwerke (figure 2.30) the most modern test equipment and machines are available that allow for all the aforementioned tests to be conducted in-house.

Figure 2.30:
Research and development centre

Tensile test machines with various load attachments allow tensile tests in small specimens (figure 2.31) or in large concrete elements (figure 2.32) also in cracked and non-cracked concrete. The load can be continually applied (force-controlled or displacement-controlled) also as either dynamic or shock load.

Figure 2.31:
Test equipment for small specimens

A modern testing equipment (figure 2.33) enables the testing of anchors subjected to loads at various angles (tensile, shear or combined tensile and shear loadings).

Figure 2.32:
Test equipment for high load capacities

Figure 2.33:
Equipment for tests at any angle for cracked and non-cracked concrete

For testing in static cracks, respectively with opened and closed cracks, both parallel and bending test equipment, are available. In a completely controlled environment long-term load tests on anchors are conducted.

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

2.9 References

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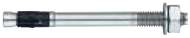
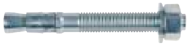
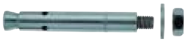
Anchor selection

3

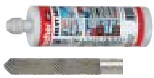
Anchor selection

Anchor type	Page	Material			Principle of function		
		Carbon steel, zinc plated (gvz)	Stainless steel corrosion resistance class III, e. g. A4	Stainless steel corrosion resistance class IV, 1.4529	Undercut	Bonding	Expansion
Anchor bolt FAZ, FAZ II 	54	●	●	●			●
Bolt FBN, FBN II 	66	●	●				●
Express Anchor EXA 	80	●					●
Zykon bolt anchor FZA 	90	●	●	●	●		
Zykon through anchor FZA-D 	102	●	●	●	●		
Zykon internally threaded anchor FZA-I 	114	●	●		●		
Zykon hammerset anchor FZEA II 	124	●	●	●	●		
High performance anchor FH II 	134	●					●
Heavy duty anchor TAM 	148	●					●
Hammerset anchor EA II 	158	●	●				●
Highbond anchor FHB II 	168	●	●	●		●	

Anchor selection

Type of installation			Installation characteristics		Screw- or bolt size	Design load in concrete C 20/25			
Through fixing	Pre-positioned fixing	Internal thread	Drill-diameter	Drill depth		non-cracked concrete carbon steel		cracked concrete carbon steel	
			[mm]	[mm]	[M]	N_{Rd} [kN]	V_{Rd} [kN]	N_{Rd} [kN]	V_{Rd} [kN]
●			8 - 24	55 - 155	8 - 24	6.0 - 47.0	9.6 - 68.8	3.3 - 33.5	6.7 - 68.8
●			6 - 20	55 - 135	6 - 20	4.0 - 36.2	4.0 - 53.6	-	-
●			8 - 20	65 - 130	8 - 20	5.7 - 34.7	8.0 - 57.3	-	-
	●		10 - 22	43 - 130	6 - 16	5.0 - 26.7	6.4 - 50.2	3.3 - 26.7	5.2 - 50.2
●			12 - 22	44 - 105	8 - 16	5.0 - 26.7	7.8 - 50.2	3.3 - 24.0	5.2 - 48.0
		●	12 - 22	44 - 130	6 - 12	5.0 - 26.7	5.7 - 18.5	3.3 - 26.7	5.2 - 18.5
		●	10 - 14	43	8 - 12	5.0	5.2 - 7.8	2.2 - 5.0	5.2 - 7.8
●			10 - 32	55 - 180	6 - 24	8.5 - 61.7	8.5 - 123.5	5.0 - 44.1	5.0 - 88.2
●	●	●	10 - 18	75 - 130	6 - 12	5.0 - 16.7	4.6 - 23.8	-	-
		●	8 - 25	32 - 85	6 - 20	5.5 - 24.0	4.0 - 47.2	-	-
●	●		10 - 25	75 - 235	8 - 24	14.6 - 91.7	10.6 - 112.8	11.2 - 73.0	10.6 - 106.4

Anchor selection

Anchor type	Page	Material			Principle of function		
		Carbon steel, zinc plated (gvz)	Stainless steel corrosion resistance class III, e. g. A4	Stainless steel corrosion resistance class IV, 1.4529	Undercut	Bonding	Expansion
Resin anchor R Chemical anchor UKA 3 	180	●	●	●		●	
Resin anchor R with RG MI 	190	●	●			●	
Injection mortar FIS V, FIS VS, FIS VW and Chemical mortar UPM 44 	200	●	●	●		●	
Injection mortar FIS V, FIS VS, FIS VW with RG MI 	214	●	●			●	
Injection mortar FIS VT 	224	●	●	●		●	
Injection mortar FIS VT with RG MI 	238	●	●			●	
Injection mortar FIS EM 	248	●	●	●		●	
Injection mortar FIS EM with rebars 	278	●	●	●		●	
Frame fixing SXS 	294	●	●				●
Frame fixing SXR 	304	●					●

Anchor selection

Type of installation			Installation characteristics		Screw- or bolt size	Design load in concrete C 20/25			
Through fixing	Pre-positioned fixing	Internal thread	Drill-diameter	Drill depth		non-cracked concrete carbon steel		cracked concrete carbon steel	
			[mm]	[mm]	[M]	N_{Rd} [kN]	V_{Rd} [kN]	N_{Rd} [kN]	V_{Rd} [kN]
	●		10 - 35	80 - 280	8 - 30	12.3 - 140.7	5.9 - 157.0	-	-
		●	14 - 32	90 - 200	8 - 20	12.8 - 76.7	7.4 - 54.9	-	-
●	●		8 - 35	50 - 360	6 - 30	4.7 - 160.2	4.0 - 157.0	-	-
		●	14 - 32	90 - 200	8 - 20	12.8 - 63.9	7.6 - 54.9	-	-
●	●		10 - 35	64 - 360	8 - 30	8.5 - 131.9	7.2 - 156.8	-	-
		●	14 - 32	90 - 200	8 - 20	12.8 - 52.8	7.6 - 54.9	-	-
●	●		12 - 35	60 - 600	8 - 30	12.7 - 262.0	7.4 - 157.6	7.0 - 219.9	7.2 - 157.6
	●		12 - 50	60 - 800	Ø 8 - 40	15.6 - 352.6	9.2 - 164.8	7.0 - 199.5	9.2 - 164.8
●			10	60	Ø 7.6 mm	1.9 - 2.8	3.5 - 4.2	1.4 - 2.3	3.3 - 4.2
●			8 - 10	60	Ø 6 - 7.6 mm	1.4 - 28	1.4 - 2.8	1.4 - 28	1.4 - 28

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 or Upat 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 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 – Option 1 for cracked concrete	**European Technical Approval** issued by a European approval authority (e.g. DIBt) on the basis of the guidelines for European technical approvals (ETAG) ETA: European Technical Approval/Options 1–12 CE: European conformity mark confirms the compliance of the building product (e.g. fixing) with the guidelines for European Technical Approvals. Products with the CE mark can be freely traded in the European economic market.
Mit allgemeiner bauaufsichtlicher Zulassung Z-21.1-958 MPA	**General building authority approval** German approval, issued by the DIBt, Berlin. Proof of compliance of the building product with the general building authority approval. confirmed by a material testing facility.
ALLGEMEINE BAUAUFSICHTLICHE CC-ZULASSUNG mit charakteristischen Tragfähigkeiten und Teilsicherheitsbeiwerten Z-21.3-1707 MPA	**General building authority approval** German approval, issued by the DIBt, Berlin for anchorings in concrete to be dimensioned according to Method A (CC method). Proof of compliance of the building product with the general building authority approval. confirmed by a material testing facility.
FM APPROVED from thread M 10	**FM Certificate** Recognised for use in local water-based fire extinguisger systems (Factory Mutual Research Corporation for Property Conservation, American insurance company).
ICC ES ESR-2691 See ICC-ES Evaluation Report at www.icc-es.org	**ICC = International Code Concoul, 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-tested fixing** The fixing was subjected to a fire test. A "Examination report regarding testing for fire behaviour" (with F class) is available.
Shock approval by the Federal office for Civil Defence, Bonn.	**Shock tested/shock approval** for shock-resistant fastenings in Civil Defence areas (Federal Ministry of Civil Defence, Bonn, Germany).
CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE	**Reference to fixing dimensioning** The fixing can be dimensioned with the fischer dimensioning software Compufix on the basis of the CC-method.
	For Sprinkler Systems. Meets the requirements according to VdS CEA 4001.

Design of anchors

Introduction

In the first parts you find general information about the basic principles of the design tables and how to handle them. In the design examples you can easily follow how to work with the tables.

The chapter 4 permits the design of fischer anchors according to their European Technical Approval (ETA). This means that all products in this chapter are approved by the European Organisation for Technical Approvals (EOTA) - except the fischer Long-shaft fixing SXS which has a German approval based on annex C of the guideline for European Technical Approval (ETAG).

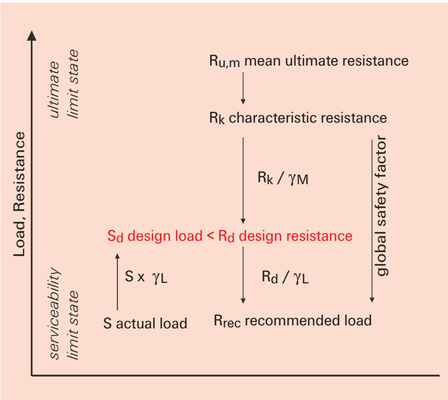
The ETA´s are valid in all member states of the European Union (EU) according the Construction Product directive (CPD).

For construction projects outside the EU anchor designs according to fischer specification (s. Technical Handbook Asia) may be sufficient.

Design of anchors

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.



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

Design method

In order to gain optimum performance of the anchors and at the same time an economical design, it is necessary to differentiate between the load direction and the mode of failure. State of the art regarding this kind of design of fastenings is the so called Concrete Capacity method (CC-method). The mean advantages of this design method are:

- Different failure modes and the corresponding load bearing capacities were taken into account, especially splitting failure under tension load and pryout failure under shear load are considered. These failure modes are often decisive in the design process.
- Differentiation of the safety factors based on different failure modes.

The used design method is based on the CC-method. However, the CC-method was simplified so that engineers could use it easily and quickly solve oncoming design questions in practical day work. For this reason in the simplified method an implying of eccentricities of tension and shear loads is not taken into account.

In terms of their load-bearing performance, resin anchors differ in a number of properties from undercut and expansion anchors. This means that specific rules and regulations must be taken into account and observed in their design. The Technical Report 029 lists these differences in a separate document.

The report also accounts for new findings and results from basic research which have evolved over the past ten years since the publication of Annex C. The most important changes affect the calculation of shear loads. Furthermore the distribution of shear loads and torsion moments within anchor groups was specified more precisely. More information can be found in TR 029.

Design actions

For design actions, a partial safety factor $\gamma_{L,G}$ = 1.35 for actions due to dead loads and $\gamma_{L,Q}$ = 1.5 for actions due to variable loads are taken into account (safety factors can vary depending on the country) . Assuming a uniform load distribution among all anchors of the fastening group one gets.

$$N_{Sd}^{h} = \frac{N_{S,G} \cdot \gamma_{L,G} + N_{S,Q} \cdot \gamma_{L,Q}}{n}$$

$$V_{Sd}^{h} = \frac{V_{S,G} \cdot \gamma_{L,G} + V_{S,Q} \cdot \gamma_{L,Q}}{n}$$

In addition to the design resistance, recommended or permissible loads are given in this handbook, using an overall partial safety factor for actions of g = 1,4.

According to ETAG 001, Annex C, concrete cone, splitting, pryout and concrete edge design resistance must be checked for the anchor group. Steel and pull-out design resistance must be verified for the highest loaded anchor of the anchor group. According to the simplified method given in this Technical Handbook all anchors of a group are loaded equally, the design resistance values given in the tables are valid for one anchor of the group (no eccentricity).

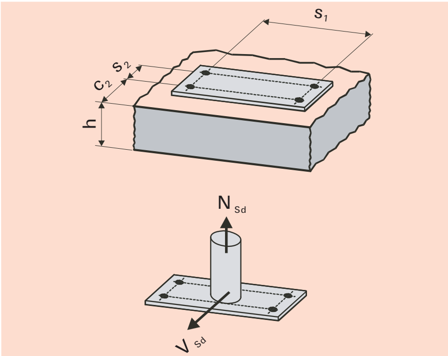
The results obtained by using the Technical Handbook lead to conservative results, i.e. the results are on the safe side. For a more complex and accurate design according to international guidelines and for optimised applications the fischer design software COMPUFIX provides customized and economic solutions.

Handling of the design tables

In the following, the design method used in this handbook will be explained using common fastening problems.

Design examples

Example 1: mechanical anchor in non-cracked concrete



Anchoring conditions		
concrete	non-cracked	C 20/25
number of anchors	group of 4 anchors	
member thickness	h	250 mm
anchor spacing direction 1	s_1	180 mm
anchor spacing direction 2	s_2	190 mm
edge distance direction 1	c_1	-
edge distance direction 2	c_2	80 mm
shear load direction	α	0°
tension design action (group)	N_{Sd}	11.55 kN
shear design action (group)	V_{Sd}	9.9 kN
tension design action (highest loaded anchor)	$N^h{}_{Sd}$	2.9 kN
shear design action (highest loaded anchor, steel failure, pry-out failure)	$V^h{}_{Sd}$	2.5 kN
shear design action (highest loaded anchor, edge failure)	$V^h{}_{Sd}$	4.95 kN
anchor		**FH 15 gvz (bolt version)**
effective anchorage depth	h_{ef}	70 mm
minimum member thickness	h_{min}	140 mm
minimum spacing	s_{min}	70 mm
critical spacing concrete cone failure	$s_{cr,N}$	210 mm
critical spacing splitting failure	$s_{cr,sp}$	320 mm
minimum edge distance	c_{min}	70 mm
critical edge distance concrete cone failure	$c_{cr,N}$	105 mm
critical edge distance splitting failure	$c_{cr,sp}$	160 mm

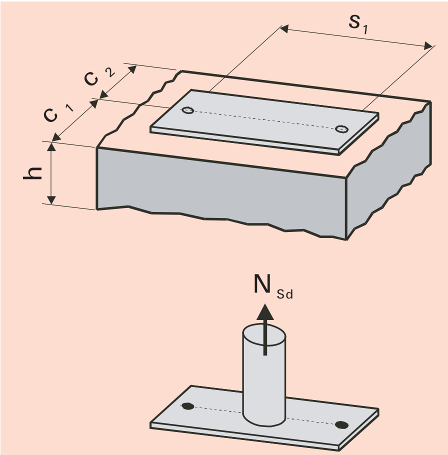
Tension loading			
steel failure			
basic design resistance		$N_{Rd,s}$	**30.9 kN**
pull-out failure			
basic design resistance		$N^0_{Rd,p}$	19.7 kN
concrete strength	C 20/25	$f_{b,p}$	1.0
		$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,p} =$	**19.7 kN**
concrete cone failure			
basic design resistance		$N^0_{Rd,s}$	19.7 kN
concrete strength	C 20/25	$f_{b,c}$	1.0
spacing s_1	180 mm	f_{s1}	0.93
spacing s_2	190 mm	f_{s2}	0.95
edge distance c_1	-	f_{c1}	-
edge distance c_2	80 mm	f_{c2}	0.82
		$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{c2} =$	**14.3 kN**
splitting failure			
basic design resistance		$N^0_{Rd,c}$	19.7 kN
concrete strength	C 20/25	$f_{b,c}$	1.0
spacing s_1	180 mm	$f_{s1,sp}$	0.78
spacing s_2	190 mm	$f_{s2,sp}$	0.80
edge distance c_1	-	$f_{c1,sp}$	-
edge distance c_2	80 mm	$f_{c2,sp}$	0.64
member thickness h	250 mm	f_h	1.47
		$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{c2,sp} \cdot f_h =$	**11.6 kN**
Minimum tension design resistance		$N_{Rd} = \min \{N_{Rd,s} ; N_{Rd,p} ; N_{Rd,c} ; N_{Rd,sp}\} =$	**11.6 kN**

4

Shear loading					
steel failure					
basic design resistance				**$V_{Rd,s}$**	**31.2 kN**
pry-out failure					
basic resistance (concrete failure)				$V^0_{Rd,cp}$ (c)	19.7 kN
concrete strength			C 20/25	$f_{b,c}$	1.0
spacing s_1			180 mm	f_{s1}	0.93
spacing s_2			190 mm	f_{s2}	0.95
edge distance c_1			-	f_{c1}	-
edge distance c_2			80 mm	f_{c2}	0.82
embedment depth			70 mm	k	2.0
				$V_{Rd,cp}$ (c) = $N^0_{Rd,cp}$ (c) · $f_{b,c}$ · f_{s1} · f_{s2} · f_{c2} · k =	**28.5 kN**
basic resitance (pull-out failure)				$N^0_{Rd,cp}$ (c)	19.7
concrete strength			C 20/25	$f_{b,p}$	1.0
embedment depth			70 mm	k	2.0
				$V_{Rd,cp}$ (p) = $N^0_{Rd,cp}$ (p) · $f_{b,p}$ · k =	**39.4 kN**
concrete edge failure					
basic design resistance				$V^0_{Rd,c}$	8.4 kN
concrete strength			C 20/25	$f_{b,c}$	1.0
shear load direction			0°	$f_{\alpha,V}$	1.0
s_1/c_{min}	= 180/70		2.57		
c_2/c_{min}	= 80/70		1.14	$f_{sc,V}{}^{n=2}$	1.07
$(h/1.5)/c_{min}$	= (250/1.5)/70		2.38		
				$V_{Rd,c}$ = $V^0_{Rd,c}$ · $f_{b,c}$ · $f_{\alpha,V}$ · $f_{sc,V}$ =	**9.0 kN**
Minimum shear design resistance				**V_{Rd} = min {$V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$}**	**9.0 kN**

Proof of anchors			
tension	$N^h_{Sd} \leq N_{Rd}$	2.9 ≤ 11.6	✓
shear	$V^h_{Sd} \leq V_{Rd}$	4.95 ≤ 9.0	✓
combined tension and shear	$N^h_{Sd} / N_{Rd} + V^h_{Sd} / V_{Rd} \leq 1.2$	2.9 / 11.6 + 4.95 / 9.0 = 0.80 ≤ 1.2	✓

Example 2: mechanical anchor in cracked concrete



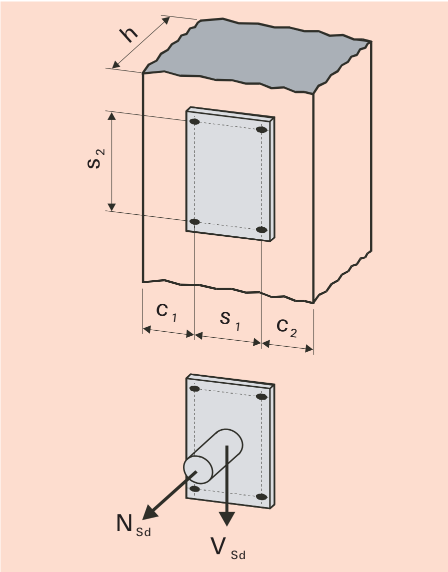
Anchoring conditions		
concrete	cracked	C 30/37
number of anchors	group of 2 anchors	
member thickness	h	320 mm
anchor spacing direction 1	s_1	125 mm
anchor spacing direction 2	s_2	-
edge distance direction 1	c_1	80 mm
edge distance direction 2	c_2	80 mm
shear load direction	α	-
tension design action (group)	N_{Sd}	18.0 kN
shear design action (group)	V_{Sd}	-
tension design action (highest loaded anchor)	N^h_{Sd}	9.0 kN
shear design action (highest loaded anchor, steel failure, pry-out failure)	V^h_{Sd}	-
shear design action (highest loaded anchor, edge failure)	V^h_{Sd}	-
anchor		**FAZ II 12 A4**
effective anchorage depth	h_{ef}	70 mm
minimum member thickness	h_{min}	140 mm
minimum spacing	s_{min}	45 mm
critical spacing concrete cone failure	$s_{cr,N}$	210 mm
critical spacing splitting failure	$s_{cr,sp}$	210 mm
minimum edge distance	min c	55 mm
critical edge distance concrete cone failure	$c_{cr,N}$	105 mm
critical edge distance splitting failure	$c_{cr,sp}$	105 mm

Tension loading			
steel failure			
basic design resistance		$\mathbf{N_{Rd,s}}$	**27.7 kN**
pull-out failure			
basic design resistance		$N^0_{Rd,p}$	10.7 kN
concrete strength	C 30/37	$f_{b,p}$	1.22
		$\mathbf{N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,p} =}$	**13.1 kN**
concrete cone failure			
basic design resistance		$N^0_{Rd,c}$	14.1 kN
concrete strength	C 30/37	$f_{b,c}$	1.22
spacing s_1	125 mm	f_{s1}	0.80
spacing s_2	-	f_{s2}	-
edge distance c_1	80 mm	f_{c1}	0.82
edge distance c_2	80 mm	f_{c2}	0.82
		$\mathbf{N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s1} \cdot f_{c1} \cdot f_{c2} =}$	**9.3 kN**
splitting failure			
basic design resistance		$N^0_{Rd,c}$	14.1 kN
concrete strength	C 30/37	$f_{b,c}$	1.22
spacing s_1	125 mm	$f_{s1,sp}$	0.80
spacing s_2	-	$f_{s2,sp}$	-
edge distance c_1	80 mm	$f_{c1,sp}$	0.82
edge distance c_2	80 mm	$f_{c2,sp}$	0.82
member thickness h	320 mm	f_h	1.50
		$\mathbf{N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s1,sp} \cdot f_{c1,sp} \cdot f_{c2,sp} \cdot f_h =}$	**13.9 kN**
Minimum tension design resistance		$\mathbf{N_{Rd} = \min\{N_{Rd,s} ; N_{Rd,p} ; N_{Rd,c} ; N_{Rd,sp}\}}$	**9.3 kN**

Shear loading				not relevant	
steel failure					
basic design resistance				$V_{Rd,s}$	-
pry-out failure					
basic resistance (concrete failure)				$V^0_{Rd,cp}$ (c)	-
concrete strength			-	$f_{b,c}$	-
spacing s_1			-	f_{s1}	-
spacing s_2			-	f_{s2}	-
edge distance c_1			-	f_{c1}	-
edge distance c_2			-	f_{c2}	-
embedment depth			-	k	-
				$V_{Rd,cp}$ (c) = $N^0_{Rd,cp}$ (c) · $f_{b,c}$ · f_{s1} · f_{s2} · f_{c1} · f_{c2} · k =	-
basic resitance (pull-out failure)				$N^0_{Rd,cp}$ (p)	-
concrete strength			-	$f_{b,p}$	-
embedment depth			-	k	-
				$V_{Rd,cp}$ (p) = $N^0_{Rd,cp}$ (p) · $f_{b,p}$ · k =	-
concrete edge failure					
basic design resistance				$V^0_{Rd,c}$	-
concrete strength			-	$f_{b,c}$	-
shear load direction			-	$f_{\alpha,V}$	-
s_2/c_{min}	=		-	$f_{sc,V}^{n=2}$	-
c_2/c_{min}	=		-		
$(h/1.5)/c_{min}$	=		-		
				$V_{Rd,c}$ = $V^0_{Rd,c}$ · $f_{b,c}$ · $f_{\alpha,V}$ · $f_{sc,V}$ =	-
Minimum shear design resistance				V_{Rd} = min {$V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$}	-

Proof of anchors			
tension	$N^h_{Sd} \leq N_{Rd}$	9.0 ≤ 9.3	✓
shear	$V^h_{Sd} \leq V_{Rd}$	-	-
combined tension and shear	$N^h_{Sd} / N_{Rd} + V^h_{Sd} / V_{Rd} \leq 1.2$	9.0 / 9.3 + - / - = 0.97 ≤ 1.2	✓

Example 3: chemical anchor with variable embedment depth in non-cracked concrete



Anchoring conditions		
concrete	non-cracked	C 40/50
number of anchors	group of 4 anchors	
member thickness	h	500 mm
anchor spacing direction 1	s_1	160 mm
anchor spacing direction 2	s_2	250 mm
edge distance direction 1	c_1	175 mm
edge distance direction 2	c_2	175 mm
shear load direction	α	90°
tension design action (group)	N_{Sd}	32.0 kN
shear design action (group)	V_{Sd}	100.0 kN
tension design action (highest loaded anchor)	N^h_{Sd}	8.0 kN
shear design action (highest loaded anchor, steel failure, pry-out failure)	V^h_{Sd}	25.0 kN
shear design action (highest loaded anchor, edge failure)	V^h_{Sd}	25.0 kN
anchor		**FIS V + M 20 A4**
effective anchorage depth	h_{ef}	200 mm
minimum member thickness	h_{min}	248 mm
minimum spacing	s_{min}	85 mm
critical spacing concrete cone failure	$s_{cr,N}$	600 mm
critical spacing splitting failure	$s_{cr,sp}$	910 mm
minimum edge distance	c_{min}	85 mm
critical edge distance concrete cone failure	$c_{cr,N}$	300 mm
critical edge distance splitting failure	$c_{cr,sp}$	455 mm

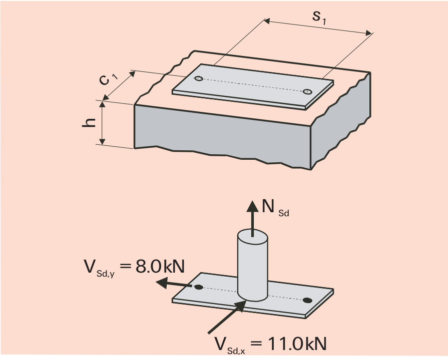
Tension loading			
steel failure			
basic design resistance		$N_{Rd,s}$	**91.4 kN**
pull-out failure			
basic design resistance		$N^0_{Rd,p}$	66.4 kN
concrete strength	C 40/50	$f_{b,p}$	1.19
spacing s_1	160 mm	f_{s1}	0.63
spacing s_2	250 mm	f_{s2}	0.71
edge distance c_1	175 mm	f_{c1}	0.69
edge distance c_2	175 mm	f_{c2}	0.69
		$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,p} \cdot f_{s1} \cdot f_{s2} \cdot f_{c1} \cdot f_{c2} =$	**16.8 kN**
concrete cone failure			
basic design resistance		$N^0_{Rd,c}$	79.2 kN
concrete strength	C 40/50	$f_{b,c}$	1.41
spacing s_1	160 mm	f_{s1}	0.63
spacing s_2	250 mm	f_{s2}	0.71
edge distance c_1	175 mm	f_{c1}	0.69
edge distance c_2	175 mm	f_{c2}	0.69
		$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{c1} \cdot f_{c2} =$	**23.8 kN**
splitting failure			
basic design resistance		$N^0_{Rd,c}$	79.2 kN
concrete strength	C 40/50	$f_{b,c}$	1.41
spacing s_1	160 mm	$f_{s1,sp}$	0.59
spacing s_2	250 mm	$f_{s2,sp}$	0.64
edge distance c_1	175 mm	$f_{c1,sp}$	0.56
edge distance c_2	175 mm	$f_{c2,sp}$	0.56
member thickness h	500 mm	f_h	1.38
		$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s1,sp} \cdot f_{s2,sp} \cdot f_{c1,sp} \cdot f_{c2,sp} \cdot f_h =$	**18.3 kN**
Minimum tension design resistance		$N_{Rd} = \min\{N_{Rd,s}; N_{Rd,p}; N_{Rd,c}; N_{Rd,sp}\}$	**16.8 kN**

Design of anchors

Shear loading						
steel failure						
basic design resistance					$V_{Rd,s}$	**54.9 kN**
pry-out failure						
spacing s_1				160 mm	f_{s1}	0.63
spacing s_2				250 mm	f_{s2}	0.71
edge distance c_1				175 mm	f_{c1}	0.69
edge distance c_2				175 mm	f_{c2}	0.69
basic resitance (concrete failure)					$N^0_{Rd,cp}$ (c)	95.0 kN
concrete strength				C 40/50	$f_{b,c}$	1.41
embedment depth				200 mm	k	2.0
					$V_{Rd,cp}$ (c) = $N^0_{Rd,cp}$ (c) $\cdot f_{b,c} \cdot f_{s1} \cdot f_{s2} \cdot f_{c1} \cdot f_{c2} \cdot k$ =	**57.1 kN**
basic resitance (pull-out failure)					$N^0_{Rd,cp}$ (p)	79.6 kN
concrete strength				500 mm	$f_{b,p}$	1.19
embedment depth				200 mm	**k**	2.00
					$V_{Rd,cp}$ (p) = $N^0_{Rd,cp}$ (p) $\cdot f_{b,p} \cdot f_{s1} \cdot f_{s2} \cdot f_{c1} \cdot f_{c2} \cdot k$ =	**40.3 kN**
concrete edge failure						
basic design resistance					$V^0_{Rd,c}$	14.7 kN
concrete strength				500 mm	$f_{b,c}$	1.41
shear load direction				90°	$f_{\alpha,V}$	2.5
s_2/c_{min}	= 250 / 85		= 2.94	minimum value relevant	$f_{sc,V}^{n=2}$	2.12
c_1/c_{min}	= 175 / 85		= 2.06			
$(h/1.5)/c_{min}$	= (500/1.5) / 85		= 3.92			
					$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}$ =	**109.9**
Minimum shear design resistance					V_{Rd} = min {$V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$}	**40.3**

Proof of anchors			
tension	$N^h_{Sd} \leq N_{Rd}$	$8.0 \leq 16.8$	✓
shear	$V^h_{Sd} \leq V_{Rd}$	$25.0 \leq 40.3$	✓
combined tension and shear	$N^h_{Sd} / N_{Rd} + V^h_{Sd} / V_{Rd} \leq 1.2$	$8.0 / 16.8 + 25.0 / 40.3 \leq 1.2$ $1.1 \leq 1.2$	✓

Example 4: mechanical anchor in cracked concrete



Anchoring conditions		
concrete	cracked	C 30/37
number of anchors	group of 2 anchors	
member thickness	h	200 mm
anchor spacing direction 1	s_1	160 mm
anchor spacing direction 2	s_2	-
edge distance direction 1	c_1	80 mm
edge distance direction 2	c_2	-
shear load direction	α	144°
tension design action (group)	N_{Sd}	15.0 kN
shear design action in $V_{Sd,x}$ and $V_{Sd,y}$ (group, by interaction)	V_{Sd}	13.6 kN
tension design action (highest loaded anchor)	$N^h{}_{Sd}$	7.5 kN
shear design action (highest loaded anchor, edge failure)	$V^h{}_{Sd}$	4.0 kN
shear design action (highest loaded anchor, steel failure, pry-out failure)	$V^h{}_{Sd}$	6.8 kN
anchor		**FAZ II 12**
effective anchorage depth	h_{ef}	70 mm
minimum member thickness	h_{min}	140 mm
minimum spacing	s_{min}	45 mm
critical spacing concrete cone failure	$s_{cr,N}$	210 mm
critical spacing splitting failure	$s_{cr,sp}$	210 mm
minimum edge distance	c_{min}	55 mm
critical edge distance concrete cone failure	$c_{cr,N}$	105 mm
critical edge distance splitting failure	$c_{cr,sp}$	105 mm

Tension loading			
steel failure			
basic design resistance		$N_{Rd,s}$	**27.7 kN**
pull-out failure			
basic design resistance (cracked concrete)		$N^0_{Rd,p}$	10.7 kN
concrete strength	C 30/37	$f_{b,p}$	1.22
		$N_{Rd,p} = N^0_{Rd,p} \cdot f_{b,p} =$	**13.1 kN**
concrete cone failure			
basic design resistance		$N^0_{Rd,c}$	14.1 kN
concrete strength	C 30/37	$f_{b,c}$	1.22
spacing s_1	160 mm	f_{s1}	0.88
spacing s_2	-	f_{s2}	-
edge distance c_1	80 mm	f_{c1}	0.82
edge distance c_2	-	f_{c2}	-
		$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s1} \cdot f_{c1} =$	**12.4 kN**
splitting failure			
basic design resistance		$N^0_{Rd,c}$	19.7 kN
concrete strength	C 30/37	$f_{b,c}$	1.22
spacing s_1	160 mm	$f_{s1,sp}$	0.88
spacing s_2	-	$f_{s2,sp}$	-
edge distance c_1	80 mm	$f_{c1,sp}$	0.82
edge distance c_2	-	$f_{c2,sp}$	-
member thickness h	200 mm	f_h	1.27
		$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s1,sp} \cdot f_{c1,sp} \cdot f_h =$	**22.0 kN**
Minimum tension design resistance		$N_{Rd} = \min\{N_{Rd,s} ; N_{Rd,p} ; N_{Rd,c} ; N_{Rd,sp}\} =$	**12.4 kN**

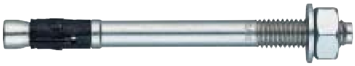
Shear loading					
steel failure					
basic resistance				$V_{Rd,s}$	**23.6 kN**
pry-out failure					
basic resistance (concrete failure)				$V^0_{Rd,cp}$ (c)	14.1 kN
concrete strength			C 30/37	$f_{b,c}$	1.22
spacing s_1			160 mm	f_{s1}	0.88
spacing s_2			-	f_{s2}	-
edge distance c_1			80 mm	f_{c1}	0.82
edge distance c_2			-	f_{c2}	-
embedment depth			70 mm	k	2.4
				$V_{Rd,cp}$ (c) = $N^0_{Rd,cp}$ (c) · $f_{b,c}$ · f_{s1} · f_{c1} · k =	**29.8 kN**
basic resitance (pull-out failure)				$N^0_{Rd,cp}$ (p)	10.7
concrete strength			C 30/37	$f_{b,p}$	1.22
embedment depth			70 mm	k	2.4
				$V_{Rd,cp}$ (p) = $N^0_{Rd,cp}$ (p) · $f_{b,p}$ · k =	**31.3 kN**
concrete edge failure					
basic design resistance				$V^0_{Rd,c}$	4.2 kN
concrete strength			C 30/37	$f_{b,c}$	1.22
shear load direction			144°	$f_{\alpha,V}$	2.5
s_1/c_{min}	= 160/55		2.91		
c_2/c_{min}	= 80/55		1.45	$f_{sc,V}^{n=2}$	1.46
$(h/1.5)/c_{min}$	= (200/1.5)/55		2.42		
				$V_{Rd,c}$ = $V^0_{Rd,c}$ · $f_{b,c}$ · $f_{\alpha,V}$ · $f_{sc,V}$ =	**18.7 kN**
Minimum shear design resistance				V_{Rd} = min {$V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$}	**18.7 kN**

Proof of anchors			
tension	$N^h_{Sd} \leq N_{Rd}$	$7.5 \leq 12.4$	✓
shear	$V^h_{Sd} \leq V_{Rd}$	$6.8 \leq 18.7$	✓
combined tension and shear	$N^h_{Sd} / N_{Rd} + V^h_{Sd} / V_{Rd} \leq 1.2$	$7.5 / 12.4 + 6.8 / 18.7 = 0.82 \leq 1.2$	✓

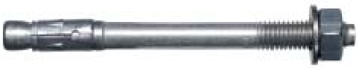
fischer Anchor bolt FAZ II

Anchor design according to ETA

1. Types



FAZ II – Anchor bolt (gvz)



FAZ II A4 – Anchor bolt (A4)

FAZ II C – Anchor bolt (C)

ETA CE
European Technical Approval – Option 1 for cracked concrete

Fire resistance classification R 120
Anchor types see test report

FM APPROVED
from thread M 10

Shock approval by the Federal office for Civil Defence, Bonn.

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 1.
- Suitable for cracked and non-cracked concrete.
- Double-shell expansion clip ensures even distribution of the load for high permissible loads.
- Small edge and axial spacing for structural elements.
- Perfectly sliding expansion clip guarantees secure conctrolled expansion, even in cracked concrete.
- Coated hexagon nut allows easy disassembly.

Materials

Anchor bolt: Carbon steel, zinc plated (5 µm) and passivated (gvz)
Stainless steel of the corrosion resistance class III, e.g. A4
Stainless steel of the corrosion resistance class IV, e.g. 1.4529 (C)

2. Ultimate loads of single anchors with large spacing and 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 load	C 20/25 N_u [kN]	15.9*)	26.4	38.6	52.9	67.5	94.3
	C 50/60 N_u [kN]	15.9*)	27.2*)	41.6*)	66.2*)	104.6	146.2
shear load	≥ C 20/25 V_u [kN]	20.7*)	29.5*)	43.0*)	78.5*)	91.1*)	110.0*)
cracked concrete							
tension load	C 20/25 N_u [kN]	13.8	22.0	27.7	37.0	47.3	66.0
	C 50/60 N_u [kN]	15.9*)	27.2*)	41.6*)	66.2*)	73.3	102.3
shear load	≥ C 20/25 V_u [kN]	20.7*)	29.5*)	43.0*)	78.5*)	91.1*)	110.0*)

*) Steel failure decisive

fischer Anchor bolt FAZ II

Anchor design according to ETA

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube(150)}$ [N/mm²]	Influence factor $f_{b,p} = f_{b,c}$ gvz / A4 / C [-]
C 20/25	20	25	1.00
C 25/30	25	30	1.10
C 30/37	30	37	1.22
C 40/50	40	50	1.41
C 45/55	45	55	1.48
C 50/60	50	60	1.55

4

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Characteristic loads

Anchor type			FAZ II 8 (gvz / A4 / C)	FAZ II 10 (gvz / A4 / C)	FAZ II 12 (gvz / A4 / C)	FAZ II 16 (gvz / A4 / C)	FAZ II 20 (gvz / A4)	FAZ II 24 (gvz / A4)
non-cracked concrete								
tension load	C 20/25	N_{Rk} [kN]	9.0	16.0	25.0	39.5	50.4	70.4
	C 50/60	N_{Rk} [kN]	13.9	24.8	38.7	61.2	78.1	109.1
shear load	≧ C 20/25	V_{Rk} [kN]	12.0	20.0	29.5	55.0	70.0	86.0
cracked concrete								
tension load	C 20/25	N_{Rk} [kN]	5.0	9.0	16.0	28.2	36.0	50.3
	C 50/60	N_{Rk} [kN]	7.7	13.9	24.8	43.7	55.8	77.9
shear load	≧ C 20/25	V_{Rk} [kN]	10.0	19.8	29.5	55.0	70.0	86.0

Design loads

Anchor type			FAZ II 8 (gvz / A4 / C)	FAZ II 10 (gvz / A4 / C)	FAZ II 12 (gvz / A4 / C)	FAZ II 16 (gvz / A4 / C)	FAZ II 20 (gvz / A4)	FAZ II 24 (gvz / A4)
non-cracked concrete								
tension load	C 20/25	N_{Rd} [kN]	6.0	10.7	16.7	26.3	33.6	47.0
	C 50/60	N_{Rd} [kN]	9.3	16.5	25.8	40.8	52.1	72.7
shear load	≧ C 20/25	V_{Rd} [kN]	9.6	16.0	23.6	44.0	56.0	68.8
cracked concrete								
tension load	C 20/25	N_{Rd} [kN]	3.3	6.0	10.7	18.8	24.0	33.5
	C 50/60	N_{Rd} [kN]	5.2	9.3	16.5	29.1	37.2	52.0
shear load	≧ C 20/25	V_{Rd} [kN]	6.7	13.2	23.6	44.0	56.0	68.8

Permissible loads [1)]

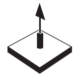
Anchor type			FAZ II 8 (gvz / A4 / C)	FAZ II 10 (gvz / A4 / C)	FAZ II 12 (gvz / A4 / C)	FAZ II 16 (gvz / A4 / C)	FAZ II 20 (gvz / A4)	FAZ II 24 (gvz / A4)
non-cracked concrete								
tension load	C 20/25	N_{perm} [kN]	4.3	7.6	11.9	18.8	24.0	33.5
	C 50/60	N_{perm} [kN]	6.6	11.8	18.4	29.1	37.2	52.0
shear load	≧ C 20/25	V_{perm} [kN]	6.9	11.4	16.9	31.4	40.0	49.1
cracked concrete								
tension load	C 20/25	N_{perm} [kN]	2.4	4.3	7.6	13.4	17.1	24.0
	C 50/60	N_{perm} [kN]	3.7	6.6	11.8	20.8	26.6	37.1
shear load	≧ C 20/25	V_{perm} [kN]	4.8	9.4	16.9	31.4	40.0	49.1
	C 50/60	V_{perm} [kN]	6.9	11.4	16.9	31.4	40.0	49.1

1) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

fischer Anchor bolt FAZ II

Anchor design according to ETA

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

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
characteristic resistance $N_{Rk,s}$ [kN]	16.0	27.0	41.5	66.0	111.0	150.0
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 for the highest loaded anchor

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

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						
characteristic resistance $N^0_{Rk,p}$ [kN]	9.0	16.0	25.0	39.5	50.4	70.4
design resistance $N^0_{Rd,p}$ [kN]	6.0	10.7	16.7	26.3	33.6	47.0
cracked concrete						
characteristic resistance $N^0_{Rk,p}$ [kN]	5.0	9.0	16.0	28.2	36.0	50.3
design resistance $N^0_{Rd,p}$ [kN]	3.3	6.0	10.7	18.8	24.0	33.5

4.3 Concrete cone failure and splitting for the most unfavourable anchor

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

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
eff. anchorage depth h_{ef} [mm]	45	60	70	85	100	125
non-cracked concrete						
characteristic resistance $N^0_{Rk,c}$ [kN]	15.2	23.4	29.5	39.5	50.4	70.4
design resistance $N^0_{Rd,c}$ [kN]	10.1	15.6	19.7	26.3	33.6	47.0
cracked concrete						
characteristic resistance $N^0_{Rk,c}$ [kN]	10.9	16.7	21.1	28.2	36.0	50.3
design resistance $N^0_{Rd,c}$ [kN]	7.2	11.2	14.1	18.8	24.0	33.5

4.3.1 Concrete cone failure
4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm]	Influence factor f_s [-] FAZ II 8 (gvz / A4 / C)	FAZ II 10 (gvz / A4 / C)	FAZ II 12 (gvz / A4 / C)	FAZ II 16 (gvz / A4 / C)	FAZ II 20 (gvz / A4)	FAZ II 24 (gvz / A4)
35	0.63					
40	0.64	0.61				
45	0.66	0.63	0.61			
55	0.70	0.65	0.63			
60	0.71	0.67	0.64	0.62		
65	0.73	0.68	0.65	0.63		
75	0.77	0.71	0.68	0.64		
100	0.86	0.78	0.74	0.69	0.67	0.63
120	0.93	0.83	0.79	0.73	0.70	0.66
140	1.00	0.89	0.83	0.77	0.73	0.68
160		0.94	0.88	0.81	0.77	0.71
180		1.00	0.93	0.85	0.80	0.74
210			1.00	0.90	0.85	0.78
260				1.00	0.93	0.84
300					1.00	0.89
380						1.00
s_{min} [mm]	35	40	45	60	95	100
$s_{cr,N}$ [mm]	140	180	210	260	300	380

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c [mm]	Influence factor f_c [-] FAZ II 8 (gvz / A4 / C)	FAZ II 10 (gvz / A4 / C)	FAZ II 12 (gvz / A4 / C)	FAZ II 16 (gvz / A4 / C)	FAZ 20 II (gvz / A4)	FAZ II 24 (gvz / A4)
40	0.68					
45	0.73	0.64				
50	0.78	0.67				
55	0.84	0.71	0.65			
65	0.94	0.79	0.72	0.64		
70	1.00	0.83	0.75	0.66		
90		1.00	0.89	0.77	0.70	
100			0.96	0.82	0.75	0.65
105			1.00	0.85	0.77	0.67
120				0.94	0.85	0.73
130				1.00	0.90	0.76
150					1.00	0.84
190						1.00
c_{min} [mm]	40	45	55	65	85	100
$c_{cr,N}$ [mm]	70	90	105	130	150	190

Intermediate values by linear interpolation.

4.3.2 Concrete splitting
4.3.2.1 Influence of spacing

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

Spacing s	Influence factor $f_{s,sp}$ [-]					
	FAZ II 8	FAZ II 10	FAZ II 12	FAZ II 16	FAZ II 20	FAZ II 24
[mm]	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4	gvz / A4
35	0.63					
40	0.64	0.61				
45	0.66	0.63	0.61			
60	0.71	0.67	0.64	0.62		
75	0.77	0.71	0.68	0.64		
100	0.86	0.78	0.74	0.69	0.64	0.62
120	0.93	0.83	0.79	0.73	0.66	0.63
140	1.00	0.89	0.83	0.77	0.69	0.66
160		0.94	0.88	0.81	0.72	0.69
180		1.00	0.93	0.85	0.74	0.71
210			1.00	0.90	0.78	0.74
260				1.00	0.85	0.80
300					0.91	0.85
370					1.00	0.93
430						1.00
s_{min} [mm]	35	40	45	60	95	100
$s_{cr,sp}$ [mm]	140	180	210	260	370	430

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c	Influence factor $f_{c,sp}$ [-]					
	FAZ II 8	FAZ II 10	FAZ II 12	FAZ II 16	FAZ II 20	FAZ II 24
[mm]	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4	gvz / A4
40	0.68					
45	0.73	0.64				
50	0.78	0.67				
55	0.84	0.71	0.65			
65	0.94	0.79	0.72	0.64		
70	1.00	0.83	0.75	0.66		
90		1.00	0.89	0.77	0.63	
100			0.96	0.82	0.66	0.62
105			1.00	0.85	0.68	0.63
120				0.94	0.74	0.68
130				1.00	0.78	0.71
150					0.85	0.77
185					1.00	0.89
215						1.00
c_{min} [mm]	40	45	55	65	85	100
$c_{cr,sp}$ [mm]	70	90	105	130	185	215

Intermediate values by linear interpolation.

fischer Anchor bolt FAZ II

Anchor design according to ETA

4.3.2.3 Influence of concrete thickness

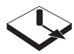
$$f_h = \left(\frac{h}{2 \cdot h_{ef}}\right)^{\frac{2}{3}} \leq 1.5$$

Thickness h [mm]	Influence factor f_h [-] FAZ II 8	FAZ II 10	FAZ II 12	FAZ II 16	FAZ II 20	FAZ II 24
100	1.07					
120	1.21	1.00				
140	1.34	1.11	1.00			
150	1.41	1.16	1.05			
160	1.47	1.21	1.09			
170	1.50	1.26	1.14	1.00		
180		1.31	1.18	1.04		
200		1.41	1.27	1.11	1.00	
220		1.50	1.35	1.19	1.07	
250			1.47	1.29	1.16	1.00
260			1.50	1.33	1.19	1.03
300				1.46	1.31	1.13
320				1.50	1.37	1.18
370					1.50	1.30
400						1.37
460						1.50
h_{ef} [mm]	45	60	70	85	100	125
h_{min} [mm]	100	120	140	170	200	250

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor



Characteristic resistance and design resistance for single anchors

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
characteristic resistance	$V_{Rk,s}$	[kN]	12.0			20.0			29.5			55.0			70.0		86.0	
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

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot k$$

Characteristic resistance and design restance for single anchors in concrete C20/25

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
eff. anchorage depth	h_{ef}	[mm]	45			60			70			85			100		125	
non-cracked concrete																		
characteristic resistance	$N^0_{Rk,cp}$ (C)	[kN]	15.2			23.4			29.5			39.5			50.4		70.4	
design resistance	$N^0_{Rd,cp}$ (C)	[kN]	10.1			15.6			19.7			26.3			33.6		47.0	
characteristic resistance	$N^0_{Rk,cp}$ (P)	[kN]	9.0			16.0			25.0			39.5			50.4		70.4	
design resistance	$N^0_{Rd,cp}$ (P)	[kN]	6.0			10.7			16.7			26.3			33.6		47.0	
cracked concrete																		
characteristic resistance	$N^0_{Rk,cp}$ (C)	[kN]	10.9			16.7			21.1			28.2			36.0		50.3	
design resistance	$N^0_{Rd,cp}$ (C)	[kN]	7.2			11.2			14.1			18.8			24.0		33.5	
characteristic resistance	$N^0_{Rk,cp}$ (P)	[kN]	5.0			9.0			16.0			28.2			36.0		50.3	
design resistance	$N^0_{Rd,cp}$ (P)	[kN]	3.3			6.0			10.7			18.8			24.0		33.5	

5.2.1 Influence of anchorage depth

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

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^{n}$$

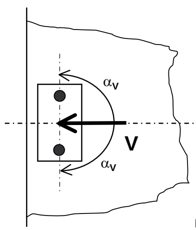
Characteristic resistance and design restance for single anchors in concrete C20/25 for edge distances c_{min}

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								
minimum edge distance	c_{min}	[mm]	40	45	55	65	95	135
characteristic resistance	$V^0_{Rk,c}$	[kN]	5.0	6.4	8.9	12.1	21.2	36.0
design resistance	$V^0_{Rd,c}$	[kN]	3.3	4.3	5.9	8.1	14.1	24.0
cracked concrete								
minimum edge distance	c_{min}	[mm]	40	45	55	65	85	100
characteristic resistance	$V^0_{Rk,c}$	[kN]	3.5	4.5	6.3	8.6	13.0	17.4
design resistance	$V^0_{Rd,c}$	[kN]	2.4	3.0	4.2	5.7	8.7	11.6

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 **Single anchor** influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\,n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 **Anchor pair** influenced only by one edge

for concrete thickness h ≧ 1.5 · c
and spacing **s ≦ 3 · c**

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for s > 3 · c

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c
and spacing **s ≦ 4.5 · h**

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for s > 4.5 · h

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	60.5	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

4

6. Summary of required proof:

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

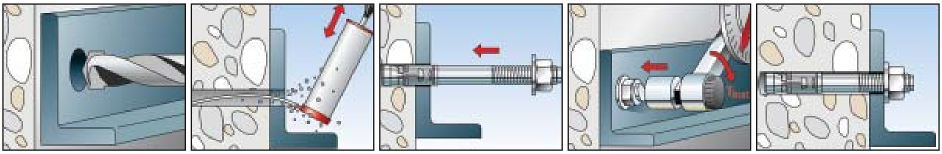
6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (C) ; $V_{Rd,cp}$ (P) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

7. Installation details

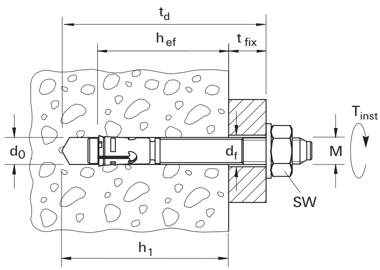


fischer Anchor bolt FAZ II

Anchor design according to ETA

8. Anchor 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
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 thickness of concrete member	h_{min}	[mm]	100	120	140	170	200	250
non-cracked concrete								
minimum spacing	s_{min}	[mm]	40	40	50	60	95	100
for required edge distances	for c	[mm]	50	60	70	95	180	200
minimum edge distances	c_{min}	[mm]	40	45	55	65	95	135
for required spacing	for s	[mm]	100	80	110	150	190	235
cracked concrete								
minimum spacing	s_{min}	[mm]	35	40	45	60	95	100
for required edge distances	for c	[mm]	50	55	70	95	140	170
minimum edge distances	c_{min}	[mm]	40	45	55	65	85	100
for required spacing	for s	[mm]	70	80	110	150	190	220

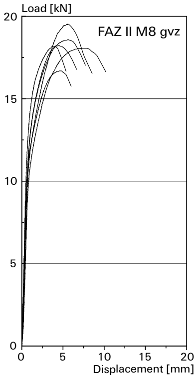


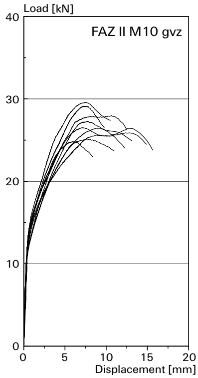
4

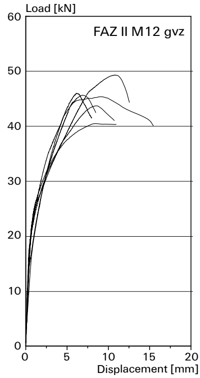
9. Mechanical characteristics

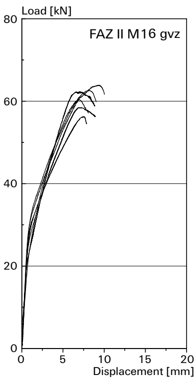
Anchor type			FAZ II 8	FAZ II 10	FAZ II 12	FAZ II 16	FAZ II 20	FAZ II 24
			gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4	gvz / A4
stressed cross sectional area cone bolt	A_s	[mm²]	21.1	36.3	55.4	85.8	159.5	231.0
resisting moment cone bolt	W	[mm³]	13.8	30.9	58.2	116.9	284.0	495.2
yield strength cone bolt	f_y	[N/mm²]	600	600	600	600	560	544
tensile strength cone bolt	f_u	[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
resisting moment threaded part	W	[mm³]	31.2	62.3	109.2	277.5	540.9	935.5
yield strength threaded part	f_y	[N/mm²]	560	560	560	560	560	544
tensile strength threaded part	f_u	[N/mm²]	700	700	700	700	750	680

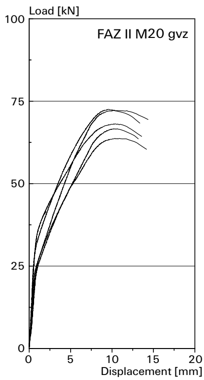
10. Load displacement curves for tension in non-cracked concrete ($f_{ck,cube\ (200)}$ = 30 N/mm²)

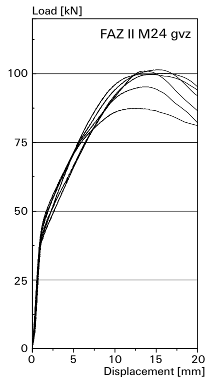












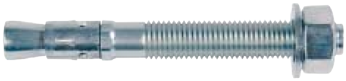
Notes

4

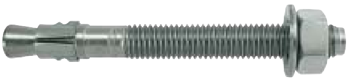
fischer Bolt FBN

Anchor design according to ETA

1. Types



FBN II – Bolt (gvz)



FBN A4 – Bolt (A4)

FBN II GS – Bolt with large washer (gvz)
(outside diameter approx. 3.5 x d)

European Technical Approval - Option 7 for non-cracked concrete

Fire resistance classification **F 120**
Anchor types see test report

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

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Features and Advantages

- European Technical Approval option 7.
- Suitable for non-cracked concrete.
- Long thread allows stand-off installation and variable effective lengths.
- 8 to 20 mm diameter also for reduced anchoring depths, e.g. for small loads or if reinforcement is encountered.
- Special expansion clip design gives optimal grip.

Materials

Cone bolt: Carbon steel, zinc plated (5 µm) and passivated (gvz)
Stainless steel of the corrosion resistance class III, e.g. A4

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

Mean values

Anchor type			FBN 6	FBN II 8	FBN 8	FBN II 8	FBN 8	FBN II 10	FBN 10	FBN II 10	FBN 10	
			A4	gvz	A4	gvz	A4	gvz	A4	gvz	A4	
h_{ef}		[mm]	40	30	35	40	48	40	42	50	50	
non-cracked concrete												
tension load	C 20/25	N_u [kN]	10.6*)	9.6	14.0	16.1*	17.5*)	15.8	18.4	22.9	23.9	
	C 50/60	N_u [kN]	10.6*)	14.9	17.5*)	16.1*	17.5*)	24.6	27.9*)	25.0*	27.9*)	
shear load	≧ C 20/25	V_u [kN]	9.0*)	11.0*	15.1*)	11.0*	15.1*)	17.0*	24.0*)	17.0*	24.0*)	
Anchor type			**FBN II 12**	**FBN 12**	**FBN II 12**	**FBN 12**	**FBN II 16**	**FBN 16**	**FBN II 16**	**FBN 16**	**FBN II 20**	
			gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	gvz
h_{ef}		[mm]	50	50	65	70	65	64	80	84	80	105
non-cracked concrete												
tension load	C 20/25	N_u [kN]	23.5	23.9	35.7	39.5	37.8	33.1	46.3	44.3	57.3	75.2
	C 50/60	N_u [kN]	36.0*	37.0	36.0*	39.9*)	58.6	53.5	67.0*	69.2*)	88.8	107.0*
shear load	≧ C 20/25	V_u [kN]	21.0*	31.6*)	21.0*	31.6*)	40.0*	56.5*)	40.0	56.5*)	67.0*	67.0*

*) Steel failure decisive

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$	Cube compressive strength $f_{ck.\,cube\,(150)}$	Influence factor $f_{b,p} = f_{b,c1}$ [-] FBN 6 A4	FBN II 8 gvz	FBN 8 A4	FBN II 10 + FBN 10, FBN II 12 + FBN 12, FBN 16 h_{ef} = 84 mm gvz / A4	FBN II 16 gvz	FBN 16 h_{ef} = 64 mm A4	FBN II 20 gvz	$f_{b,c2}$ [-]
	[N/mm²]	[N/mm²]								
C 20/25	20	25	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
C 25/30	25	30	1.08	1.10	1.08	1.10	1.10	1.06	1.10	1.10
C 30/37	30	37	1.17	1.22	1.17	1.22	1.22	1.12	1.22	1.22
C 40/50	40	50	1.32	1.41	1.32	1.41	1.41	1.23	1.41	1.41
C 45/55	45	55	1.37	1.48	1.37	1.48	1.48	1.27	1.48	1.48
C 50/60	50	60	1.42	1.55	1.42	1.55	1.55	1.30	1.55	1.55

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3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Characteristic loads

Anchor type / h_{ef} [mm]	FBN 6 A4 40	FBN II 8 gvz 30*	FBN 8 A4 35*	FBN II 8 gvz 40	FBN 8 A4 48	FBN II 10 gvz 40	FBN 10 A4 42	FBN II 10 gvz 50	FBN 10 A4 50	
non-cracked concrete										
tension load C 20/25 N_{Rk} [kN]	6.0	6.0	7.5	12.8	9.0	12.8	12.0	17.8	12.0	
C 50/60 N_{Rk} [kN]	8.5	9.3	10.7	16.0	12.8	19.8	18.6	25.0	18.6	
shear load C 20/25 V_{Rk} [kN]	6.0	6.0	7.5	11.0	9.0	12.8	12.0	17.0	12.0	
C 50/60 V_{Rk} [kN]	7.5	9.3	10.7	11.0	12.6	17.0	18.6	17.0	18.6	
Anchor type / h_{ef} [mm]	**FBN II 12 gvz 50**	**FBN 12 A4 50**	**FBN II 12 gvz 65**	**FBN 12 A4 70**	**FBN II 16 gvz 65**	**FBN 16 A4 64**	**FBN II 16 gvz 80**	**FBN 16 A4 84**	**FBN II 20 gvz 80**	**FBN II 20 gvz 105**
non-cracked concrete										
tension load C 20/25 N_{Rk} [kN]	17.8	16.0	26.4	25.0	26.4	20.0	36.1	38.8	36.1	54.2
C 50/60 N_{Rk} [kN]	27.6	24.8	36.0	38.7	40.9	31.0	55.9	60.1	55.9	84.0
shear load C 20/25 V_{Rk} [kN]	17.8	16.0	21.0	26.3	40.0	40.0	40.0	47.1	67.0	
C 50/60 V_{Rk} [kN]	21.0	24.8	21.0	26.3	40.0	47.1	40.0	47.1	67.0	

Design and permissible loads see next page.

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Design loads

Anchor type	FBN 6 A4	FBN II 8 gvz	FBN 8 A4	FBN II 8 gvz	FBN 8 A4	FBN II 10 gvz	FBN 10 A4	FBN II 10 gvz	FBN 10 A4	
h_{ef} [mm]	40	30*	35*	40	48	40	42	50	50	
non-cracked concrete										
tension load C 20/25 N_{Rd} [kN]	4.0	4.0	4.2	8.5	6.0	8.5	6.7	11.9	8.0	
C 50/60 N_{Rd} [kN]	5.7	6.2	5.9	11.4	8.5	13.2	10.3	17.9	12.4	
shear load C 20/25 V_{Rd} [kN]	4.0	4.0	5.0	8.5	6.0	8.5	8.0	11.9	8.0	
C 50/60 V_{Rd} [kN]	5.0	6.2	7.1	8.8	8.4	13.2	12.4	13.6	12.4	
Anchor type	**FBN II 12 gvz**	**FBN 12 A4**	**FBN II 12 gvz**	**FBN 12 A4**	**FBN II 16 gvz**	**FBN 16 A4**	**FBN II 16 gvz**	**FBN 16 A4**	**FBN II 20 gvz**	**FBN II 20 gvz**
h_{ef} [mm]	50	50	65	70	65	64	80	84	80	105
non-cracked concrete										
tension load C 20/25 N_{Rd} [kN]	11.9	8.9	17.6	13.9	17.6	11.1	24.0	18.5	24.0	36.2
C 50/60 N_{Rd} [kN]	18.4	13.8	25.4	21.5	27.3	14.4	37.2	28.6	37.2	56.0
shear load C 20/25 V_{Rd} [kN]	11.9	10.7	16.8	17.5	32.0	26.7	32.0	31.4	48.1	53.6
C 50/60 V_{Rd} [kN]	16.8	16.5	16.8	17.5	32.0	31.4	32.0	31.4	53.6	53.6

Permissible loads [1)]

Anchor type	FBN 6 A4	FBN II 8 gvz	FBN 8 A4	FBN II 8 gvz	FBN 8 A4	FBN II 10 gvz	FBN 10 A4	FBN II 10 gvz	FBN 10 A4	
h_{ef} [mm]	40	30*	35*	40	48	40	42	50	50	
non-cracked concrete										
tension load C 20/25 N_{perm} [kN]	2.9	2.9	3.0	6.1	4.3	6.1	4.8	8.5	5.7	
C 50/60 N_{perm} [kN]	4.1	4.4	4.2	8.2	6.1	9.4	7.4	12.8	8.9	
shear load C 20/25 V_{perm} [kN]	2.9	2.9	3.6	6.1	4.3	6.1	5.7	8.5	5.5	
C 50/60 V_{perm} [kN]	3.6	4.4	5.1	6.3	6.0	9.4	8.9	9.7	8.9	
Anchor type	**FBN II 12 gvz**	**FBN 12 A4**	**FBN II 12 gvz**	**FBN 12 A4**	**FBN II 16 gvz**	**FBN 16 A4**	**FBN II 16 gvz**	**FBN 16 A4**	**FBN II 20 gvz**	**FBN II 20 gvz**
h_{ef} [mm]	50	50	65	70	65	64	80	84	80	105
non-cracked concrete										
tension load C 20/25 N_{perm} [kN]	8.5	6.3	12.6	9.9	12.6	7.9	17.2	13.2	17.2	25.8
C 50/60 N_{perm} [kN]	13.1	9.8	18.1	15.4	19.5	10.3	26.6	20.4	26.6	40.0
shear load C 20/25 V_{perm} [kN]	8.5	7.6	12.0	12.5	22.9	19.0	22.9	22.4	34.3	38.3
C 50/60 V_{perm} [kN]	12.0	11.8	12.0	12.5	22.9	22.4	22.9	22.4	38.3	38.3

* Use restricted to anchoring of structural components which are statically indeterminate.

1) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

4. Load direction: tension

4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			FBN 6 A4	FBN II 8 gvz	FBN 8 A4	FBN II 10 gvz	FBN 10 A4	FBN II 12 gvz	FBN 12 A4	FBN II 16 gvz	FBN 16 A4	FBN II 20 gvz
characteristic resistance	$N_{Rk,s}$	[kN]	10.0	16.0	17.0	25.0	27.0	36.0	40.0	67.0	69.0	107.0
design resistance	$N_{Rd,s}$	[kN]	6.2	11.4	10.8	17.9	17.1	25.4	24.7	44.7	41.6	71.3

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

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

Characteristic resistance and design resistance for single anchors in concrete C 20/25

Anchor type			FBN 6 A4	FBN II 8 gvz	FBN 8 A4	FBN II 8 gvz	FBN 8 A4	FBN II 10 gvz	FBN 10 A4	FBN II 10 gvz	FBN 10 A4	
h_{ef}		[mm]	40	30*	35*	40	48	40	42	50	50	
non-cracked concrete												
characteristic resistance	$N^0_{Rk,p}$	[kN]	6.0	6.0	7.5	12.8	9.0	12.8	12.0	17.8	12.0	
design resistance	$N^0_{Rd,p}$	[kN]	4.0	4.0	4.2	8.5	6.0	8.5	6.7	11.9	8.0	
Anchor type			**FBN II 12 gvz**	**FBN 12 A4**	**FBN II 12 gvz**	**FBN 12 A4**	**FBN II 16 gvz**	**FBN 16 A4**	**FBN II 16 gvz**	**FBN 16 A4**	**FBN II 20 gvz**	**FBN II 20 gvz**
h_{ef}		[mm]	50	50	65	70	65	64	80	84	80	105
non-cracked concrete												
characteristic resistance	$N^0_{Rk,p}$	[kN]	17.8	16.0	26.4	25.0	26.4	20.0	36.1	38.8	36.1	54.2
design resistance	$N^0_{Rd,p}$	[kN]	11.9	8.9	17.6	13.9	17.6	11.1	24.0	21.6	24.0	36.2

4.3 Concrete cone failure and splitting for the most unfavourable anchor

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c1} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c1} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C 20/25

Anchor type			FBN 6 A4	FBN II 8 gvz	FBN 8 A4	FBN II 8 gvz	FBN 8 A4	FBN II 10 gvz	FBN 10 A4	FBN II 10 gvz	FBN 10 A4	
h_{ef}		[mm]	40	30*	35*	40	48	40	42	50	50	
non-cracked concrete												
characteristic resistance	$N^0_{Rk,c}$	[kN]	12.8	8.3	10.4	12.8	16.8	12.8	13.7	17.8	17.8	
design resistance	$N^0_{Rd,c}$	[kN]	8.5	5.5	5.8	8.5	11.2	8.5	7.6	11.9	11.9	
Anchor type			**FBN II 12 gvz**	**FBN 12 A4**	**FBN II 12 gvz**	**FBN 12 A4**	**FBN II 16 gvz**	**FBN 16 A4**	**FBN II 16 gvz**	**FBN 16 A4**	**FBN II 20 gvz**	**FBN II 20 gvz**
h_{ef}		[mm]	50	50	65	70	65	64	80	84	80	105
non-cracked concrete												
characteristic resistance	$N^0_{Rk,c}$	[kN]	17.8	17.8	26.4	29.5	26.4	25.8	36.1	38.8	36.1	54.2
design resistance	$N^0_{Rd,c}$	[kN]	11.9	9.9	17.6	16.4	17.6	14.3	24.0	18.5	24.0	36.2

* Use restricted to anchoring of structural components which are statically indeterminate.

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm]	Influence factor f_s [-] FBN 6 A4	FBN II 8 gvz	FBN 8 A4	FBN II 8 gvz	FBN 8 A4	FBN II 10 gvz	FBN 10 A4	FBN II 10 gvz	FBN 10 A4
↓ h_{ef} [mm]	40	30*	35*	40	48	40	42	50	50
35									
40	0.67	0.72		0.67					
45	0.69	0.75		0.69					
50	0.71	0.78	0.73	0.71	0.68	0.71	0.69	0.67	
55	0.73	0.81	0.75	0.73	0.70	0.73	0.71	0.68	
60	0.75	0.83	0.77	0.75	0.71	0.75	0.73	0.70	0.70
75	0.81	0.92	0.84	0.81	0,77	0.81	0.79	0.75	0.75
90	0.88	1.00	0.91	0.88	0.82	0.88	0.85	0.80	0.80
100	0.92		0.95	0.92	0.86	0.92	0.88	0.83	0.83
105	0.94		1.00	0.94	0.88	0.94	0.90	0.85	0.85
120	1.00			1.00	0.93	1.00	0.96	0.90	0.90
130					0.96		1.00	0.93	0.93
140					1.00			0.97	0.97
145								0.98	0.98
150								1.00	1.00
s_{min} [mm]	40	40	50	40	50	50	50	50	60
$s_{cr,N}$ [mm]	120	90	110	120	140	120	130	150	150

Spacing s [mm]	Influence factor f_s [-] FBN II 12 gvz	FBN 12 A4	FBN II 12 gvz	FBN 12 A4	FBN II 16 gvz	FBN 16 A4	FBN II 16 gvz	FBN 16 A4	FBN II 20 gvz	FBN II 20 gvz
↓ h_{ef} [mm]	50	50	65	70	65	64	80	84	80	105
65										
70	0.73		0.68							
75	0.75		0.69							
80	0.77		0.71	0.69						
90	0.80		0.73	0.71	0.73	0.74	0.69			
100	0.83	0.83	0.76	0.74	0.76	0.76	0.71	0.70		
120	0.90	0.90	0.81	0.79	0.81	0.82	0.75	0.74	0.75	0.69
130	0.93	0.93	0.83	0.81	0.83	0.84	0.77	0.76	0.77	0.71
140	0.97	0.97	0.86	0.83	0.86	0.87	0.79	0.78	0.79	0.72
150	1.00	1.00	0.88	0.86	0.88	0.89	0.81	0.80	0.81	0.74
170			0.94	0.90	0.94	0.95	0.85	0.84	0.85	0.77
175			0.95	0.92	0.95	0.96	0.86	0.85	0.86	0.78
190			0.99	0.95	0.99	1.00	0.90	0.89	0.90	0.80
195			1.00	0.96	1.00		0.91	0.89	0.91	0.81
200				0.98			0.92	0.90	0.92	0.82
210				1.00			0.94	0.92	0.94	0.83
240							1.00	0.98	1.00	0.88
250								1.00		0.90
315										1.00
s_{min} [mm]	70	95	70	80	90	90	90	100	120	
$s_{cr,N}$ [mm]	150	150	195	210	195	190	240	250	240	315

* Use restricted to anchoring of structural components which are statically indeterminate

fischer Bolt FBN

Anchor design according to ETA

4.3.1.2 Influence of edge distances

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c [mm]		Influence factor f_s [-]									
		FBN 6 A4	FBN II 8 gvz	FBN 8 A4	FBN II 8 gvz	FBN 8 A4	FBN II 10 gvz	FBN 10 A4	FBN II 10 gvz	FBN 10 A4	
↓	h_{ef} [mm]	40	30*	35*	40	48	40	42	50	50	
35		0.69				0.64					
40		0.75	0.91		0.75	0.68					
45		0.81	1.00	0.86	0.81	0.73					
50		0.87		0.93	0.87	0.78			0.75		
55		0.93		1.00	0.93	0.84			0.80	0.80	
60		1.00			1.00	0.89		0.94	0.85	0.85	
65						0.94		1.00	0.90	0.90	
70						1.00			0.95	0.95	
75									1.00	1.00	
80							1.00				
c_{min}	[mm]	35	40	45	40	35	80	60	50	55	
$c_{cr,N}$	[mm]	60	45	55	60	70	60	65	75	75	

Edge distance c [mm]		Influence factor f_s [-]									
		FBN II 12 gvz	FBN 12 A4	FBN II 12 gvz	FBN 12 A4	FBN II 16 gvz	FBN 16 A4	FBN II 16 gvz	FBN 16 A4	FBN II 20 gvz	FBN II 20 gvz
↓	h_{ef} [mm]	50	50	65	70	65	64	80	84	80	105
70				0.79							
75				0.82	0.78						
80				0.86	0.82		0.88				
85				0.90	0.85		0.92				
90				0.94	0.89		0.96	0.81			
95			1.00	0.98	0.93		1.00	0.84			
100		1.00		1.00	0.96			0.87	0.85		
105					1.00			0.90	0.88		
120						1.00		1.00	0.97	1.00	0.82
125									1.00		0.84
150											0.96
160											1.00
c_{min}	[mm]	100	95	70	75	120	80	90	100	120	
$c_{cr,N}$	[mm]	75	75	98	105	98	95	120	125	120	158

* Use restricted to anchoring of structural components which are statically indeterminate.

4

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s [mm] ↓	Influence factor f_s [-] FBN 6 A4	FBN II 8 gvz	FBN 8 A4	FBN II 8 gvz	FBN 8 A4	FBN II 10 gvz	FBN 10 A4	FBN II 10 gvz	FBN 10 A4
h_{ef} [mm]	40	30*	35*	40	48	40	42	50	50
40	0.60	0.61		0.61					
45	0.61	0.62		0.62					
50	0.63	0.63	0.64	0.63	0.60	0.63	0.62	0.63	
55	0.64	0.64	0.65	0.64	0.61	0.64	0.63	0.64	
60	0.65	0.66	0.67	0.66	0.63	0.65	0.64	0.65	0.62
100	0.75	0.76	0.78	0.76	0.71	0.75	0.74	0.75	0.70
140	0.85	0.87	0.89	0.87	0.79	0.85	0.83	0.85	0.78
160	0.90	0.92	0.94	0.92	0.83	0.90	0.88	0.90	0.82
180	0.95	0.97	1.00	0.97	0.88	0.94	0.92	0.94	0.86
190	0.98	1.00		1.00	0.90	0.98	0.95	0.98	0.88
200	1.00				0.92	1.00	0.98	1.00	0.90
210					0.94		1.00		0.92
240					1.00				0.98
250									1.00
s_{min} [mm]	40	40	50	40	50	50	50	50	60
$s_{cr,sp}$ [mm]	200	190	180	190	240	200	210	200	250

Spacing s [mm] ↓	Influence factor f_s [-] FBN II 12 gvz	FBN 12 A4	FBN II 12 gvz	FBN 12 A4	FBN II 16 gvz	FBN 16 A4	FBN II 16 gvz	FBN 16 A4	FBN II 20 gvz	FBN II 20 gvz
h_{ef} [mm]	50	50	65	70	65	64	80	84	80	105
65										
70	0.62		0.62							
75	0.63		0.63							
80	0.64		0.64	0.61						
90	0.66		0.66	0.63	0.63	0.64	0.63			
100	0.67	0.70	0.67	0.64	0.64	0.66	0.64	0.62		
120	0.71	0.74	0.71	0.67	0.67	0.69	0.67	0.64	0.66	
140	0.74	0.78	0.74	0.70	0.70	0.72	0.70	0.67	0.69	
170	0.79	0.84	0.79	0.74	0.74	0.77	0.74	0.70	0.73	
200	0.84	0.90	0.84	0.79	0.79	0.81	0.79	0.74	0.77	
250	0.93	1.00	0.93	0.86	0.86	0.89	0.86	0.80	0.84	
280	0.98		0.98	0.90	0.90	0.94	0.90	0.83	0.88	
290	1.00		1.00	0.91	0.91	0.95	0.91	0.85	0.89	
320				0.96	0.96	1.00	0.96	0.88	0.93	
350				1.00	1.00		1.00	0.92	0.97	
370								0.95	1.00	
420								1.00		
500										
s_{min} [mm]	70	95	70	80	90	90	90	100	120	
$s_{cr,sp}$ [mm]	290	250	290	350	350	320	350	420	370	

* Use restricted to anchoring of structural components which are statically indeterminate.

fischer Bolt FBN

Anchor design according to ETA

4.3.2.2 Influence of edge distances

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c [mm] ↓	Influence factor f_s [-]								
	FBN 6 A4	FBN II 8 gvz	FBN 8 A4	FBN II 8 gvz	FBN 8 A4	FBN II 10 gvz	FBN 10 A4	FBN II 10 gvz	FBN 10 A4
h_{ef} [mm]	40	30*	35*	40	48	40	42	50	50
35	0.54				0.51				
40	0.57	0.59		0.59	0.53				
45	0.61	0.62	0.64	0.62	0.56				
50	0.64	0.65	0.67	0.65	0.58			0.64	
55	0.67	0.69	0.71	0.69	0.61			0.67	0.60
60	0.70	0.73	0.75	0.72	0.64		0.68	0.70	0.62
65	0.74	0.76	0.79	0.76	0.66		0.72	0.74	0.65
70	0.77	0.80	0.83	0.80	0.69		0.75	0.77	0.68
75	0.81	0.84	0.87	0.84	0.72		0.78	0.81	0.70
80	0.85	0.88	0.91	0.88	0.75	0.85	0.82	0.85	0.73
85	0.88	0.92	0.96	0.92	0.78	0.88	0.85	0.88	0.76
90	0.92	0.96	1.00	0.96	0.81	0.92	0.89	0.92	0.79
95	0.96	1.00		1.00	0.84	0.96	0.93	0.96	0.82
100	1.00				0.87	1.00	0.96	1.00	0.85
105					0.90		1.00		0.88
120					1.00				0.97
125									1.00
c_{min} [mm]	35	40	45	40	35	80	60	50	55
$c_{cr,sp}$ [mm]	100	95	90	95	120	100	105	100	125

Edge distance c [mm] ↓	Influence factor f_s [-]									
	FBN II 12 gvz	FBN 12 A4	FBN II 12 gvz	FBN 12 A4	FBN II 16 gvz	FBN 16 A4	FBN II 16 gvz	FBN 16 A4	FBN II 20 gvz	FBN II 20 gvz
h_{ef} [mm]	50	50	65	70	65	64	80	84	80	105
70			0.63							
75			0.65	0.59						
80			0.67	0.61		0.64				
90			0.72	0.65		0.68	0.65			
100	0.77	0.85	0.77	0.68		0.72	0.68	0.62		
105	0.79	0.88	0.79	0.70		0.74	0.70	0.64		
120	0.87	0.97	0.87	0.76	0.76	0.81	0.76	0.68	0.74	
125	0.89	1.00	0.89	0.78	0.78	0.83	0.78	0.70	0.76	
140	0.97		0.97	0.85	0.85	0.90	0.85	0.75	0.81	
145	1.00		1.00	0.87	0.87	0.93	0.87	0.77	0.83	
160				0.93	0.93	1.00	0.93	0.82	0.89	
175				1.00	1.00		1.00	0.87	0.96	
185								0.91	1.00	
190								0.93		
200								0.96		
210								1.00		
c_{min} [mm]	100	95	70	75	120	80	90	100	120	
$c_{cr,sp}$ [mm]	145	125	145	175	175	160	175	210	185	

* Use restricted to anchoring of structural components which are statically indeterminate.

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{2 \cdot h_{ef}} \right)^{\frac{2}{3}} \leq 1.5$$

Thickness h [mm]	Influence factor f_s [-]															
	FBN 6	FBN II 8	FBN 8	FBN II 8	FBN 8	FBN II 10	FBN 10	FBN II 10 FBN 10 FBN II 12 FBN 12	FBN II 12	FBN 12	FBN II 16	FBN 16	FBN II 16	FBN 16	FBN II 20	
↓ h_{ef} [mm]	40	30	35	40	48	40	42	50	65	70	65	64	80	84	80	105
100	1.16	1.41	1.27	1.16	1.03	1.16	1.12	1.00								
120	1.31	1.50	1.43	1.31	1.16	1.31	1.27	1.13	0.95		0.95					
130	1.38		1.50	1.38	1.22	1.38	1.34	1.19	1.00		1.00	1.01				
140	1.45			1.45	1.29	1.45	1.41	1.25	1.05	1.00	1.05	1.06				
150	1.50			1.50	1.35	1.50	1.47	1.31	1.10	1.05	1.10	1.11				
160					1.41		1.50	1.37	1.15	1.09	1.15	1.16	1.00		1.00	
170					1.46			1.42	1.20	1.14	1.20	1.21	1.04	1.01	1.04	
180					1.50			1.48	1.24	1.18	1.24	1.26	1.08	1.05	1.08	
190								1.50	1.29	1.23	1.29	1.30	1.12	1.09	1.12	
200									1.33	1.27	1.33	1.35	1.16	1.12	1.16	0.97
210									1.38	1.31	1.38	1.39	1.20	1.16	1.20	1.00
220									1.42	1.35	1.42	1.43	1.24	1.20	1.24	1.03
230									1.46	1.39	1.46	1.48	1.27	1.23	1.27	1.06
240									1.50	1.43	1.50	1.50	1.31	1.27	1.31	1.09
250										1.47			1.35	1.30	1.35	1.12
260										1.50			1.38	1.34	1.38	1.15
270													1.42	1.37	1.42	1.18
280													1.45	1.41	1.45	1.21
290													1.49	1.44	1.49	1.24
300													1.50	1.47	1.50	1.27
310														1.50		1.30
320																1.32
360																1.43
390																1.50
h_{min} [mm]	100	100	100	100	100	100	100	100	120	140	120	130	160	170	160	200

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type	FBN 6 A4	FBN II 8 gvz	FBN 8 A4	FBN II 10 gvz	FBN 10 A4	FBN II 12 gvz	FBN 12 A4	FBN II16 gvz	FBN 16 A4	FBN II 20 gvz
characteristic resistance $V_{Rk,s}$ [kN]	7,5	11.0	12.6	17.0	20.0	21.0	26.3	40.0	47.1	67.0
design resistance $V_{Rd,s}$ [kN]	5.0	8.8	8.4	13.6	13.3	16.8	17.5	32.0	31.4	53.6

5.2 Pryout-failure for the most unfavourable anchor

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c1} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C 20/25

Anchor type		FBN 6	FBN II 8	FBN 8	FBN II 8	FBN 8	FBN II 10	FBN 10	FBN II 10	FBN 10	
		A4	gvz	A4	gvz	A4	gvz	A4	gvz	A4	
h_{ef}	[mm]	40	30*	35	40	48	40	42	50	50	
non-cracked concrete											
characteristic resistance	$N^0_{Rk,cp}$ (C) [kN]	12.8	8.3	10.4	12.8	16.8	12.8	13.7	17.8	17.8	
design resistance	$N^0_{Rd,cp}$ (C) [kN]	8.5	5.5	7.0	8.5	11.2	8.5	9.1	11.9	11.9	
characteristic resistance	$N^0_{Rk,cp}$ (P) [kN]	6.0	6.0	7.5	12.8	9.0	12.8	12.0	17.8	12.0	
design resistance	$N^0_{Rd,cp}$ (P) [kN]	4.0	4.0	5.0	8.5	6.0	8.5	8.0	11.9	8.0	
Anchor type		FBN II 12	FBN 12	FBN II 12	FBN 12	FBN II 16	FBN 16	FBN II 16	FBN 16	FBN II 20	
		gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	gvz
h_{ef}	[mm]	50	50	65	70	65	64	80	84	80	105
non-cracked concrete											
characteristic resistance	$N^0_{Rk,cp}$ (C) [kN]	17.8	17.8	26.4	29.5	26.4	25.8	36.1	38.8	36.1	54.2
design resistance	$N^0_{Rd,cp}$ (C) [kN]	11.9	11.9	17.6	19.7	17.6	17.2	24.0	25.9	24.0	36.2
characteristic resistance	$N^0_{Rk,cp}$ (P) [kN]	17.8	16.0	26.4	25.0	26.4	20.0	36.1	38.8	36.1	54.2
design resistance	$N^0_{Rd,cp}$ (P) [kN]	11.9	10.7	17.6	16.7	17.6	13.3	24.0	25.9	24.0	36.2

* Use restricted to anchoring of structural components which are statically indeterminate.

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c2} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C 20/25 for edge distances c_{min}

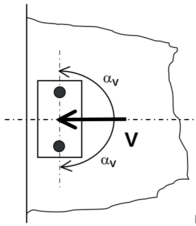
Anchor type		FBN 6	FBN II 8	FBN 8	FBN II 8	FBN 8	FBN II 10	FBN 10	FBN II 10	FBN 10	
		A4	gvz	A4	gvz	A4	gvz	A4	gvz	A4	
h_{ef}	[mm]	40	30*	35*	40	48	40	42	50	50	
non-cracked concrete											
minimum edge distance	c_{min} [mm]	35	40	45	40	35	80	60	50	55	
characteristic resistance	$V^0_{Rk,c}$ [kN]	3.9	4.7	5.6	4.9	4.2	12.9	8.8	7.1	8.1	
design resistance	$V^0_{Rd,c}$ [kN]	2.6	3.1	3.7	3.3	2.8	8.6	5.9	4.7	5.4	
Anchor type		FBN II 12	FBN 12	FBN II 12	FBN 12	FBN II 16	FBN 16	FBN II 16	FBN 16	FBN II 20	
		gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	gvz
h_{ef}	[mm]	50	50	65	70	65	64	80	84	80	105
non-cracked concrete											
minimum edge distance	c_{min} [mm]	100	95	70	75	120	80	90	100	120	120
characteristic resistance	$V^0_{Rk,c}$ [kN]	18.5	17.2	12.0	13.3	25.6	14.9	18.1	21.0	27.4	28.9
design resistance	$V^0_{Rd,c}$ [kN]	12.3	11.5	8.0	8.9	17.0	9.9	12.1	14.0	18.2	19.3

* Use restricted to anchoring of structural components which are statically indeterminate.

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

4

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 Single anchor influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}^{\ n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}^{\ n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\ n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 Anchor pair influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$
and spacing $s \leqq 3 \cdot c$

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for $s > 3 \cdot c$

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$
and spacing $s \leqq 4.5 \cdot h$

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for $s > 4.5 \cdot h$

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2,89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

6. Summary of required proof:

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

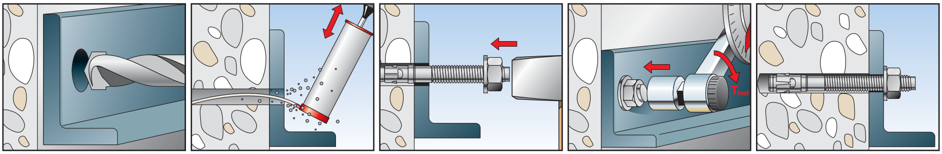
6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

7. Installation details

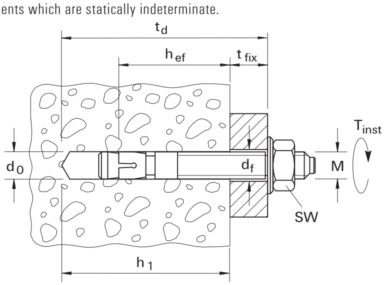


8. Anchor characteristics

Anchor type	FBN 6	FBN II 8	FBN 8	FBN II 8	FBN 8	FBN II 10	FBN 10	FBN II 10	FBN 10
	A4	gvz	A4	gvz	A4	gvz	A4	gvz	A4
h_{ef} [mm]	40	30*	35*	40	48	40	42	50	50
diameter of thread	M 6	M 8	M8	M 8	M 8	M 10	M 10	M 10	M 10
nominal drill hole diameter d_0 [mm]	6	8	8	8	8	10	10	10	10
drill depth h_1 [mm]	55	46	43	56	63	58	51	68	68
effective anchorage depth h_{ef} [mm]	40	30	35	40	48	40	42	50	50
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	≦ 9	≦ 9	≦ 12	≦ 12	≦ 12	≦ 12
wrench size SW [mm]	10	13	13	13	13	17	17	17	17
required torque T_{inst} [Nm]	7.5	15	15	15	15	30	30	30	30
minimum thickness of concrete member h_{min} [mm]	100	100	100	100	100	100	100	100	100
minimum spacing s_{min} [mm]	40	40	50	40	50	50	50	50	60
minimum edge distances c_{min} [mm]	35	40	45	40	35	80	60	50	55

Anchor type	FBN II 12	FBN 12	FBN II 12	FBN 12	FBN II 16	FBN 16	FBN II 16	FBN 16	FBN II 20	
	gvz	A4	gvz	A4	gvz	A4	gvz	A4	gvz	gvz
h_{ef} [mm]	50	50	65	70	65	64	80	84	80	105
diameter of thread	M 12	M 12	M 12	M 12	M 16	M 16	M 16	M 16	M 20	
nominal drill hole diameter d_0 [mm]	12	12	12	12	16	16	16	16	20	
drill depth h_1 [mm]	70	61	85	90	89	79	104	108	110	135
effective anchorage depth h_{ef} [mm]	50	50	65	70	65	64	80	84	80	105
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	≦ 14	≦ 14	≦ 14	≦ 18	≦ 18	≦ 18	≦ 18	≦ 22	
wrench size SW [mm]	19	19	19	19	24	24	24	24	30	
required torque T_{inst} [Nm]	50	50	50	50	100	100	100	100	200	
minimum thickness of concrete member h_{min} [mm]	100	100	120	140	120	130	160	170	160	200
minimum spacing s_{min} [mm]	70	95	70	80	90	90	90	100	120	
minimum edge distances c_{min} [mm]	100	95	70	75	120	80	90	100	120	

* Use restricted to anchoring of structural components which are statically indeterminate.

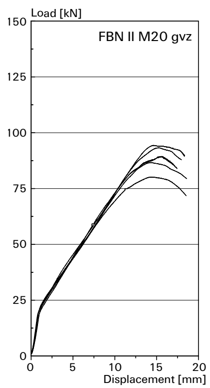


9. Mechanical characteristics

Anchor type			FBN 6 A4	FBN II 8 gvz	FBN 8 A4	FBN II 10 gvz	FBN 10 A4	FBN II 12 gvz	FBN 12 A4	FBN II 16 gvz	FBN 16 A4	FBN II 20 gvz
stressed cross sectional area reduced part of the cone bolt	A_s	[mm²]	13.2	22.9	23.8	36.3	37.4	55.4	54.1	103.9	103.9	165.0
resisting moment reduced part of the cone bolt	W	[mm³]	6.8	15.5	16.3	30.9	32.3	58.2	56.1	149.3	149.3	299.3
yield strength reduced part of the cone bolt	f_y	[N/mm²]	625	560	600	560	600	580	575	580	500	580
tensile strength reduced part of the cone bolt	f_u	[N/mm²]	840	700	790	700	790	650	775	650	690	650
stressed cross sectional area threaded part	A_s	[mm²]	20.1	36.6	36.6	58.0	58.0	84.3	84.3	157.0	157.0	245.0
resisting moment threaded part	W	[mm³]	12.7	31.2	31.2	62.3	62.3	109.2	109.2	277.5	277.5	540.9
yield strength threaded part	f_y	[N/mm²]	625	480	600	480	600	480	575	480	500	520
tensile strength threaded part	f_u	[N/mm²]	750	600	690	600	690	600	625	600	600	650

4

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



Upat EXA Express-anchor

Anchor design according to ETA

1. Types

EXA - Express anchor (gvz)

European Technical Approval - Option 7 for non-cracked concrete

Fire resistance classification F 120

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 7.
- Suitable for non-cracked concrete.
- Double-clip method tried and tested gives double security.
- Minimum installation slippage gives powerful torque and rapid grip after just a few turns.

Materials

Cone bolt: Carbon steel, zinc plated (5 µm) and passivated (gvz)

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

Mean values

Anchor type				EXA 8 gvz	EXA 10 gvz	EXA 12 gvz	EXA 16 gvz	EXA 20 gvz
non-cracked concrete								
tension load	C 20/25	N_u	[kN]	16.0	22.0	35.0	52.9	70.6
	C 50/60	N_u	[kN]	22.8*)	34.2	47.7*)	62.2*)	107.9*)
shear load	≧ C 20/25	V_u	[kN]	15.8*)	23.3*)	32.9*)	58.7*)	82.9*)

*) Steel failure decisive

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube(150)}$ [N/mm²]	Influence factor $f_{b,p} = f_{b,c}$ [-]
C 20/25	20	25	1.00
C 25/30	25	30	1.10
C 30/37	30	37	1.22
C 40/50	40	50	1.41
C 45/55	45	55	1.48
C 50/60	50	60	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Characteristic loads

Anchor type			EXA 8 gvz	EXA 10 gvz	EXA 12 gvz	EXA 16 gvz	EXA 20 gvz
non-cracked concrete							
tension load	C 20/25	N_{Rk} [kN]	12.0	16.0	25.0	35.0	52.0
	C 50/60	N_{Rk} [kN]	18.6	24.8	38.7	54.2	80.6
shear load	C 20/25	V_{Rk} [kN]	12.0	16.0	23.0	51.0	75.0
	C 50/60	V_{Rk} [kN]	13.0	19.0	23.0	51.0	75.0

Design loads

Anchor type			EXA 8 gvz	EXA 10 gvz	EXA 12 gvz	EXA 16 gvz	EXA 20 gvz
non-cracked concrete							
tension load	C 20/25	N_{Rd} [kN]	5.7	8.9	13.9	23.3	34.7
	C 50/60	N_{Rd} [kN]	8.9	13.8	21.5	36.1	53.7
shear load	C 20/25	V_{Rd} [kN]	8.0	10.7	15.3	38.9	57.3
	C 50/60	V_{Rd} [kN]	8.7	12.7	15.3	38.9	57.3

Permissible loads [1)]

Anchor type			EXA 8 gvz	EXA 10 gvz	EXA 12 gvz	EXA 16 gvz	EXA 20 gvz
non-cracked concrete							
tension load	C 20/25	N_{perm} [kN]	4.1	6.3	9.9	16.7	24.8
	C 50/60	N_{perm} [kN]	6.3	9.8	15.4	25.8	38.4
shear load	C 20/25	V_{perm} [kN]	5.7	7.6	11.0	27.8	40.9
	C 50/60	V_{perm} [kN]	6.2	9.0	11.0	27.8	40.9

1) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

4. Load direction: tension

4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			EXA 8	EXA 10	EXA 12	EXA 16	EXA 20
			gvz	gvz	gvz	gvz	gvz
characteristic resistance	$N_{Rk,s}$	[kN]	23.0	35.0	48.0	62.0	108.0
design resistance	$N_{Rd,s}$	[kN]	15.5	24.3	34.3	39.5	68.8

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

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			EXA8	EXA 10	EXA 12	EXA 16	EXA 20
			gvz	gvz	gvz	gvz	gvz
non-cracked concrete							
characteristic resistance	$N^0_{Rk,p}$	[kN]	12.0	16.0	25.0	35.0	52.0
design resistance	$N^0_{Rd,p}$	[kN]	5.7	8.9	13.9	23.3	34.7

4

4.3 Concrete cone failure and splitting for the most unfavourable anchor

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			EXA 8	EXA 10	EXA 12	EXA 16	EXA 20
			gvz	gvz	gvz	gvz	gvz
eff. anchorage depth	h_{ef}	[mm]	47	49	67	85	103
non-cracked concrete							
characteristic resistance	$N^0_{Rk,c}$	[kN]	16.2	17.3	27.6	39.5	52.7
design resistance	$N^0_{Rd,c}$	[kN]	7.7	9.6	15.4	26.3	35.1

4.3.1 Concrete cone failure
4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s	Influence factor f_s [-]				
	EXA 8	EXA 10	EXA 12	EXA 16	EXA 20
[mm]	gvz	gvz	gvz	gvz	gvz
45	0.66				
50	0.68	0.67			
75	0.77	0.76	0.69		
85	0.80	0.79	0.71	0.67	
105	0.87	0.86	0.76	0.71	0.67
120	0.93	0.91	0.80	0.74	0.69
140	1.00	0.98	0.85	0.77	0.73
145		0.99	0.86	0.78	0.73
170			0.92	0.83	0.78
200			1.00	0.89	0.82
220				0.93	0.86
255				1.00	0.91
280					0.95
310					1.00
s_{min} [mm]	45	50	75	85	105
$s_{cr,N}$ [mm]	141	147	201	255	309

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c	Influence factor f_c [-]				
	EXA 8	EXA 10	EXA 12	EXA 16	EXA 20
[mm]	gvz	gvz	gvz	gvz	gvz
40	0.68				
45	0.73				
50	0.78				
55	0.83				
60	0.88				
65	0.94	0.91			
70	0.99	0.96			
75		1.00			
90			0.91	0.78	
95			0.95	0.81	
100			0.99	0.83	0.74
115				0.92	0.81
130				1.00	0.88
155					1.00
c_{min} [mm]	40	65	90	90	100
$c_{cr,N}$ [mm]	71	74	101	128	155

Intermediate values by linear interpolation.

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s	Influence factor $f_{s,sp}$ [-]				
	EXA 8	EXA 10	EXA 12	EXA 16	EXA 20
[mm]	gvz	gvz	gvz	gvz	gvz
45	0.57				
50	0.58	0.57			
75	0.61	0.61	0.59		
85	0.63	0.63	0.60	0.60	
105	0.66	0.65	0.62	0.62	0.60
150	0.73	0.72	0.68	0.68	0.65
200	0.80	0.79	0.74	0.74	0.69
250	0.88	0.87	0.79	0.79	0.74
300	0.95	0.94	0.85	0.85	0.79
330	1.00	0.99	0.89	0.89	0.82
340		1.00	0.90	0.90	0.83
350			0.91	0.91	0.84
400			0.97	0.97	0.89
425			1.00	1.00	0.91
450					0.94
515					1.00
s_{min} [mm]	45	50	75	85	105
$s_{cr,sp}$ [mm]	330	340	425	425	515

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s^2_{cr,sp}}$$

Edge distance c	Influence factor $f_{c,sp}$ [-]				
	EXA 8	EXA 10	EXA 12	EXA 16	EXA 20
[mm]	gvz	gvz	gvz	gvz	gvz
40	0.48				
50	0.52				
65	0.57	0.56			
90	0.67	0.66	0.59	0.59	
100	0.71	0.70	0.62	0.62	0.57
120	0.79	0.78	0.68	0.68	0.62
140	0.88	0.86	0.74	0.74	0.67
165	1.00	0.98	0.83	0.83	0.73
170		1.00	0.85	0.85	0.75
200			0.95	0.95	0.83
215			1.00	1.00	0.87
240					0.95
260					1.00
c_{min} [mm]	40	65	90	90	100
$c_{cr,sp}$ [mm]	165	170	215	215	260

Intermediate values by linear interpolation.

4.3.2.3 Influence of concrete thickness

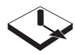
$$f_h = \left(\frac{h}{2 \cdot h_{ef}} \right)^{\frac{2}{3}} \leq 1.5$$

Thickness h [mm]	Influence factor f_h [-] EXA 8	EXA 10	EXA 12	EXA 16	EXA 20
100	1.04	1.01			
120	1.18	1.14			
140	1.30	1.27	1.03		
150	1.37	1.33	1.08		
170	1.48	1.44	1.17	1.00	
180	1.50	1.50	1.22	1.04	
200			1.31	1.11	
210			1.35	1.15	1.01
220			1.39	1.19	1.04
250			1.50	1.29	1.14
280				1.39	1.23
300				1.46	1.28
320				1.50	1.34
350					1.42
380					1.50
h_{ef} [mm]	47	49	67	85	103
h_{min} [mm]	100	100	135	170	205

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor



Characteristic resistance and design resistance for single anchors

Anchor type			EXA 8 gvz	EXA 10 gvz	EXA 12 gvz	EXA 16 gvz	EXA 20 gvz
characteristic resistance	$V_{Rk,s}$	[kN]	13.0	19.0	23.0	51.0	75.0
design resistance	$V_{Rd,s}$	[kN]	8.7	12.7	15.3	38.9	57.3

5.2 Pryout - failure for the most unfavourable anchor

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			EXA 8 gvz	EXA 10 gvz	EXA 12 gvz	EXA 16 gvz	EXA 20 gvz
eff. anchorage depth	h_{ef}	[mm]	47	49	67	85	103
non-cracked concrete							
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	16.2	17.3	27.6	39.5	52.7
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	10.8	11.5	18.4	26.3	35.1
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	12.0	16.0	25.0	35.0	52.0
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	8.0	10.7	16.7	23.3	34.7

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

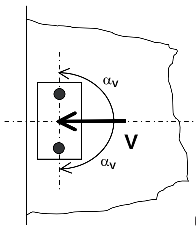
Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

Anchor type			EXA 8 gvz	EXA 10 gvz	EXA 12 gvz	EXA 16 gvz	EXA 20 gvz
non-cracked concrete							
minimum edge distance	c_{min}	[mm]	40	65	90	90	100
characteristic resistance	$V^0_{Rk,c}$	[kN]	5.0	10.0	16.8	18.4	22.8
design resistance	$V^0_{Rd,c}$	[kN]	3.4	6.7	11.2	12.2	15.2

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

4

5.3.2 Influence of spacing and edge distance

5.3.2.1 **Single anchor** influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\,n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 **Anchor pair** influenced only by one edge

for concrete thickness h ≧ 1.5 · c
and spacing **s ≦ 3 · c**

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for s > 3 · c

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c
and spacing **s ≦ 4.5 · h**

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for s > 4.5 · h

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

6. Summary of required proof:

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

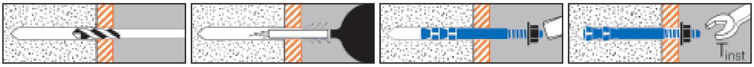
6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

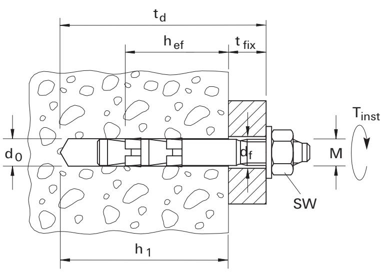
N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

7. Installation details



8. Anchor characteristics

Anchor type			EXA 8 gvz	EXA 10 gvz	EXA 12 gvz	EXA 16 gvz	EXA 20 gvz
			M 8	M 10	M 12	M 16	M 20
nominal drill hole diameter	d_0	[mm]	8	10	12	16	20
drill depth	h_1	[mm]	65	70	90	110	130
eff. anchorage depth	h_{ef}	[mm]	47	49	67	85	103
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
wrench size	SW	[mm]	13	17	19	24	30
required torque	T_{inst}	[Nm]	14	45	65	110	230
minimum thickness of concrete member	h_{min}	[mm]	100	100	135	170	205
minimum spacing	s_{min}	[mm]	45	50	75	85	105
for required edge distances	for c	[mm]	60	85	90	145	170
minimum edge distances	c_{min}	[mm]	40	65	90	90	100
for required spacing	for s	[mm]	100	100	75	145	170



Upat EXA Express-anchor

Anchor design according to ETA

9. Mechanical characteristics

Anchor type			EXA 8 gvz	EXA 10 gvz	EXA 12 gvz	EXA 16 gvz	EXA 20 gvz
stressed cross sectional area reduced part	A_s	[mm²]	28.5	44.8	63.6	113.0	196.1
resisting moment reduced part	W	[mm³]	15.5	33.7	60.3	153.2	281.1
yield strength reduced part	f_y	[N/mm²]	650	650	650	420	420
tensile strength reduced part	f_u	[N/mm²]	800	780	750	550	550
stressed cross sectional area threaded part	A_s	[mm²]	36.6	58.0	84.3	157.0	245.0
resisting moment threaded part	W	[mm³]	31.2	62.3	109.2	277.5	540.9
yield strength threaded part	f_y	[N/mm²]	650	650	650	420	420
tensile strength threaded part	f_u	[N/mm²]	800	780	750	550	550

fischer Zykon anchor FZA

Anchor design according to ETA

1. Types

FZA – Bolt anchor (gvz)

FZA – Bolt anchor (A4)

FZA – Bolt anchor (C)

European Technical Approval – Option 1 for cracked concrete

Feuerwiderstandsklasse F 90/120
Dübelgrößen siehe Prüfbericht

size of anchor in accordance with fire regulations

FM APPROVED from thread M 10

PROTEZIONE CIVILE PROTECTION CIVILE ZIVILSCHUTZ

Shock approval by the Federal Office for Civil Defense, Bonn.

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

4

Features and Advantages

- European Technical Approval option 1.
- Suitable for cracked and non-cracked concrete.
- Positive fit in the undercut gives additional security.
- Almost expansion-free operation allows cost-efficient fixing with very small edge and axial spacing.
- Single-step drilling process simultaneously produces the undercut, saving installation time.
- Immediate load-bearing capability avoids installation interruptions (no interruption for resin curing times, unlike chemical anchors).
- Simple visual inspection of the green ring mark ensures 100% function.

Materials

Bolt: Carbon steel, zinc plated (5 µm) and passivated (gvz)
Stainless steel of the corrosion resistance class III, e.g. A4
Stainless steel of the corrosion resistance class IV, e.g. 1.4529 (C)

2. Ultimate loads of single anchors with large spacing and 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 load	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 load	≧ 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 load	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 load	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*)

*) Steel failure decisive

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube(150)}$ [N/mm²]	Influence factor $f_{b,p} = f_{b,c}$ [-]
C 20/25	20	25	1.00
C 25/30	25	30	1.10
C 30/37	30	37	1.22
C 40/50	40	50	1.41
C 45/55	45	55	1.48
C 50/60	50	60	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Characteristic loads

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 load	C 20/25	N_{Rk} [kN]		9.0			9.0			9.0			12.0			20.0			30.0			40.0			40.0	
	C 50/60	N_{Rk} [kN]		13.9			13.9			13.9			18.6			31.0			46.5			62.0			62.0	
shear load	C 20/25	V_{Rk} [kN]	8.0	7.0			11.7			11.7		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			18.1		14.7	12.8		23.2	20.3		33.8	29.5		62.8	55.0		62.8	55.0	
cracked concrete																										
tension load	C 20/25	N_{Rk} [kN]		6.0			6.0			6.0			9.0			12.0			20.0			36.0			40.0	
	C 50/60	N_{Rk} [kN]		9.3			9.3			9.3			13.9			18.6			31.0			55.8			62.0	
shear load	C 20/25	V_{Rk} [kN]	7.8	7.0			7.8			7.8			11.7		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			12.1			12.1		14.7	12.8		23.2	20.3		33.8	29.5		62.8	55.0		62.8	55.0	

Design loads

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 load	C 20/25	N_{Rd} [kN]		5.0			5.0			5.0			8.0			13.3			20.0			26.7			26.7	
	C 50/60	N_{Rd} [kN]	7.7	7.5	7.7		7.7			7.7			12.4			20.7			31.0			41.3			41.3	
shear load	C 20/25	V_{Rd} [kN]	6.4	4.5	5.6		7.8			7.8		10.4	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 50/60	V_{Rd} [kN]	6.4	4.5	5.6	11.8	8.2	10.2		12.1		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 load	C 20/25	N_{Rd} [kN]		3.3			3.3			3.3			6.0			8.0			13.3			24.0			26.7	
	C 50/60	N_{Rd} [kN]		5.2			5.2			5.2			9.3			12.4			20.7			37.2			41.3	
shear load	C 20/25	V_{Rd} [kN]	5.2	4.5	5.2		5.2			5.2			7.8		16.0	13.0	16.0	26.7	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		8.1			8.1		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

Permissible loads see next page.

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Permissible loads [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 load	C 20/25	N_{perm} [kN]	3.6			3.6			3.6			5.7			9.5			14.3			19.0			19.0		
	C 50/60	N_{perm} [kN]	5.5	5.4	5.5	5.5			5.5			8.9			14.8			22.1			29.5			29.5		
shear load	C 20/25	V_{perm} [kN]	4.6	3.2	4.0	5.6			5.6			7.4	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 50/60	V_{perm} [kN]	4.6	3.2	4.0	8.4	5.9	7.3	8.6			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 load	C 20/25	N_{perm} [kN]	2.4			2.4			2.4			4.3			5.7			9.5			17.1			19.0		
	C 50/60	N_{perm} [kN]	3.7			3.7			3.7			6.6			8.9			14.8			26.6			29.5		
shear load	C 20/25	V_{perm} [kN]	3.7	3.2	3.7	3.7			3.7			5.6			11.4	9.3	11.4	19.0	13.5	16.9	34.3	25.2	31.4	35.9	25.2	31.4
	C 50/60	V_{perm} [kN]	4.6	3.2	4.0	5.8			5.8			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 load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

4. Load direction: tension

4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

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	gzv	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
characteristic resistance	$N_{Rk,s}$ [kN]	16.1	14.1		29.3	25.6		46.4	40.6		29.3	25.6		46.4	40.6		67.4	59.0		126.0	110.0		126.0	110.0	
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

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

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

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																									
characteristic resistance	$N^0_{Rk,p}$ [kN]	9.0			9.0			9.0			12.0			20.0			30.0			40.0			40.0		
design resistance	$N^0_{Rd,p}$ [kN]	5.0			5.0			5.0			8.0			13.3			20.0			26.7			26.7		
cracked concrete																									
characteristic resistance	$N^0_{Rk,p}$ [kN]	6.0			6.0			6.0			9.0			12.0			20.0			40.0			40.0		
design resistance	$N^0_{Rd,p}$ [kN]	3.3			3.3			3.3			6.0			8.0			13.3			26.7			26.7		

4.3 Concrete cone failure and splitting for the most unfavourable anchor

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FZA 10x40 M 6 (gvz / A4 / C)	FZA 12x40 M 8 (gvz / A4 / C)	FZA 14x40 M 10 (gvz / A4 / C)	FZA 12x50 M 8 (gvz / A4 / C)	FZA 14x60 M 10 (gvz / A4 / C)	FZA 18x80 M 12 (gvz / A4 / C)	FZA 22x100 M 16 (gvz / A4 / C)	FZA 22x125 M 16 (gvz / A4 / C)
eff. anchorage depth	h_{ef}	[mm]	40	40	40	50	60	80	100	125
non-cracked concrete										
characteristic resistance	$N^0_{Rk,c}$	[kN]	12.8	12.8	12.8	17.8	23.4	36.1	50.4	70.4
design resistance	$N^0_{Rd,c}$	[kN]	7.1	7.1	7.1	11.9	15.6	24.0	33.6	47.0
cracked concrete										
characteristic resistance	$N^0_{Rk,c}$	[kN]	9.1	9.1	9.1	12.7	16.7	25.8	36.0	50.3
design resistance	$N^0_{Rd,c}$	[kN]	5.1	5.1	5.1	8.5	11.2	17.2	24.0	33.5

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm]	Influence factor f_s [-] FZA 10x40 M 6 (gvz / A4 / C)	FZA 12x40 M 8 (gvz / A4 / C)	FZA 14x40 M 10 (gvz / A4 / C)	FZA 12x50 M 8 (gvz / A4 / C)	FZA 14x60 M 10 (gvz / A4 / C)	FZA 18x80 M 12 (gvz / A4 / C)	FZA 22x100 M 16 (gvz / A4 / C)	FZA 22x125 M 16 (gvz / A4 / C)
40	0.67	0.67						
45	0.69	0.69						
50	0.71	0.71		0.67				
55	0.73	0.73		0.68				
60	0.75	0.75		0.70	0.67			
70	0.79	0.79	0.79	0.73	0.69			
80	0.83	0.83	0.83	0.77	0.72	0.67		
100	0.92	0.92	0.92	0.83	0.78	0.71	0.67	
120	1.00	1.00	1.00	0.90	0.83	0.75	0.70	
125				0.92	0.85	0.76	0.71	0.67
150				1.00	0.92	0.81	0.75	0.70
180					1.00	0.88	0.80	0.74
200						0.92	0.83	0.77
240						1.00	0.90	0.82
300							1.00	0.90
375								1.00
s_{min} [mm]	40	40	70	50	60	80	100	125
$s_{cr,N}$ [mm]	120	120	120	150	180	240	300	375

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c	Influence factor f_c [-]							
	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
[mm]	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C
35	0.69							
40	0.75	0.75						
45	0.81	0.81		0.70				
55	0.93	0.93		0.80	0.71			
60	1.00	1.00		0.85	0.75			
70			1.00	0.95	0.83	0.69		
75				1.00	0.87	0.72		
90					1.00	0.81		
100						0.87	0.75	
120						1.00	0.85	
125							0.87	0.75
150							1.00	0.85
190								1.00
c_{min} [mm]	35	40	70	45	55	70	100	125
$c_{cr,N}$ [mm]	60	60	60	75	90	120	150	190

Intermediate values by linear interpolation.

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s	Influence factor $f_{s,sp}$ [-]							
	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
[mm]	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C
40	0.67	0.67						
45	0.69	0.69						
50	0.71	0.71		0.67				
55	0.73	0.73		0.68				
60	0.75	0.75		0.70	0.67			
70	0.79	0.79	0.79	0.73	0.69			
80	0.83	0.83	0.83	0.77	0.72	0.67		
100	0.92	0.92	0.92	0.83	0.78	0.71	0.67	
120	1.00	1.00	1.00	0.90	0.83	0.75	0.70	
125				0.92	0.85	0.76	0.71	0.67
150				1.00	0.92	0.81	0.75	0.70
180					1.00	0.88	0.80	0.74
200						0.92	0.83	0.77
240						1.00	0.90	0.82
300							1.00	0.90
375								1.00
s_{min} [mm]	40	40	70	50	60	80	100	125
$s_{cr,sp}$ [mm]	120	120	120	150	180	240	300	375

Intermediate values by linear interpolation.

fischer Zykon anchor FZA

Anchor design according to ETA

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c [mm]	Influence factor $f_{c,sp}$ [-] 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
35	0.69							
40	0.75	0.75						
45	0.81	0.81		0.70				
55	0.93	0.93		0.80	0.71			
60	1.00	1.00		0.85	0.75			
70			1.00	0.95	0.83	0.69		
75				1.00	0.87	0.72		
90					1.00	0.81		
100						0.87	0.75	
120						1.00	0.85	
125							0.87	0.75
150							1.00	0.85
190								1.00
c_{min} [mm]	35	40	70	45	55	70	100	125
$c_{cr,sp}$ [mm]	60	60	60	75	90	120	150	190

Intermediate values by linear interpolation.

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{2 \cdot h_{ef}}\right)^{\frac{2}{3}} \leq 1.5$$

Thickness h [mm]	Influence factor f_h [-] 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
100	1.16	1.16	1.16					
110	1.24	1.24	1.24	1.07				
130	1.38	1.38	1.38	1.19	1.05			
150	1.50	1.50	1.50	1.31	1.16			
160				1.37	1.21	1.00		
190				1.50	1.36	1.12		
200					1.41	1.16	1.00	
220					1.50	1.24	1.07	
250						1.35	1.16	1.00
300						1.50	1.31	1.13
350							1.45	1.25
370							1.50	1.30
400								1.37
460								1.50
h_{ef} [mm]	40	40	40	50	60	80	100	125
h_{min} [mm]	100	100	100	110	130	160	200	250

Intermediate values by linear interpolation.

4

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

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	gzv	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
characteristic resistance	$V_{Rk,s}$	[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	
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

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FZA 10x40 M 6 (gvz, A4, C)	FZA 12x40 M 8 (gvz, A4, C)	FZA 14x40 M 10 (gvz, A4, C)	FZA 12x50 M 8 (gvz, A4, C)	FZA 14x60 M 10 (gvz, A4, C)	FZA 18x80 M 12 (gvz, A4, C)	FZA 22x100 M 16 (gvz, A4, C)	FZA 22x125 M 16 (gvz, A4, C)
eff. anchorage depth	h_{ef}	[mm]	40	40	40	50	60	80	100	125
non-cracked concrete										
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	12.8	12.8	12.8	17.8	23.4	36.1	50.4	70.4
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	8.5	8.5	8.5	11.9	15.6	24.0	33.6	47.0
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	9.0	9.0	9.0	12.0	20.0	30.0	40.0	40.0
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	6.0	6.0	6.0	8.0	13.3	20.0	26.7	26.7
cracked concrete										
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	9.1	9.1	9.1	12.7	16.7	25.8	36.0	50.3
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	6.1	6.1	6.1	8.5	11.2	17.2	24.0	33.5
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	6.0	6.0	6.0	9.0	12.0	20.0	40.0	40.0
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	4.0	4.0	4.0	6.0	8.0	13.3	26.7	26.7

5.2.1 Influence of anchorage depth

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

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^{n}$$

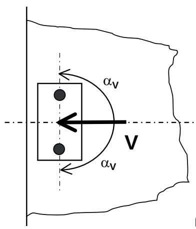
Characteristic resistance and design restance for single anchors in concrete C20/25 for edge distances c_{min}

Anchor type			FZA 10x40 M 6 (gvz / A4 / C)	FZA 12x40 M 8 (gvz / A4 / C)	FZA 14x40 M 10 (gvz / A4 / C)	FZA 12x50 M 8 (gvz / A4 / C)	FZA 14x60 M 10 (gvz / A4 / C)	FZA 18x80 M 12 (gvz / A4 / C)	FZA 22x100 M 16 (gvz / A4 / C)	FZA 22x125 M 16 (gvz / A4 / C)
non-cracked concrete										
minimum edge distance	c_{min}	[mm]	35	40	70	45	55	70	100	125
characteristic resistance	$V^0_{Rk,c}$	[kN]	4.2	5.2	11.2	6.4	8.8	13.4	23.0	32.1
design resistance	$V^0_{Rd,c}$	[kN]	2.8	3.5	7.5	4.2	5.9	8.9	15.3	21.4
cracked concrete										
minimum edge distance	c_{min}	[mm]	35	40	70	45	55	70	100	125
characteristic resistance	$V^0_{Rk,c}$	[kN]	3.0	3.7	7.9	4.5	6.2	9.5	16.3	22.8
design resistance	$V^0_{Rd,c}$	[kN]	2.0	2.5	5.3	3.0	4.2	6.3	10.8	15.2

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 **Single anchor** influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 **Anchor pair** influenced only by one edge

for concrete thickness h ≧ 1.5 · c
and spacing **s ≦ 3 · c**

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for s > 3 · c

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c
and spacing **s ≦ 4.5 · h**

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for s > 4.5 · h

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2,89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

6. Summary of required proof:

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

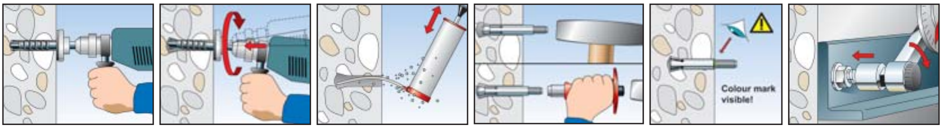
6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

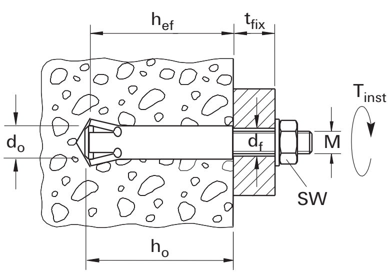
N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

7. Installation details



8. Anchor characteristics

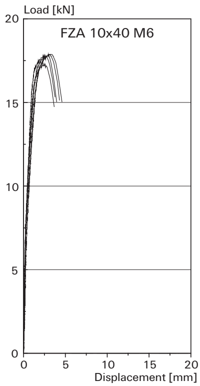
Anchor type			FZA 10x40 M 6 gvz | A4 | C	FZA 12x40 M 8 gvz | A4 | C	FZA 14x40 M 10 gvz | A4 | C	FZA 12x50 M 8 gvz | A4 | C	FZA 14x60 M 10 gvz | A4 | C	FZA 18x80 M 12 gvz | A4 | C	FZA 22x100 M 16 gvz | A4 | C	FZA 22x125 M 16 gvz | A4 | C
diameter of thread			M 6	M 8	M 10	M 8	M 10	M 12	M 16	M 16
nominal drill hole diameter	d_0	[mm]	10	12	14	12	14	18	22	22
drill depth	h_0	[mm]	43	44	45	54	65	85	105	130
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	20	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

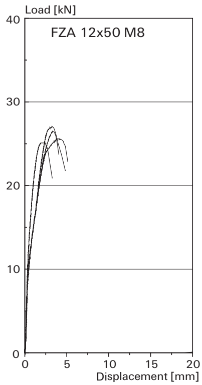


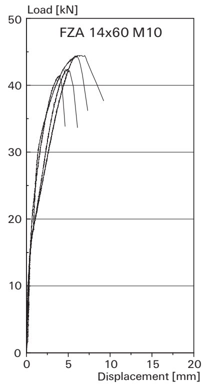
9. Mechanical characteristics

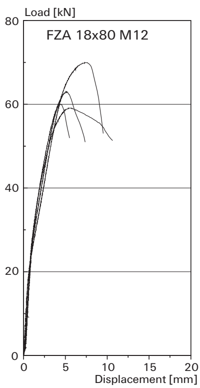
Anchor type			FZA 10x40 M 6			FZA 12x40 M 8			FZA 14x40 M 10			FZA 12x50 M 8			FZA 14x60 M 10			FZA 18x80 M 12			FZA 22x100 M 16			FZA 22x125 M 16		
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gzv	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
stressed cross sectional area cone bolt	A_s	[mm²]	20.1			36.6			58.0			36.6			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		
yield strength cone bolt	f_y	[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_u	[N/mm²]	800	700		800	700		800	700		800	700		800	700		800	700		800	700		800	700	

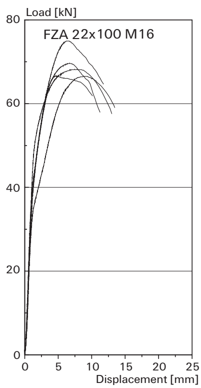
10. Load displacement curves for tension in non-cracked concrete ($f_{ck,cube\ (200)}$ = 30 N/mm²)

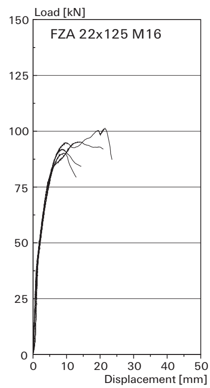










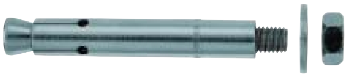


4

fischer Zykon through anchor FZA-D

Anchor design according to ETA

1. Types



FZA-D – Through anchor (gvz)

FZA-D – Through anchor (A4)

FZA-D – Through anchor (C)

European Technical Approval – Option 1 for cracked concrete

Shock approval by the Federal office for Civil Defence, Bonn.

Fire resistance classification F 90/120

size of anchor in accordance with fire regulations

FM APPROVED

from thread M 10

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 1.
- Suitable for cracked and non-cracked concrete.
- Positive fit in the undercut gives additional security.
- Almost expansion-free operation allows cost-efficient fixing with very small edge and axial spacing.
- Single-step drilling process simultaneously produces the undercut, saving installation time.
- Immediate load-bearing capability avoids installation interruptions (no interruption for resin curing times, unlike chemical anchors).
- Simple visual inspection of the green ring mark ensures 100% function.

Materials

Bolt: Carbon steel, zinc plated (5 µm) and passivated (gvz)
Stainless steel of the corrosion resistance class III, e.g. A4
Stainless steel of the corrosion resistance class IV, e.g. 1.4529 (C)

2. Ultimate loads of single anchors with large spacing and 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 load	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 load	≥ 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 load	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 load	≥ 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*)

*) Steel failure decisive

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube(150)}$ [N/mm²]	Influence factor $f_{b,p} = f_{b,c}$ [-]
C 20/25	20	25	1.00
C 25/30	25	30	1.10
C 30/37	30	37	1.22
C 40/50	40	50	1.41
C 45/55	45	55	1.48
C 50/60	50	60	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Characteristic loads

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 load	C 20/25	N_{Rk} [kN]	9.0			12.0			12.0			20.0			20.0		30.0			30.0			40.0	
	C 50/60	N_{Rk} [kN]	13.9			18.6			18.6			31.0			31.0		46.5			46.5			62.0	
shear load	C 20/25	V_{Rk} [kN]	11.7			14.7	12.8		14.7	12.8		23.2	20.3		23.2	20.3	33.8	29.5		33.8	29.5		62.8	55.0
	≧ C 40/50	V_{Rk} [kN]	14.7	12.8		14.7	12.8		14.7	12.8		23.2	20.3		23.2	20.3	33.8	29.5		33.8	29.5		62.8	55.0
cracked concrete																								
tension load	C 20/25	N_{Rk} [kN]	6.0			9.0			9.0			12.0			12.0		20.0			20.0			36.0	
	C 50/60	N_{Rk} [kN]	9.3			13.9			13.9			18.6			18.6		31.0			31.0			55.8	
shear load	C 20/25	V_{Rk} [kN]	7.8			11.7			11.7			23.2	20.3		23.2	20.3	33.8	29.5		33.8	29.5		62.8	55.0
	≧ C 40/50	V_{Rk} [kN]	11.0			14.7	12.8		14.7	12.8		23.2	20.3		23.2	20.3	33.8	29.5		33.8	29.5		62.8	55.0

Design loads

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 load	C 20/25	N_{Rd} [kN]	5.0			8.0			8.0			13.3			13.3		20.0			20.0			26.7	
	C 50/60	N_{Rd} [kN]	7.7			12.4			12.4			20.7			20.7		31.0			31.0			41.3	
shear load	C 20/25	V_{Rd} [kN]	7.8			12.4	8.2	10.2	10.4	8.2	10.2	18.6	13.0	16.2	18.6	13.0	27.0	18.9	23.6	27.0	18.9	23.6	50.2	35.3
	C 50/60	V_{Rd} [kN]	11.8	8.2	10.2	11.8	8.2	10.2	11.8	8.2	10.2	18.6	13.0	16.2	18.6	13.0	27.0	18.9	23.6	27.0	18.9	23.6	50.2	35.3
cracked concrete																								
tension load	C 20/25	N_{Rd} [kN]	3.3			6.0			6.0			8.0			8.0		13.3			13.3			24.0	
	C 50/60	N_{Rd} [kN]	5.2			9.3			9.3			12.4			12.4		20.7			20.7			37.2	
shear load	C 20/25	V_{Rd} [kN]	5.2			7.8			7.8			16.0	13.0	16.0	16.0	13.0	26.7	18.9	23.6	26.7	18.9	23.6	48.0	35.3
	C 50/60	V_{Rd} [kN]	8.1			11.8	8.2	10.2	11.8	8.2	10.2	18.6	13.0	16.2	18.6	13.0	27.0	18.9	23.6	27.0	18.9	23.6	50.2	35.3

Permissible loads see next page.

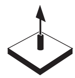
3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Permissible loads [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 load	C 20/25	N_{perm} [kN]	3.6			5.7			5.7			9.5			9.5		14.3			14.3			19.0	
	C 50/60	N_{perm} [kN]	5.5			8.9			8.9			14.8			14.8		22.1			22.1			29.5	
shear load	C 20/25	V_{perm} [kN]	5.6			7.4	5.9	7.3	7.4	5.9	7.3	13.3	9.3	11.6	13.3	9.3	19.3	13.5	16.9	19.3	13.5	16.9	35.9	25.2
	C 50/60	V_{perm} [kN]	8.4	5.9	7.3	8.4	5.9	7.3	8.4	5.9	7.3	13.3	9.3	11.6	13.3	9.3	19.3	13.5	16.9	19.3	13.5	16.9	35.9	25.2
cracked concrete																								
tension load	C 20/25	N_{perm} [kN]	2.4			4.3			4.3			5.7			5.7		9.5			9.5			17.1	
	C 50/60	N_{perm} [kN]	3.7			6.6			6.6			8.9			8.9		14.8			14.8			26.6	
shear load	C 20/25	V_{perm} [kN]	3.7			5.6			5.6			11.4	9.3	11.4	11.4	9.3	19.0	13.5	16.9	19.0	13.5	16.9	34.3	25.2
	C 50/60	V_{perm} [kN]	5.8			8.4	5.9	7.3	8.4	5.9	7.3	13.3	9.3	11.6	13.3	9.3	19.3	13.5	16.9	19.3	13.5	16.9	35.9	25.2

[1] Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

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	gzv	A4	C	gvz	A4	gvz	A4	C	gvz	A4	C	gvz	A4
characteristic resistance	$N_{Rk,s}$	[kN]	29.3	25.6		29.3	25.6		29.3	25.6		46.4	40.6		46.4	40.6	67.4	59.0		67.4	59.0		126.0	110.0
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

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

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

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																								
characteristic resistance	$N^0_{Rk,p}$	[kN]	9.0			12.0			12.0			20.0			20.0		30.0			30.0			40.0	
design resistance	$N^0_{Rd,p}$	[kN]	5.0			8.0			8.0			13.3			13.3		20.0			20.0			26.7	
cracked concrete																								
characteristic resistance	$N^0_{Rk,p}$	[kN]	6.0			9.0			9.0			12.0			12.0		20.0			20.0			40.0	
design resistance	$N^0_{Rd,p}$	[kN]	3.3			6.0			6.0			8.0			8.0		13.3			13.3			26.7	

fischer Zykon through anchor FZA-D

Anchor design according to ETA

4.3 Concrete cone failure and splitting for the most unfavourable anchor

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FZA 12x50 M 8 D (gvz, A4, C)	FZA 12x60 M 8 D (gvz, A4, C)	FZA 12x80 M 8 D (gvz, A4, C)	FZA 14x80 M 10 D (gvz, A4, C)	FZA 14x100 M 10 D (gvz, A4)	FZA 18x100 M 12 D (gvz, A4, C)	FZA 18x130 M 12 D (gvz, A4, C)	FZA 22x125 M 16 D (gvz, A4)
eff. anchorage depth	h_{ef}	[mm]	40	50	50	60	60	80	80	100
non-cracked concrete										
characteristic resistance	$N^0_{Rk,c}$	[kN]	12.8	17.8	17.8	23.4	23.4	36.1	36.1	50.4
design resistance	$N^0_{Rd,c}$	[kN]	7.1	11.9	11.9	15.6	15.6	24.0	24.0	33.6
cracked concrete										
characteristic resistance	$N^0_{Rk,c}$	[kN]	9.1	12.7	12.7	16.7	16.7	25.8	25.8	36.0
design resistance	$N^0_{Rd,c}$	[kN]	5.1	8.5	8.5	11.2	11.2	17.2	17.2	24.0

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm]	Influence factor f_s [-]: FZA 12x50 M 8 D (gvz, A4, C)	FZA 12x60 M 8 D (gvz, A4, C)	FZA 12x80 M 8 D (gvz, A4, C)	FZA 14x80 M 10 D (gvz, A4, C)	FZA 14x100 M 10 D (gvz, A4)	FZA 18x100 M 12 D (gvz, A4, C)	FZA 18x130 M 12 D (gvz, A4, C)	FZA 22x125 M 16 D (gvz, A4)
40	0.67							
45	0.69							
50	0.71	0.67	0.67					
55	0.73	0.68	0.68					
60	0.75	0.70	0.70	0.67	0.67			
70	0.79	0.73	0.73	0.69	0.69			
75	0.81	0.75	0.75	0.71	0.71			
80	0.83	0.77	0.77	0.72	0.72	0.67	0.67	
100	0.92	0.83	0.83	0.78	0.78	0.71	0.71	0.67
120	1.00	0.90	0.90	0.83	0.83	0.75	0.75	0.70
150		1.00	1.00	0.92	0.92	0.81	0.81	0.75
180				1.00	1.00	0.88	0.88	0.80
200						0.92	0.92	0.83
240						1.00	1.00	0.90
250								0.92
300								1.00
s_{min} [mm]	40	50	50	60	60	80	80	100
$s_{cr,N}$ [mm]	120	150	150	180	180	240	240	300

Intermediate values by linear interpolation.

fischer Zykon through anchor FZA-D

Anchor design according to ETA

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c [mm]	Influence factor f_c [-] FZA 12x50 M 8 D gvz / A4 / C	FZA 12x60 M 8 D gvz / A4 / C	FZA 12x80 M 8 D gvz / A4 / C	FZA 14x80 M 10 D gvz / A4 / C	FZA 14x100 M 10 D gvz / A4	FZA 18x100 M 12 D gvz / A4 / C	FZA 18x130 M 12 D gvz / A4 / C	FZA 22x125 M 16 D gvz / A4
35	0.69							
45	0.81	0.70	0.70					
50	0.87	0.75	0.75					
55	0.93	0.80	0.80	0.71	0.71			
60	1.00	0.85	0.85	0.75	0.75			
70		0.95	0.95	0.83	0.83	0.69	0.69	
75		1.00	1.00	0.87	0.87	0.72	0.72	
90				1.00	1.00	0.81	0.81	
100						0.87	0.87	0.75
120						1.00	1.00	0.85
150								1.00
c_{min} [mm]	35	45	45	55	55	70	70	100
$c_{cr,N}$ [mm]	60	75	75	90	90	120	120	150

Intermediate values by linear interpolation.ermediate values by linear interpolation.

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s [mm]	Influence factor $f_{s,sp}$ [-] FZA 12x50 M 8 D gvz / A4 / C	FZA 12x60 M 8 D gvz / A4 / C	FZA 12x80 M 8 D gvz / A4 / C	FZA 14x80 M 10 D gvz / A4 / C	FZA 14x100 M 10 D gvz / A4	FZA 18x100 M 12 D gvz / A4 / C	FZA 18x130 M 12 D gvz / A4 / C	FZA 22x125 M 16 D gvz / A4
40	0.67							
45	0.69							
50	0.71	0.67	0.67					
55	0.73	0.68	0.68					
60	0.75	0.70	0.70	0.67	0.67			
70	0.79	0.73	0.73	0.69	0.69			
75	0.81	0.75	0.75	0.71	0.71			
80	0.83	0.77	0.77	0.72	0.72	0.67	0.67	
100	0.92	0.83	0.83	0.78	0.78	0.71	0.71	0.67
120	1.00	0.90	0.90	0.83	0.83	0.75	0.75	0.70
150		1.00	1.00	0.92	0.92	0.81	0.81	0.75
180				1.00	1.00	0.88	0.88	0.80
200						0.92	0.92	0.83
240						1.00	1.00	0.90
250								0.92
300								1.00
s_{min} [mm]	40	50	50	60	60	80	80	100
$s_{cr,sp}$ [mm]	120	150	150	180	180	240	240	300

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c	Influence factor $f_{c,sp}$ [-]							
	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
[mm]	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4	gvz / A4 / C	gvz / A4 / C	gvz / A4
35	0.69							
45	0.81	0.70	0.70					
50	0.87	0.75	0.75					
55	0.93	0.80	0.80	0.71	0.71			
60	1.00	0.85	0.85	0.75	0.75			
70		0.95	0.95	0.83	0.83	0.69	0.69	
75		1.00	1.00	0.87	0.87	0.72	0.72	
90				1.00	1.00	0.81	0.81	
100						0.87	0.87	0.75
120						1.00	1.00	0.85
150								1.00
c_{min} [mm]	35	45	45	55	55	70	70	100
$c_{cr,sp}$ [mm]	60	75	75	90	90	120	120	150

Intermediate values by linear interpolation.

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{2 \cdot h_{ef}} \right)^{\frac{2}{3}} \leq 1.5$$

Thickness h	Influence factor f_h [-]							
[mm]	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
100	1.16							
110	1.24	1.07	1.07					
130	1.38	1.19	1.19	1.05	1.05			
150	1.50	1.31	1.31	1.16	1.16			
160		1.37	1.37	1.21	1.21	1.00	1.00	
180		1.48	1.48	1.31	1.31	1.08	1.08	
190		1.50	1.50	1.36	1.36	1.12	1.12	
200				1.41	1.41	1.16	1.16	1.00
220				1.50	1.50	1.24	1.24	1.07
250						1.35	1.35	1.16
280						1.45	1.45	1.25
300						1.50	1.50	1.31
350								1.45
370								1.50
h_{ef} [mm]	40	50	50	60	60	80	80	100
h_{min} [mm]	100	110	110	130	130	160	160	200

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

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	gzv	A4	C	gvz	A4	gvz	A4	C	gvz	A4	C	gvz	A4
characteristic resistance	$V_{Rk,s}$	[kN]	14.7	12.8		14.7	12.8		14.7	12.8		23.2	20.3		23.2	20.3	33.8	29.5		33.8	29.5		62.8	55.0
design resistance	$V_{Rd,s}$	[kN]	11.8	8.2	10.2	11.8	8.2	10.2	11.8	8.2	10.2	18.6	13.0	16.2	18.6	13.0	27.0	18.9	23.6	27.0	18.9	23.6	50.2	35.3

5.2 Pryout-failure for the most unfavourable anchor

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FZA 12x50 M 8 D (gvz, A4, C)	FZA 12x60 M 8 D (gvz, A4, C)	FZA 12x80 M 8 D (gvz, A4, C)	FZA 14x80 M 10 D (gvz, A4, C)	FZA 14x100 M 10 D (gvz, A4)	FZA 18x100 M 12 D (gvz, A4, C)	FZA 18x130 M 12 D (gvz, A4, C)	FZA 22x125 M 16 D (gvz, A4)
eff. anchorage depth	h_{ef}	[mm]	40	50	50	60	60	80	80	100
non-cracked concrete										
characteristic resistance	$N^0_{Rk.cp}$ (c)	[kN]	12.8	17.8	17.8	23.4	23.4	36.1	36.1	50.4
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	8.5	11.9	11.9	15.6	15.6	24.0	24.0	33.6
characteristic resistance	$N^0_{Rk.cp}$ (p)	[kN]	9.0	12.0	12.0	20.0	20.0	30.0	30.0	40.0
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	6.0	8.0	8.0	13.3	13.3	20.0	20.0	26.7
cracked concrete										
characteristic resistance	$N^0_{Rk.cp}$ (c)	[kN]	9.1	12.7	12.7	16.7	16.7	25.8	25.8	36.0
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	6.1	8.5	8.5	11.2	11.2	17.2	17.2	24.0
characteristic resistance	$N^0_{Rk.cp}$ (p)	[kN]	6.0	9.0	9.0	12.0	12.0	20.0	20.0	40.0
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	4.0	6.0	6.0	8.0	8.0	13.3	13.3	26.7

5.2.1 Influence of anchorage depth

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

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

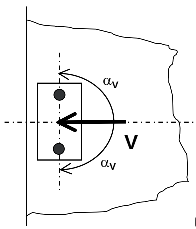
Characteristic resistance and design restance for single anchors in concrete C20/25 for edge distances c_{min}

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										
minimum edge distance	c_{min}	[mm]	35	45	45	55	55	70	70	100
characteristic resistance	$V^0_{Rk,c}$	[kN]	4.4	6.4	6.4	8.8	8.8	13.4	13.4	23.0
design resistance	$V^0_{Rd,c}$	[kN]	2.9	4.2	4.2	5.9	5.9	8.9	8.9	15.3
cracked concrete										
minimum edge distance	c_{min}	[mm]	35	45	45	55	55	70	70	100
characteristic resistance	$V^0_{Rk,c}$	[kN]	3.1	4.5	4.5	6.2	6.2	9.5	9.5	16.3
design resistance	$V^0_{Rd,c}$	[kN]	2.1	3.0	3.0	4.2	4.2	6.3	6.3	10.8

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 Single anchor influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$

$$f_{sc,V}{}^{n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$

$$f_{sc,V}{}^{n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}{}^{n=1}$, edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

fischer Zykon through anchor FZA-D

Anchor design according to ETA

5.3.2.2 Anchor pair influenced only by one edge

4

for concrete thickness $h \geqq 1.5 \cdot c$
and spacing $\mathbf{s \leqq 3 \cdot c}$

$$f_{sc,V}^{n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for $s > 3 \cdot c$

$$f_{sc,V}^{n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$
and spacing $\mathbf{s \leqq 4.5 \cdot h}$

$$f_{sc,V}^{n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for $s > 4.5 \cdot h$

$$f_{sc,V}^{n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2,89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

fischer Zykon through anchor FZA-D

Anchor design according to ETA

6. Summary of required proof:

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

6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

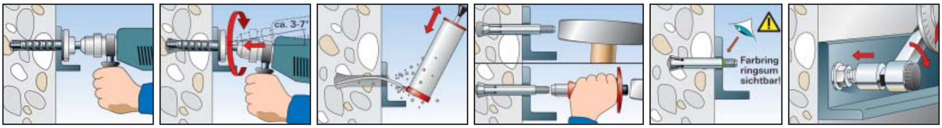
6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor

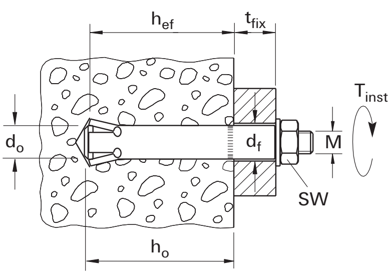
N_{Rd} ; V_{Rd} = design resistance including safety factors

7. Installation details



8. Anchor characteristics

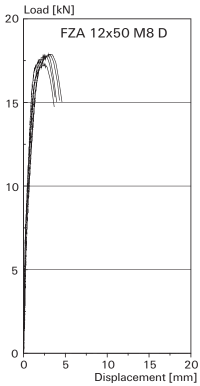
Anchor type			FZA 12x50 M 8 D gvz | A4 | C	FZA 12x60 M 8 D gvz | A4 | C	FZA 12x80 M 8 D gvz | A4 | C	FZA 14x80 M 10 D gvz | A4 | C	FZA 14x100 M 10 D gvz | A4	FZA 18x100 M 12 D gvz | A4 | C	FZA 18x130 M 12 D gvz | A4 | C	FZA 22x125 M 16 D gvz | A4
diameter of thread			M 8	M 8	M 8	M 10	M 10	M 12	M 12	M 16
nominal drill hole diameter	d_0	[mm]	12	12	12	14	14	18	18	22
drill depth	h_0	[mm]	44	54	54	65	65	85	85	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

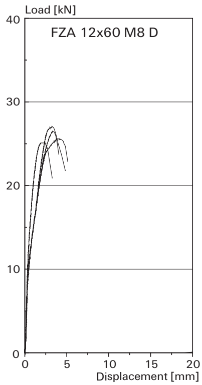


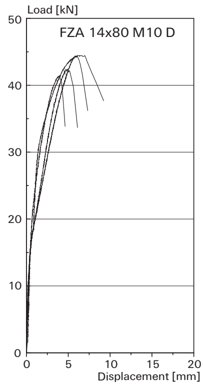
9. Mechanical characteristics

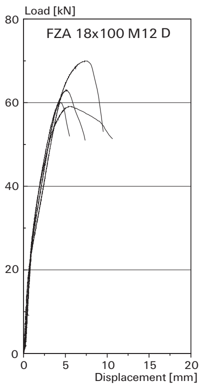
Anchor type			FZA 12x50 M 8 D			FZA 12x60 M 8 D			FZA 12x80 M 8 D			FZA 14x80 M 10 D			FZA 14x100 M 10 D		FZA 18x100 M 12 D			FZA 18x130 M 12 D			FZA 22x125 M 16 D	
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gzv	A4	C	gvz	A4	gvz	A4	C	gvz	A4	C	gvz	A4
stressed cross sectional area cone bolt	A_s	[mm²]	36.6			36.6			36.6			58.0			58.0		84.3			84.3			157	
resisting moment cone bolt	W	[mm³]	31.2			31.2			31.2			62.3			62.3		109			109			278	
yield strength cone bolt	f_y	[N/mm²]	640	450	560	640	450	560	640	450	560	640	450	560	640	450	640	450	560	640	450	560	640	450
tensile strength cone bolt	f_u	[N/mm²]	800	700		800	700		800	700		800	700		800	700	800	700		800	700		800	700

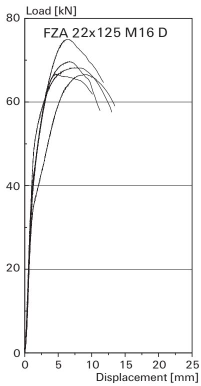
10. Load displacement curves for tension in non-cracked concrete ($f_{ck,cube\ (200)}$ = 30 N/mm²)











Notes

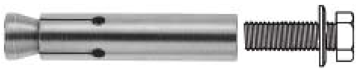
4

fischer Zykon internally-threaded anchor FZA-I

Anchor design according to ETA

1. Types

FZA-I – Internally-threaded anchor (gvz)



FZA-I – Internally-threaded anchor (A4)

European Technical Approval – Option 1 for cracked concrete

Shock approval by the Federal office for Civil Defence, Bonn.

Fire resistance classification F 90/120

size of anchor in accordance with fire regulations

FM APPROVED

from thread M 10

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

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Features and Advantages

- European Technical Approval option 1.
- Suitable for cracked and non-cracked concrete.
- Positive fit in the undercut gives additional security.
- Almost expansion-free operation allows cost-efficient fixing with very small edge and axial spacing.
- Single-step drilling process simultaneously produces the undercut, saving installation time.
- Immediate load-bearing capability avoids installation interruptions (no interruption for resin curing times, unlike chemical anchors).

Materials

Bolt: Carbon steel, zinc plated (5 µm) and passivated (gvz)
Stainless steel of the corrosion resistance class III, e.g. A4

2. Ultimate loads of single anchors with large spacing and 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 load ≥ 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 load ≥ 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 load 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 load 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 load ≥ 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*)

*) Steel failure decisive

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

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

fischer Zykon internally-threaded anchor FZA-I

Anchor design according to ETA

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck.\,cyl}$ [N/mm²]	Cube compressive strength $f_{ck.\,cube\,(150)}$ [N/mm²]	Influence factor $f_{b,p} = f_{b,c}$ [-]
C 20/25	20	25	1.00
C 25/30	25	30	1.10
C 30/37	30	37	1.22
C 40/50	40	50	1.41
C 45/55	45	55	1.48
C 50/60	50	60	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Characteristic loads

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 load	C 20/25	N_{Rk} [kN]	9.0		12.0	20.0	17.9	26.9	22.7	40.0		40.0	
	C 50/60	N_{Rk} [kN]	13.9	13.5	13.5	22.9	17.9	26.9	22.7	62.0	53.1	62.0	53.1
shear load	≧ 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 load	C 20/25	N_{Rk} [kN]	6.0		9.0	12.0		20.0		36.0		40.0	
	C 50/60	N_{Rk} [kN]	9.3		13.5	18.6	17.9	26.9	22.7	55.8	53.1	62.0	53.1
shear load	≧ C 20/25	V_{Rk} [kN]	7.8	6.7	6.7	11.4	9.0	13.4	11.3	31.5	26.6	31.5	26.6

Design loads

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 load	C 20/25	N_{Rd} [kN]	5.0		7.5	13.1	9.9	13.5	12.6	26.7		26.7	
	C 50/60	N_{Rd} [kN]	7.7	7.5	7.5	13.1	9.9	13.5	12.6	31.5	29.5	31.5	29.5
shear load	≧ 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 load	C 20/25	N_{Rd} [kN]	3.3		6.0	8.0		13.3	12.6	24.0		26.7	
	C 50/60	N_{Rd} [kN]	5.2		7.5	12.4	9.9	13.5	12.6	31.5	29.5	31.5	29.5
shear load	≧ C 20/25	V_{Rd} [kN]	5.2	4.5	4.5	7.6	6.0	7.9	7.5	18.5	17.7	18.5	17.7

Permissible loads 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 load	C 20/25	N_{perm} [kN]	3.6		5.4	9.3	7.1	9.6	9.0	19.0		19.0	
	C 50/60	N_{perm} [kN]	5.5	5.4	5.4	9.3	7.1	9.6	9.0	22.5	21.1	22.5	21.1
shear load	≧ C 20/25	V_{perm} [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 load	C 20/25	N_{perm} [kN]	2.4		4.3	5.7		9.5	9.0	17.1		19.0	
	C 50/60	N_{perm} [kN]	3.7		5.4	8.9	7.1	9.6	9.0	22.5	21.1	22.5	21.1
shear load	≧ C 20/25	V_{perm} [kN]	3.7	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 classification 8.8

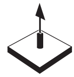
2) The values apply to screws with a strength classification A4 - 70

3) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

fischer Zykon internally-threaded anchor FZA-I

Anchor design according to ETA

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

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)
characteristic resistance $N_{Rk,s}$ [kN]	17.2	13.5	13.5	22.9	17.9	26.9	22.7	63.0	53.1	63.0	53.1
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 classification 8.8

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

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

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

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						
characteristic resistance $N^0_{Rk,p}$ [kN]	9.0	12.0	20.0	30.0	40.0	40.0
design resistance $N^0_{Rd,p}$ [kN]	5.0	8.0	13.3	20.0	26.7	26.7
cracked concrete						
characteristic resistance $N^0_{Rk,p}$ [kN]	6.0	9.0	12.0	20.0	40.0	40.0
design resistance $N^0_{Rd,p}$ [kN]	3.3	6.0	8.0	13.3	26.7	26.7

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

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

4.3 Concrete cone failure and splitting for the most unfavourable anchor

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

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)
eff. anchorage depth h_{ef} [mm]	40	50	60	80	100	125
non-cracked concrete						
characteristic resistance $N^0_{Rk,c}$ [kN]	12.8	17.8	23.4	36.1	50.4	70.4
design resistance $N^0_{Rd,c}$ [kN]	7.1	11.9	15.6	24.0	33.6	47.0
cracked concrete						
characteristic resistance $N^0_{Rk,c}$ [kN]	9.1	12.7	16.7	25.8	36.0	50.3
design resistance $N^0_{Rd,c}$ [kN]	5.1	8.5	11.2	17.2	24.0	33.5

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s	Influence factor f_s [-]					
	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
[mm]	gvz / A4	A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4
40	0.67					
45	0.69					
50	0.71	0.67				
55	0.73	0.68				
60	0.75	0.70	0.67			
75	0.81	0.75	0.71			
80	0.83	0.77	0.72	0.67		
100	0.92	0.83	0.78	0.71	0.67	
120	1.00	0.90	0.83	0.75	0.70	
125		0.92	0,85	0.76	0.71	0.67
150		1.00	0.92	0.81	0.75	0.70
180			1.00	0.88	0.80	0.74
200				0.92	0.83	0.77
240				1.00	0.90	0.82
300					1.00	0.90
375						1.00
s_{min} [mm]	40	50	60	80	100	125
$s_{cr,N}$ [mm]	120	150	180	240	300	375

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c	Influence factor f_c [-]					
	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
[mm]	gvz / A4	A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4
35	0.69					
40	0.75					
45	0.81	0.70				
50	0.87	0.75				
55	0.93	0.80	0.71			
60	1.00	0.85	0.75			
70		0.95	0.83	0.69		
75		1.00	0.87	0.72		
90			1.00	0.81		
100				0.87	0.75	
120				1.00	0.85	
125					0.87	0.75
150					1.00	0.85
190						1.00
c_{min} [mm]	35	45	55	70	100	125
$c_{cr,N}$ [mm]	60	75	90	120	150	190

Intermediate values by linear interpolation.

4

4.3.2 Concrete splitting
4.3.2.1 Influence of spacing

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

Spacing s [mm]	Influence factor $f_{s,sp}$ [-] 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
40	0.67					
45	0.69					
50	0.71	0.67				
55	0.73	0.68				
60	0.75	0.70	0.67			
75	0.81	0.75	0.71			
80	0.83	0.77	0.72	0.67		
100	0.92	0.83	0.78	0.71	0.67	
120	1.00	0.90	0.83	0.75	0.70	
125		0.92	0.85	0.76	0.71	0.67
150		1.00	0.92	0.81	0.75	0.70
180			1.00	0.88	0.80	0.74
200				0.92	0.83	0.77
240				1.00	0.90	0.82
300					1.00	0.90
375						1.00
s_{min} [mm]	40	50	60	80	100	125
$s_{cr,sp}$ [mm]	120	150	180	240	300	375

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c [mm]	Influence factor $f_{c,sp}$ [-] 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
35	0.69					
40	0.75					
45	0.81	0.70				
50	0.87	0.75				
55	0.93	0.80	0.71			
60	1.00	0.85	0.75			
70		0.95	0.83	0.69		
75		1.00	0.87	0.72		
90			1.00	0.81		
100				0.87	0.75	
120				1.00	0.85	
125					0.87	0.75
150					1.00	0.85
190						1.00
c_{min} [mm]	35	45	55	70	100	125
$c_{cr,sp}$ [mm]	60	75	90	120	150	190

Intermediate values by linear interpolation.

fischer Zykon internally-threaded anchor FZA-I

Anchor design according to ETA

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{2 \cdot h_{ef}} \right)^{\frac{2}{3}} \leq 1.5$$

Thickness h [mm]	Influence factor f_h [-] 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
100	1.16					
110	1.24	1.07				
130	1.38	1.19	1.05			
150	1.50	1.31	1.16			
160		1.37	1.21	1.00		
180		1.48	1.31	1.08		
190		1.50	1.36	1.12		
200			1.41	1.16	1.00	
220			1.50	1.24	1.07	
250				1.35	1.16	1.00
300				1.50	1.31	1.13
350					1.45	1.25
370					1.50	1.30
400						1.37
450						1.48
460						1.50
h_{ef} [mm]	40	50	60	80	100	125
h_{min} [mm]	100	110	130	160	200	250

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

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]
characteristic resistance $V_{Rk,s}$ [kN]	8.6	6.7	6.7	11.4	9.0	13.4	11.3	31.5	26.6	31.5	26.6
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 classification 8.8

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

5.2 Pryout-failure for the most unfavourable anchor

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

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]
eff. anchorage depth h_{ef} [mm]	40	50	60	80	100	125
non-cracked concrete						
characteristic resistance $N^0_{Rk,cp}$ (c) [kN]	12.8	17.8	23.4	36.1	50.4	70.4
design resistance $N^0_{Rd,cp}$ (c) [kN]	8.5	11.9	15.6	24.0	33.6	47.0
characteristic resistance $N^0_{Rk,cp}$ (p) [kN]	9.0	12.0	20.0	30.0	40.0	40.0
design resistance $N^0_{Rd,cp}$ (p) [kN]	6.0	8.0	13.3	20.0	26.7	26.7
cracked concrete						
characteristic resistance $N^0_{Rk,cp}$ (c) [kN]	9.1	12.7	16.7	25.8	36.0	50.3
design resistance $N^0_{Rd,cp}$ (c) [kN]	6.1	8.5	11.2	17.2	24.0	33.5
characteristic resistance $N^0_{Rk,cp}$ (p) [kN]	6.0	9.0	12.0	20.0	40.0	40.0
design resistance $N^0_{Rd,cp}$ (p) [kN]	4.0	6.0	8.0	13.3	26.7	26.7

5.2.1 Influence of anchorage depth

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

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

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													
minimum edge distance	c_{min}	[mm]	35		45	55		70		100		125	
characteristic resistance	$V^0_{Rk,c}$	[kN]	4.4		6.4	8.8		13.4		23.0		32.1	
design resistance	$V^0_{Rd,c}$	[kN]	2.9		4.2	5.9		8.9		15.3		21.4	
cracked concrete													
minimum edge distance	c_{min}	[mm]	35		45	55		70		100		125	
characteristic resistance	$V^0_{Rk,c}$	[kN]	3.1		4.5	6.2		9.5		16.3		22.8	
design resistance	$V^0_{Rd,c}$	[kN]	2.1		3.0	4.2		6.3		10.8		15.2	

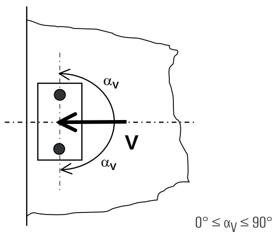
1) The values apply to screws with a strength classification 8.8

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

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 **Single anchor** influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$

$$f_{sc,V}^{\,n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$

$$f_{sc,V}^{\,n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\,n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 **Anchor pair** influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$
and spacing $\mathbf{s \leqq 3 \cdot c}$

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for $s > 3 \cdot c$

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$
and spacing $\mathbf{s \leqq 4.5 \cdot h}$

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for $s > 4.5 \cdot h$

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2,89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

fischer Zykon internally-threaded anchor FZA-I

Anchor design according to ETA

6. Summary of required proof:

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

6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

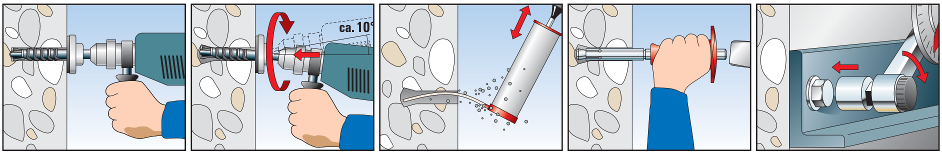
6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

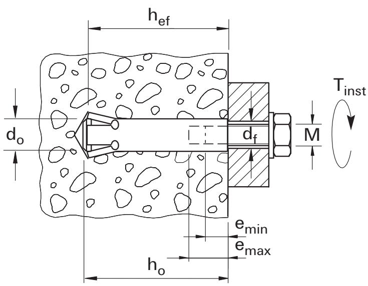
4

7. Installation details



8. Anchor 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
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]	44		54	65		85		105		130	
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	
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	



fischer FIXING SYSTEMS

Status 05/2010

fischer Zykon internally-threaded anchor FZA-I

Anchor design according to ETA

9. Mechanical 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	gzv	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		102.7		297.4		297.4	
resisting moment screw	W	[mm³]	12.7		12.7	31.2		62.3		109.2		109.2	
yield strength cone bolt	f_y	[N/mm²]	470	355	355	470	355	375	355	375	355	375	355
tensile strength cone bolt	f_u	[N/mm²]	690	540	540	690	540	640	540	640	540	640	540

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fischer Zykon hammerset anchor FZEA II

Anchor design according to ETA

1. Types

FZEA II – Zykon hammerset anchor (gvz)

FZEA II A4 – Zykon hammerset anchor (A4)

FZEA II C – Zykon hammerset anchor (C)

European Technical Approval – Option 1 for cracked concrete

Fire resistance classification R 120 Anchor types see test report

FM APPROVED from thread M 10

Shock approval by the Federal Office for Civil Defense, Bonn.

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

4

Features and Advantages

- European Technical Approval option 1.
- Suitable for cracked and non-cracked concrete.
- Positive fit in the undercut gives additional security.
- Almost expansion-free operation allows cost-efficient fixing with small axial and edge spacing.
- Single-step drilling process simultaneously produces the undercut, saving installation time.
- Simple visual inspection reduces installation outlay (no test loading necessary to check whether properly set).

Materials

Anchor: Carbon steel, zinc plated (5 µm) and passivated (gvz)
Stainless steel of the corrosion resistance class III, e.g. A4
Stainless steel of the corrosion resistance class IV, e.g. 1.4529 (C)

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

Mean values

Anchor type	FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12		
	gvz [1]	A4 [2]	C [2]	gvz [1]	A4 [2]	C [2]	gvz [1]	A4 [2]	C [2]
non-cracked concrete									
tension load C 20/25 N_u [kN]	9.6*)	12.2*)		17.0*)	17.1		17.1		
C 50/60 N_u [kN]	9.6*)	12.2*)		17.0*)	21.6*)		19.7*)	25.1*)	
shear load ≧ C 20/25 V_u [kN]	10.2*)	15.1*)		17.1*)	19.5*)		23.4*)	26.0*)	
cracked concrete									
tension load C 20/25 N_u [kN]	9.6*)	12.0		12.0			12.0		
C 50/60 N_u [kN]	9.6*)	12.2*)		17.0*)	18.5		18.5		
shear load ≧ C 20/25 V_u [kN]	10.2*)	15.1*)		17.1*)	19.5*)		23.4*)	26.0*)	

*) Steel failure decisive

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

[2] The values apply to screws with a strength classification A4 - 70 or f_{uk} = 700 N/mm² respectively

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck.\,cyl}$ [N/mm²]	Cube compressive strength $f_{ck.\,cube\,(150)}$ [N/mm²]	Influence factor $f_{b,p} = f_{b,c}$ [-]
C 20/25	20	25	1.00
C 25/30	25	30	1.10
C 30/37	30	37	1.22
C 40/50	40	50	1.41
C 45/55	45	55	1.48
C 50/60	50	60	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Characteristic loads

Anchor type		FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12		
		gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete										
tension load	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 load	C 20/25 V_{Rk} [kN]	8.3	10.0		11.7			11.7		
	C 50/60 V_{Rk} [kN]	8.3	10.0		13.6	15.0		18.1		
cracked concrete										
tension load	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 load	C 20/25 V_{Rk} [kN]	5.2			9.8			11.7		
	C 50/60 V_{Rk} [kN]	8.1			13.6	15.0		18.1		

Design loads

Anchor type		FZEA II 10x40 M 8						FZEA II 12x40 M 10						FZEA II 14x40 M 12					
		gvz		A4		C		gvz		A4		C		gvz		A4		C	
screw strength class		5.6	8.8	A4-50	A4-70	C-50	C-70	5.6	8.8	A4-50	A4-70	C-50	C-70	5.6	8.8	A4-50	A4-70	C-50	C-70
non-cracked concrete																			
tension load	C 20/25 N_{Rd} [kN]	5.0						5.0						5.0					
	C 50/60 N_{Rd} [kN]	6.4		5.5	7.8	5.5	7.8	7.8						7.8					
shear load	C 20/25 V_{Rd} [kN]	5.2	6.6	3.8	7.8	3.8	7.8	7.8		5.8	7.8	5.8	7.8	7.8					
	C 50/60 V_{Rd} [kN]	5.2	6.6	3.8	8.0	3.8	8.0	8.5	10.9	5.8	12.0	5.8	12.0	11.9	12.1	7.9	12.1	7.9	12.1
cracked concrete																			
tension load	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 load	C 20/25 V_{Rd} [kN]	3.5						6.5		5.8	6.5	5.8	6.5	7.8					
	C 50/60 V_{Rd} [kN]	5.2	5.4	3.8	5.4	3.8	5.4	8.5	10.1	5.8	10.1	5.8	10.1	11.9	12.1	7.9	12.1	7.9	12.1

Permissible loads see next page.

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Permissible loads [1)]

Anchor type			FZEA II 10x40 M 8						FZEA II 12x40 M 10						FZEA II 14x40 M 12					
			gvz		A4		C		gvz		A4		C		gvz		A4		C	
screw strength class			5.6	8.8	A4-50	A4-70	C-50	C-70	5.6	8.8	A4-50	A4-70	C-50	C-70	5.6	8.8	A4-50	A4-70	C-50	C-70
non-cracked concrete																				
tension load	C 20/25 N_{perm}	[kN]	3.6						3.6						3.6					
	C 50/60 N_{perm}	[kN]	4.6		4.0	5.5	4.0	5.5	5.5						5.5					
shear load	C 20/25 V_{perm}	[kN]	3.7	4.7	2.7	5.6	2.7	5.6	5.6		4.1	5.6	4.1	5.6	5.6				5.7	5.6
	C 50/60 V_{perm}	[kN]	3.7	4.7	2.7	5.7	2.7	5.7	6.1	7.8	4.1	8.6	4.1	8.6	8.5	8.6	5.7	8.6	5.7	8.6
cracked concrete																				
tension load	C 20/25 N_{perm}	[kN]	1.6						3.0						3.6					
	C 50/60 N_{perm}	[kN]	2.5						4.6						5.5					
shear load	C 20/25 V_{perm}	[kN]	2.5						4.6		4.1	4.6	4.1	4.6	5.6					
	C 50/60 V_{perm}	[kN]	3.7	3.8	2.7	3.8	2.7	3.8	6.1	7.2	4.1	7.2	4.1	7.2	8.5	8.6	5.7	8.6	5.7	8.6

1) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

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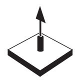
4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12		
			gvz	A4	C	gvz	A4	C	gvz	A4	C
characteristic resistance	$N_{Rk,s}$	[kN]	9.6	12.2		17.0	21.6		19.7	25.0	
design resistance	$N_{Rd,s}$	[kN]	6.4[1)]	5.5[2)]		11.3[1)]	9.8[2)]		13.1[1)]	11.4[2)]	
	$N_{Rd,s}$	[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 classification 5.6

2) The values apply to screws with a strength classification A4 - 50 or f_{uk} = 500 N/mm² respectively

3) The values apply to screws with a strength classification 8.8

4) The values apply to screws with a strength classification A4 - 70 or f_{uk} = 700 N/mm² respectively

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

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12		
			gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete											
characteristic resistance	$N^0_{Rk,p}$	[kN]	9.0			9.0			9.0		
design resistance	$N^0_{Rd,p}$	[kN]	5.0			5.0			5.0		
cracked concrete											
characteristic resistance	$N^0_{Rk,p}$	[kN]	4.0			7.5			9.0		
design resistance	$N^0_{Rd,p}$	[kN]	2.2			4.2			5.0		

4.3 Concrete cone failure and splitting for the most unfavourable anchor

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12		
			gvz	A4	C	gvz	A4	C	gvz	A4	C
eff. anchorage depth	h_{ef}	[mm]	40			40			40		
non-cracked concrete											
characteristic resistance	$N^0_{Rk,c}$	[kN]	12.8			12.8			12.8		
design resistance	$N^0_{Rd,c}$	[kN]	7.1			7.1			7.1		
cracked concrete											
characteristic resistance	$N^0_{Rk,c}$	[kN]	9.1			9.1			9.1		
design resistance	$N^0_{Rd,c}$	[kN]	5.1			5.1			5.1		

4

4.3.1 Concrete cone failure
4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s	Influence factor f_s [-]									
	FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12			
[mm]		gvz	A4	C	gvz	A4	C	gvz	A4	C
40			0.67							
45			0.69			0.69				
50			0.71			0.71			0.71	
60			0.75			0.75			0.75	
70			0.79			0.79			0.79	
75			0.81			0.81			0.81	
80			0.83			0.83			0.83	
90			0.88			0.88			0.88	
100			0.92			0.92			0.92	
120			1.00			1.00			1.00	
s_{min}	[mm]		40			45			50	
$s_{cr,N}$	[mm]		120			120			120	

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s^2_{cr,N}}$$

Edge distance c	Influence factor f_c [-]									
	FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12			
[mm]		gvz	A4	C	gvz	A4	C	gvz	A4	C
40			0.75							
45			0.81			0.81				
50			0.87			0.87			0.87	
60			1.00			1.00			1.00	
c_{min}	[mm]		40			45			50	
$c_{cr,N}$	[mm]		60			60			60	

Intermediate values by linear interpolation.

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s	Influence factor $f_{s,sp}$ [-]								
	FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12		
[mm]	gvz	A4	C	gvz	A4	C	gvz	A4	C
40		0.62							
45		0.63			0.63				
50		0.65			0.65			0.65	
60		0.68			0.68			0.68	
70		0.71			0.71			0.71	
75		0.72			0.72			0.72	
80		0.74			0.74			0.74	
90		0.76			0.76			0.76	
100		0.79			0.79			0.79	
120		0.85			0.85			0.85	
150		0.94			0.94			0.94	
170		1.00			1.00			1.00	
s_{min} [mm]		40			45			50	
$s_{cr,sp}$ [mm]		170			170			170	

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s^2_{cr,sp}}$$

Edge distance c	Influence factor $f_{c,sp}$ [-]								
	FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12		
[mm]	gvz	A4	C	gvz	A4	C	gvz	A4	C
40		0.62							
45		0.66			0.66				
50		0.70			0.70			0.70	
60		0.78			0.78			0.78	
70		0.86			0.86			0.86	
85		1.00			1.00			1.00	
c_{min} [mm]		40			45			50	
$c_{cr,sp}$ [mm]		85			85			85	

Intermediate values by linear interpolation.

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{2 \cdot h_{ef}}\right)^{\frac{2}{3}} \leq 1.5$$

Thickness h [mm]	Influence factor f_h [-] FZEA II 10x40 M 8	FZEA II 12x40 M 10	FZEA II 14x40 M 12
80	1.00	1.00	1.00
90	1.08	1.08	1.08
100	1.16	1.16	1.16
120	1.31	1.31	1.31
140	1.45	1.45	1.45
150	1.50	1.50	1.50
h_{ef}	40	40	40
h_{min} [mm]	80	80	80

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type		FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12		
		gvz	A4	C	gvz	A4	C	gvz	A4	C
characteristic resistance	$V_{Rk,s}$ [kN]	8.3	10.0		13.6	15.0		19.1	20.6	
design resistance	$V_{Rd,s}$ [kN]	5.2[1]	3.8[2]		8.5[1]	5.8[2]		11.9[1]	7.9[2]	
	$V_{Rd,s}$ [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 classification 5.6
[2] The values apply to screws with a strength classification A4 - 50 or f_{uk} = 500 N/mm² respectively
[3] The values apply to screws with a strength classification 8.8
[4] The values apply to screws with a strength classification A4 - 70 or f_{uk} = 700 N/mm² respectively

5.2 Pryout-failure for the most unfavourable anchor

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type		FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12		
		gvz	A4	C	gvz	A4	C	gvz	A4	C
eff. anchorage depth	h_{ef} [mm]		40			40			40	
non-cracked concrete										
characteristic resistance	$N^0_{Rk,cp}$ (c) [kN]		12.8			12.8			12.8	
design resistance	$N^0_{Rd,cp}$ (c) [kN]		8.5			8.5			8.5	
characteristic resistance	$N^0_{Rk,cp}$ (p) [kN]		9.0			9.0			9.0	
design resistance	$N^0_{Rd,cp}$ (p) [kN]		6.0			6.0			6.0	
cracked concrete										
characteristic resistance	$N^0_{Rk,cp}$ (c) [kN]		9.1			9.1			9.1	
design resistance	$N^0_{Rd,cp}$ (c) [kN]		6.1			6.1			6.1	
characteristic resistance	$N^0_{Rk,cp}$ (p) [kN]		4.0			7.5			9.0	
design resistance	$N^0_{Rd,cp}$ (p) [kN]		2.7			5.0			6.0	

5.2.1 Influence of anchorage depth

Type of anchor	k
FZEA 10x40 M 8	1.3
FZEA 12x40 M 10	1.3
FZEA 14x40 M 12	1.3

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

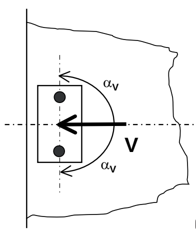
Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

Anchor type			FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12		
			gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete											
minimum edge distance	c_{min}	[mm]	40			45			50		
characteristic resistance	$V^0_{Rk,c}$	[kN]	5.1			6.1			7.2		
design resistance	$V^0_{Rd,c}$	[kN]	3.4			4.1			4.8		
cracked concrete											
minimum edge distance	c_{min}	[mm]	40			45			50		
characteristic resistance	$V^0_{Rk,c}$	[kN]	3.6			4.3			5.1		
design resistance	$V^0_{Rd,c}$	[kN]	2.4			2.9			3.4		

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

4

5.3.2 Influence of spacing and edge distance

5.3.2.1 **Single anchor** influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\,n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 **Anchor pair** influenced only by one edge

for concrete thickness h ≧ 1.5 · c
and spacing **s ≦ 3 · c**

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for s > 3 · c

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c
and spacing **s ≦ 4.5 · h**

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for s > 4.5 · h

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

fischer Zykon hammerset anchor FZEA II

Anchor design according to ETA

6. Summary of required proof:

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

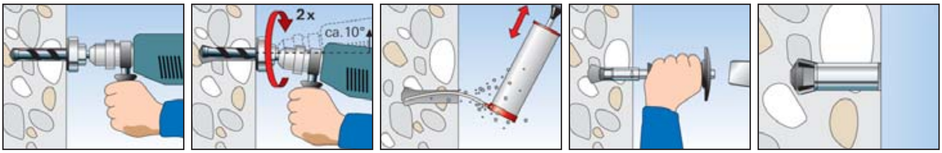
6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

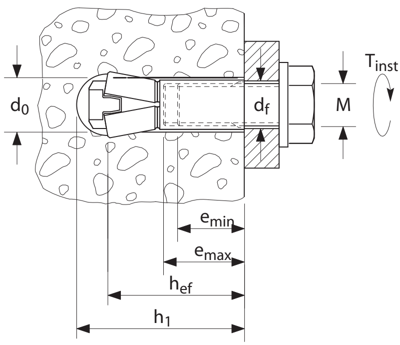
N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

7. Installation details



8. Anchor characteristics

Anchor type			FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12		
			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		

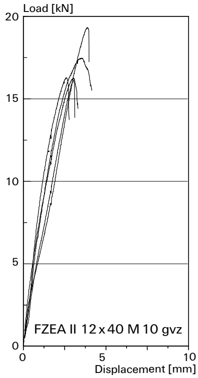


9. Mechanical characteristics

Anchor type			FZEA II 10x40 M 8			FZEA II 12x40 M 10			FZEA II 14x40 M 12		
			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		
yield strength sleeve	f_y	[N/mm²]	410	520		410	520		410	520	
tensile strength sleeve	f_u	[N/mm²]	510	650		510	650		510	650	

*) Begin of expansion segment

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



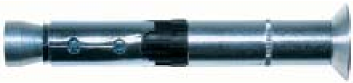
4

fischer High performance anchor FH II

Anchor design according to ETA

1. Types

FH II-S – with hexagon head (gvz)



FH II-SK – with countersunk head (gvz)

FH II-H – with cap nut (gvz)

FH II-B – with hexagon nut (gvz)

European Technical Approval – Option 1 for cracked concrete

Fire resistance classification R 120
Anchor types see test report

size of anchor in accordance with fire regulations

from thread M 8

Shock approval by the Federal Office for Civil Defense, Bonn.

ICC ES ESR-2691
See ICC-ES Evaluation Report at www.icc-es.org

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 1.
- Suitable for cracked and non-cracked concrete.
- The black plastic ring effects contraction in length when tightened.
- No protruding thread with the FH II-S, FH II-H and FH II-SK versions.
- Cap nut, hexagon-head screw or countersunk head for visible fastenings with sophisticated design.
- All anchors can be removed flush with the surface.

Materials

Screw with hexagon head:	Carbon steel, zinc plated (5 µm) and passivated (gvz)
Threaded rod with countersunk head:	Carbon steel, zinc plated (5 µm) and passivated (gvz)
Threaded rod with cap nut:	Carbon steel, zinc plated (5 µm) and passivated (gvz)
Threaded rod with hexagon nut:	Carbon steel, zinc plated (5 µm) and passivated (gvz)

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

Mean values

Anchor type				FH II 10 B/H gvz	FH II 10 S/SK gvz	FH II 12 B/H gvz	FH II 12 S/SK gvz	FH II 15 B/H gvz	FH II 15 S/SK gvz	FH II 18 B/H gvz	FH II 18 S/SK gvz
non-cracked concrete											
tension load	C20/25	N_u	[kN]	16.1*)		29.3*)		39.5		48.1	
	C50/60	N_u	[kN]	16.1*)		29.3*)		46.4*)		67.4*)	
shear load	≧ C20/25	V_u	[kN]	15.5*)	17.0	24.0*)	29.0*)	39.0*)	46.0*)	57.0*)	66.0*)
cracked concrete											
tension load	C20/25	N_u	[kN]	10.0		19.6		28.1		34.1	
	C50/60	N_u	[kN]	15.5		29.3*)		43.6		52.9	
shear load	≧ C20/25	V_u	[kN]	10.0		24.0*)	29.0*)	39.0*)	46.0*)	57.0*)	66.0*)

*) Steel failure decisive.

Anchor type				FH II 24 B/H gvz	FH II 24 S/SK gvz	FH II 28 B/H gvz	FH II 28 S/SK gvz	FH II 32 B/H gvz	FH II 32 S/SK gvz
non-cracked concrete									
tension load	C20/25	N_u	[kN]	67.2		93.9		123.5	
	C50/60	N_u	[kN]	104.1		145.5		191.3	
shear load	≧ C20/25	V_u	[kN]	105.0*)	119.0*)	121.0*)	140.0*)	149.0*)	181.0*)
cracked concrete									
tension load	C20/25	N_u	[kN]	48.0		67.1		88.2	
	C50/60	N_u	[kN]	74.4		103.9		136.6	
shear load	≧ C20/25	V_u	[kN]	96.0		121.0*)	134.2	149.0*)	176.4

*) Steel failure decisive.

4

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ 1) [N/mm²]	Cube compressive strength $f_{ck,cube(150)}$ 2) [N/mm²]	Influence factor $f_{b,p} = f_{b,c}$ [-]
C 20/25	20	25	1.00
C 25/30	25	30	1.10
C 30/37	30	37	1.22
C 40/50	40	50	1.41
C 45/55	45	55	1.48
C 50/60	50	60	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Characteristic loads

Anchor type		FH II 10		FH II 12		FH II 15		FH II 18	
		B/H gvz	S/SK gvz	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz
non-cracked concrete									
tension load	C20/25 N_{Rk} [kN]	12.8		23.4		29.5		36.1	
	C50/60 N_{Rk} [kN]	16.1		29.3		45.7		55.9	
shear load	C20/25 V_{Rk} [kN]	12.8		24.0	29.0	39.0	46.0	57.0	66.0
	C50/60 N_{Rk} [kN]	15.5	18.0	24.0	29.0	39.0	46.0	57.0	66.0
cracked concrete									
tension load	C20/25 N_{Rk} [kN]	7.5		12.0		16.0		25.0	
	C50/60 N_{Rk} [kN]	11.6		18.6		24.8		38.7	
shear load	C20/25 V_{Rk} [kN]	7.5		24.0		32.0		50.0	
	C50/60 V_{Rk} [kN]	11.6		24.0	29.0	39.0	46.0	57.0	66.0

4

Anchor type		FH II 24		FH II 28		FH II 32	
		B/H gvz	S/SK gvz	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz
non-cracked concrete							
tension load	C20/25 N_{Rk} [kN]	50.4		70.4		92.6	
	C50/60 N_{Rk} [kN]	78.1		109.1		143.4	
shear load	C20/25 V_{Rk} [kN]	100.8		121.0	140.0	149.0	181.0
	C50/60 V_{Rk} [kN]	105.0	119.0	121.0	140.0	149.0	181.0
cracked concrete							
tension load	C20/25 N_{Rk} [kN]	36.0		50.3		66.1	
	C50/60 N_{Rk} [kN]	55.8		77.9		102.5	
shear load	C20/25 V_{Rk} [kN]	72.0		100.6		132.3	
	C50/60 V_{Rk} [kN]	105.0	111.5	121.0	140.0	149.0	181.0

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Design loads

Anchor type	FH II 10		FH II 12		FH II 15		FH II 18	
	B/H	S/SK	B/H	S/SK	B/H	S/SK	B/H	S/SK
	gvz	gvz	gvz	gvz	gvz	gvz	gvz	gvz
non-cracked concrete								
tension load C20/25 N_{Rd} [kN]	8.5		15.6		19.7		24.0	
C50/60 N_{Rd} [kN]	10.7		19.5		30.5		37.2	
shear load C20/25 V_{Rd} [kN]	8.5		19.2	23.2	31.2	36.8	45.6	48.1
C50/60 V_{Rd} [kN]	12.4	13.2	19.2	23.2	31.2	36.8	45.6	52.8
cracked concrete								
tension load C20/25 N_{Rd} [kN]	5.0		8.0		10.7		16.7	
C50/60 N_{Rd} [kN]	7.7		12.4		16.5		25.8	
shear load C20/25 V_{Rd} [kN]	5.0		16.0		21.3		33.3	
C50/60 V_{Rd} [kN]	7.7		19.2	23.2	31.2	33.0	45.6	51.6

Anchor type	FH II 24		FH II 28		FH II 32	
	B/H	S/SK	B/H	S/SK	B/H	S/SK
	gvz	gvz	gvz	gvz	gvz	gvz
non-cracked concrete						
tension load C20/25 N_{Rd} [kN]	33.6		47.0		61.7	
C50/60 N_{Rd} [kN]	52.1		72.7		95.6	
shear load C20/25 V_{Rd} [kN]	67.2		93.9		119.2	123.5
C50/60 V_{Rd} [kN]	84.0	95.2	96.8	112.0	119.2	144.8
cracked concrete						
tension load C20/25 N_{Rd} [kN]	24.0		33.5		44.1	
C50/60 N_{Rd} [kN]	37.2		52.0		68.3	
shear load C20/25 V_{Rd} [kN]	48.0		67.1		88.2	
C50/60 V_{Rd} [kN]	74.4		96.8	103.9	119.2	136.6

Permissible loads see next page.

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Permissible loads [1)]

Anchor type				FH II 10		FH II 12		FH II 15		FH II 18	
				B/H gvz	S/SK gvz	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz
non-cracked concrete											
tension load	C20/25	N_{perm}	[kN]	6.1		11.2		14.1		17.2	
	C50/60	N_{perm}	[kN]	7.7		14.0		21.8		26.6	
shear load	C20/25	V_{perm}	[kN]	6.1		13.7	16.6	22.3	26.3	32.6	34.3
	C50/60	V_{perm}	[kN]	8.9	9.4	13.7	16.6	22.3	26.3	32.6	37.7
cracked concrete											
tension load	C20/25	N_{perm}	[kN]	3.6		5.7		7.6		11.9	
	C50/60	N_{perm}	[kN]	5.5		8.9		11.8		18.4	
shear load	C20/25	V_{perm}	[kN]	3.6		11.4		15.2		23.8	
	C50/60	V_{perm}	[kN]	5.5		13.7	16.6	22.3	23.6	32.6	36.9

Anchor type				FH II 24		FH II 28		FH II 32	
				B/H gvz	S/SK gvz	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz
non-cracked concrete									
tension load	C20/25	N_{perm}	[kN]	24.0		33.5		44.1	
	C50/60	N_{perm}	[kN]	37.2		52.0		68.3	
shear load	C20/25	V_{perm}	[kN]	48.0		67.1		85.1	88.2
	C50/60	V_{perm}	[kN]	60.0	68.0	69.1	80.0	85.1	103.4
cracked concrete									
tension load	C20/25	N_{perm}	[kN]	17.1		24.0		31.5	
	C50/60	N_{perm}	[kN]	26.6		37.1		48.8	
shear load	C20/25	V_{perm}	[kN]	34.3		47.9		63.0	
	C50/60	V_{perm}	[kN]	53.1		69.1	74.2	85.1	97.6

[1)] Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

4

4. Load direction: tension

4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			FH II 10 gvz	FH II 12 gvz	FH II 15 gvz	FH II 18 gvz	FH II 24 gvz	FHA II 28 gvz	FH II 32 gvz
characteristic resistance	$N_{Rk,s}$	[kN]	16.1	29.3	46.4	67.4	125.3	195.8	282.0
design resistance	$N_{Rd,s}$	[kN]	10.7	19.5	30.9	44.9	83.5	130.5	188.0

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

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FH II 10 gvz	FH II 12 gvz	FH II 15 gvz	FH II 18 gvz	FH II 24 gvz	FH II 28 gvz	FH II 32 gvz
non-cracked concrete									
characteristic resistance	$N^0_{Rk,p}$	[kN]	12.8	23.4	29.5	36.1	50.4	70.4	92.6
design resistance	$N^0_{Rd,p}$	[kN]	8.5	15.6	19.7	24.0	33.6	47.0	61.7
cracked concrete									
characteristic resistance	$N^0_{Rk,p}$	[kN]	7.5	12.0	16.0	25.0	36.0	50.3	66.1
design resistance	$N^0_{Rd,p}$	[kN]	5.0	8.0	10.7	16.7	24.0	33.5	44.1

4.3 Concrete cone failure and splitting for the most unfavourable anchor

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FH II 10 gvz	FH II 12 gvz	FH II 15 gvz	FH II 18 gvz	FH II 24 gvz	FH II 28 gvz	FH II 32 gvz
eff. anchorage depth	h_{ef}	[mm]	40	60	70	80	100	125	150
non-cracked concrete									
characteristic resistance	$N^0_{Rk,c}$	[kN]	12.8	23.4	29.5	36.1	50.4	70.4	92.6
design resistance	$N^0_{Rd,c}$	[kN]	8.5	15.6	19.7	24.0	33.6	47.0	61.7
cracked concrete									
characteristic resistance	$N^0_{Rk,c}$	[kN]	9.1	16.7	21.1	25.8	36.0	50.3	66.1
design resistance	$N^0_{Rd,c}$	[kN]	6.1	11.2	14.1	17.2	24.0	33.5	44.1

fischer High performance anchor FH II

Anchor design according to ETA

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s	Influence factor f_s [-]						
	FH II 10	FH II 12	FH II 15	FH II 18	FH II 24	FH II 28	FH II 32
[mm]	gvz	gvz	gvz	gvz	gvz	gvz	gvz
40	0.67						
50	0.71	0.64					
60	0.75	0.67	0.64				
70	0.79	0.69	0.67	0.65			
80	0.83	0.72	0.69	0.67	0.63		
100	0.92	0.78	0.74	0.71	0.67	0.63	
120	1.00	0.85	0.80	0.76	0.70	0.67	0.63
150		0.92	0.86	0.81	0.75	0.70	0.67
170		0.97	0.90	0.85	0.78	0.73	0.69
180		1.00	0.93	0.88	0.80	0.74	0.70
200			0.98	0.92	0.83	0.77	0.72
210			1.00	0.94	0.85	0.78	0.73
240				1.00	0.90	0.82	0.77
300					1.00	0.91	0.83
380						1.00	0.92
450							1.00
s_{min} [mm]	40	50	60	70	80	100	120
$s_{cr,N}$ [mm]	120	180	210	240	300	375	450

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c	Influence factor f_c [-]						
	FH II 10	FH II 12	FH II 15	FH II 18	FH II 24	FH II 28	FH II 32
[mm]	gvz	gvz	gvz	gvz	gvz	gvz	gvz
40	0.75						
50	0.87	0.67					
60	1.00	0.75	0.68				
70		0.83	0.75	0.69			
80		0.91	0.82	0.75	0.66		
90		1.00	0.83	0.81	0.70		
100			0.96	0.87	0.75	0.66	
105			1.00	0.90	0.77	0.68	
120				1.00	0.85	0.73	0.66
140					0.95	0.81	0.72
150					1.00	0.85	0.75
185						0.99	0.86
225							1.00
c_{min} [mm]	40	50	60	70	80	100	120
$c_{cr,N}$ [mm]	60	90	105	120	150	188	225

Intermediate values by linear interpolation.

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s	Influence factor $f_{s,sp}$ [-]						
	FH II 10	FH II 12	FH II 15	FH II 18	FH II 24	FH II 28	FH II 32
[mm]	gvz	gvz	gvz	gvz	gvz	gvz	gvz
40	0.61						
50	0.63	0.58					
60	0.66	0.60	0.59				
70	0.68	0.62	0.61	0.60			
80	0.71	0.63	0.63	0.62	0.61		
95	0.75	0.66	0.65	0.64	0.63		
100	0.76	0.67	0.66	0.65	0.63	0.60	
120	0.82	0.70	0.69	0.68	0.66	0.63	0.61
135	0.86	0.73	0.71	0.70	0.68	0.64	0.62
150	0.89	0.75	0.73	0.72	0.70	0.66	0.63
160	0.92	0.77	0.75	0.74	0.71	0.67	0.64
170	0.95	0.78	0.77	0.75	0.72	0.68	0.65
190	1.00	0.82	0.80	0.78	0.75	0.70	0.67
240		0.90	0.88	0.85	0.82	0.75	0.71
280		0.97	0.94	0.91	0.87	0.79	0.75
340			1.00	1.00	0.95	0.85	0.80
380					1.00	0.90	0.83
420						0.94	0.87
480						1.00	0.92
570							1.00
s_{min} [mm]	40	50	60	70	80	100	120
$s_{cr,sp}$ [mm]	190	300	320	340	380	480	570

Intermediate values by linear interpolation.

4

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c	Influence factor $f_{c,sp}$ [-]						
	FH II 10	FH II 12	FH II 15	FH II 18	FH II 24	FH II 28	FH II 32
[mm]	gvz	gvz	gvz	gvz	gvz	gvz	gvz
40	0.59						
50	0.65	0.53					
60	0.73	0.57	0.56				
70	0.80	0.62	0.60	0.58			
80	0.88	0.66	0.64	0.62	0.59		
95	1.00	0.73	0.70	0.68	0.64		
100		0.75	0.72	0.70	0.65	0.58	
120		0.85	0.81	0.78	0.73	0.64	0.59
150		1.00	0.95	0.91	0.84	0.72	0.65
160			1.00	0.95	0.88	0.75	0.68
170				1.00	0.92	0.78	0.70
190					1.00	0.84	0.75
240						1.00	0.88
285							1.00
c_{min} [mm]	40	50	60	70	80	100	120
$c_{cr,sp}$ [mm]	95	150	160	170	190	240	285

Intermediate values by linear interpolation.

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{2 \cdot h_{ef}}\right)^{\frac{2}{3}} \leq 1.5$$

Thickness h	Influence factor f_h [-]						
[mm]	FH II 10	FH II 12	FH II 15	FH II 18	FH II 24	FH II 28	FH II 32
80	1.00						
100	1.16						
120	1.31	1.00					
140	1.45	1.11	1.00				
150	1.50	1.16	1.05				
160		1.21	1.09	1.00			
200		1.41	1.27	1.16	1.00		
220		1.50	1.35	1.24	1.07		
250			1.47	1.35	1.16	1.00	
260			1.50	1.38	1.19	1.03	
290				1.49	1.28	1.10	
300				1.50	1.31	1.13	1.00
340					1.42	1.23	1.09
370					1.50	1.30	1.15
400						1.37	1.21
460						1.50	1.33
500							1.41
550							1.50
h_{ef} [mm]	40	60	70	80	100	125	150
h_{min} [mm]	80	120	140	160	200	250	300

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Anchor type			FH II 10		FH II 12		FH II 15		FH II 18	
			B/H gvz	S/SK gvz	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz
characteristic resistance	$V_{Rk.s}$	[kN]	15.5	18.0	24.0	29.0	39.0	46.0	57.0	66.0
design resistance	$V_{Rd.s}$	[kN]	12.4	14.4	19.2	23.2	31.2	36.8	45.6	52.8
Anchor type			**FH II 24**		**FH II 28**		**FH II 32**			
			B/H gvz	S/SK gvz	B/H gvz	S/SK gvz	B/H gvz	S/SK gvz		
characteristic resistance	$V_{Rk.s}$	[kN]	105.0	119.0	121.0	140.0	149.0	181.0		
design resistance	$V_{Rd.s}$	[kN]	84.0	95.2	96.8	112.0	119.2	144.8		

5.2 Pryout-failure for the most unfavourable anchor

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot k$$

4

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FH II 10 gvz	FH II 12 gvz	FH II 15 gvz	FH II 18 gvz	FH II 24 gvz	FH II 28 gvz	FH II 32 gvz
eff. Anchorage depth	h_{ef}	[mm]	40	60	70	80	100	125	150
non-cracked concrete									
characteristic resistance	$N^0_{Rk.cp}$ (c)	[kN]	12.8	23.4	29.5	36.1	50.4	70.4	92.6
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	8.5	15.6	19.7	24.0	33.6	47.0	61.7
characteristic resistance	$N^0_{Rk.cp}$ (p)	[kN]	12.8	23.4	29.5	36.1	50.4	70.4	92.6
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	8.5	15.6	19.7	24.0	33.6	47.0	61.7
cracked concrete									
characteristic resistance	$N^0_{Rk.cp}$ (c)	[kN]	9.1	16.7	21.1	25.8	36.0	50.3	66.1
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	6.1	11.2	14.1	17.2	24.0	33.5	44.1
characteristic resistance	$N^0_{Rk.cp}$ (p)	[kN]	7.5	12.0	16.0	25.0	36.0	50.3	66.1
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	5.0	8.0	10.7	16.7	24.0	33.5	44.1

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

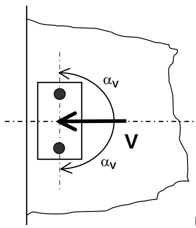
Anchor type	FH II 10 gvz	FH II 12 gvz	FH II 15 gvz	FH II 18 gvz	FH II 24 gvz	FH II 28 gvz	FH II 32 gvz
non-cracked concrete							
minimum edge distance c_{min} [mm]	40	60	70	80	100	120	180
characteristic resistance $V^0_{Rk,c}$ [kN]	5.1	9.6	12.6	15.9	23.3	31.8	56.7
design resistance $V^0_{Rd,c}$ [kN]	3.4	6.4	8.4	10.6	15.5	21.2	37.8
cracked concrete							
minimum edge distance c_{min} [mm]	40	50	60	70	80	100	120
characteristic resistance $V^0_{Rk,c}$ [kN]	3.6	5.4	7.3	9.5	12.5	17.9	24.2
design resistance $V^0_{Rd,c}$ [kN]	2.4	3.6	4.9	6.3	8.3	12.0	16.1

4

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 **Single anchor** influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$

$$f_{sc,V}{}^{n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$

$$f_{sc,V}{}^{n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}{}^{n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 Anchor pair influenced only by one edge

for concrete thickness h ≧ 1.5 · c
and spacing **s ≦ 3 · c**

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for s > 3 · c

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c
and spacing **s ≦ 4.5 · h**

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for s > 4.5 · h

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2,89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

6. Summary of required proof:

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

6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

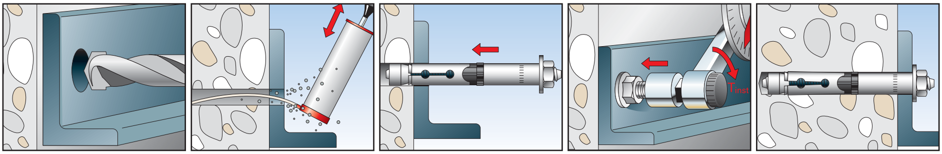
$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

fischer High performance anchor FH II

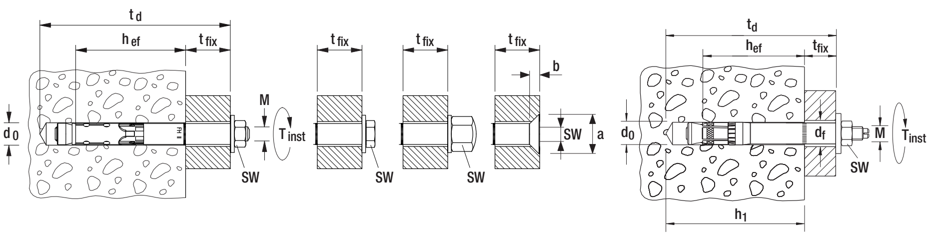
Anchor design according to ETA

7. Installation details



8. Anchor characteristics

Anchor type			FH II 10 gvz	FH II 12 gvz	FH II 15 gvz	FH II 18 gvz	FH II 24 gvz	FH II 28 gvz	FH II 32 gvz
diameter of thread			M 6	M 8	M 10	M 12	M 16	M 20	M 24
nominal drill hole diameter	d_0	[mm]	10	12	15	18	24	28	32
drill depth	h_1	[mm]	55	80	90	105	125	150	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	≦ 30	≦ 34
drill hole depth for through fixing	t_d	[mm]	$t_d = h_1 + t_{fix}$						
wrench size	SW	[mm]	10	13	17	19	24	30	36
wrench size type SK hexagonal socket	SW	[mm]	4	5	6	8	-	-	-
countersunk head drill hole diameter type SK	a	[mm]	19.5	22	25	32	-	-	-
countersunk drill depth type SK	b	[mm]	5	5.8	5.8	8	-	-	-
required torque type S, SK	T_{inst}	[Nm]	10	22.5	40	80	160[2)]	180	200
required torque type H			10	22.5	40	80	90	-	-
required torque type B	T_{inst}	[Nm]	10	17.5	38	80	120	180	200
min. thickness of concrete member	h_{min}	[mm]	80	120	140	160	200	250	300
non-cracked concrete									
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									
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



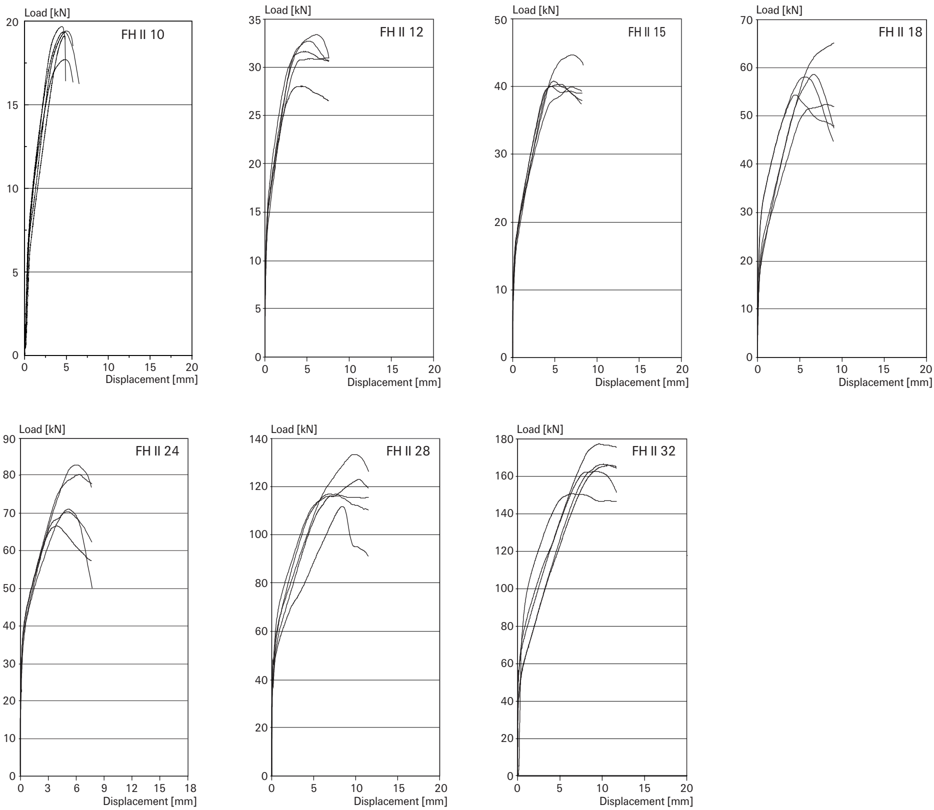
fischer High performance anchor FH II

Anchor design according to ETA

9. Mechanical characteristics

Anchor type			FH II 10	FH II 12	FH II 15	FH II 18	FH II 24	FH II 28	FH II 32
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
Yield strength threaded rod	f_y	[N/mm²]	640	640	640	640	640	640	640
Tensile strength threaded rod	f_u	[N/mm²]	800	800	800	800	800	800	800

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

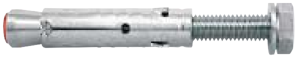


fischer Heavy-duty anchor TAM

Anchor design according to ETA

1. Types

TA M – with internal thread (gvz)



TA M-S – bolt anchor (gvz)

TA M-T– through anchor (gvz)

4

Features and Advantages

- European Technical Approval option 7.
- Suitable for non-cracked concrete.
- Suitabel for all bolts or studs with metric threads.
- Surface-flush fixing allows the mounted item to be removed and refitted several times.
- Plastic cap protects against contamination with drilling dust and ensures the thread remains freerunning.
- Fixing easily driven in, saves effort on installation.
- Three-part expansion sleeve allows even load distribution and small edge and axial spacing.

Materials

Anchor bolt: Carbon steel, zinc plated (5 µm) and passivated (gvz)

2. Ultimate loads of single anchors with large spacing and 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 load	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 load	≥ C 20/25	V_u	[kN]	6.9*)	14.6*)	21.4*)	32.9*)

*) Steel failure decisive

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

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube(150)}$ [N/mm²]	Influence factor $f_{b,p} = f_{b,c}$ [-]
C 20/25	20	25	1.00
C 25/30	25	30	1.10
C 30/37	30	37	1.22
C 40/50	40	50	1.41
C 45/55	45	55	1.48
C 50/60	50	60	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Characteristic loads

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 load C 20/25 N_{Rk} [kN]	7.5	12.0	20.0	25.0
C 50/60 N_{Rk} [kN]	11.6	18.6	31.0	38.7
shear load ≧ C 20/25 V_{Rk} [kN]	5.8	11.7	19.2	29.8

Design loads

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 load C 20/25 N_{Rd} [kN]	5.0	8.0	13.3	16.7
C 50/60 N_{Rd} [kN]	7.7	12.4	20.7	25.8
shear load ≧ C 20/25 V_{Rd} [kN]	4.6	9.4	15.4	23.8

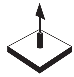
Permissible loads [2]

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 load C 20/25 N_{perm} [kN]	3.6	5.7	9.5	11.9
C 50/60 N_{perm} [kN]	5.5	8.9	14.8	18.4
shear load ≧ C 20/25 V_{perm} [kN]	3.3	6.7	11.0	17.0

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

2) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			TA M 6 gvz [1]	TA M 8 gvz [1]	TA M 10 gvz [1]	TA M 12 gvz [1]
characteristic resistance	$N_{Rk,s}$	[kN]	16.0	29.3	46.4	67.4
design resistance	$N_{Rd,s}$	[kN]	10.7	19.5	30.9	44.9

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

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

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

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						
characteristic resistance	$N^0_{Rk,p}$	[kN]	7.5	12.0	20.0	25.0
design resistance	$N^0_{Rd,p}$	[kN]	5.0	8.0	13.3	16.7

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

4.3 Concrete cone failure and splitting for the most unfavourable anchor

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

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						
characteristic resistance	$N^0_{Rk,c}$	[kN]	12.8	15.2	20.6	29.5
design resistance	$N^0_{Rd,c}$	[kN]	8.5	10.1	13.7	19.7

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

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s	Influence factor f_s [-]			
	TA M 6	TA M 8	TA M 10	TA M 12
[mm]	gvz	gvz	gvz	gvz
80	0.83			
90	0.88	0.83		
100	0.92	0.87		
110	0.96	0.91	0.75	
120	1.00	0.94	0.77	
135		1.00	0.81	
150			0.84	
160			0.86	0.88
170			0.89	0.90
180			0.91	0.93
190			0.93	0.95
200			0.95	0.98
210			0.98	1.00
220			1.00	
s_{min} [mm]	80	90	110	160
$s_{cr,N}$ [mm]	120	135	220	210

Intermediate values by linear interpolation

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c	Influence factor f_c [-]			
	TA M 6	TA M 8	TA M 10	TA M 12
[mm]	gvz	gvz	gvz	gvz
50	0.87			
60	1.00	0.91		
65		0.97		
70		1.00	0.73	
90			0.86	
100			0.93	
110			1.00	
120				1.00
c_{min} [mm]	50	60	70	120
$c_{cr,N}$ [mm]	60	68	110	105

Intermediate values by linear interpolation.

4

4.3.2 Concrete splitting
4.3.2.1 Influence of spacing

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

Spacing s	Influence factor $f_{s,sp}$ [-]			
	TA M 6	TA M 8	TA M 10	TA M 12
[mm]	gvz	gvz	gvz	gvz
80	0.83			
90	0.88	0.75		
100	0.92	0.78		
110	0.96	0.81	0.67	
120	1.00	0.83	0.68	
150		0.92	0.73	
160		0.94	0.74	0.69
180		1.00	0.77	0.71
200			0.80	0.74
225			0.84	0.77
250			0.88	0.80
300			0.95	0.86
330			1.00	0.89
350				0.92
400				0.98
420				1.00
s_{min} [mm]	80	90	110	160
$s_{cr,sp}$ [mm]	120	180	330	420

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c	Influence factor $f_{c,sp}$ [-]			
	TA M 6	TA M 8	TA M 10	TA M 12
[mm]	gvz	gvz	gvz	gvz
50	0.87			
60	1.00	0.75		
70		0.83	0.59	
90		1.00	0.67	
100			0.71	
110			0.75	
120			0.79	0.68
135			0.86	0.73
150			0.93	0.78
165			1.00	0.84
185				0.91
200				0.96
210				1.00
c_{min} [mm]	50	60	70	120
$c_{cr,sp}$ [mm]	60	90	165	210

Intermediate values by linear interpolation.

fischer Heavy-duty anchor TAM

Anchor design according to ETA

4.3.2.3 Influence of concrete thickness

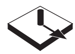
$$f_h = \left(\frac{h}{2 \cdot h_{ef}}\right)^{\frac{2}{3}} \leq 1.5$$

Thickness h [mm]	Influence factor f_h [-] TA M 6	TA M 8	TA M 10	TA M 12
100	1.16	1.07		
110	1.24	1.14	1.00	
140	1.45	1.34	1.17	1.00
150	1.50	1.41	1.23	1.05
170		1.50	1.34	1.14
210			1.50	1.31
240				1.43
260				1.50
h_{ef} [mm]	40	45	55	70
h_{min} [mm]	100	100	110	140

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor



Characteristic resistance and design resistance for single anchors

Anchor type	TA M 6 gvz [1]	TA M 8 gvz [1]	TA M 10 gvz [1]	TA M 12 gvz [1]
characteristic resistance $V_{Rk,s}$ [kN]	5.8	11.7	19.2	29.8
design resistance $V_{Rd,s}$ [kN]	4.6	9.4	15.4	23.8

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

5.2 Pryout-failure for the most unfavourable anchor

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot k$$

Characteristic resistance and design restance for single anchors in concrete C20/25

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				
characteristic resistance $N^0_{Rk,cp}$ (C) [kN]	12.8	15.2	20.6	29.5
design resistance $N^0_{Rd,cp}$ (C) [kN]	8.5	10.1	13.7	19.7
characteristic resistance $N^0_{Rk,cp}$ (P) [kN]	7.5	12.0	20.0	25.0
design resistance $N^0_{Rd,cp}$ (P) [kN]	5.0	8.0	13.3	16.7

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

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design restance for single anchors in concrete C20/25 for edge distances c_{min}

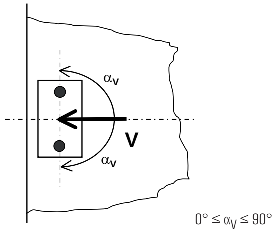
Anchor type			TA M 6 gvz [1]	TA M 8 gvz [1]	TA M 10 gvz [1]	TA M 12 gvz [1]
non-cracked concrete						
minimum edge distance	c_{min}	[mm]	50	60	70	120
characteristic resistance	$V^0_{Rk,c}$	[kN]	6.8	9.1	12.0	26.3
design resistance	$V^0_{Rd,c}$	[kN]	4.5	6.1	8.0	17.5

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

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 **Single anchor** influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\,n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 **Anchor pair** influenced only by one edge

4

for concrete thickness h ≧ 1.5 · c
and spacing **s ≦ 3 · c**

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for s > 3 · c

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c
and spacing **s ≦ 4.5 · h**

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for s > 4.5 · h

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

fischer Heavy-duty anchor TAM

Anchor design according to ETA

6. Summary of required proof:

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

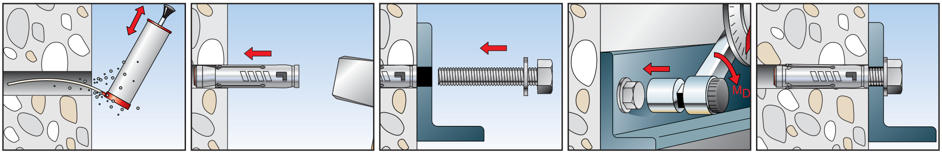
6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

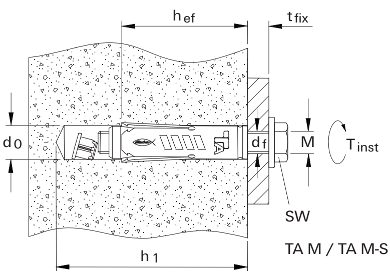
N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

7. Installation details

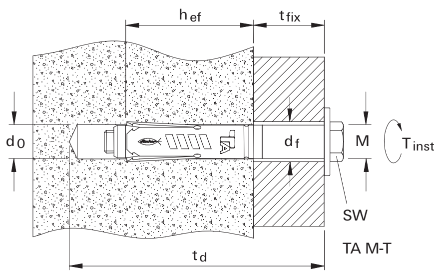


8. Anchor characteristics

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	t_d	[mm]	90	95	110	120
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
wrench size type S; T	SW	[mm]	10	13	17	19
required 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



TA M / TA M-S



TA M-T

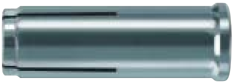
9. Mechanical characteristics

Anchor type			TA M 6	TA M 8	TA M 10	TA M 12
			gvz	gvz	gvz	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	109.2
yield strength screw	f_y	[N/mm²]	640	640	640	640
tensile strength screw	f_u	[N/mm²]	800	800	800	800

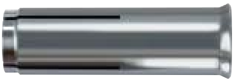
fischer Hammerset anchor EA II

Anchor design according to ETA

1. Types



EA II – Hammerset anchor (gvz)



EA II – Hammerset anchor (A4)

European Technical Approval - Option 7 for non-cracked concrete

For multiple fixings of non-structural applications in cracked concrete

FM APPROVED from thread M 10

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 7.
- Suitable for non-cracked concrete.
- Low setting depth reduces drilling time and facilitates cost-effective mounting.
- Surface flush anchor permits multiple releasing and fixing of the fixture.

Materials

Anchor: Carbon steel, zinc plated (5 µm) and passivated (gvz)
Stainless steel of the corrosion resistance class III, e.g. A4

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 load ≧ 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 load ≧ 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

*) Steel failure decisive

1) The values apply to screws with a strength classification 5.8

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

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube(150)}$ [N/mm²]	Influence factor $f_{b,p} = f_{b,c}$ [-]
C 20/25	20	25	1.00
C 25/30	25	30	1.10
C 30/37	30	37	1.22
C 40/50	40	50	1.41
C 45/55	45	55	1.48
C 50/60	50	60	1.55

fischer Hammerset anchor EA II

Anchor design according to ETA

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Characteristic loads

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 load	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 load	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

Design loads

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 load	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		37.2	
shear load	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

Permissible loads [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 load	C 20/25	N_{perm} [kN]	3.9		3.9		6.1		3.9		6.1		8.5		12.6		17.2	
	C 50/60	N_{perm} [kN]	4.8	5.4	6.1		8.2	9.3	6.1		9.4		13.1		19.5		26.6	
shear load	C 20/25	V_{perm} [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_{perm} [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

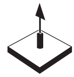
* Use restricted to anchoring of structural components which are statically indeterminate.

1) The values apply to screws with a strength classification 5.8

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

3) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

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
characteristic resistance	$N_{Rk,s}$	[kN]	8.0	10.1	10.1	13.5	14.1	14.6	18.3	17.2	17.2	19.6	14.6	18.3	17.2	17.2	19.6	23.2	29.0	21.8	21.8	24.9
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
characteristic resistance	$N_{Rk,s}$	[kN]	23.2	29.0	21.8	21.8	24.9	33.7	42.1	39.6	39.6	45.1	62.7	78.3	64.7	64.7	73.8	97.9	122.4	102.8	102.8	117.2
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

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

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

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
non-cracked concrete																		
characteristic resistance	$N^0_{Rk,p}$	[kN]	8.3		8.3		12.8		8.3		12.8		17.8		26.4		36.1	
design resistance	$N^0_{Rd,p}$	[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 Concrete cone failure and splitting for the most unfavourable anchor

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

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
eff. anchorage depth	h_{ef}	[mm]	30		30		40		30		40		50		65		80	
non-cracked concrete																		
characteristic resistance	$N^0_{Rk,c}$	[kN]	8.3		8.3		12.8		8.3		12.8		17.8		26.4		36.1	
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 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s	Influence factor f_s [-]							
	EA II M6*	EA II M8*	EA II M8x40	EA II M10x30*	EA II M10	EA II M12	EA II M16	EA II M20
[mm]	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4
65	0.86							
70	0.89							
75	0.92							
80	0.94							
85	0.97			0.97				
90	1.00			1.00				
95		1.00	0.90		0.90			
110			0.96		0.96			
120			1.00		1.00			
145						0.98		
150						1.00		
180							0.96	
190							0.99	0.90
195							1.00	0.91
220								0.96
240								1.00
s_{min} [mm]	65	95	95	85	95	145	180	190
$s_{cr,N}$ [mm]	90	90	120	90	120	150	195	240

Intermediate values by linear interpolation.

* Use restricted to anchoring of structural components which are statically indeterminate.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c	Influence factor f_c [-]							
	EA II M6*	EA II M8*	EA II M8x40	EA II M10x30*	EA II M10	EA II M12	EA II M16	EA II M20
[mm]	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4
115	1.00							
140		1.00	1.00	1.00				
160					1.00			
200						1.00		
240							1.00	
280								1.00
c_{min} [mm]	115	140	140	140	160	200	240	280
$c_{cr,N}$ [mm]	45	45	60	45	60	75	97	120

Intermediate values by linear interpolation.

* Use restricted to anchoring of structural components which are statically indeterminate.

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s	Influence factor $f_{s,sp}$ [-]							
	EA II M6*	EA II M8*	EA II M8x40	EA II M10x30*	EA II M10	EA II M12	EA II M16	EA II M20
[mm]	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4
65	0.65							
75	0.68							
85	0.70			0.70				
95	0.73	0.73	0.67	0.73	0.65			
110	0.76	0.76	0.70	0.76	0.67			
130	0.81	0.81	0.73	0.81	0.70			
145	0.85	0.85	0.76	0.85	0.73	0.71		
160	0.88	0.88	0.79	0.88	0.75	0.73		
180	0.93	0.93	0.82	0.93	0.78	0.76	0.70	
190	0.85	0.95	0.84	0.95	0.80	0.77	0.71	0.67
210	1.00	1.00	0.88	1.00	0.83	0.80	0.73	0.69
250			0.95		0.89	0.86	0.77	0.72
280			1.00		0.94	0.90	0.81	0.75
320					1.00	0.96	0.85	0.79
350						1.00	0.88	0.81
400							0.94	0.86
455							1.00	0.91
500								0.95
560								1.00
s_{min} [mm]	65	95	95	85	95	145	180	190
$s_{cr,sp}$ [mm]	210	210	280	210	320	350	455	560

Intermediate values by linear interpolation.

* Use restricted to anchoring of structural components which are statically indeterminate.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s^2_{cr,sp}}$$

Edge distance c	Influence factor $f_{c,sp}$ [-]							
	EA II M6*	EA II M8*	EA II M8x40	EA II M10x30*	EA II M10	EA II M12	EA II M16	EA II M20
[mm]	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4
115	1.00							
140		1.00	1.00	1.00				
160					1.00			
200						1.00		
240							1.00	
280								1.00
c_{min} [mm]	115	140	140	140	160	200	240	280
$c_{cr,sp}$ [mm]	105	105	140	105	160	175	227	280

* Use restricted to anchoring of structural components which are statically indeterminate.

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{2 \cdot h_{ef}} \right)^{\frac{2}{3}} \leq 1.5$$

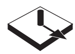
Thickness h	Influence factor f_h [-]							
	EA II M6*	EA II M8*	EA II M8x40	EA II M10x30*	EA II M10	EA II M12	EA II M16	EA II M20
[mm]	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4
100	1.41	1.41	1.16					
110	1.50	1.50	1.24					
120			1.31	1.50	1.31	1.13		
140			1.45		1.45	1.25		
150						1.31		
160						1.37	1.15	
190						1.50	1.29	
200							1.33	1.16
220							1.42	1.24
240							1.50	1.31
260								1.38
280								1.45
300								1.50
h_{ef} [mm]	30	30	40	30	40	50	65	80
h_{min} [mm]	100	100	100	120	120	120	160	200

Intermediate values by linear interpolation.

* Use restricted to anchoring of structural components which are statically indeterminate.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor



Characteristic resistance and design resistance for single anchors

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
characteristic resistance	$V_{Rk,s}$	[kN]	4.0	5.0	5.0	6.8	7.0	7.3	9.2	8.6	8.6	9.8	7.3	9.2	8.6	8.6	9.8	11.6	14.5	10.9	10.9	12.4
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
characteristic resistance	$V_{Rk,s}$	[kN]	11.6	14.5	10.9	10.9	12.4	16.9	21.1	19.8	19.8	22.6	31.0	39.0	32.0	32.0	37.0	49.0	61.0	51.0	51.0	59.0
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

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

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
eff. anchorage depth h_{ef} [mm]	30	30	40	30	40	50	65	80
non-cracked concrete								
characteristic resistance $N^0_{Rk,cp}$ (c) [kN]	8.3	8.3	12.8	8.3	12.8	17.8	26.4	36.1
design resistance $N^0_{Rd,cp}$ (c) [kN]	5.5	5.5	8.5	5.5	8.5	11.9	17.6	24.0
characteristic resistance $N^0_{Rk,cp}$ (p) [kN]	8.3	8.3	12.8	8.3	12.8	17.8	26.4	36.1
design resistance $N^0_{Rd,cp}$ (p) [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.

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

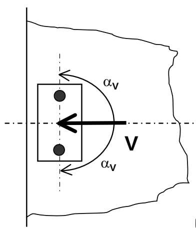
Anchor type	EA II M6*	EA II M8*	EA II M8x40	EA II M10x30*	EA II M10	EA II M12	EA II M16	EA II M20
	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4	gvz / A4
non-cracked concrete								
minimum edge distance c_{min} [mm]	115	140	140	140	160	200	240	280
characteristic resistance $V^0_{Rk,c}$ [kN]	20.1	27.0	27.9	27.5	34.3	49.1	67.2	87.5
design resistance $V^0_{Rd,c}$ [kN]	13.4	18.0	18.6	18.3	22.8	32.7	44.8	58.3

* Use restricted to anchoring of structural components which are statically indeterminate.

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 Single anchor influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\,n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 Anchor pair influenced only by one edge

for concrete thickness h ≧ 1.5 · c
and spacing **s ≦ 3 · c**

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for s > 3 · c

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c
and spacing **s ≦ 4.5 · h**

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for s > 4.5 · h

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2,89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

fischer Hammerset anchor EA II

Anchor design according to ETA

6. Summary of required proof:

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

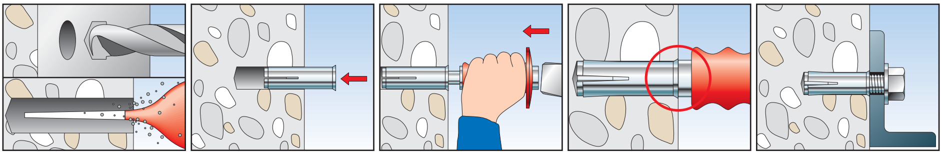
6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

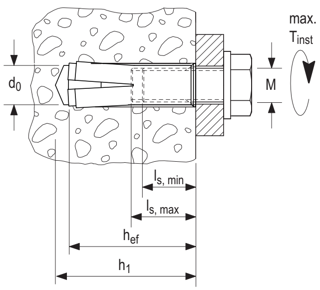
N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

7. Installation details



8. Anchor characteristics

Anchor type			EA II M6 (gvz / A4)	EA II M8 (gvz / A4)	EA II M8x40 (gvz / A4)	EA II M10x30 (gvz / A4)	EA II M10 (gvz / A4)	EA II M12 (gvz / A4)	EA II M16 (gvz / A4)	EA II M20 (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		157.0		245.0	
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		109.0		276.7		540.3	
yield strength sleeve	f_y	[N/mm²]	455	520	455	520	455	520	455	520	455	520	455	520	455	520	455	520
tensile strength sleeve	f_u	[N/mm²]	570	650	570	650	570	650	570	650	570	650	570	650	570	650	570	650

* Begin of expansion element

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fischer Highbond anchor FHB II

Anchor design according to ETA

1. Types

FHB II - S

FHB II - L

FHB II-P - Resin capsule

FHB II-PF Quick Version - Resin capsule

FIS HB 345 S - Injection mortar

FIS HB 150 C - Injection mortar

European Technical Approval – 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.
- Two setting methods: With FHB II-P resin capsule or with FIS - HB injection system.
- Simple push-through installation for optimum handling.
- Suitability for cracked concrete ensures maximum safety.
- Low-expansion function allows cost-efficient fixing with small edge and axial spacing.
- FHB II-PF Resin capsule allows quickest curing e.g. 2 min > 20 °C.

Materials

Anchor rod:	Carbon steel, zinc plated (5 µm) and passivated (gvz)
	Stainless steel of the corrosion resistance class III, e.g. A4
	Stainless steel of the corrosion resistance class IV, e.g. 1.4529 (C)
Injection mortar:	Vinylester resin (styrene-free), quartz sand and hardener
Resin capsule:	Vinylester resin (styrene-free), quartz sand and hardener

2. Ultimate loads of single anchors with large spacing and edge distance 1)

Mean values

Anchor type	FHB II 8x60			FHB II 10x60			FHB II 10x95			FHB II 12x75			FHB II 12x120		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete, temperature range - 40 °C to + 50 °C															
tension load C 20/25 N_u [kN]	21.9*)			21.9*)			34.4*)			34.4*)			49.8*)		
C 50/60 N_u [kN]	21.9*)			21.9*)			34.4*)			34.4*)			49.8*)		
shear load ≥ C 20/25 V_u [kN]	15.0*)	21.4*)	20.5*)	21.3*)	26.9*)	30.2*)	24.9*)	32.9*)	33.9*)	29.8*)	39.1*)	43.8*)	42.4*)	49.0*)	48.8*)
cracked concrete, temperature range - 40 °C to + 50 °C															
tension load C 20/25 N_u [kN]	19.6			21.9*)			34.4*)			30.7			49.8*)		
C 50/60 N_u [kN]	21.9*)			21.9*)			34.4*)			34.4*)			49.8*)		
shear load ≥ C 20/25 V_u [kN]	15.0*)	21.4*)	20.5*)	21.3*)	26.9*)	30.2*)	24.9*)	32.9*)	33.9*)	29.8*)	39.1*)	43.8*)	42.4*)	49.0*)	48.8*)

Anchor type	FHB II 16x95			FHB II 16x160			FHB II 20x210			FHB II 24x170		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
non-cracked concrete, temperature range - 40 °C to + 50 °C												
tension load C 20/25 N_u [kN]	61.6*)			96.6*)			137.6*)			128.5*)		
C 50/60 N_u [kN]	61.6*)			96.6*)			137.6*)			128.5*)		
shear load ≥ C 20/25 V_u [kN]	61.6*)	77.9*)	85.8*)	72.6*)	89.2*)	91.7*)	116.1*)	133.4*)	148.4*)	127.1*)	151.6*)	175.7*)
cracked concrete, temperature range - 40 °C to + 50 °C												
tension load C 20/25 N_u [kN]	43.8			95.6			137.6*)			104.7*)		
C 50/60 N_u [kN]	61.6*)			96.6*)			137.6*)			128.5*)		
shear load ≥ C 20/25 V_u [kN]	61.6*)	77.9*)	85.8*)	72.6*)	89.2*)	91.7*)	116.1*)	133.4*)	148.4*)	127.1*)	151.6*)	175.7*)

1) The loads apply to temperatures in the substrate in the area of the resin T ≤ + 50 °C.

*) Steel failure decisive

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube(150)}$ [N/mm²]	Influence factor $f_{b,p} = f_{b,c}$ [-]
C 20/25	20	25	1.00
C 25/30	25	30	1.10
C 30/37	30	37	1.22
C 40/50	40	50	1.41
C 45/55	45	55	1.48
C 50/60	50	60	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [2)]

Characteristic loads

Anchor type	FHB II 8x60			FHB II 10x60			FHB II 10x95			FHB II 12x75			FHB II 12x120			FHB II 16x95			FHB II 16x160			FHB II 20x210			FHB II 24x170		
	gvz	A4	C	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 - 40 °C to + 50 °C																											
tension load																											
C 20/25 N_{Rk} [kN]		21.9			21.9			34.4			32.7			49.8			46.7			96.6			137.6			111.7	
C 50/60 N_{Rk} [kN]		21.9			21.9			34.4			34.4			49.8			61.6			96.6			137.6			128.5	
shear load																											
≥ C 20/25 V_{Rk} [kN]	13.2	14.6		18.8	23.2		20.8	23.2		27.3	33.7		30.3	33.7		50.8	62.7		56.3	62.7		87.9	97.9		114.2	124.5	141.0
cracked concrete, temperature range - 40 °C to + 50 °C																											
tension load																											
C 20/25 N_{Rk} [kN]		16.7			16.7			33.3			23.4			47.3			33.3			72.9			109.6			79.8	
C 50/60 N_{Rk} [kN]		21.9			21.9			34.4			34.4			49.8			51.6			96.6			137.6			123.6	
shear load																											
≥ C 20/25 V_{Rk} [kN]	13.2	14.6		18.8	23.2		20.8	23.2		27.3	33.7		30.3	33.7		50.8	62.7		56.3	62.7		87.9	97.9		114.2	124.5	141.0

Design loads

Anchor type	FHB II 8x60			FHB II 10x60			FHB II 10x95			FHB II 12x75			FHB II 12x120			FHB II 16x95			FHB II 16x160			FHB II 20x210			FHB II 24x170		
	gvz	A4	C	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 - 40 °C to + 50 °C																											
tension load																											
C 20/25 N_{Rd} [kN]		14.6			14.6			22.9			21.8			33.2			31.1			64.4			91.7			74.5	
C 50/60 N_{Rd} [kN]		14.6			14.6			22.9			22.9			33.2			41.1			64.4			91.7			85.7	
shear load																											
≥ C 20/25 V_{Rd} [kN]	10.6	11.7		15.0	18.6		16.6	18.6		21.8	27.0		24.2	27.0		40.6	50.2		45.0	50.2		70.3	78.3		91.4	99.6	112.8
cracked concrete, temperature range - 40 °C to + 50 °C																											
tension load																											
C 20/25 N_{Rd} [kN]		11.2			11.2			22.2			15.6			31.5			22.0			48.6			73.0			53.2	
C 50/60 N_{Rd} [kN]		14.6			14.6			22.9			22.9			33.2			34.4			64.4			91.7			82.4	
shear load																											
C 20/25 V_{Rd} [kN]	10.6	11.7		15.0	18.6		16.6	18.6		21.8	27.0		24.2	27.0		40.6	44.4		45.0	50.2		70.3	78.3		91.4	99.6	106.4
≥ C 30/37 V_{Rd} [kN]	10.6	11.7		15.0	18.6		16.6	18.6		21.8	27.0		24.2	27.0		40.6	50.2		45.0	50.2		70.3	78.3		91.4	99.6	112.8

Permissible loads see next page.

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [2)]

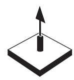
Permissible loads [1)]

Anchor type	FHB II 8x60			FHB II 10x60			FHB II 10x95			FHB II 12x75			FHB II 12x120			FHB II 16x95			FHB II 16x160			FHB II 20x210			FHB II 24x170		
	gvz	A4	C	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 - 40 °C to + 50 °C																											
tension load																											
C 20/25 N_{perm} [kN]	10.4			10.4			16.4			15.6			23.7			22.2			46.0			65.5			53.2		
C 50/60 N_{perm} [kN]	10.4			10.4			16.4			16.4			23.7			29.3			46.0			65.5			61.2		
shear load																											
≥ C 20/25 V_{perm} [kN]	7.5	8.3		10.7	13.3		11.9	13.3		15.6	19.3		17.3	19.3		29.0	35.8		32.2	35.8		50.2	55.9		65.3	71.1	80.6
cracked concrete, temperature range - 40 °C to + 50 °C																											
tension load																											
C 20/25 N_{perm} [kN]	8.0			8.0			15.9			11.1			22.5			15.9			34.7			52.2			38.0		
C 50/60 N_{perm} [kN]	10.4			10.4			16.4			16.4			23.7			24.6			46.0			65.5			58.9		
shear load																											
C 20/25 V_{perm} [kN]	7.5	8.3		10.7	13.3		11.9	13.3		15.6	19.3		17.3	19.3		29.0	31.7		32.2	35.8		50.2	55.9		65.3	71.1	76.0
≥ C 30/37 V_{perm} [kN]	7.5	8.3		10.7	13.3		11.9	13.3		15.6	19.3		17.3	19.3		29.0	35.8		32.2	35.8		50.2	55.9		65.3	71.1	80.6

1) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.
2) The loads apply to temperatures in the substrate in the area of the resin T ≤ + 50 °C.

4

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type	FHB II 8x60 (gvz / A4 / C)	FHB II 10x60 (gvz / A4 / C)	FHB II 10x95 (gvz / A4 / C)	FHB II 12x75 (gvz / A4 / C)	FHB II 12x120 (gvz / A4 / C)	FHB II 16x95 (gvz / A4 / C)	FHB II 16x160 (gvz / A4 / C)	FHB II 20x210 (gvz / A4 / C)	FHB II 24x170 (gvz / A4 / C)
characteristic resistance $N_{Rk,s}$ [kN]	21.9	21.9	34.4	34.4	49.8	61.6	96.6	137.6	128.5
design resistance $N_{Rd,s}$ [kN]	14.6	14.6	22.9	22.9	33.2	41.1	64.4	91.7	85.7

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

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type	FHB II 8x60 (gvz / A4 / C)	FHB II 10x60 (gvz / A4 / C)	FHB II 10x95 (gvz / A4 / C)	FHB II 12x75 (gvz / A4 / C)	FHB II 12x120 (gvz / A4 / C)	FHB II 16x95 (gvz / A4 / C)	FHB II 16x160 (gvz / A4 / C)	FHB II 20x210 (gvz / A4 / C)	FHB II 24x170 (gvz / A4 / C)
eff. anchorage depth h_{ef} [mm]	60	60	95	75	120	95	160	210	170
non-cracked concrete, temperature range - 40 °C to + 50 °C									
characteristic resistance $N^0_{Rk,p}$ [kN]	23.4	23.4	46.7	32.7	66.3	46.7	102.0	153.4	111.7
design resistance $N^0_{Rd,p}$ [kN]	15.6	15.6	31.1	21.8	44.2	31.1	68.0	102.3	74.5
cracked concrete, temperature range - 40 °C to + 50 °C									
characteristic resistance $N^0_{Rk,p}$ [kN]	16.7	16.7	33.3	23.4	47.3	33.3	72.9	109.6	79.8
design resistance $N^0_{Rd,p}$ [kN]	11.2	11.2	22.2	15.6	31.5	22.2	48.6	73.0	53.2

fischer Highbond anchor FHB II

Anchor design according to ETA

4.3 Concrete cone failure and splitting for the most unfavourable anchor[1)]

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FHB II 8x60 gvz | A4 | C	FHB II 10x60 gvz | A4 | C	FHB II 10x95 gvz | A4 | C	FHB II 12x75 gvz | A4 | C	FHB II 12x120 gvz | A4 | C	FHB II 16x95 gvz | A4 | C	FHB II 16x160 gvz | A4 | C	FHB II 20x210 gvz | A4 | C	FHB II 24x170 gvz | A4 | C
eff. anchorage depth	h_{ef}	[mm]	60	60	95	75	120	95	160	210	170
non-cracked concrete, temperature range - 40 °C to + 50 °C											
characteristic resistance	$N^0_{Rk,c}$	[kN]	23.4	23.4	46.7	32.7	66.3	46.7	102.0	153.4	111.7
design resistance	$N^0_{Rd,c}$	[kN]	15.6	15.6	31.1	21.8	44.2	31.1	68.0	102.3	74.5
cracked concrete, temperature range - 40 °C to + 50 °C											
characteristic resistance	$N^0_{Rk,c}$	[kN]	16.7	16.7	33.3	23.4	47.3	33.3	72.9	109.6	79.8
design resistance	$N^0_{Rd,c}$	[kN]	11.2	11.2	22.2	15.6	31.5	22.2	48.6	73.0	53.2

[1)] The loads apply to temperatures in the substrate in the area of the resin T ≤ + 50 °C.

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm]	Influence factor f_s [-] FHB II 8x60 gvz | A4 | C	FHB II 10x60 gvz | A4 | C	FHB II 10x95 gvz | A4 | C	FHB II 12x75 gvz | A4 | C	FHB II 12x120 gvz | A4 | C	FHB II 16x95 gvz | A4 | C	FHB II 16x160 gvz | A4 | C	FHB II 20x210 gvz | A4 | C	FHB II 24x170 gvz | A4 | C
40	0.61	0.61	0.57	0.59					
50	0.64	0.64	0.59	0.61	0.57	0.59			
70	0.69	0.69	0.62	0.66	0.60	0.62	0.57		
80	0.72	0.72	0.64	0.68	0.61	0.64	0.58		0.58
90	0.75	0.75	0.66	0.70	0.63	0.66	0.59	0.57	0.59
150	0.92	0.92	0.76	0.83	0.71	0.76	0.66	0.62	0.65
180	1.00	1.00	0.82	0.90	0.75	0.82	0.69	0.64	0.68
225			0.89	1.00	0.81	0.89	0.73	0.68	0.72
285			1.00		0.90	1.00	0.80	0.73	0.78
360					1.00		0.88	0.79	0.85
400							0.92	0.82	0.89
450							0.97	0.86	0.94
480							1.00	0.88	0.97
510								0.90	1.00
550								0.94	
630								1.00	
s_{min} [mm]	40	40	40	40	50	50	70	90	80
$s_{cr,N}$ [mm]	180	180	285	225	360	285	480	630	510

Intermediate values by linear interpolation.

4

fischer Highbond anchor FHB II

Anchor design according to ETA

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c [mm]	Influence factor f_c [-] FHB II 8x60 gvz / A4 / C	FHB II 10x60 gvz / A4 / C	FHB II 10x95 gvz / A4 / C	FHB II 12x75 gvz / A4 / C	FHB II 12x120 gvz / A4 / C	FHB II 16x95 gvz / A4 / C	FHB II 16x160 gvz / A4 / C	FHB II 20x210 gvz / A4 / C	FHB II 24x170 gvz / A4 / C
40	0.60	0.60	0.50	0.55					
50	0.67	0.67	0.54	0.60	0.50	0.54			
70	0.83	0.83	0.63	0.72	0.57	0.63	0.51		
80	0.91	0.91	0.68	0.78	0.60	0.68	0.53		0.52
90	1.00	1.00	0.73	0.85	0.64	0.73	0.56	0.51	0.55
115			0.85	1.00	0.73	0.85	0.62	0.55	0.61
145			1.00		0.85	1.00	0.71	0.61	0.68
180					1.00		0.81	0.68	0.78
200							0.87	0.73	0.83
240							1.00	0.82	0.95
255								0.85	1.00
285								0.93	
315								1.00	
c_{min} [mm]	40	40	40	40	50	50	70	90	80
$c_{cr,N}$ [mm]	90	90	143	113	180	143	240	315	255

Intermediate values by linear interpolation.

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s [mm]	Influence factor $f_{s,sp}$ [-] FHB II 8x60 gvz / A4 / C	FHB II 10x60 gvz / A4 / C	FHB II 10x95 gvz / A4 / C	FHB II 12x75 gvz / A4 / C	FHB II 12x120 gvz / A4 / C	FHB II 16x95 gvz / A4 / C	FHB II 16x160 gvz / A4 / C	FHB II 20x210 gvz / A4 / C	FHB II 24x170 gvz / A4 / C
40	0.57	0.57	0.54	0.57					
50	0.58	0.58	0.55	0.58	0.54	0.57			
70	0.62	0.62	0.57	0.62	0.56	0.60	0.56		
80	0.63	0.63	0.89	0.63	0.57	0.62	0.57		0.58
90	0.65	0.65	0.89	0.65	0.58	0.63	0.58	0.57	0.59
150	0.75	0.75	0.66	0.75	0.63	0.72	0.63	0.62	0.65
200	0.83	0.83	0.71	0.83	0.67	0.79	0.67	0.66	0.70
250	0.92	0.92	0.76	0.92	0.71	0.87	0.72	0.70	0.75
300	1.00	1.00	0.82	1.00	0.75	0.94	0.76	0.74	0.79
340			0.86		0.78	1.00	0.79	0.77	0.83
400			0.92		0.83		0.84	0.82	0.89
475			1.00		0.90		0.91	0.88	0.97
510					0.93		0.94	0.90	1.00
580					0.98		1.00	0.96	
600					1.00			0.98	
630								1.00	
s_{min} [mm]	40	40	40	40	50	50	70	90	80
$s_{cr,sp}$ [mm]	300	300	475	300	600	340	580	630	510

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c	Influence factor $f_{c,sp}$ [-]								
	FHB II 8x60	FHB II 10x60	FHB II 10x95	FHB II 12x75	FHB II 12x120	FHB II 16x95	FHB II 16x160	FHB II 20x210	FHB II 24x170
[mm]	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C	gvz / A4 / C
40	0.49	0.49	0.44	0.49					
50	0.53	0.53	0.46	0.53	0.44	0.51			
70	0.62	0.62	0.51	0.62	0.47	0.58	0.48		
80	0.66	0.66	0.54	0.66	0.49	0.62	0.50		0.52
90	0.70	0.70	0.56	0.70	0.51	0.66	0.52	0.51	0.55
120	0.85	0.85	0.64	0.85	0.57	0.78	0.58	0.56	0.62
150	1.00	1.00	0.73	1.00	0.64	0.91	0.65	0.62	0.70
170			0.78		0.68	1.00	0.69	0.66	0.75
238			1.00		0.84		0.86	0.82	0.95
255					0.88		0.91	0.85	1.00
290					0.97		1.00	0.94	
300					1.00			0.96	
315								1.00	
c_{min} [mm]	40	40	40	40	50	50	70	90	80
$c_{cr,sp}$ [mm]	150	150	238	150	300	170	290	315	255

Intermediate values by linear interpolation.

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{2 \cdot h_{ef}} \right)^{\frac{2}{3}} \leq 1.5$$

Thickness h	Influence factor f_h [-]								
[mm]	FHB II 8x60	FHB II 10x60	FHB II 10x95	FHB II 12x75	FHB II 12x120	FHB II 16x95	FHB II 16x160	FHB II 20x210	FHB II 24x170
100	0.89	0.89							
120	1.00	1.00		0.86					
140	1.11	1.11	0.82	0.96					
150	1.16	1.16	0.85	1.00		0.85			
170	1.26	1.26	0.93	1.09	0.79	0.93			
220	1.50	1.50	1.10	1.29	0.94	1.10	0.78		
240			1.17	1.37	1.00	1.17	0.83		0.79
280			1.29	1.50	1.11	1.29	0.91	0.76	0.88
350			1.50		1.29	1.50	1.06	0.89	1.02
400					1.41		1.16	0.97	1.11
440					1.50		1.24	1.03	1.19
500							1.35	1.12	1.29
590							1.50	1.25	1.44
630								1.31	1.50
700								1.41	
770								1.50	
h_{ef}	60	60	95	75	120	95	160	210	170
h_{min} [mm]	100	100	140	120	170	150	220	280	240

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type		FHB II 8x60			FHB II 10x60			FHB II 10x95			FHB II 12x75			FHB II 12x120			FHB II 16x95			FHB II 16x160			FHB II 20x210			FHB II 24x170		
		gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
characteristic resistance $V_{Rk,s}$	[kN]	13.2	14.6		18.8	23.2		20.8	23.2		27.3	33.7		30.3	33.7		50.8	62.7		56.3	62.7		87.9	97.9		114.2	124.5	141.0
design resistance $V_{Rd,s}$	[kN]	10.6	11.7		15.0	18.6		16.6	18.6		21.8	27.0		24.2	27.0		40.6	50.2		45.0	50.2		70.3	78.3		91.4	99.6	112.8

5.2 Pryout-failure for the most unfavourable anchor [1)]

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type	FHB II 8x60 gvz | A4 | C	FHB II 10x60 gvz | A4 | C	FHB II 10x95 gvz | A4 | C	FHB II 12x75 gvz | A4 | C	FHB II 12x120 gvz | A4 | C	FHB II 16x95 gvz | A4 | C	FHB II 16x160 gvz | A4 | C	FHB II 20x210 gvz | A4 | C	FHB II 24x170 gvz | A4 | C
eff. anchorage depth h_{ef} [mm]	60	60	95	75	120	95	160	210	170
non-cracked concrete, temperature range - 40 °C to + 50 °C									
characteristic resistance $N^0_{Rk,cp}$ (c) [kN]	23.4	23.4	46.7	32.7	66.3	46.7	102.0	153.4	111.7
design resistance $N^0_{Rd,cp}$ (c) [kN]	15.6	15.6	31.1	21.8	44.2	31.1	68.0	102.3	74.5
characteristic resistance $N^0_{Rk,cp}$ (p) [kN]	23.4	23.4	46.4	32.7	66.3	46.7	102.0	153.4	111.7
design resistance $N^0_{Rd,cp}$ (p) [kN]	15.6	15.6	31.1	21.8	44.2	31.1	68.0	102.3	74.5
cracked concrete, temperature range - 40 °C to + 50 °C									
characteristic resistance $N^0_{Rk,cp}$ (c) [kN]	16.7	16.7	33.3	23.4	47.3	33.3	72.9	109.6	79.8
design resistance $N^0_{Rd,cp}$ (c) [kN]	11.2	11.2	22.2	15.6	31.5	22.2	48.6	73.0	53.2
characteristic resistance $N^0_{Rk,cp}$ (p) [kN]	16.7	16.7	33.3	23.4	47.3	33.3	72.9	109.6	79.8
design resistance $N^0_{Rd,cp}$ (p) [kN]	11.2	11.2	22.2	15.6	31.5	22.2	48.6	73.0	53.2

1) The loads apply to temperatures in the substrate in the area of the resin T ≤ + 50 °C.

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

4

5.3 Concrete edge failure for the most unfavourable anchor[1)]

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

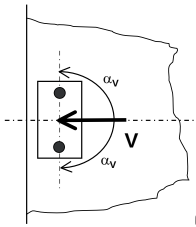
Anchor type			FHB II 8x60 gvz A4 C	FHB II 10x60 gvz A4 C	FHB II 10x95 gvz A4 C	FHB II 12x75 gvz A4 C	FHB II 12x120 gvz A4 C	FHB II 16x95 gvz A4 C	FHB II 16x160 gvz A4 C	FHB II 20x210 gvz A4 C	FHB II 24x170 gvz A4 C
non-cracked concrete, temperature range - 40 °C to + 50 °C											
minimum edge distance	c_{min}	[mm]	40	40	40	40	50	50	70	90	80
characteristic resistance	$V^0_{Rk,c}$	[kN]	5.5	5.5	6.4	6.0	9.3	8.9	16.0	25.3	20.6
design resistance	$V^0_{Rd,c}$	[kN]	3.7	3.7	4.2	4.0	6.2	6.0	10.7	16.9	13.7
cracked concrete, temperature range - 40 °C to + 50 °C											
minimum edge distance	c_{min}	[mm]	40	40	40	40	50	50	70	90	80
characteristic resistance	$V^0_{Rk,c}$	[kN]	3.9	3.9	4.5	4.2	6.6	6.3	11.3	17.9	14.6
design resistance	$V^0_{Rd,c}$	[kN]	2.6	2.6	3.0	2.8	4.4	4.2	7.6	12.0	9.7

1) The loads apply to temperatures in the substrate in the area of the resin $T \leq + 50$ °C.

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 **Single anchor** influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\,n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 **Anchor pair** influenced only by one edge

for concrete thickness h ≧ 1.5 · c
and spacing **s ≦ 3 · c**

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for s > 3 · c

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c
and spacing **s ≦ 4.5 · h**

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for s > 4.5 · h

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

6. Summary of required proof:

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

6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

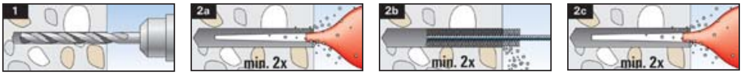
$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor

N_{Rd} ; V_{Rd} = design resistance including safety factors

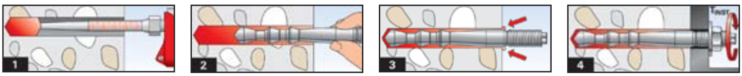
7. Installation details

Drill a hole



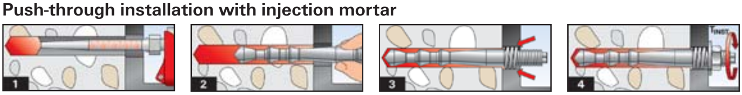
Preparation injection mortar

Pre-positioned installation with injection mortar

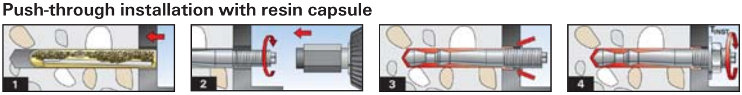


Pre-positioned installation with resin capsule

Push-through installation with injection mortar



Push-through installation with resin capsule



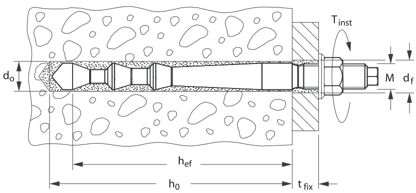
fischer Highbond anchor FHB II

Anchor design according to ETA

4

8. Anchor characteristics

Anchor type			FHB II 8x60 gvz | A4 | C	FHB II 10x60 gvz | A4 | C	FHB II 10x95 gvz | A4 | C	FHB II 12x75 gvz | A4 | C	FHB II 12x120 gvz | A4 | C	FHB II 16x95 gvz | A4 | C	FHB II 16x160 gvz | A4 | C	FHB II 20x210 gvz | A4 | C	FHB II 24x170 gvz | A4 | C
diameter of thread			M 8	M 10	M 10	M 12	M 12	M 16	M 16	M 20	M 24
nominal drill hole diameter	d_0	[mm]	10	10	12	12	14	16	18	25	25
drill depth	h_0	[mm]	75	75	110	90	135	110	175	235	190
effective anchorage depth	h_{ef}	[mm]	60	60	95	75	120	95	160	210	170
clearance-hole in fixture to be attached	d_f	[mm]	≤ 9	≤ 12	≤ 12	≤ 14	≤ 14	≤ 18	≤ 18	≤ 22	≤ 26
wrench size	SW	[mm]	13	17	17	19	19	24	24	30	36
required torque	T_{inst}	[Nm]	15	15	20	30	40	50	60	100	100
minimum thickness of concrete member	h_{min}	[mm]	100	100	140	120	170	150	220	280	240
minimum spacing	s_{min}	[mm]	40	40	40	40	50	50	70	90	80
minimum edge distances	c_{min}	[mm]	40	40	40	40	50	50	70	90	80



9.1 Gelling and curing times for installation with cartridges

Cartridge temperature (minimum + 5 °C)	Gelling 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 the curing time should be doubled. For longer installation times, i.e. when interruptions occur in work, the static mixer should be replaced.

9.2 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 from the moment of contact between resin and hardener. For installation, the capsule temperature must be at least + 5 °C. In wet concrete the curing time should be doubled.

10. Mechanical characteristics

Anchor type			FHB II 8x60 gvz | A4 | C	FHB II 10x60 gvz | A4 | C	FHB II 10x95 gvz | A4 | C	FHB II 12x75 gvz | A4 | C	FHB II 12x120 gvz | A4 | C	FHB II 16x95 gvz | A4 | C	FHB II 16x160 gvz | A4 | C	FHB II 20x210 gvz | A4 | C	FHB II 24x170 gvz | A4 | C
stressed cross sectional area anchor rod	A_s	[mm^2]	37	58	58	84	84	157	157	245	353
resisting moment anchor rod	W	[mm^3]	31	62	62	109	109	278	278	541	936
yield strength anchor rod	f_y	[N/mm^2]	640	640	640	640	640	640	640	640	640
tensile strength anchor rod	f_u	[N/mm^2]	800	800	800	800	800	800	800	800	800

Notes

fischer Resin anchor R and Upat UKA 3 Chemical anchor

Anchor design according to ETA

1. Types

European Technical Approval - Option 7 for non-cracked concrete

Fire resistance-classification up to F 120

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

RG M 8 - M 20 / UKA 3 Ankerstange ASTA
- threaded rod (gvz) with external hexagon head

RG M 8 - M 20 / UKA 3 Ankerstange ASTA
- threaded rod (A4 and C) with external hexagon head

RG M 24 - M 30 / UKA 3 Ankerstange ASTA
- threaded rod (gvz) straight cut

RG M 24 - M 30 / UKA 3 Ankerstange ASTA
- threaded rod (A4 and C) straight cut

R M - Resin capsule R M 8 - M 30
UKA 3 Verbundanker Patrone

Features and Advantages

- European Technical Approval option 7.
- Suitable for non-cracked concrete.
- High-performance resin guarantees for high loads.
- Universal fixing system for a broad range of applications on building sites.
- The resin anchoring is free of expansion forces and permits low axial spacing and edge distances.
- Wide range for many applications.
- Threaded rods are supplied with an easy to use hexagonal installation drive.

Materials

Threaded rod :	Carbon steel grade 5.8, zinc plated (5 µm) and passivated (gvz) Stainless steel of the corrosion resistance class III, e.g. A4 Stainless steel of the corrosion resistance class IV, e.g. 1.4529 (C)
Resin capsule:	Vinylester resin (styrene-free), quartz sand and hardener

2. Ultimate loads of single anchors with large spacing and edge distance [1)]

Mean values

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	
			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 - 40 °C to + 50 °C																		
tension load	C 20/25	N_u [kN]	19.0*)	26.0*)	30.0*)	41.0*)	44.0*)	55.3	79.6		127.0*)	128.2	179.4		239.0*)	240.3	281.5	
	C 50/60	N_u [kN]	19.0*)	26.0*)	30.0*)	41.0*)	44.0*)	59.0*)	82.0*)	107.4	127.0*)	172.0*)	183.0*	242.3*)	239.0*)	322.0*)	292.0*)	380.0
shear load	≧ C 20/25	V_u [kN]	9.2*)	12.8*)	14.5*)	20.3*)	21.1*)	29.5*)	39.2*)	54.8*)	61.2*)	85.7*)	88.2*)	123.4*)	105.1*)	160.8*)	140.2*)	196.2*)

1) The loads apply to fischer threaded rods with strength classification 5.8, premium-drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

*) Steel failure decisive

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube\,(150)}$ [N/mm²]	Influence factor $f_{b,p}$ [-]	Influence factor $f_{b,c}$ [-]
C 20/25	20	25	1.00	1.00
C 25/30	25	30	1.06	1.10
C 30/37	30	37	1.14	1.22
C 40/50	40	50	1.27	1.41
C 45/55	45	55	1.31	1.48
C 50/60	50	60	1.35	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [1)]

Characteristic loads

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		
			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 -40 °C to +50 °C																										
tension load	C 20/25	N_{Rk} [kN]	19.0	22.1		30.0	31.1		41.5			59.7			96.1			134.6			180.2			211.1		
	C 50/60	N_{Rk} [kN]	19.0	26.0		30.0	41.0		44.0	56.0		80.6			127.0	129.8		181.7			239.0	243.3		285.0		
shear load	≧ C 20/25	V_{Rk} [kN]	7.4	12.8		13.3	20.3		19.3	29.5		35.9	54.8		56.0	85.7		80.7	123.4		105.1	160.8		128.3	196.2	

Design loads

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		
			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 -40 °C to +50 °C																										
tension load	C 20/25	N_{Rd} [kN]	12.3			17.3			27.6			39.8			64.1			89.7			120.1			140.7		
	C 50/60	N_{Rd} [kN]	12.8	13.9	16.6	20.1	21.9	23.3	29.5	31.6	37.3	53.7			85.2	86.5		121.1			160.4	162.2		190.0		
shear load	≧ 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	44.8	54.9	68.6	64.6	79.1	98.7	84.1	103.1	128.6	102.6	125.8	157.0

Permissible loads [2)]

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		
			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 -40 °C to +50 °C																										
tension load	C 20/25	N_{perm} [kN]	8.8			12.3			19.7			28.4			45.8			64.1			85.8			100.5		
	C 50/60	N_{perm} [kN]	9.1	9.9	11.3	14.4	15.7	16.7	21.1	22.5	26.7	38.4			60.9	61.8		86.5			114.6	115.9		135.7		
shear load	≧ C 20/25	V_{perm} [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	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 with strength classification 5.8, premium-drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

2) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

*) Steel failure decisive

4. Load direction: tension

4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type		RG M 8			RG M 10			RG M 12			RG M 16			RG M 20			RG M 24			RG M 27			RG M 30		
		gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
characteristic resistance $N_{Rk,s}$	[kN]	19.0	26.0		30.0	41.0		44.0	59.0		82.0	110.0		127.0	172.0		183.0	247.0		239.0	322.0		292.0	393.0	
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	114.7	122.8	132.1	164.7	160.4	172.2	214.7	196.0	210.2	262.0

4.2 Pull-out/pull-through failure for the highest loaded anchor [1)]

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type		RG M 8	RG M 10	RG M 12	RG M 16	RG M 20	RG M 24	RG M 27	RG M 30
		gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C
eff. anchorage depth h_{ef}	[mm]	80	90	110	125	170	210	250	280
non-cracked concrete temperature range - 40 °C to + 50 °C									
characteristic resistance $N^0_{Rk,p}$	[kN]	22.1	31.1	41.5	59.7	96.1	134.6	180.2	211.1
Design resistance $N^0_{Rd,p}$	[kN]	12.3	17.3	27.6	39.8	64.1	89.7	120.2	140.7

1) The loads apply to fischer threaded rods with strength classification 5.8, premium-drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

4.3 Concrete cone failure and splitting for the most unfavourable anchor [1)]

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

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
		gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C	gvz | A4 | C
eff. anchorage depth h_{ef}	[mm]	80	90	110	125	170	210	250	280
non-cracked concrete temperature range - 40 °C to + 50 °C									
characteristic resistance $N^0_{Rk,c}$	[kN]	36.1	43.1	58.3	70.6	111.9	153.7	199.6	236.6
design resistance $N^0_{Rd,c}$	[kN]	20.1	24.0	38.8	47.1	74.6	102.5	133.1	157.7

1) The loads apply to fischer threaded rods with strength classification 5.8, premium-drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm]	Influence factor f_s [-] R M 8 / RG M 8 (gvz | A4 | C)	R M 10 / RG M 10 (gvz | A4 | C)	R M 12 / RG M 12 (gvz | A4 | C)	R M 16 / RG M 16 (gvz | A4 | C)	R M 20 / RG M 20 (gvz | A4 | C)	R M 24 / RG M 24 (gvz | A4 | C)	R M 27 / RG M 27 (gvz | A4 | C)	R M 30 / RG M30 (gvz | A4 | C)
40	0.58							
45	0.59	0.58						
55	0.61	0.60	0.58					
65	0.64	0.62	0.60	0.59				
85	0.68	0.66	0.63	0.61	0.58			
105	0.72	0.69	0.66	0.64	0.60	0.58		
125	0.76	0.73	0.69	0.67	0.62	0.60	0.58	
140	0.79	0.76	0.71	0.69	0.64	0.61	0.59	0.58
240	1.00	0.94	0.86	0.82	0.74	0.69	0.66	0.64
270		1.00	0.91	0.86	0.76	0.71	0.68	0.66
330			1.00	0.94	0.82	0.76	0.72	0.70
375				1.00	0.87	0.80	0.75	0.72
510					1.00	0.90	0.84	0.80
630						1.00	0.92	0.88
750							1.00	0.95
840								1.00
s_{min} [mm]	40	45	55	65	85	105	125	140
$s_{cr,N}$ [mm]	240	270	330	375	510	630	750	840

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c [mm]	Influence factor f_c [-] R M 8 / RG M 8 (gvz | A4 | C)	R M 10 / RG M 10 (gvz | A4 | C)	R M 12 / RG M 12 (gvz | A4 | C)	R M 16 / RG M 16 (gvz | A4 | C)	R M 20 / RG M 20 (gvz | A4 | C)	R M 24 / RG M 24 (gvz | A4 | C)	R M 27 / RG M 27 (gvz | A4 | C)	R M 30 / RG M 30 (gvz | A4 | C)
40	0.53							
45	0.56	0.53						
55	0.61	0.58	0.53					
65	0.66	0.63	0.57	0.54				
85	0.78	0.72	0.65	0.61	0.53			
105	0.90	0.83	0.73	0.68	0.58	0.53		
125	1.00	0.94	0.81	0.75	0.63	0.57	0.53	
140		1.00	0.88	0.81	0.67	0.60	0.56	0.53
190				1.00	0.81	0.71	0.64	0.61
255					1.00	0.85	0.76	0.71
315						1.00	0.88	0.81
375							1.00	0.92
420								1.00
c_{min} [mm]	40	45	55	65	85	105	125	140
$c_{cr,N}$ [mm]	120	135	165	188	255	315	375	420

Intermediate values by linear interpolation.

fischer Resin anchor R and Upat UKA 3 Chemical anchor

Anchor design according to ETA

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s [mm]	Influence factor $f_{s,sp}$ [-] R M 8 / RG M 8 (gvz, A4, C)	R M 10 / RG M 10 (gvz, A4, C)	R M 12 / RG M 12 (gvz, A4, C)	R M 16 / RG M 16 (gvz, A4, C)	R M 20 / RG M 20 (gvz, A4, C)	R M 24 / RG M 24 (gvz, A4, C)	R M 27 / RG M 27 (gvz, A4, C)	R M 30 / RG M 30 (gvz, A4, C)
40	0.56							
45	0.56	0.55						
55	0.58	0.57	0.56					
65	0.59	0.58	0.57	0.56				
85	0.62	0.60	0.59	0.57	0.56			
105	0.65	0.63	0.61	0.59	0.57	0.56		
125	0.68	0.65	0.63	0.61	0.58	0.57	0.57	
140	0.70	0.67	0.65	0.62	0.59	0.58	0.57	0.56
350	1.00	0.92	0.86	0.80	0.74	0.70	0.68	0.66
420		1.00	0.94	0.86	0.78	0.74	0.72	0.69
480			1.00	0.91	0.82	0.78	0.75	0.72
580				1.00	0.89	0.84	0.80	0.77
740					1.00	0.93	0.89	0.84
860						1.00	0.95	0.90
960							1.00	0.94
1080								1.00
s_{min} [mm]	40	45	55	65	85	105	125	140
$s_{cr,sp}$ [mm]	350	420	480	580	740	860	960	1080

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s^2_{cr,sp}}$$

Edge distance c [mm]	Influence factor $f_{c,sp}$ [-] R M 8 / RG M 8 (gvz, A4, C)	R M 10 / RG M 10 (gvz, A4, C)	R M 12 / RG M 12 (gvz, A4, C)	R M 16 / RG M 16 (gvz, A4, C)	R M 20 / RG M 20 (gvz, A4, C)	R M 24 / RG M 24 (gvz, A4, C)	R M 27 / RG M 27 (gvz, A4, C)	R M 30 / RG M 30 (gvz, A4, C)
40	0.47							
45	0.49	0.46						
55	0.52	0.49	0.47					
65	0.56	0.52	0.50	0.47				
85	0.63	0.58	0.55	0.51	0.47			
105	0.70	0.64	0.60	0.55	0.50	0.48		
125	0.78	0.70	0.65	0.59	0.54	0.51	0.49	
140	0.85	0.75	0.69	0.63	0.56	0.53	0.51	0.49
175	1.00	0.87	0.79	0.71	0.62	0.58	0.55	0.53
240			1.00	0.87	0.74	0.68	0.64	0.60
370					1.00	0.89	0.82	0.76
430						1.00	0.92	0.84
480							1.00	0.91
540								1.00
c_{min} [mm]	40	45	55	65	85	105	125	140
$c_{cr,sp}$ [mm]	175	210	240	290	370	430	480	540

Intermediate values by linear interpolation.

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{\frac{2}{3}} \leq \left(\frac{2 \cdot h_{ef}}{h_{min}}\right)^{\frac{2}{3}}$$

Thickness h [mm]	**Influence factor f_h [-]** 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
110	1.00							
120	1.06	1.00						
150	1.23	1.16	1.00					
160	1.28	1.21	1.04	1.00				
180		1.31	1.13	1.08				
200			1.21	1.16				
220			1.29	1.24	1.00			
240				1.31	1.06			
250				1.35	1.09			
280					1.17	1.00		
300					1.23	1.05		
330					1.31	1.12	1.00	
370						1.20	1.08	1.00
410						1.29	1.16	1.07
450							1.23	1.14
520								1.25
h_{min} [mm]	110	120	150	160	220	280	330	370
h_{ef} [mm]	80	90	110	125	170	210	250	280

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			**RG M 8**			**RG M 10**			**RG M 12**			**RG M 16**			**RG M 20**			**RG M 24**			**RG M 27**			**RG M 30**		
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
characteristic resistance	$V_{Rk,s}$	[kN]	7.4	12.8		13.3	20.3		19.3	29.5		35.9	54.8		56.0	85.7		80.7	123.4		105.1	160.8		128.3	196.2	
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	103.1	128.6	102.6	125.8	157.0

5.2 Pryout-failure for the most unfavourable anchor [1)]

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot f_s \cdot f_c \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C 20/25

Anchor type			**R M 8 RG M 8** gvz / A4 / C	**R M 10 RG M 10** gvz / A4 / C	**R M 12 RG M 12** gvz / A4 / C	**R M 16 RG M 16** gvz / A4 / C	**R M 20 RG M 20** gvz / A4 / C	**R M 24 RG M 24** gvz / A4 / C	**R M 27 RG M 27** gvz / A4 / C	**R M 30 RG M 30** gvz / A4 / C
eff. anchorage depth	h_{ef}	[mm]	80	90	110	125	170	210	250	280
non-cracked concrete										
temperature range - 40 °C to + 50 °C										
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	36.1	43.1	58.3	70.6	111.9	153.7	199.6	236.6
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	24.1	28.7	38.8	47.1	74.6	102.5	133.1	157.7
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	22.1	31.1	41.5	59.7	96.1	134.6	180.2	211.1
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	14.7	20.7	27.6	39.8	64.1	89.7	120.2	140.7

1) The loads apply to fischer threaded rods with strength classification 5.8, premium-drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor [1)]

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

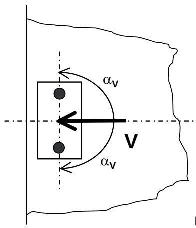
Anchor type	R M 8 RG M 8 gvz / A4 / C	R M 10 RG M 10 gvz / A4 / C	R M 12 RG M 12 gvz / A4 / C	R M 16 RG M 16 gvz / A4 / C	R M 20 RG M 20 gvz / A4 / C	R M 24 RG M 24 gvz / A4 / C	R M 27 RG M 27 gvz / A4 / C	R M 30 RG M 30 gvz / A4 / C
non-cracked concrete **temperature range - 40 °C to + 50 °C**								
minimum edge distance c_{min} [mm]	40	45	55	65	85	105	125	140
characteristic resistance $V^0_{Rk,c}$ [kN]	5.6	7.0	9.8	13.3	21.1	30.1	40.1	48.7
design resistance $V^0_{Rd,c}$ [kN]	3.7	4.7	6.6	8.9	14.1	20.1	26.8	32.4

1) The loads apply to fischer threaded rods with strength classification 5.8, premium-drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of α_V > 90° it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 Single anchor influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}{}^{n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}{}^{n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}{}^{n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

4

5.3.2.2 **Anchor pair** influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$
and spacing **$s \leqq 3 \cdot c$**

$$f_{sc,V}^{\;n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for $s > 3 \cdot c$

$$f_{sc,V}^{\;n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$
and spacing **$s \leqq 4.5 \cdot h$**

$$f_{sc,V}^{\;n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for $s > 4.5 \cdot h$

$$f_{sc,V}^{\;n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\;n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

6. Summary of required proof:

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

6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

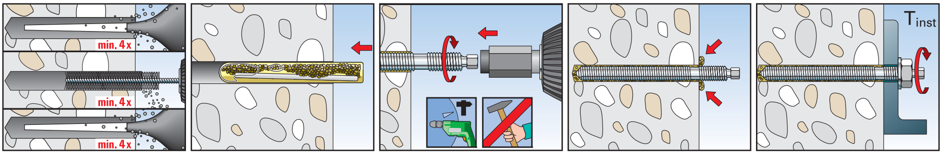
6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leq 1.2$$

N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

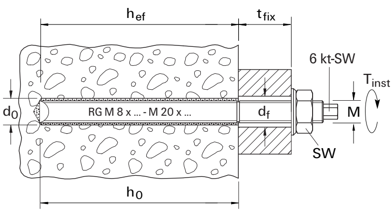
4

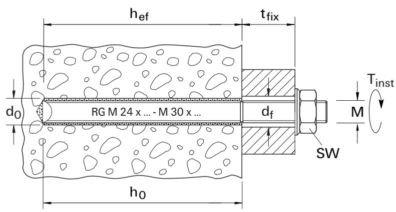
7. Installation details



8. Anchor characteristics

Anchor type			R M 8 RG M 8 gvz / A4 / C	R M 10 RG M 10 gvz / A4 / C	R M 12 RG M 12 gvz / A4 / C	R M 16 RG M 16 gvz / A4 / C	R M 20 RG M 20 gvz / A4 / C	R M 24 RG M 24 gvz / A4 / C	R M 27 RG M 27 gvz / A4 / C	R M 30 RG M 30 gvz / A4 / C
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

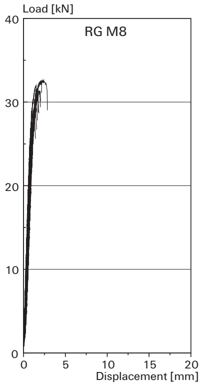
Temperature at anchoring base	Curing time in dry concrete	Curing time in wet concrete
- 5 °C – - 1 °C	4 h	8 h
± 0 °C – + 9 °C	45 min.	90 min.
+ 10 °C – + 20 °C	20 min.	40 min.
> + 20 °C	10 min.	20 min.

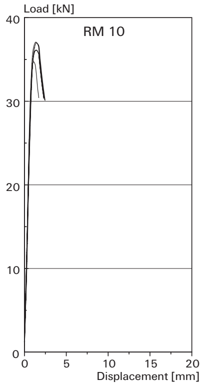
The anchor may be installed in dry or wet concrete or in flooded holes excepting sea water (premium-cleaning acc. to ETA-approval).

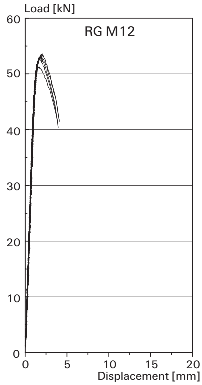
10. Mechanical characteristics

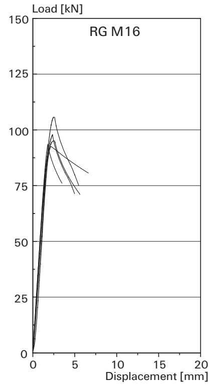
Anchor type			RG M 8			RG M 10			RG M 12			RG M 16			RG M 20			RG M 24			RG M 27			RG M 30		
			gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
stressed cross sectional area anchor rod	A_s	[mm²]	36.6			58.0			84.3			157.0			245.0			353.0			459.0			561.0		
resisting moment anchor rod	W	[mm³]	31.2			62.3			109.2			277.5			540.9			935.5			1387.0			1874.2		
yield strength anchor rod	f_y	[N/mm²]	420	450	560	420	450	560	420	450	560	420	450	560	420	450	560	420	450	560	420	450	560	420	450	560
tensile strength anchor rod	f_u	[N/mm²]	520	700		520	700		520	700		520	700		520	700		520	700		520	700		520	700	

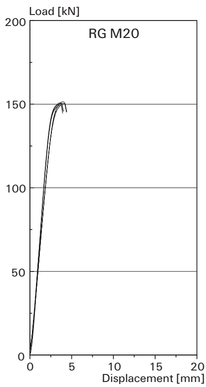
11. Load displacement curves for tension in non-cracked concrete ($f_{ck,cube\,(200)}$ = 30 N/mm²)

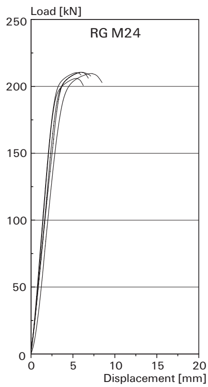


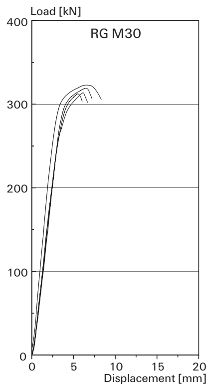












fischer Resin anchor R with RG MI

Anchor design according to ETA

1. Types

RG MI – Internal-threaded anchor (gvz)

RG MI A4 – Internal-threaded anchor (A4)

R M - Resin capsule

4

Features and Advantages

- European Technical Approval option 7.
- Suitable for non-cracked concrete.
- Universal fixing system for a broad range of applications on building sites.
- The resin anchoring is free of expansion forces and permits low axial spacing and edge distances.
- Extensive range of accessories for a wide variety of applications.

Materials

Internal-threaded anchor:	Carbon steel grade 5.8, zinc plated (5 µm) and passivated (gvz)
	Stainless steel of the corrosion resistance class III, e.g. A4
Resin capsule:	Vinylester resin (styrene-free), quartz sand and hardener

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

Mean values

Anchor type	RM + RG M 8 I		RM + RG M 10 I		RM + RG M 12 I		RM + RG M 16 I		RM + RG M 20 I	
	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4
non-cracked concrete temperature range - 40 °C to + 50 °C										
tension load C 20/25 N_u [kN]	19.0*)	26.0*)	30.0*)	41.0*)	44.0*)	59.0*)	82.0*)	100.0	127.0*)	153.3
shear load ≥ C 20/25 V_u [kN]	9.3*)	12.8*)	14.8*)	20.3*)	21.5*)	29.5*)	39.9*)	54.8*)	62.4*)	85.7*)

*) Steel failure decisive

1) The values apply to screws with the strength classification 5.8

2) The loads apply to fischer internal-threaded anchor RGMI, premium-drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

fischer Resin anchor R with RG MI

Anchor design according to ETA

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube\,(150)}$ [N/mm²]	Influence factor $f_{b,p}$ [-]	Influence factor $f_{b,c}$ [-]
C 20/25	20	25	1.00	1.00
C 25/30	25	30	1.06	1.10
C 30/37	30	37	1.14	1.22
C 40/50	40	50	1.27	1.41
C 45/55	45	55	1.31	1.48
C 50/60	50	60	1.35	1.55

4

3. Characteristic, design and permissible loads of single anchors with large [3] spacing and edge distance

Characteristic loads

Anchor type	RG M 8 I		RG M 10 I		RG M 12 I		RG M 16 I		RG M 20 I	
	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4
non-cracked concrete temperature range - 40 °C to + 50 °C										
tension load C 20/25 N_{Rk} [kN]	19.0	26.0	30.0	35.0	44.0	50.0	75.0	75.0	115.0	115.0
C 50/60 N_{Rk} [kN]	19.0	26.0	30.0	41.0	44.0	59.0	82.0	101.3	127.0	155.3
shear load ≧ C 20/25 V_{Rk} [kN]	9.3	12.8	14.8	20.3	21.5	29.5	39.9	54.8	62.4	85.7

Design loads

Anchor type	RG M 8 I		RG M 10 I		RG M 12 I		RG M 16 I		RG M 20 I	
	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4
non-cracked concrete temperature range - 40 °C to + 50 °C										
tension load C 20/25 N_{Rd} [kN]	12.8	13.9	20.1	21.9	29.5	31.6	50.0	50.0	76.7	76.7
C 50/60 N_{Rd} [kN]	12.8	13.9	20.1	21.9	29.5	31.6	55.0	58.8	85.2	91.4
shear load ≧ C 20/25 V_{Rd} [kN]	7.4	8.2	11.8	13.0	17.2	18.9	31.9	35.1	49.9	54.9

Permissible loads [2]

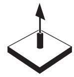
Anchor type	RG M 8 I		RG M 10 I		RG M 12 I		RG M 16 I		RG M 20 I	
	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4
non-cracked concrete temperature range - 40 °C to + 50 °C										
tension load C 20/25 N_R [kN]	9.1	9.9	14.4	15.7	21.1	22.5	35.7	35.7	54.8	54.8
C 50/60 N_R [kN]	9.1	9.9	14.4	15.7	21.1	22.5	39.3	42.0	60.9	65.3
shear load ≧ C 20/25 V_R [kN]	5.3	5.9	8.5	9.3	12.3	13.5	22.8	25.1	35.7	39.2

[1] The values apply to screws with the strength classification 5.8

[2] Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

[3] The loads apply to fischer internal-threaded anchor RGMI, premium-drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			RG M 8 I			RG M 10 I			RG M 12 I		
			gvz		A4	gvz		A4	gvz		A4
			5.8	8.8		5.8	8.8		5.8	8.8	
characteristic resistance	$N_{Rk,s}$	[kN]	19.0	29.0	26.0	30.0	46.0	41.0	44.0	68.0	59.0
design resistance	$N_{Rd,s}$	[kN]	12.8	19.3	13.9	20.1	30.7	21.9	29.5	45.3	31.6

Anchor type			RG M 16 I			RG M 20 I		
			gvz		A4	gvz		A4
			5.8	8.8		5.8	8.8	
characteristic resistance	$N_{Rk,s}$	[kN]	82.0	109.3	110.0	127.0	182.0	171.0
design resistance	$N_{Rd,s}$	[kN]	55.0	72.9	58.8	85.2	121.3	91.4

4

4.2 Pull-out/pull-through failure for the highest loaded anchor [1)]

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

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 **temperature range - 40 °C to + 50 °C**							
characteristic resistance	$N^0_{Rk,p}$	[kN]	30.0	35.0	50.0	75.0	115.0
design resistance	$N^0_{Rd,p}$	[kN]	20.0	23.3	33.3	50.0	76.7

1) The loads apply to fischer internal-threaded anchor RGMI, premium-drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details“).

4.3 Concrete cone failure and splitting for the most unfavourable anchor [1)]

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

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 **temperature range - 40 °C to + 50 °C**							
characteristic resistance	$N^0_{Rk,c}$	[kN]	43.1	43.1	70.6	102.2	142.8
design resistance	$N^0_{Rd,c}$	[kN]	28.7	28.7	47.1	68.1	95.2

1) The loads apply to fischer internal-threaded anchor RGMI, premium-drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details“).

4.3.1 Concrete cone failure
4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm]	Influence factor f_s [-] RG M 8 I	RG M 10 I	RG M 12 I	RG M 16 I	RG M 20 I
45	0.58	0.58			
60	0.61	0.61	0.58		
80	0.65	0.65	0.61	0.58	
100	0.69	0.69	0.63	0.60	0.58
125	0.73	0.73	0.67	0.63	0.60
150	0.78	0.78	0.70	0.66	0.63
200	0.87	0.87	0.77	0.71	0.67
250	0.96	0.96	0.83	0.76	0.71
270	1.00	1.00	0.86	0.78	0.73
300			0.90	0.81	0.75
375			1.00	0.89	0.81
480				1.00	0.90
600					1.00
s_{min} [mm]	45	45	60	80	100
$s_{cr,N}$ [mm]	270	270	375	480	600

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c [mm]	Influence factor f_c [-] RG M 8 I	RG M 10 I	RG M 12 I	RG M 16 I	RG M 20 I
45	0.53	0.53			
60	0.60	0.60	0.53		
80	0.70	0.70	0.59	0.53	
100	0.80	0.80	0.66	0.58	0.53
125	0.94	0.94	0.75	0.65	0.58
135	1.00	1.00	0.79	0.68	0.61
150			0.85	0.72	0.64
170			0.93	0.78	0.68
190			1.00	0.84	0.73
200				0.87	0.75
240				1.00	0.85
300					1.00
c_{min} [mm]	45	45	60	80	100
$c_{cr,N}$ [mm]	135	135	188	240	300

Intermediate values by linear interpolation.

4

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s	Influence factor $f_{s,sp}$ [-]				
[mm]	RG M 8 I	RG M 10 I	RG M 12 I	RG M 16 I	RG M 20 I
45	0.56	0.56			
60	0.58	0.58	0.57		
80	0.61	0.61	0.59	0.58	
100	0.64	0.63	0.61	0.60	0.58
125	0.67	0.66	0.64	0.63	0.59
150	0.71	0.70	0.67	0.66	0.61
200	0.78	0.76	0.73	0.71	0.65
300	0.92	0.89	0.84	0.81	0.73
360	1.00	0.97	0.91	0.88	0.77
380		1.00	0.93	0.90	0.79
440			1.00	0.96	0.83
480				1.00	0.86
540					0.91
600					0.95
660					1.00
s_{min} [mm]	45	45	60	80	100
$s_{cr,sp}$ [mm]	360	380	440	480	660

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c	Influence factor $f_{c,sp}$ [-]				
[mm]	RG M 8 I	RG M 10 I	RG M 12 I	RG M 16 I	RG M 20 I
45	0.48	0.48			
50	0.50	0.49			
60	0.53	0.52	0.50		
80	0.60	0.59	0.55	0.53	
100	0.67	0.65	0.61	0.58	0.52
125	0.77	0.74	0.68	0.65	0.56
150	0.87	0.84	0.76	0.72	0.61
180	1.00	0.96	0.86	0.81	0.67
190		1.00	0.89	0.84	0.69
220			1.00	0.93	0.75
240				1.00	0.79
300					0.93
330					1.00
c_{min} [mm]	45	45	60	80	100
$c_{cr,sp}$ [mm]	180	190	220	240	330

Intermediate values by linear interpolation.

fischer Resin anchor R with RG MI

Anchor design according to ETA

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{\frac{2}{3}} \leq \left(\frac{2 \cdot h_{ef}}{h_{min}}\right)^{\frac{2}{3}}$$

Thickness h	Influence factor f_h [-]				
[mm]	RG M 8 I	RG M 10 I	RG M 12 I	RG M 16 I	RG M 20 I
120	1.00	1.00			
140	1.11	1.11			
150	1.16	1.16			
180	1.31	1.31	1.04		
200			1.11		
220			1.19	1.00	
250			1.29	1.09	
270				1.15	1.00
300				1.23	1.07
320				1.28	1.12
380					1.26
400					1.30
h_{min} [mm]	120	120	170	220	270
h_{ef} [mm]	90	90	125	160	200

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type	RG M 8 I			RG M 8 I			RG M 12 I			RG M 16 I			RG M 20 I		
	gvz		A4	gvz		A4	gvz		A4	gvz		A4	gvz		A4
	5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8	
characteristic resistance $V_{Rk,s}$ [kN]	9.3	14.6	12.8	14.8	23.2	20.3	21.5	33.7	29.5	39.9	62.7	54.8	62.4	91.1	85.7
design resistance $V_{Rd,s}$ [kN]	7.4	11.7	8.2	11.8	18.6	13.0	17.2	27.0	18.9	31.9	50.2	35.1	49.9	72.9	54.9

5.2 Pryout-failure for the most unfavourable anchor [1)]

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot f_s \cdot f_c \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C 20/25

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					
temperature range - 40 °C to + 50 °C					
characteristic resistance $N^0_{Rk,cp}$ (c) [kN]	43.1	43.1	70.6	102.2	142.8
design resistance $N^0_{Rd,cp}$ (c) [kN]	28.7	28.7	47.1	68.1	95.2
characteristic resistance $N^0_{Rk,cp}$ (p) [kN]	30.0	35.0	50.0	75.0	115.0
design resistance $N^0_{Rd,cp}$ (p) [kN]	20.0	23.3	33.3	50.0	76.7

1) The loads apply to fischer internal-threaded anchor RGMI, premium-drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor [1)]

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

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 - 40 °C to + 50 °C							
minimum edge distance	c_{min}	[mm]	45	45	60	80	100
characteristic resistance	$V^0_{Rk,c}$	[kN]	7.3	7.8	12.4	19.8	29.1
design resistance	$V^0_{Rd,c}$	[kN]	4.9	5.2	8.3	13.2	19.4

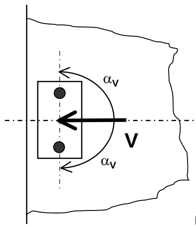
1) The loads apply to fischer internal-threaded anchor RGMI, premium-drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

4

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 Single anchor influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}{}^{n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}{}^{n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}{}^{n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 Anchor pair influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$
and spacing $\mathbf{s \leqq 3 \cdot c}$

$$f_{sc,V}^{\;n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for $s > 3 \cdot c$

$$f_{sc,V}^{\;n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$
and spacing $\mathbf{s \leqq 4.5 \cdot h}$

$$f_{sc,V}^{\;n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for $s > 4.5 \cdot h$

$$f_{sc,V}^{\;n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\;n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

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6. Summary of required proof:

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

6.2 Shear: $V^{h}_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

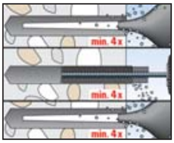
$$\frac{N^{h}_{Sd}}{N_{Rd}} + \frac{V^{h}_{Sd}}{V_{Rd}} \leqq 1.2$$

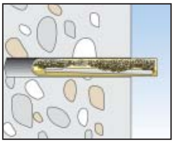
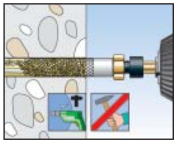
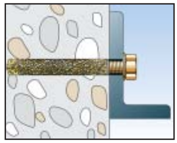
N^{h}_{Sd} ; V^{h}_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

fischer Resin anchor R with RG MI

Anchor design according to ETA

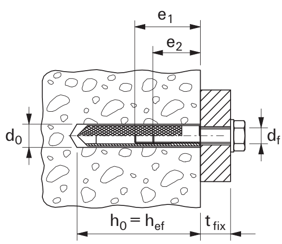
7. Installation details



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]	12	15	18	24	30
	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 – - 1 °C	4 h	8 h
± 0 °C – + 9 °C	45 min.	90 min.
+ 10 °C – + 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).

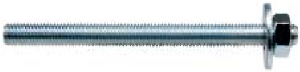
10. Mechanical characteristics

Anchor type			RG M 8 I			RG M 10 I			RG M 12 I			RG M 16 I			RG M 20 I		
			gvz		A4	gvz		A4	gvz		A4	gvz		A4	gvz		A4
			5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8	
stressed cross sectional area - screw	A_S	[mm²]	36.6			58.0			84.3			157.0			245.0		
resisting moment - screw	W	[mm³]	31.2			62.3			109.2			277.5			540.9		
yield strength - screw	f_y	[N/mm²]	400	640	450	400	640	450	400	640	450	400	640	450	400	640	450
tensile strength - screw	f_u	[N/mm²]	500	800	700	500	800	700	500	800	700	500	800	700	500	800	700
stressed cross sectional area - internal-threaded anchor	A_S	[mm²]	72.5			137.1			161.8			210.4			350.5		
resisting moment - internal-threaded anchor	W	[mm³]	147.8			361.4			496.6			836.9			1755.3		
yield strength - internal-threaded anchor	f_y	[N/mm²]	420		450	420		450	420		450	420		450	420		450
tensile strength - internal-threaded anchor	f_u	[N/mm²]	520		700	520		700	520		700	520		700	520		700

fischer Injection mortar FIS V, FIS VS, FIS VW and Upat UPM 44

Anchor design according to ETA

1. Types



FIS A M 6 - M 30 – threaded rod (gvz)
straight cut

FIS A M 6 - M 30 – threaded rod (A4 and C)
straight cut

RG M 8 - M 20 / UKA 3 Ankerstange ASTA
- threaded rod (gvz) with external hexagon head

RG M 8 - M 20 / UKA 3 Ankerstange ASTA
- threaded rod (A4 and C) with external hexagon head

RG M 24 - M 30 / UKA 3 Ankerstange ASTA
- threaded rod (gvz) straight cut

RG M 24 - M 30 / UKA 3 Ankerstange ASTA
- threaded rod (A4 and C) straight cut

FIS VS - Injection mortar
FIS VS 360 S

FIS V - Injection mortar
FIS V 360 S, FIS V 950 S

UPM 44
Injection mortar

FIS VW - Injection mortar
FIS VW 360 S

European Technical Approval - Option 7 for non-cracked concrete

Fire resistance classification
F 120
Anchor types see test report

ESR-6149
See ICC-ES Evaluation Report at www.icc-es.org
(valid for FIS V)

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 7.
- Suitable for non-cracked concrete.
- High-performance hybrid resin for high loads in almost all building materials.
- Universal fixing system for a broad range of applications on building sites.
- The resin anchoring is free of expansion forces and permits low spacings and edge distances.
- Extensive range of accessories for a wide variety of applications.
- Special summer version FIS VS with longer gelling time for applications in tropical areas.
- Special winter version FIS VW with shorter gelling time for applications during winter.
- A variety of approvals cover many applications in nearly all building materials and guarantee maximum safety.

Materials

Threaded rod :	Carbon steel, zinc plated (5 µm) and passivated (gvz) Stainless steel of the corrosion resistance class III, e.g. A4 Stainless steel of the corrosion resistance class IV, e.g. 1.4529 (C)
Injection mortar:	Vinylester resin (styrene-free), hydraulic additives, quartz sand and hardener

2. Ultimate loads of single anchors with large spacing and edge distance [1)]

Mean values

Anchor type	FIS V M 6		FIS V M 6		FIS V M 8		FIS V M 8		FIS V M 10		FIS V M 10		FIS V M 12		FIS V M 12	
	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C
h_{ef} [mm]	50		72		64		96		80		120		96		144	
non-cracked concrete, temperature range - 40 °C to + 50 °C																
tension load C 20/25 N_u [kN]	11.0	11.3	11.0*)	14.0*)	19.0*	23.6	19.0*)	26.0*)	30.0	36.9	30.0*)	41.0*)	44.0*	53.1	44.0*)	59.0*)
C 50/60 N_u [kN]	11.0*)	14.0	11.0*)	14.0*)	19.0*)	26.0	19.0*)	26.0*)	30.0	41.0	30.0*)	41.0*)	44.0*	59.0	44.0*)	59.0*)
shear load ≧ C 20/25 V_u [kN]	5.0*)	7.0*)	5.0*)	7.0 *)	9.2*)	12.8*)	9.2*)	12.8*)	14.5*)	20.3	14.5*)	20.3*)	21.1*)	29.5	21.1*)	29.5*)

Anchor type	FIS V M 16		FIS V M 16		FIS V M 20		FIS V M 20		FIS V M 24		FIS V M 24		FIS V M 30		FIS V M 30	
	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C
h_{ef} [mm]	128		192		160		240		192		288		240		360	
non-cracked concrete, temperature range - 40 °C to + 50 °C																
tension load C 20/25 N_u [kN]	82.0	85.8	82.0*)	110.0*)	127.0	127.3	127.0*)	171.0*)	173.7		183.0*)	247.0*)	251.0		292.0*)	384.5
C 50/60 N_u [kN]	82.0	108.1	82.0*)	110.0*)	127.0	160.4	127.0*)	171.0*)	183.0	218.9	183.0*)	247.0*)	292.0	323.0	292.0	392.0*)
shear load ≧ C 20/25 V_u [kN]	39.2*)	54.8*)	39.2*)	54.8*)	61.2*)	85.7*)	61.2*)	85.7*)	88.2*)	123.4*)	88.2*)	123.4*)	140.2*)	196.2*)	140.2	196.2*)

[1)] The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details“).

*) Steel failure decisive

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube\,(150)}$ [N/mm²]	Influence factor $f_{b,p}$ [-]	Influence factor $f_{b,c}$ [-]
C 20/25	20	25	1.00	1.00
C 25/30	25	30	1.05	1.10
C 30/37	30	37	1.10	1.22
C 40/50	40	50	1.19	1.41
C 45/55	45	55	1.22	1.48
C 50/60	50	60	1.26	1.55

4

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [1)]

Characteristic loads

Anchor type	FIS V M 6			FIS V M 6			FIS V M 8			FIS V M 8			FIS V M 10			FIS V M 10			FIS V M12			FIS V M 12		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef} [mm]	50			72			64			96			80			120			96			144		
non-cracked concrete temperature range - 40 °C to + 50 °C																								
tension load C 20/25 N_{Rk} [kN]	8.5			11.0	12.2		17.7			19.0	26.0		27.6			30.0	41.0		39.8			44.0	59.0	
C 50/60 N_{Rk} [kN]	10.7			11.0	14.0		19.0	22.3		19.0	26.0		30.0	34.8		30.0	41.0		44.0	50.2		44.0	59.0	
shear load ≧ C 20/25 V_{Rk} [kN]	5.0	7.0		5.0	7.0		9.2	12.8		9.2	12.8		14.5	20.3		14.5	20.3		21.1	29.5		21.1	29.5	

Anchor type	FIS V M 16			FIS V M 16			FIS V M 20			FIS V M 20			FIS V M 24			FIS V M 24			FIS V M30			FIS V M 30		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef} [mm]	128			192			160			240			192			288			240			360		
non-cracked concrete temperature range - 40 °C to + 50 °C																								
tension load C 20/25 N_{Rk} [kN]	64.3			82.0	96.5		95.5			127.0	143.3		130.0			183.0	195.4		187.4			288.4		
C 50/60 N_{Rk} [kN]	81.1			82.0	110.0		120.3			127.0	171.0		164.2			183.0	246.2		242.3			292.0	363.4	
shear load ≧ C 20/25 V_{Rk} [kN]	39.2	54.8		39.2	54.8		61.2	85.7		61.2	85.7		88.2	123.4		88.2	123.4		140.2	196.2		140.2	196.2	

Design loads

Anchor type	FIS V M 6			FIS V M 6			FIS V M 8			FIS V M 8			FIS V M 10			FIS V M 10			FIS V M12			FIS V M 12		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef} [mm]	50			72			64			96			80			120			96			144		
non-cracked concrete temperature range - 40 °C to + 50 °C																								
tension load C 20/25 N_{Rd} [kN]	4.7			6.8			9.8			12.8	13.9	14.7	15.4			20.3	21.9	23.0	22.1			29.7	31.6	33.2
C 50/60 N_{Rd} [kN]	5.9			7.4	7.5	8.6	12.4			12.8	13.9	17.3	19.4			20.3	21.9	27.3	27.9			29.7	31.6	39.3
shear load ≧ C 20/25 V_{Rd} [kN]	4.0	4.5	5.6	4.0	4.5	5.6	7.4	8.2	10.2	7.4	8.2	10.2	11.6	13.0	16.2	11.6	13.0	16.2	16.9	18.9	23.6	16.9	18.9	23.6

Anchor type	FIS V M 16			FIS V M 16			FIS V M 20			FIS V M 20			FIS V M 24			FIS V M 24			FIS V M30			FIS V M 30		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef} [mm]	128			192			160			240			192			288			240			360		
non-cracked concrete temperature range - 40 °C to + 50 °C																								
tension load C 20/25 N_{Rd} [kN]	35.7			53.6			53.1			79.6			72.4			108.6			104.1			160.2		
C 50/60 N_{Rd} [kN]	45.0			55.4	58.8	67.6	66.9			85.8	91.4	100.3	91.2			123.6	132.1	136.8	134.6			197.3	201.9	
shear load ≧ C 20/25 V_{Rd} [kN]	31.4	35.1	43.8	31.4	35.1	43.8	49.0	54.9	68.6	49.0	54.9	68.6	70.6	79.1	98.7	70.6	79.1	98.7	112.2	125.8	157.0	112.2	125.8	157.0

[1)] The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details“).

Permissible loads see next page.

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [1)]

Permissible loads [2)]

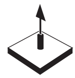
Anchor type	FIS V M 6			FIS V M 6			FIS V M 8			FIS V M 8			FIS V M 10			FIS V M 10			FIS V M12			FIS V M 12		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef} [mm]	50			72			64			96			80			120			96			144		
non-cracked concrete																								
temperature range - 40 °C to + 50 °C																								
tension load C 20/25 N_{perm} [kN]	3.4			4.8			7.0			9.2	9.9	10.5	11.0			14.5	15.7	16.5	15.8			21.2	22.5	23.7
C 50/60 N_{perm} [kN]	4.2			5.3		6.1	8.8			9.2	9.9	12.4	13.8			14.5	15.7	19.5	19.9			21.2	22.5	28.1
shear load ≧ C 20/25 V_{perm} [kN]	2.9	3.2	4.0	2.9	3.2	4.0	5.3	5.9	7.3	5.3	5.9	7.3	8.3	9.3	11.6	8.3	9.3	11.6	12.1	13.5	16.9	12.1	13.5	16.9

Anchor type	FIS V M 16			FIS V M 16			FIS V M 20			FIS V M 20			FIS V M 24			FIS V M 24			FIS V M30			FIS V M 30		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef} [mm]	128			192			160			240			192			288			240			360		
non-cracked concrete																								
temperature range - 40 °C to + 50 °C																								
tension load C 20/25 N_{perm} [kN]	25.5			38.3			37.9			56.8			51.7			77.6			74.4			114.4		
C 50/60 N_{perm} [kN]	32.2			39.6	42.0	48.3	47.8			61.3	65.3	71.6	65.1			88.3	94.3	97.7	96.1			140.9	144.2	
shear load ≧ C 20/25 V_{perm} [kN]	22.4	25.1	31.3	22.4	25.1	31.3	35.0	39.2	49.0	35.0	39.2	49.0	50.4	56.5	70.5	50.4	56.5	70.5	80.1	89.8	112.1	80.1	89.8	112.1

[1)] The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

[2)] Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type	FIS V M 6				FIS V M 8				FIS V M 10				FIS V M 12			
	gvz		A4	C	gvz		A4	C	gvz		A4	C	gvz		A4	C
	5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8		
characteristic resistance $N_{Rk,s}$ [kN]	11.0	16.0	14.0	14.0	19.0	26.0	26.0	26.0	30.0	46.0	41.0	41.0	44.0	67.0	59.0	59.0
design resistance $N_{Rd,s}$ [kN]	7.4	10.7	7.5	9.3	12.8	19.3	13.9	17.3	20.3	30.7	21.9	27.3	29.7	44.7	31.6	39.3

Anchor type	FIS V M 16				FIS V M 20				FIS V M 24				FIS V M 30			
	gvz		A4	C	gvz		A4	C	gvz		A4	C	gvz		A4	C
	5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8		
characteristic resistance $N_{Rk,s}$ [kN]	82.0	126.0	110.0	110.0	127.0	196.0	171.0	171.0	183.0	282.0	247.0	247.0	292.0	449.0	392.0	392.0
design resistance $N_{Rd,s}$ [kN]	55.4	84.0	58.8	73.3	85.8	130.7	91.4	114.0	123.6	188.0	132.1	164.7	197.3	299.3	209.6	261.3

4.2 Pull-out/pull-through failure for the highest loaded anchor [1)]

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type	FIS V M 6		FIS V M 8		FIS V M 10		FIS V M 12		FIS V M 16		FIS V M 20		FIS V M 24		FIS V M 30	
eff. anchorage depth h_{ef} [mm]	50	72	64	96	80	120	96	144	128	192	160	240	192	288	240	360
non-cracked concrete																
temperature range - 40 °C to + 50 °C																
characteristic resistance $N^0_{Rk,p}$ [kN]	8.5	12.2	17.7	26.5	27.6	41.5	39.8	59.7	64.3	96.5	95.5	143.3	130.3	195.4	192.3	288.4
Design resistance $N^0_{Rd,p}$ [2)] [kN]	4.7	6.8	9.8	14.7	15.4	23.0	22.1	33.2	35.7	53.6	53.1	79.6	72.4	108.6	106.8	160.2

[1)] The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

[2)] Intermediate values for $N^0_{Rd,p}$ depending on $h_{ef,var}$ can be determined by linear interpolation.

4.3 Concrete cone failure and splitting for the most unfavourable anchor [1)]

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			**FIS V M 6**		**FIS V M 8**		**FIS V M 10**		**FIS V M 12**		**FIS V M 16**		**FIS V M 20**		**FIS V M 24**		**FIS V M 30**	
eff. anchorage depth	h_{ef}	[mm]	50	72	64	96	80	120	96	144	128	192	160	240	192	288	240	360
non-cracked concrete **temperature range - 40 °C to + 50 °C**																		
characteristic resistance	$N^0_{Rk,c}$	[kN]	17.8	30.8	25.4	47.4	36.1	66.3	47.4	87.1	73.0	134.1	102.0	187.4	134.1	246.3	187.4	344.3
design resistance	$N^0_{Rd,c}$ [2)]	[kN]	9.9	17.1	14.3	26.3	20.0	36.8	26.3	48.4	40.5	74.5	56.7	104.1	74.5	136.9	104.1	191.3

[1)] The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

[2)] Intermediate values for $N^0_{Rd,c}$ depending on $h_{ef,var}$ can be determined according: $N^0_{Rd,cp\ (c)\ (h_{ef,var})} = N^0_{Rd,cp\ (c)\ (h_{ef,min})} \cdot \left(\frac{h_{ef,var}}{h_{ef,min}}\right)^{1.5}$

4

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm] ↓	**Influence factor f_s [-]**															
	FIS V M 6		**FIS M 8**		**FIS V M 10**		**FIS V M 12**		**FIS V M 16**		**FIS V M 20**		**FIS V M 24**		**FIS V M 30**	
h_{ef} [mm]	**50**	**72**	**64**	**96**	**80**	**120**	**96**	**144**	**128**	**192**	**160**	**240**	**192**	**288**	**240**	**360**
40	0.63	0.59	0.60	0.57												
45	0.65	0.60	0.62	0.58	0.59	0.56										
55	0.68	0.63	0.64	0.60	0.61	0.58	0.60	0.56								
65	0.72	0.65	0.67	0.61	0.64	0.59	0.61	0.58	0.58	0.56						
85	0.78	0.70	0.72	0.65	0.68	0.62	0.65	0.60	0.61	0.57	0.59	0.56				
105	0.85	0.74	0.77	0.68	0.72	0.65	0.68	0.62	0.64	0.59	0.61	0.57	0.59	0.56		
120	0.90	0.78	0.81	0.71	0.75	0.67	0.71	0.64	0.66	0.60	0.63	0.58	0.60	0.57		
140	0.97	0.82	0.86	0.74	0.79	0.69	0.74	0.66	0.68	0.62	0.65	0.60	0.62	0.58	0.60	0.56
150	1.00	0.85	0.89	0.76	0.81	0.71	0.76	0.67	0.70	0.63	0.66	0.60	0.63	0.59	0.60	0.57
195		0.95	1.00	0.84	0.91	0.77	0.84	0.73	0.75	0.67	0.70	0.64	0.67	0.61	0.64	0.59
215		1.00		0.87	0.95	0.80	0.87	0.75	0.78	0.69	0.72	0.65	0.69	0.62	0.65	0.60
240				0.92	1.00	0.83	0.92	0.78	0.81	0.71	0.75	0.67	0.71	0.64	0.67	0.61
290				1.00		0.90	1.00	0.84	0.88	0.75	0.80	0.70	0.75	0.67	0.70	0.63
360						1.00		0.92	0.97	0.81	0.88	0.75	0.81	0.71	0.75	0.67
430								1.00		0.87	0.95	0.80	0.87	0.75	0.80	0.70
480										0.92	1.00	0.83	0.92	0.78	0.83	0.72
575										1.00		0.90	1.00	0.83	0.90	0.77
720												1.00		0.92	1.00	0.83
865														1.00		0.90
1080																1.00
s_{min} [mm]	40	40	40	40	45	45	55	55	65	65	85	85	105	105	140	140
$s_{cr,N}$ [mm]	150	216	192	288	240	360	288	432	384	576	480	720	576	864	720	1080

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c [mm]	Influence factor f_c [-]															
	FIS V M 6		FIS V M 8		FIS V M 10		FIS V M 12		FIS V M 16		FIS V M 20		FIS V M 24		FIS V M 30	
↓ h_{ef} [mm]	50	72	64	96	80	120	96	144	128	192	160	240	192	288	240	360
40	0.66	0.56	0.58	0.50												
45	0.70	0.58	0.62	0.52	0.56	0.48										
55	0.80	0.64	0.69	0.56	0.61	0.52	0.56	0.49								
60	0.85	0.67	0.72	0.58	0.64	0.53	0.58	0.50								
65	0.90	0.71	0.76	0.61	0.66	0.55	0.61	0.51	0.54	0.47						
75	1.00	0.77	0.83	0.65	0.72	0.58	0.65	0.54	0.57	0.49						
85		0.84	0.91	0.70	0.78	0.62	0.70	0.57	0.60	0.51	0.55	0.48				
95		0.91	0.99	0.75	0.84	0.66	0.75	0.60	0.63	0.53	0.57	0.49				
105		0.98		0.79	0.90	0.69	0.79	0.63	0.67	0.55	0.60	0.51	0.55	0.48		
120				0.87	1.00	0.75	0.87	0.67	0.72	0.58	0.64	0.53	0.58	0.50		
140				0.98		0.83	0.98	0.74	0.79	0.63	0.69	0.57	0.63	0.53	0.57	0.49
180						1.00		0.87	0.95	0.72	0.81	0.64	0.72	0.58	0.64	0.53
215								1.00		0.81	0.92	0.70	0.81	0.64	0.70	0.57
290										1.00		0.85	1.00	0.75	0.85	0.66
360												1.00		0.87	1.00	0.75
430														1.00		0.84
540																1.00
c_{min} [mm]	40	40	40	40	45	45	55	55	65	65	85	85	105	105	140	140
$c_{cr,N}$ [mm]	75	108	96	144	120	180	144	216	192	288	240	360	288	432	360	540

Intermediate values by linear interpolation.

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s [mm] ↓		Influence factor $f_{s,sp}$ [-]															
		FIS V M 6		FIS V M 8		FIS V M 10		FIS V M 12		FIS V M 16		FIS V M 20		FIS V M 24		FIS V M 30	
	h_{ef} [mm]	50	72	64	96	80	120	96	144	128	192	160	240	192	288	240	360
40		0.60	0.55	0.56	0.55												
45		0.61	0.56	0.57	0.55	0.56	0.54										
55		0.64	0.57	0.59	0.57	0.57	0.55	0.56	0.54								
65		0.66	0.58	0.60	0.58	0.58	0.56	0.57	0.55	0.55	0.54						
85		0.71	0.61	0.63	0.60	0.61	0.58	0.59	0.57	0.57	0.55	0.55	0.54				
105		0.76	0.63	0.66	0.63	0.63	0.60	0.61	0.58	0.58	0.56	0.57	0.55	0.56	0.54		
140		0.85	0.68	0.72	0.67	0.68	0.63	0.65	0.61	0.61	0.58	0.59	0.57	0.57	0.56	0.56	0.55
200		1.00	0.75	0.81	0.74	0.75	0.69	0.71	0.66	0.66	0.62	0.63	0.60	0.61	0.58	0.58	0.56
250			0.81	0.89	0.80	0.81	0.74	0.76	0.70	0.70	0.65	0.66	0.62	0.63	0.60	0.61	0.58
280			0.85	0.94	0.84	0.86	0.77	0.79	0.73	0.72	0.67	0.68	0.64	0.65	0.61	0.62	0.59
320			0.90	1.00	0.89	0.90	0.81	0.83	0.76	0.75	0.69	0.70	0.66	0.67	0.63	0.64	0.60
340			0.93		0.91	0.93	0.83	0.85	0.77	0.77	0.70	0.72	0.67	0.68	0.64	0.64	0.61
400			1.00		0.99	1.00	0.88	0.92	0.82	0.82	0.74	0.75	0.69	0.71	0.66	0.67	0.63
450							0.93	0.97	0.86	0.86	0.77	0.78	0.72	0.74	0.68	0.69	0.65
520							1.00		0.92	0.91	0.81	0.83	0.75	0.77	0.71	0.72	0.67
570									0.96	0.95	0.84	0.86	0.78	0.80	0.73	0.74	0.69
620									1.00	0.99	0.87	0.89	0.80	0.83	0.75	0.76	0.70
680											0.91	0.93	0.83	0.86	0.77	0.79	0.72
830											1.00		0.90	0.94	0.83	0.85	0.77
950													0.96	1.00	0.88	0.90	0.81
1030													1.00		0.92	0.94	0.83
1240															1.00		0.90
1540																	1.00
s_{min}	[mm]	40	40	40	40	45	45	55	55	65	65	85	85	105	105	140	140
$s_{cr,sp}$	[mm]	200	400	320	410	400	520	480	620	630	830	790	1030	950	1240	1180	1540

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c [mm]	Influence factor $f_{c,sp}$ [-]															
	FIS V M 6		FIS V M 8		FIS V M 10		FIS V M 12		FIS V M 16		FIS V M 20		FIS V M 24		FIS V M 30	
↓ h_{ef} [mm]	50	72	64	96	80	120	96	144	128	192	160	240	192	288	240	360
40	0.57	0.46	0.48	0.45												
45	0.61	0.47	0.50	0.47	0.47	0.44										
55	0.67	0.50	0.54	0.49	0.50	0.46	0.47	0.44								
65	0.74	0.53	0.58	0.52	0.53	0.48	0.50	0.46	0.46	0.43						
85	0.88	0.59	0.66	0.58	0.59	0.53	0.55	0.50	0.50	0.46	0.46	0.44				
100	1.00	0.64	0.72	0.63	0.64	0.56	0.58	0.53	0.52	0.48	0.49	0.45				
105		0.65	0.74	0.65	0.65	0.58	0.60	0.54	0.53	0.49	0.49	0.46	0.47	0.44		
140		0.77	0.90	0.76	0.77	0.66	0.69	0.61	0.60	0.54	0.55	0.50	0.51	0.47	0.48	0.45
160		0.85	1.00	0.83	0.85	0.71	0.75	0.65	0.64	0.57	0.58	0.52	0.54	0.49	0.50	0.46
180		0.92		0.90	0.92	0.77	0.81	0.69	0.68	0.60	0.61	0.54	0.56	0.51	0.52	0.48
200		1.00		0.98	1.00	0.82	0.87	0.74	0.73	0.63	0.64	0.57	0.59	0.53	0.54	0.49
205				1.00		0.84	0.89	0.75	0.74	0.63	0.65	0.57	0.59	0.53	0.54	0.49
240						0.94	1.00	0.83	0.82	0.69	0.71	0.62	0.64	0.57	0.58	0.52
260						1.00		0.87	0.86	0.72	0.74	0.64	0.67	0.59	0.60	0.54
285								0.94	0.93	0.76	0.79	0.67	0.70	0.61	0.63	0.56
310								1.00	0.99	0.81	0.83	0.71	0.74	0.64	0.65	0.58
340										0.86	0.89	0.75	0.78	0.67	0.69	0.60
395										0.96	1.00	0.82	0.87	0.73	0.75	0.65
415										1.00		0.85	0.90	0.75	0.78	0.67
475												0.94	1.00	0.82	0.85	0.72
515												1.00		0.87	0.90	0.75
590														0.96	1.00	0.82
620														1.00		0.85
770																1.00
c_{min} [mm]	40	40	40	40	45	45	55	55	65	65	85	85	105	105	140	140
$c_{cr,sp}$ [mm]	100	200	160	205	200	260	240	310	315	415	395	515	475	620	590	770

Intermediate values by linear interpolation.

4

4.3.2.3 Influence of concrete thickness

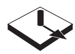
$$f_h = \left(\frac{h}{h_{min}}\right)^{\frac{2}{3}} \leq \left(\frac{2 \cdot h_{ef}}{h_{min}}\right)^{\frac{2}{3}}$$

Thickness h [mm]	**Influence factor f_h [-]**															
	FIS V M 6		**FIS V M 8**		**FIS V M 10**		**FIS V M 12**		**FIS V M 16**		**FIS V M 20**		**FIS V M 24**		**FIS V M 30**	
↓ **h_{ef} [mm]**	**50**	**72**	**64**	**96**	**80**	**120**	**96**	**144**	**128**	**192**	**160**	**240**	**192**	**288**	**240**	**360**
100	1.00		1.00													
110		1.05	1.07		1.00											
120		1.11	1.13		1.06											
130		1.18		1.02	1.12		1.02									
140		1.24		1.07	1.17		1.07									
150				1.12	1.23	1.00	1.12									
180				1.27		1.13	1.27	1.02	1.06							
190				1.31		1.17	1.31	1.06	1.10							
210						1.25		1.13	1.18		1.01					
230						1.33		1.20	1.25	1.01	1.07					
250								1.27	1.32	1.06	1.13		1.01			
310										1.23	1.30	1.05	1.16		1.00	
400												1.24		1.11	1.19	
430												1.31		1.16	1.24	1.00
580																1.22
720																1.41
h_{min} [mm]	100	102	100	126	110	150	126	174	164	228	208	288	248	344	310	430
h_{ef} [mm]	50	72	64	96	80	120	96	144	128	192	160	240	192	288	240	360

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor



Characteristic resistance and design resistance for single anchors

Anchor type	**FIS V M 6**				**FIS V M 8**				**FIS V M 10**				**FIS V M 12**			
	gvz		**A4**	**C**	**gvz**		**A4**	**C**	**gvz**		**A4**	**C**	**gvz**		**A4**	**C**
	5.8	**8.8**			**5.8**	**8.8**			**5.8**	**8.8**			**5.8**	**8.8**		
characteristic resistance $V_{Rk,s}$ [kN]	5.0	8.0	7.0	7.0	9.2	14.6	12.8	12.8	14.5	23.2	20.3	20.3	21.1	33.7	29.5	29.5
design resistance $V_{Rd,s}$ [kN]	4.0	6.4	4.5	5.6	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 V M 16**				**FIS V M 20**				**FIS V M 24**				**FIS V M 30**			
	gvz		**A4**	**C**	**gvz**		**A4**	**C**	**gvz**		**A4**	**C**	**gvz**		**A4**	**C**
	5.8	**8.8**			**5.8**	**8.8**			**5.8**	**8.8**			**5.8**	**8.8**		
characteristic resistance $V_{Rk,s}$ [kN]	39.2	62.8	54.8	54.8	61.2	98.0	85.7	85.7	88.2	141.2	123.4	123.4	140.2	224.4	196.2	196.2
design resistance $V_{Rd,s}$ [kN]	31.4	50.2	35.1	43.8	49.0	78.4	54.9	68.6	70.6	113.0	79.1	98.7	112.2	179.5	125.8	157.0

5.2 Pryout-failure for the most unfavourable anchor [1)]

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot f_s \cdot f_c \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C 20/25

Anchor type			FIS V M 6		FIS V M 8		FIS V M 10		FIS V M 12		FIS V M 16		FIS V M 20		FIS V M 24		FIS V M 30	
eff. anchorage depth	h_{ef}	[mm]	50	72	64	96	80	120	96	144	128	192	160	240	192	288	240	360
non-cracked concrete temperature range - 40 °C to + 50 °C																		
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	17.8	30.8	25.8	47.4	36.1	66.3	47.4	87.1	73.0	134.1	102.0	187.4	134.1	246.3	187.4	344.3
design resistance	$N^0_{Rd,cp}$ (c) [3)]	[kN]	11.9	20.5	17.2	31.6	24.0	44.2	31.6	58.1	48.7	89.4	68.0	124.9	89.4	164.2	124.9	229.5
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	8.5	12.2	17.7	26.5	27.6	41.5	39.8	59.7	64.3	96.5	95.5	143.3	130.3	195.4	192.3	288.4
design resistance	$N^0_{Rd,cp}$ (p) [2)]	[kN]	5.7	8.1	11.8	17.7	18.4	27.6	26.5	39.8	42.9	64.3	63.7	95.5	86.9	130.3	128.2	192.3

1) The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

2) Intermediate values for $N^0_{Rd,cp}$ (p) depending on $h_{ef,var}$ can be determined by linear interpolation.

3) Intermediate values for $N^0_{Rd,cp}$ (c) depending on $h_{ef,var}$ can be determined according: $N^0_{Rd,cp}(c)(h_{ef,var}) = N^0_{Rd,cp}(c)(h_{ef,min}) \cdot \left(\frac{h_{ef,var}}{h_{ef,min}}\right)^{1.5}$

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor [1)]

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

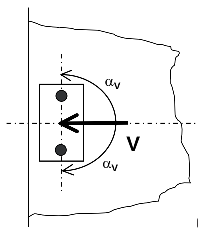
Anchor type			FIS V M 6		FIS V M 8		FIS V M 10		FIS V M 12		FIS V M 16		FIS V M 20		FIS V M 24		FIS V M 30	
h_{ef}		[mm]	50	72	64	96	80	120	96	144	128	192	160	240	192	288	240	360
non-cracked concrete temperature range - 40 °C to + 50 °C																		
minimum edge distance	c_{min}	[mm]	40	40	40	40	45	45	55	55	65	65	85	85	105	105	140	140
characteristic resistance	$V^0_{Rk,c}$	[kN].	4.8	5.2	5.3	5.8	6.8	7.5	9.5	10.6	13.4	15.1	20.7	23.4	29.3	33.3	46.4	52.9
design resistance	$V^0_{Rd,c}$	[kN]	3.2	3.4	3.6	3.9	4.5	5.0	6.3	7.0	8.9	10.0	13.8	15.6	19.6	22.2	30.9	35.2

1) The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



0° ≤ α_V ≤ 90°

In case of α_V > 90° it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example

4

4.5.3.2 Influence of spacing and edge distance

5.3.2.1 **Single anchor** influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$

$$f_{sc,V}^{\,n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$

$$f_{sc,V}^{\,n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\,n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 **Anchor pair** influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$
and spacing $\mathbf{s \leqq 3 \cdot c}$

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for $s > 3 \cdot c$

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$
and spacing $\mathbf{s \leqq 4.5 \cdot h}$

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for $s > 4.5 \cdot h$

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

6. Summary of required proof:

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

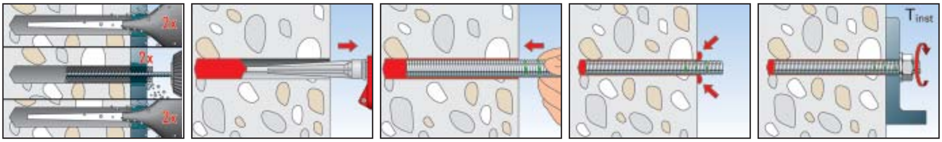
6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

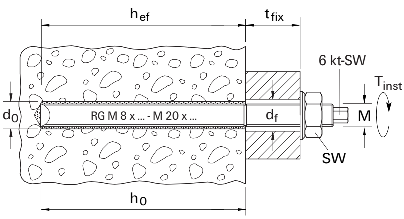
7. Installation details

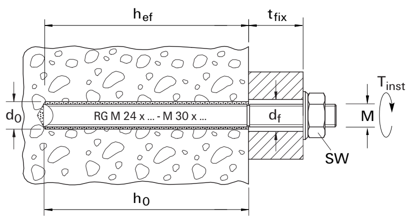


8. Anchor characteristics

Anchor type			FIS V M 6		FIS V M 8		FIS V M 10		FIS V M 12		FIS V M 16		FIS V M 20		FIS V M 24		FIS V M 30	
	h_{ef}	[mm]	**50**	**72**	**64**	**96**	**80**	**120**	**96**	**144**	**128**	**192**	**160**	**240**	**192**	**288**	**240**	**360**
diameter of thread			M 6		M 8		M 10		M 12		M 16		M 20		M 24		M 30	
nominal drill hole diameter	d_0	[mm]	8	8	10	10	12	12	14	14	18	18	24	24	28	28	35	35
drill depth	h_0	[mm]	50	72	64	96	80	120	96	144	128	192	160	240	192	288	240	360
clearance-hole in fixture to be attached	d_f	[mm]	≦ 7	≦ 7	≦ 9	≦ 9	≦ 12	≦ 12	≦ 14	≦ 14	≦ 18	≦ 18	≦ 22	≦ 22	≦ 26	≦ 26	≦ 33	≦ 33
wrench size	SW	[mm]	10	10	13	13	17	17	19	19	24	24	30	30	36	36	46	46
required torque	T_{inst}	[Nm]	5	5	10	10	20	20	40	40	60	60	120	120	150	150	300	300
minimum thickness of concrete member	h_{min}	[mm]	100 *	102 *	100 *	126 *	110 *	150 *	126 *	174 *	164 *	228 *	208 *	288 *	248 *	344 *	310 *	430 *
minimum spacing	s_{min}	[mm]	40	40	40	40	45	45	55	55	65	65	85	85	105	105	140	140
minimum edge distances	c_{min}	[mm]	40	40	40	40	45	45	55	55	65	65	85	85	105	105	140	140
mortar filling quantity		[scale units]	2	2	2	3	3	5	4	6	8	11	20	29	28	42	53	79

* Intermediate values by linear interpolation.





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9. Gelling and curing times

Cartridge temperature (minimum + 5 °C)	Gelling time FIS VW	Gelling time FIS V	Gelling time 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	Curing time [1)] FIS V	Curing time [1)] FIS VS
- 5 °C – 0 °C	180 min.	24 h	–
± 0 °C – 5 °C	180 min.	180 min.	6 h
+ 5 °C – 10 °C	50 min.	90 min.	180 min.
+ 10 °C – 20 °C	30 min.	60 min.	120 min.
+ 20 °C – 30 °C	–	45 min.	60 min.
+ 30 °C – 40 °C	–	35 min.	30 min.
+ 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 should be replaced.

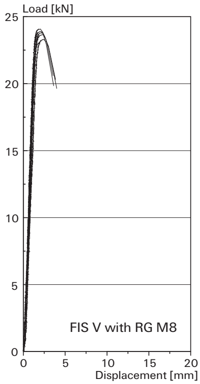
1) For wet concrete the curing time must be doubled.

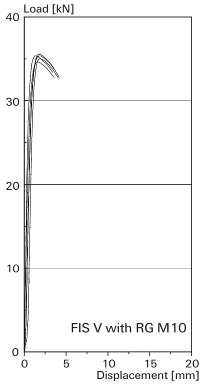
10. Mechanical characteristics

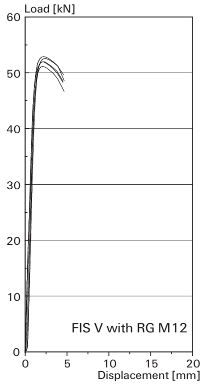
Anchor type			FIS A M 6				FIS A M 8				FIS A M 10				FIS A M 12			
			gvz		A4	C	gvz		A4	C	gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8		
stressed cross sectional area anchor rod	A_s	[mm²]	20.1				36.6				58.0				84.3			
resisting moment anchor rod	W	[mm³]	12.7				31.2				62.3				109.2			
yield strength anchor rod	f_y	[N/mm²]	420	640	450	560	420	640	450	560	420	640	450	560	420	640	450	560
tensile strength anchor rod	f_u	[N/mm²]	520	800	700	700	520	800	700	700	520	800	700	700	520	800	700	700

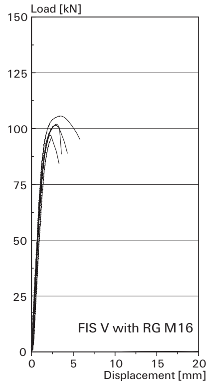
Anchor type			FIS A M 16				FIS A M 20				FIS A M 24				FIS A M 30			
			gvz		A4	C	gvz		A4	C	gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8		
stressed cross sectional area anchor rod	A_s	[mm²]	157.0				245.0				353.0				561.0			
resisting moment anchor rod	W	[mm³]	277.5				540.9				935.5				1874.2			
yield strength anchor rod	f_y	[N/mm²]	420	640	450	560	420	640	450	560	420	640	450	560	420	640	450	560
tensile strength anchor rod	f_u	[N/mm²]	520	800	700	700	520	800	700	700	520	800	700	700	520	800	700	700

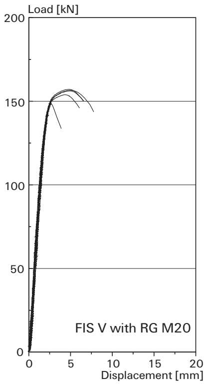
11. Load displacement curves for tension in non-cracked concrete ($f_{ck,cube\,(200)}$ = 30 N/mm^2)

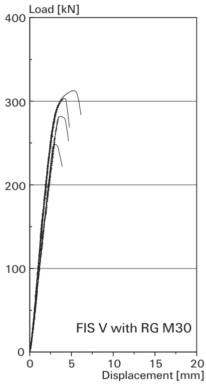












fischer Injection mortar FIS V, FIS VS and FIS VW with RG MI

Anchor design according to ETA

1. Types

RG MI – Internal-threaded anchor (gvz)

RG MI A4 – Internal-threaded anchor (A4)

FIS V - Injection mortar FIS V 360 S, FIS V 950 S

FIS VS - Injection mortar FIS VS 150 C, FIS VS 100 P,
FIS VS 360 S, FIS VW 360 S

ETA
European Technical Approval - Option 7 for non-cracked concrete

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 7.
- Suitable for non-cracked concrete.
- High-performance hybrid resin for high loads in almost all building materials.
- Universal fixing system for a broad range of applications on building sites.
- The resin anchoring is free of expansion forces and permits low spacings and edge distances.
- Extensive range of accessories for a wide variety of applications.
- Special summer version FIS VS with longer gelling time for applications in tropical areas and special winter version FIS VW for cold regions.
- A variety of approvals cover many applications in nearly all building materials and guarantee maximum safety.

Materials

Internal-threaded anchor :	Carbon steel grade 5.8, zinc plated (5 µm) and passivated (gvz)
	Stainless steel of the corrosion resistance class III, e.g. A4
Injection mortar:	Vinylester resin (styrene-free), hydraulic additives, quartz sand and hardener

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

Mean values

Anchor type	FIS V RG M 8 I		FIS V RG M 10 I		FIS V RG M 12 I		FIS V RG M 16 I		FIS V RG M 20 I	
	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4
non-cracked concrete, temperature range - 40 °C to + 50 °C										
tension load C 20/25 N_u [kN]	19.0*)	26.0*)	30.0*)	41.0*)	44.0*)	59.0*)	82.0*)	100.0*)	127.0*)	153.3*)
shear load ≥ C 20/25 V_u [kN]	9.5*)	12.8*)	15.1*)	20.3*)	21.9*)	29.5*)	40.7*)	54.8*)	63.3*)	85.7*)

*) Steel failure decisive

1) The values apply to screws with the strength classification 5.8

2) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube\,(150)}$ [N/mm²]	Influence factor $f_{b,p}$ [-]	Influence factor $f_{b,c}$ [-]
C 20/25	20	25	1.00	1.00
C 25/30	25	30	1.05	1.10
C 30/37	30	37	1.10	1.22
C 40/50	40	50	1.19	1.41
C 45/55	45	55	1.22	1.48
C 50/60	50	60	1.26	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [3)]

Characteristic loads

Anchor type	FIS V RG M 8 I		FIS V RG M 10 I		FIS V RG M 12 I		FIS V RG M 16 I		FIS V RG M 20 I	
	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4
non-cracked concrete, temperature range - 40 °C to + 50 °C										
tension load C 20/25 N_{Rk} [kN]	19.0	26.0	30.0	40.0	44.0	50.0	75.0	75.0	115.0	115.0
C 50/60 N_{Rk} [kN]	19.0	26.0	30.0	41.0	44.0	59.0	82.0	94.5	127.0	144.9
shear load ≥ C 20/25 V_{Rk} [kN]	9.5	12.8	15.1	20.3	21.9	29.5	40.7	54.8	63.6	85.7

Design loads

Anchor type	FIS V RG M 8 I		FIS V RG M 10 I		FIS V RG M 12 I		FIS V RG M 16 I		FIS V RG M 20 I	
	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4
non-cracked concrete, temperature range - 40 °C to + 50 °C										
tension load C 20/25 N_{Rd} [kN]	12.8	13.9	20.3	21.9	27.8	27.8	41.7	41.7	63.9	63.9
C 50/60 N_{Rd} [kN]	12.8	13.9	20.3	21.9	29.7	31.6	52.5	52.5	80.5	80.5
shear load ≥ C 20/25 V_{Rd} [kN]	7.6	8.2	12.1	13.0	17.5	18.9	32.6	35.1	50.9	54.9

1) The values apply to screws with the strength classification 5.8

2) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

3) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

Permissible loads see next page.

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [3)]

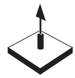
Permissible loads [2)]

Anchor type		FIS V RG M 8 I		FIS V RG M 10 I		FIS V RG M 12 I		FIS V RG M 16 I		FIS V RG M 20 I	
		gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4
non-cracked concrete, temperature range - 40 °C to + 50 °C											
tension load	C 20/25 N_{perm} [kN]	9.2	9.9	14.5	15.7	19.8	19.8	29.8	29.8	45.6	45.6
	C 50/60 N_{perm} [kN]	9.2	9.9	14.5	15.7	21.2	22.5	37.5	37.5	57.5	57.5
shear load	≧ C 20/25 V_{perm} [kN]	5.4	5.9	8.6	9.3	12.5	13.5	23.3	25.1	36.3	39.2

1) The values apply to screws with the strength classification 5.8
2) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.
3) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

4

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			FIS V RG M 8 I			FIS V RG M 10 I			FIS V RG M 12 I		
			gvz		A4	gvz		A4	gvz		A4
			5.8	8.8		5.8	8.8		5.8	8.8	
characteristic resistance	$N_{Rk,s}$	[kN]	19.0	29.0	26.0	30.0	46.0	41.0	44.0	67.0	59.0
design resistance	$N_{Rd,s}$	[kN]	12.8	19.3	13.9	20.3	30.7	21.9	29.7	44.7	31.6

Anchor type			FIS V RG M 16 I			FIS V RG M 20 I		
			gvz		A4	gvz		A4
			5.8	8.8		5.8	8.8	
characteristic resistance	$N_{Rk,s}$	[kN]	82.0	109.0	110.0	127.0	182.0	171.0
design resistance	$N_{Rd,s}$	[kN]	55.4	72.7	58.8	85.8	121.3	91.4

4.2 Pull-out/pull-through failure for the highest loaded anchor [1)]

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FIS V	FIS V	FIS V	FIS V	FIS V
eff. anchorage depth	h_{ef}	[mm]	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 - 40 °C to + 50 °C							
characteristic resistance	$N^0_{Rk,p}$	[kN]	30.0	40.0	50.0	75.0	115.0
Design resistance	$N^0_{Rd,p}$	[kN]	16.7	22.2	27.8	41.7	63.9

1) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

4.3 Concrete cone failure and splitting for the most unfavourable anchor [1)]

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FIS V RG M 8 I	FIS V RG M 10 I	FIS V RG M 12 I	FIS V RG M 16 I	FIS V RG M 20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
non-cracked concrete, temperature range - 40 °C to + 50 °C							
characteristic resistance	$N^0_{Rk,c}$	[kN]	43.1	43.1	70.6	102.2	142.8
design resistance	$N^0_{Rd,c}$	[kN]	24.0	24.0	39.2	56.8	79.4

1) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s	Influence factor f_s [-]				
[mm]	FIS V RG M 8 I	FIS V RG M 10 I	FIS V RG M 12 I	FIS V RG M 16 I	FIS V RG M 20 I
40	0.57				
45	0.58	0.58			
60	0.61	0.61	0.58		
80	0.65	0.65	0.61	0.58	
100	0.69	0.69	0.63	0.60	
125	0.73	0.73	0.67	0.63	0.61
150	0.78	0.78	0.70	0.66	0.63
200	0.87	0.87	0.77	0.71	0.67
250	0.96	0.96	0.83	0.76	0.71
270	1.00	1.00	0.86	0.78	0.73
300			0.90	0.81	0.75
375			1.00	0.89	0.82
480				1.00	0.91
590					1.00
s_{min} [mm]	40	45	60	80	125
$s_{cr,N}$ [mm]	270	270	375	480	590

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c	Influence factor f_c [-]				
[mm]	FIS V RG M 8 I	FIS V RG M 10 I	FIS V RG M 12 I	FIS V RG M 16 I	FIS V RG M 20 I
40	0.51				
45	0.53	0.53			
60	0.60	0.60	0.53		
80	0.70	0.70	0.59	0.53	
100	0.80	0.80	0.66	0.58	
125	0.94	0.94	0.75	0.65	0.59
135	1.00	1.00	0.79	0.68	0.61
150			0.85	0.72	0.64
170			0.93	0.78	0.69
185			0.99	0.82	0.72
200			1.00	0.87	0.76
240				1.00	0.86
250					0.88
295					1.00
c_{min} [mm]	40	45	60	80	125
$c_{cr,N}$ [mm]	135	135	188	240	295

Intermediate values by linear interpolation.

4.3.2 Concrete splitting
4.3.2.1 Influence of spacing

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

Spacing s	Influence factor $f_{s,sp}$ [-]				
[mm]	FIS V RG M 8 I	FIS V RG M 10 I	FIS V RG M 12 I	FIS V RG M 16 I	FIS V RG M 20 I
40	0.56				
45	0.56	0.56			
60	0.58	0.58	0.57		
80	0.61	0.61	0.59	0.57	
100	0.64	0.64	0.61	0.59	
125	0.67	0.67	0.64	0.62	0.59
150	0.71	0.71	0.67	0.64	0.61
200	0.78	0.78	0.73	0.69	0.64
300	0.92	0.92	0.84	0.78	0.71
360	1.00	1.00	0.91	0.83	0.76
400			0.95	0.87	0.79
440			1.00	0.91	0.81
500				0.96	0.86
540				1.00	0.89
600					0.93
700					1.00
s_{min} [mm]	40	45	60	80	125
$s_{cr,sp}$ [mm]	360	360	440	540	700

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c	Influence factor $f_{c,sp}$ [-]				
[mm]	FIS V RG M 8 I	FIS V RG M 10 I	FIS V RG M 12 I	FIS V RG M 16 I	FIS V RG M 20 I
40	0.47				
45	0.48	0.48			
60	0.53	0.53	0.50		
80	0.60	0.60	0.55	0.51	
100	0.67	0.67	0.61	0.56	
125	0.77	0.77	0.68	0.61	0.55
150	0.87	0.87	0.76	0.67	0.59
180	1.00	1.00	0.86	0.75	0.65
200			0.93	0.80	0.68
220			1.00	0.86	0.72
270				1.00	0.82
300					0.89
350					1.00
c_{min} [mm]	40	45	60	80	125
$c_{cr,sp}$ [mm]	180	180	220	270	350

Intermediate values by linear interpolation.

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{\frac{2}{3}} \leq \left(\frac{2 \cdot h_{ef}}{h_{min}}\right)^{\frac{2}{3}}$$

Thickness h [mm]	Influence factor f_h [-] FIS V RG M 8 I	FIS V RG M 10 I	FIS V RG M 12 I	FIS V RG M 16 I	FIS V RG M 20 I
120	1.00				
125	1.03	1.00			
150	1.16	1.13			
165	1.24	1.20	1.00		
180	1.31	1.28	1.06		
205			1.16	1.00	
220			1.21	1.05	
230			1.25	1.08	
250			1.32	1.14	
260				1.17	1.00
300				1.29	1.10
320				1.35	1.15
380					1.29
400					1.33
h_{min} [mm]	120	125	165	205	260
h_{ef} [mm]	90	90	125	160	200

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			FIS V RG M 8 I			FIS V RG M 8 I			FIS V RG M 12 I			FIS V RG M 16 I			FIS V RG M 20 I		
			gvz		A4	gvz		A4	gvz		A4	gvz		A4	gvz		A4
			5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8	
characteristic resistance	$V_{Rk,s}$	[kN]	9.5	14.6	12.8	15.1	23.2	20.3	21.9	33.7	29.5	40.7	62.7	54.8	63.6	91.1	85.7
design resistance	$V_{Rd,s}$	[kN]	7.6	11.7	8.2	12.1	18.6	13.0	17.5	27.0	18.9	32.6	50.2	35.1	50.9	60.7	54.9

5.2 Pryout-failure for the most unfavourable anchor [1)]

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot f_s \cdot f_c \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C 20/25

Anchor type			FIS V RG M 8 I	FIS V RG M 10 I	FIS V RG M 12 I	FIS V RG M 16 I	FIS V RG M 20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
non-cracked concrete, temperature range - 40 °C to + 50 °C							
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	43.1	43.1	70.6	102.2	142.8
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	28.7	28.7	47.1	68.1	95.2
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	30.0	40.0	50.0	75.0	115.0
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	20.0	26.7	33.3	50.0	76.7

1) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor [1)]

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

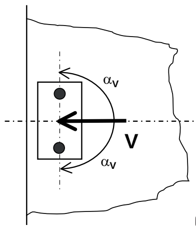
Anchor type			FIS V RG M 8 I	FIS V RG M 10 I	FIS V RG M 12 I	FIS V RG M 16 I	FIS V RG M 20 I
non-cracked concrete, temperature range - 40 °C to + 50 °C							
minimum edge distance	c_{min}	[mm]	40	45	60	80	125
characteristic resistance	$V^0_{Rk,c}$	[kN]	6.3	7.8	12.4	19.8	38.0
design resistance	$V^0_{Rd,c}$	[kN]	4.2	5.2	8.3	13.2	25.3

[1)] The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 Single anchor influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}{}^{n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}{}^{n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}{}^{n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 Anchor pair influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$
and spacing $\mathbf{s \leqq 3 \cdot c}$

$$f_{sc,V}^{\ n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for $s > 3 \cdot c$

$$f_{sc,V}^{\ n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$
and spacing $\mathbf{s \leqq 4.5 \cdot h}$

$$f_{sc,V}^{\ n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for $s > 4.5 \cdot h$

$$f_{sc,V}^{\ n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\ n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

6. Summary of required proof:

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

6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

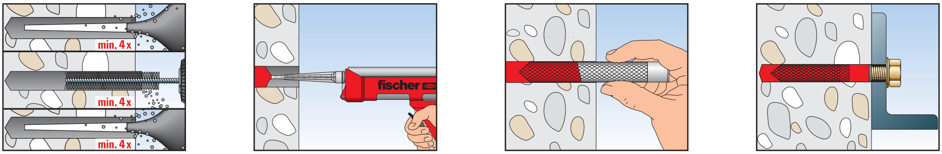
$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

fischer Injection mortar FIS V, FIS VS and FIS VW with RG MI

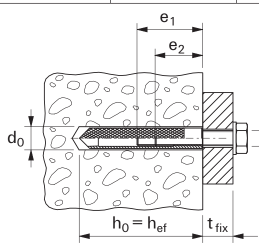
Anchor design according to ETA

7. Installation details



8. Anchor characteristics

Anchor type			FIS V RG M 8 I	FIS V RG M 10 I	FIS V RG M 12 I	FIS V RG M 16 I	FIS V 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]	12	15	18	24	30
	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



9. Gelling and curing times

Cartridge temperature (minimum + 5 °C)	Gelling time FIS V	Gelling time FIS VS	Gelling 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 FIS V	Curing time FIS VS	Curing time FIS VW
– 5 °C	24 h	–	180 min.
± 0 °C	180 min.	6 h	180 min.
+ 5 °C	90 min.	180 min.	50 min.
+ 10 °C	60 min.	120 min.	30 min.
+ 20 °C	45 min.	60 min.	30 min.
+ 30 °C	35 min.	30 min.	–
+ 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 should be replaced.

fischer Injection mortar FIS V, FIS VS and FIS VW with RG MI

Anchor design according to ETA

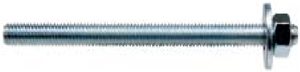
10. Mechanical characteristics

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		
			gvz		A4	gvz		A4	gvz		A4	gvz		A4	gvz		A4
			5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8	
stressed cross sectional area - screw	A_s	[mm²]	36.6			58.0			84.3			157.0			245.0		
resisting moment - screw	W	[mm³]	31.2			62.3			109.2			277.5			540.9		
yield strength - screw	f_y	[N/mm²]	400	640	450	400	640	450	400	640	450	400	640	450	400	640	450
tensile strength - screw	f_u	[N/mm²]	500	800	700	500	800	700	500	800	700	500	800	700	500	800	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm²]	72.5			137.1			161.8			210.4			350.5		
resisting moment - internal-threaded anchor	W	[mm³]	147.8			361.4			496.6			836.9			1755.3		
yield strength - internal-threaded anchor	f_y	[N/mm²]	420		450	420		450	420		450	420		450	420		450
tensile strength - internal-threaded anchor	f_u	[N/mm²]	520		700	520		700	520		700	520		700	520		700

fischer Injection mortar FIS VT

Anchor design according to ETA

1. Types



FIS A M 6 – threaded rod (gvz)
straight cut

FIS A M 6 – threaded rod (A4 and C)
straight cut

RG M 8 - M 20 - threaded rod (gvz)
with external hexagon head

RG M 8 - M 20 - threaded rod (A4 and C)
with external hexagon head

RG M 24 - M 30 - threaded rod (gvz)
straight cut

RG M 24 - M 30 - threaded rod (A4 and C)
straight cut

Injection mortar FIS VT

European Technical Approval - Option 7 for non-cracked concrete

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 7.
- Suitable for non-cracked concrete.
- Universal fixing system for a broad range of applications on building sites.
- The resin anchoring is free of expansion forces and permits low axial spacing and edge distances.
- Extensive range of accessories for a wide variety of applications.

Materials

Threaded rod :	Carbon steel, zinc plated (5 µm) and passivated (gvz)
	Stainless steel of the corrosion resistance class III, e.g. A4
	Stainless steel of the corrosion resistance class IV, e.g. 1.4529 (C)
Injection mortar:	Vinylester resin (styrene-free), quartz sand and hardener

2. Ultimate loads of single anchors with large spacing and edge distance [1)]

Mean values

Anchor type				FIS VT M8		FIS VT M8		FIS VT M10		FIS VT M10		FIS VT M12		FIS VT M12		FIS VT M16	
				gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C
h_{ef}			[mm]	64		96		80		120		96		144		128	
non-cracked concrete temperature range - 40 °C to + 50 °C																	
tension load	C 20/25	N_u	[kN]	19.0*)	20.4	19.0*)	26.0*)	30.0*)	31.8	30.0*)	41.0*)	44.0*)	45.8	44.0*)	59.0*)	72.9	
	C 50/60	N_u	[kN]	19.0*)	25.7	19.0*)	26.0*)	30.0*)	40.1	30.0*)	41.0*)	44.0*)	57.8	44.0*)	59.0*)	82.0*)	91.9
shear load	≧ C 20/25	V_u	[kN]	9.2	13.0*)	9.2	13.0*)	14.5	20.0*)	14.5	20.0*)	21.1	30.0*)	21.1	30.0*)	39.2*)	55.0*)

Anchor type				FIS VT M16		FIS VT M20		FIS VT M20		FIS VT M24		FIS VT M24		FIS VT M30		FIS VT M30	
				gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C
h_{ef}			[mm]	192		160		240		192		288		240		360	
non-cracked concrete temperature range - 40 °C to + 50 °C																	
tension load	C 20/25	N_u	[kN]	82.0*)	109.4	107.2		127.0*)	160.8	144.8		183.0*)	217.1	211.1		292.0*)	316.7
	C 50/60	N_u	[kN]	82.0*)	110.0*)	127.0*)	135.1	127.0*)	172.0*)	182.4		183.0*)	246.0*)	266.0		292.0*)	393.0*)
shear load	≧ C 20/25	V_u	[kN]	39.2*)	55.0*)	61.2*)	86.0*)	61.2*)	86.0*)	88.2*)	123.0*)	88.2*)	123.0*)	140.2*)	196.0*)	140.2*)	196.0*)

1) The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

*) Steel failure decisive

4

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube\,(150)}$ [N/mm²]	Influence factor $f_{b,p}$ [-]	Influence factor $f_{b,c}$ [-]
C 20/25	20	25	1.00	1.00
C 25/30	25	30	1.05	1.10
C 30/37	30	37	1.10	1.22
C 40/50	40	50	1.19	1.41
C 45/55	45	55	1.22	1.48
C 50/60	50	60	1.26	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [1)]

Characteristic loads

Anchor type	FIS VT M 8			FIS VT M 8			FIS VT M 10			FIS VT M 10			FIS VT M 12			FIS VT M 12			FIS VT M16		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef} [mm]	64			96			80			120			96			144			128		
non-cracked concrete temperature range - 40 °C to + 50 °C																					
tension load C 20/25 N_{Rk} [kN]	15.3			19.0	22.9		23.9			30.0	35.8		34.4			44.0	51.6		54.7		
C 50/60 N_{Rk} [kN]	19.0	19.3		19.0	26.0		30.0			30.0	41.0		43.3			44.0	59.0		68.9		
shear load ≧ C 20/25 V_{Rk} [kN]	9.0	13.0		9.0	13.0		14.0	20.0		14.0	20.0		21.0	30.0		21.0	30.0		38.0	55.0	

Anchor type	FIS VT M 16			FIS VT M 20			FIS VT M 20			FIS VT M 24			FIS VT M 24			FIS VT M 30			FIS V M 30		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef} [mm]	192			160			240			192			288			240			360		
non-cracked concrete temperature range - 40 °C to + 50 °C																					
tension load C 20/25 N_{Rk} [kN]	82.0			80.4			120.6			108.6			162.9			158.3			237.5		
C 50/60 N_{Rk} [kN]	82.0	103.4		101.3			127.0	152.0		138.8			183.0	205.2		199.5			292.0	299.3	
shear load ≧ C 20/25 V_{Rk} [kN]	38.0	55.0		60.0	86.0		60.0	86.0		86.0	123.0		86.0	123.0		137.0	196.0		137.0	196.0	

Design loads

Anchor type	FIS VT M 8			FIS VT M 8			FIS VT M 10			FIS VT M 10			FIS VT M 12			FIS VT M 12			FIS VT M16		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef} [mm]	64			96			80			120			96			144			128		
non-cracked concrete temperature range - 40 °C to + 50 °C																					
tension load C 20/25 N_{Rd} [kN]	8.5			12.7			13.3			19.9			19.1			28.7			30.4		
C 50/60 N_{Rd} [kN]	10.7			12.8	13.9	16.0	16.7			20.1	21.9	25.1	24.1			29.5	31.6	36.1	38.3		
shear load ≧ C 20/25 V_{Rd} [kN]	7.2	8.3	10.4	7.2	8.3	10.4	11.2	12.8	16.0	11.2	12.8	16.0	16.8	19.2	24.0	16.8	19.2	24.0	30.4	35.3	44.0

Anchor type	FIS VT M 16			FIS VT M 20			FIS VT M 20			FIS VT M 24			FIS VT M 24			FIS VT M 30			FIS V M 30		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef} [mm]	192			160			240			192			288			240			360		
non-cracked concrete temperature range - 40 °C to + 50 °C																					
tension load C 20/25 N_{Rd} [kN]	45.6			44.7			67.0			60.3			90.5			88.0			131.9		
C 50/60 N_{Rd} [kN]	55.0	57.4		56.3			84.4			76.0			114.0			110.8			166.3		
shear load ≧ C 20/25 V_{Rd} [kN]	30.4	35.3	44.0	48.0	55.1	68.8	48.0	55.1	68.8	68.8	78.8	98.4	68.8	78.8	98.4	109.6	125.6	156.8	109.6	125.6	156.8

1) The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

Permissible loads see next page.

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [1)]

Permissible loads [2)]

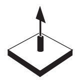
Anchor type	FIS VT M 8			FIS VT M 8			FIS VT M 10			FIS VT M 10			FIS VT M 12			FIS VT M 12			FIS VT M16		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef} [mm]	64			96			80			120			96			144			128		
non-cracked concrete																					
temperature range - 40 °C to + 50 °C																					
tension load C 20/25 N_{perm} [kN]	6.1			9.1			9.5			14.2			13.6			20.5			21.7		
C 50/60 N_{perm} [kN]	7.6			9.1	9.9	11.5	11.9			14.4	15.7	17.9	17.2			21.1	22.5	25.6	27.3		
shear load ≧ C 20/25 V_{perm} [kN]	5.1	6.0	7.4	5.1	6.0	7.4	8.0	9.2	11.4	8.0	9.2	11.4	12.0	13.7	17.1	12.0	13.7	17.1	21.7	25.2	31.4

Anchor type	FIS VT M 16			FIS VT M 20			FIS VT M 20			FIS VT M 24			FIS VT M 24			FIS VT M 30			FIS V M 30		
	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef} [mm]	192			160			240			192			288			240			360		
non-cracked concrete																					
temperature range - 40 °C to + 50 °C																					
tension load C 20/25 N_{perm} [kN]	32.6			31.9			47.9			43.1			64.6			62.8			94.2		
C 50/60 N_{perm} [kN]	39.3	41.0		40.2			60.3			54.3			81.4			79.2			118.8		
shear load ≧ C 20/25 V_{perm} [kN]	21.7	25.2	31.4	34.3	39.4	49.1	34.3	39.4	49.1	49.1	56.3	70.3	49.1	56.3	70.3	78.3	89.7	112.0	78.3	89.7	112.0

1) The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

2) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type	FIS VT M 8				FIS VT M 10				FIS VT M 12				FIS VT M 16			
	gvz		A4	C	gvz		A4	C	gvz		A4	C	gvz		A4	C
	5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8		
characteristic resistance $N_{Rk,s}$ [kN]	19.0	29.0	26.0	26.0	30.0	46.0	41.0	41.0	44.0	67.0	59.0	59.0	82.0	126.0	110.0	110.0
design resistance $N_{Rd,s}$ [kN]	12.8	19.3	13.9	17.3	20.1	30.7	21.9	27.3	29.5	44.7	31.6	39.3	55.0	84.0	58.8	73.3

Anchor type	FIS VT M 20				FIS VT M 24				FIS VT M 30			
	gvz		A4	C	gvz		A4	C	gvz		A4	C
	5.8	8.8			5.8	8.8			5.8	8.8		
characteristic resistance $N_{Rk,s}$ [kN]	127.0	196.0	172.0	172.0	183.0	282.0	246.0	246.0	292.0	449.0	393.0	393.0
design resistance $N_{Rd,s}$ [kN]	85.2	130.7	92.0	114.7	122.8	188.0	131.6	164.0	196.0	299.3	210.2	262.0

4.2 Pull-out/pull-through failure for the highest loaded anchor [1)]

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type	FIS VT M 8		FIS VT M 10		FIS VT M 12		FIS VT M 16		FIS VT M 20		FIS VT M 24		FIS VT M 30	
eff. anchorage depth h_{ef} [mm]	64	96	80	120	96	144	128	192	160	240	192	288	240	360
non-cracked concrete														
temperature range - 40 °C to + 50 °C														
characteristic resistance $N^0_{Rk,p}$ [kN]	15.3	22.9	23.9	35.8	34.4	51.6	54.7	82.0	80.4	120.6	108.6	162.9	158.3	237.5
design resistance $N^0_{Rd,p}$ [2)] [kN]	8.5	12.7	13.3	19.9	19.1	28.7	30.4	45.6	44.7	67.0	60.3	90.5	88.0	131.9

1) The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

2) Intermediate values for $N^0_{Rd,p}$ depending on $h_{ef,var}$ can be determined by linear interpolation.

4.3 Concrete cone failure and splitting for the most unfavourable anchor [1)]

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FIS VT M 8		FIS VT M 10		FIS VT M 12		FIS VT M 16		FIS VT M 20		FIS VT M 24		FIS VT M 30	
eff. anchorage depth	h_{ef}	[mm]	64	96	80	120	96	144	128	192	160	240	192	288	240	360
non-cracked concrete **temperature range - 40 °C to + 50 °C**																
characteristic resistance	$N^0_{Rk,c}$	[kN]	25.8	47.4	36.1	66.3	47.4	87.1	73.0	134.1	102.0	187.4	134.1	246.3	187.4	344.3
design resistance	$N^0_{Rd,c}$ [2)]	[kN]	14.3	26.3	20.0	36.8	26.3	48.4	40.5	74.5	56.7	104.1	74.5	136.9	104.1	191.3

[1)] The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

[2)] Intermediate values for $N^0_{Rd,c}$ depending on $h_{ef,var}$ can be determined according: $N^0_{Rd,cp\,(c)\,(h_{ef,var})} = N^0_{Rd,cp\,(c)\,(h_{ef,min})} \cdot \left(\frac{h_{ef,var}}{h_{ef,min}}\right)^{1.5}$

4

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm]		**FIS VT M 8**		**FIS VT M 10**		**FIS VT M 12**		**FIS VT M 16**		**FIS VT M 20**		**FIS VT M 24**		**FIS VT M 30**	
↓	h_{ef} **[mm]**	**64**	**96**	**80**	**120**	**96**	**144**	**128**	**192**	**160**	**240**	**192**	**288**	**240**	**360**
40		0.60	0.57												
45		0.62	0.58	0.59	0.56										
55		0.64	0.60	0.61	0.58	0.60	0.56								
65		0.67	0.61	0.64	0.59	0.61	0.58	0.58	0.56						
85		0.72	0.65	0.68	0.62	0.65	0.60	0.61	0.57	0.59	0.56				
105		0.77	0.68	0.72	0.65	0.68	0.62	0.64	0.59	0.61	0.57	0.59	0.56		
120		0.81	0.71	0.75	0.67	0.71	0.64	0.66	0.60	0.63	0.58	0.60	0.57		
140		0.86	0.74	0.79	0.69	0.74	0.66	0.68	0.62	0.65	0.60	0.62	0.58	0.60	0.56
190		0.99	0.83	0.90	0.76	0.83	0.72	0.75	0.66	0.70	0.63	0.66	0.61	0.63	0.59
215			0.87	0.95	0.80	0.87	0.75	0.78	0.69	0.72	0.65	0.69	0.62	0.65	0.60
240			0.92	1.00	0.83	0.92	0.78	0.81	0.71	0.75	0.67	0.71	0.64	0.67	0.61
290			1.00		0.90	1.00	0.84	0.88	0.75	0.80	0.70	0.75	0.67	0.70	0.63
360					1.00		0.92	0.97	0.81	0.88	0.75	0.81	0.71	0.75	0.67
430							1.00		0.87	0.95	0.80	0.87	0.75	0.80	0.70
480									0.92	1.00	0.83	0.92	0.78	0.83	0.72
575									1.00		0.90	1.00	0.83	0.90	0.77
720											1.00		0.92		0.83
865													1.00		0.90
1080															1.00
s_{min}	[mm]	40	40	45	45	55	55	65	65	85	85	105	105	140	140
$s_{cr,N}$	[mm]	192	288	240	360	288	432	384	576	480	720	576	864	720	1080

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c [mm]		FIS VT M 8		FIS VT M 10		FIS VT M 12		FIS VT M 16		FIS VT M 20		FIS VT M 24		FIS VT M 30	
↓	h_{ef} [mm]	64	96	80	120	96	144	128	192	160	240	192	288	240	360
40		0.58	0.50												
45		0.62	0.52	0.56	0.48										
55		0.69	0.56	0.61	0.52	0.56	0.49								
60		0.72	0.58	0.64	0.53	0.58	0.50								
65		0.76	0.61	0.66	0.55	0.61	0.51	0.54	0.47						
70		0.79	0.63	0.69	0.57	0.63	0.53	0.55	0.48						
85		0.91	0.70	0.78	0.62	0.70	0.57	0.60	0.51	0.55	0.48				
95		0.99	0.75	0.84	0.66	0.75	0.60	0.63	0.53	0.57	0.49				
105			0.79	0.90	0.69	0.79	0.63	0.67	0.55	0.60	0.51	0.55	0.48		
120			0.87	1.00	0.75	0.87	0.67	0.72	0.58	0.64	0.53	0.58	0.50		
145			1.00		0.85	1.00	0.75	0.81	0.64	0.71	0.58	0.64	0.53	0.58	0.50
180					1.00		0.87	0.95	0.72	0.81	0.64	0.72	0.58	0.64	0.53
215							1.00		0.81	0.92	0.70	0.81	0.64	0.70	0.57
290									1.00		0.85	1.00	0.75	0.85	0.66
360											1.00		0.87	1.00	0.75
430													1.00		0.84
540															1.00
c_{min}	[mm]	40	40	45	45	55	55	65	65	85	85	105	105	140	140
$c_{cr,N}$	[mm]	96	144	120	180	144	216	192	288	240	360	288	432	360	540

Intermediate values by linear interpolation.

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s [mm] ↓	FIS VT M 8		FIS VT M 10		FIS VT M 12		FIS VT M 16		FIS VT M 20		FIS VT M 24		FIS VT M 30	
h_{ef} [mm]	64	96	80	120	96	144	128	192	160	240	192	288	240	360
40	0.56	0.55												
45	0.57	0.55	0.56	0.54										
55	0.59	0.57	0.57	0.55	0.56	0.54								
65	0.60	0.58	0.58	0.56	0.57	0.55	0.55	0.54						
85	0.63	0.60	0.61	0.58	0.59	0.57	0.57	0.55	0.55	0.54				
105	0.66	0.63	0.63	0.60	0.61	0.58	0.58	0.56	0.57	0.55	0.56	0.54		
140	0.72	0.67	0.68	0.63	0.65	0.61	0.61	0.58	0.59	0.57	0.57	0.56	0.56	0.55
220	0.84	0.77	0.78	0.71	0.73	0.68	0.67	0.63	0.64	0.61	0.62	0.59	0.59	0.57
320	1.00	0.89	0.90	0.81	0.83	0.76	0.75	0.69	0.70	0.66	0.67	0.63	0.64	0.60
400		0.99	1.00	0.88	0.92	0.82	0.82	0.74	0.75	0.69	0.71	0.66	0.67	0.63
410		1.00		0.89	0.93	0.83	0.83	0.75	0.76	0.70	0.72	0.67	0.67	0.63
480				0.96	1.00	0.89	0.88	0.79	0.80	0.73	0.75	0.69	0.70	0.66
520				1.00		0.92	0.91	0.81	0.83	0.75	0.77	0.71	0.72	0.67
620						1.00	0.99	0.87	0.89	0.80	0.83	0.75	0.76	0.70
630							1.00	0.88	0.90	0.81	0.83	0.75	0.77	0.70
790								0.98	1.00	0.88	0.92	0.82	0.83	0.76
830								1.00		0.90	0.94	0.83	0.85	0.77
950										0.96	1.00	0.88	0.90	0.81
1030										1.00		0.92	0.94	0.83
1180												0.98	1.00	0.88
1240												1.00		0.90
1540														1.00
s_{min} [mm]	40	40	45	45	55	55	65	65	85	85	105	105	140	140
$s_{cr,sp}$ [mm]	320	410	400	520	480	620	630	830	790	1030	950	1240	1180	1540

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c [mm] ↓ h_{ef} [mm]	FIS VT M 8		FIS VT M 10		FIS VT M 12		FIS VT M 16		FIS VT M 20		FIS VT M 24		FIS VT M 30	
	64	**96**	**80**	**120**	**96**	**144**	**128**	**192**	**160**	**240**	**192**	**288**	**240**	**360**
40	0.48	0.45												
45	0.50	0.47	0.47	0.44										
55	0.54	0.49	0.50	0.46	0.47	0.44								
65	0.58	0.52	0.53	0.48	0.50	0.46	0.46	0.43						
85	0.66	0.58	0.59	0.53	0.55	0.50	0.50	0.46	0.46	0.44				
105	0.74	0.65	0.65	0.58	0.60	0.54	0.53	0.49	0.49	0.46	0.47	0.44		
110	0.76	0.66	0.67	0.59	0.61	0.55	0.54	0.49	0.50	0.46	0.47	0.44		
125	0.83	0.71	0.72	0.63	0.65	0.58	0.57	0.51	0.52	0.48	0.49	0.46		
140	0.90	0.76	0.77	0.66	0.69	0.61	0.60	0.54	0.55	0.50	0.51	0.47	0.48	0.45
160	1.00	0.83	0.85	0.71	0.75	0.65	0.64	0.57	0.58	0.52	0.54	0.49	0.50	0.46
200		0.98	1.00	0.82	0.87	0.74	0.73	0.63	0.64	0.57	0.59	0.53	0.54	0.49
205		1.00		0.84	0.89	0.75	0.74	0.63	0.65	0.57	0.59	0.53	0.54	0.49
240				0.94	1.00	0.83	0.82	0.69	0.71	0.62	0.64	0.57	0.58	0.52
260				1.00		0.87	0.86	0.72	0.74	0.64	0.67	0.59	0.60	0.54
310						1.00	0.99	0.81	0.83	0.71	0.74	0.64	0.65	0.58
315							1.00	0.82	0.84	0.71	0.75	0.64	0.66	0.58
395								0.96	1.00	0.82	0.87	0.73	0.75	0.65
415								1.00		0.85	0.90	0.75	0.78	0.66
475										0.94	1.00	0.82	0.85	0.72
515										1.00		0.87	0.90	0.75
590												0.96	1.00	0.82
620												1.00		0.85
770														1.00
c_{min} [mm]	40	40	45	45	55	55	65	65	85	85	105	105	140	140
$c_{cr,sp}$ [mm]	160	205	200	260	240	310	315	415	395	515	475	620	590	770

Intermediate values by linear interpolation.

4

4.3.2.3 Influence of concrete thickness

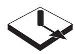
$$f_h = \left(\frac{h}{h_{min}}\right)^{\frac{2}{3}} \leq \left(\frac{2 \cdot h_{ef}}{h_{min}}\right)^{\frac{2}{3}}$$

Thickness h [mm] ↓	Influence factor f_h [-]													
	FIS VT M 8		FIS VT M 10		FIS VT M 12		FIS VT M 16		FIS VT M 20		FIS VT M 24		FIS VT M 30	
h_{ef} [mm]	64	96	80	120	96	144	128	192	160	240	192	288	240	360
100	1.00													
110	1.07		1.00											
120	1.13		1.06											
130		1.02	1.12		1.02									
140		1.07	1.17		1.07									
150		1.12	1.23	1.00	1.12									
170		1.22		1.09	1.22		1.02							
180		1.27		1.13	1.27	1.02	1.06							
220				1.29		1.17	1.22		1.04					
230				1.33		1.20	1.25	1.01	1.07					
250						1.27	1.32	1.06	1.13		1.01			
290								1.17	1.25	1.00	1.11			
310								1.23	1.30	1.05	1.16		1.00	
430										1.31		1.16	1.24	1.00
520												1.32		1.14
620														1.28
720														1.41
h_{min} [mm]	100	126	110	150	126	174	164	228	208	288	248	344	310	430
h_{ef} [mm]	64	96	80	120	96	144	128	192	160	240	192	288	240	360

Intermediate values by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor



Characteristic resistance and design resistance for single anchors

Anchor type			FIS VT M 8				FIS VT M 10				FIS VT M 12				FIS VT M 16			
			gvz		A4	C	gvz		A4	C	gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8		
characteristic resistance	$V_{Rk,s}$	[kN]	9.0	12.0	13.0	13.0	14.0	20.0	20.0	20.0	21.0	28.0	30.0	30.0	38.0	53.0	55.0	55.0
design resistance	$V_{Rd,s}$	[kN]	7.2	9.6	8.3	10.4	11.2	16.0	12.8	16.0	16.8	22.4	19.2	24.0	30.4	42.4	35.3	44.0

Anchor type			FIS VT M 20				FIS VT M 24				FIS VT M 30			
			gvz		A4	C	gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8			5.8	8.8		
characteristic resistance	$V_{Rk,s}$	[kN]	60.0	82.0	86.0	86.0	86.0	118.0	123.0	123.0	137.0	188.0	196.0	196.0
design resistance	$V_{Rd,s}$	[kN]	48.0	65.6	55.1	68.8	68.8	94.4	78.8	98.4	109.6	150.4	125.6	156.8

5.2 Pryout-failure for the most unfavourable anchor [1)]

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot f_s \cdot f_c \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C 20/25

Anchor type			FIS VT M 8		FIS VT M 10		FIS VT M 12		FIS VT M 16		FIS VT M 20		FIS VT M 24		FIS VT M 30	
eff. anchorage depth	h_{ef}	[mm]	64	96	80	120	96	144	128	192	160	240	192	288	240	360
non-cracked concrete temperature range - 40 °C to + 50 °C																
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	25.8	47.4	36.1	66.3	47.4	87.1	73.0	134.1	102.0	187.4	134.1	246.3	187.4	344.3
design resistance	$N^0_{Rd,cp}$ (c) [3)]	[kN]	17.2	31.6	24.0	44.2	31.6	58.1	48.7	89.4	68.0	124.9	89.4	164.2	124.9	229.5
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	15.3	22.9	23.9	35.8	34.4	51.6	54.7	82.0	80.4	120.6	108.6	162.9	158.3	237.5
design resistance	$N^0_{Rd,cp}$ (p) [2)]	[kN]	10.2	15.3	15.9	23.9	22.9	34.4	36.5	54.7	53.6	80.4	72.4	108.6	105.6	158.3

[1)] The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

[2)] Intermediate values for $N^0_{Rd,cp}(p)$ depending on $h_{ef,var}$ can be determined by linear interpolation.

[3)] Intermediate values for $N^0_{Rd,cp}(c)$ depending on $h_{ef,var}$ can be determined according: $N^0_{Rd,cp\,(c)\,(h_{ef,var})} = N^0_{Rd,cp\,(c)\,(h_{ef,min})} \cdot \left(\frac{h_{ef,var}}{h_{ef,min}}\right)^{1.5}$

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor [1)]

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

Anchor type			FIS VT M 8		FIS VT M 10		FIS VT M 12		FIS VT M 16		FIS VT M 20		FIS VT M 24		FIS VT M 30	
h_{ef}		[mm]	**64**	**96**	**80**	**120**	**96**	**144**	**128**	**192**	**160**	**240**	**192**	**288**	**240**	**360**
non-cracked concrete temperature range - 40 °C to + 50 °C																
minimum edge distance	c_{min}	[mm]	40	40	45	45	55	55	65	65	85	85	105	105	140	140
characteristic resistance	$V^0_{Rk,c}$	[kN]	5.3	5.8	6.8	7.5	9.5	10.6	13.4	15.1	20.7	23.4	29.3	33.3	46.4	52.9
design resistance	$V^0_{Rd,c}$ [2)]	[kN]	3.6	3.9	4.5	5.0	6.3	7.0	8.9	10.0	13.8	15.6	19.6	22.2	30.9	35.2

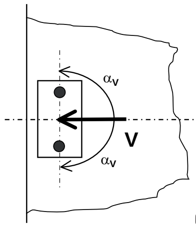
[1)] The loads apply to fischer threaded rods with strength classification 5.8, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

[2)] Intermediate values for $V^0_{Rd,c}$ by linear interpolation

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 **Single anchor** influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}^{\ n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}^{\ n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\ n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 **Anchor pair** influenced only by one edge

for concrete thickness h ≧ 1.5 · c
and spacing **s ≦ 3 · c**

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for s > 3 · c

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c
and spacing **s ≦ 4.5 · h**

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for s > 4.5 · h

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	**anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$**															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

4

6. Summary of required proof:

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

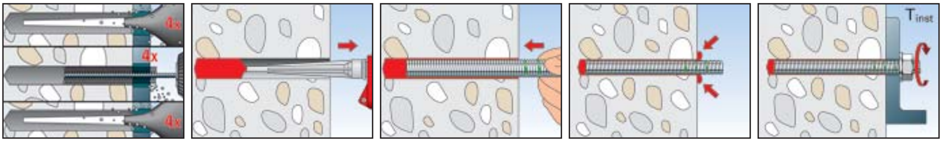
6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

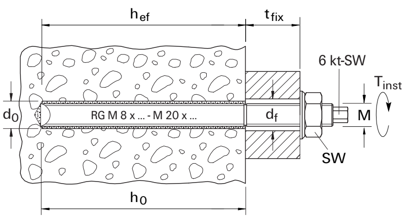
7. Installation details

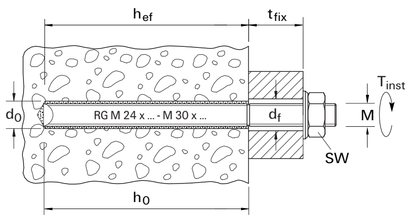


8. Anchor characteristics

Anchor type			FIS VT M 8		FIS VT M 10		FIS VT M 12		FIS VT M 16		FIS VT M 20		FIS VT M 24		FIS VT M 30	
	h_{ef}	[mm]	64	96	80	120	96	144	128	192	160	240	192	288	240	360
diameter of thread			M 8		M 10		M 12		M 16		M 20		M 24		M 30	
nominal drill hole diameter	d_0	[mm]	10	10	12	12	14	14	18	18	24	24	28	28	35	35
drill depth	h_0	[mm]	64	96	80	120	96	144	128	192	160	240	192	288	240	360
clearance-hole in fixture to be attached	d_f	[mm]	≤ 9	≤ 9	≤ 12	≤ 12	≤ 14	≤ 14	≤ 18	≤ 18	≤ 22	≤ 22	≤ 26	≤ 26	≤ 33	≤ 33
wrench size	SW	[mm]	13	13	17	17	19	19	24	24	30	30	36	36	46	46
required torque	T_{inst}	[Nm]	10	10	20	20	40	40	60	60	120	120	150	150	300	300
minimum thickness of concrete member	h_{min}	[mm]	100 *	126 *	110 *	150 *	125 *	174 *	164 *	228 *	208 *	288 *	288 *	344 *	310 *	430 *
minimum spacing	s_{min}	[mm]	40	40	45	45	55	55	65	65	85	85	105	105	140	140
minimum edge distances	c_{min}	[mm]	40	40	45	45	55	55	65	65	85	85	105	105	140	140
mortar filling quantity		[scale units]	2	3	3	5	4	6	8	11	20	29	28	42	53	79

* Intermediate values by linear interpolation.





9. Gelling and curing times

Cartridge temperature (minimum + 5 °C)	Gelling 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 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.
For longer installation times, i.e. when interruptions occur in work, the static mixer should be replaced.
For wet concrete the curing time must be doubled.

10. Mechanical characteristics

Anchor type			FIS VT M8				FIS VT M10				FIS VT M12				FIS VT M16				
			gvz		A4	C	gvz		A4	C	gvz		A4	C	gvz			A4	C
			5.8	8.8			5.8	8.8			5.8	8.8			5.8	8.8	10.9		
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				
yield strength - anchor rod	f_y	[N/mm²]	420	640	450	560	420	640	450	560	420	640	450	560	420	640	900	450	560
tensile strength - anchor rod	f_u	[N/mm²]	520	800	700	700	520	800	700	700	520	800	700	700	520	800	1000	700	700

Anchor type			FIS VT M20				FIS VT M24				FIS VT M30			
			gvz		A4	C	gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8			5.8	8.8		
stressed cross sectional area - anchor rod	A_s	[mm²]	245.0				353.0				561.0			
resisting moment - anchor rod	W	[mm³]	540.9				935.5				1874.2			
yield strength - anchor rod	f_y	[N/mm²]	420	640	450	560	420	640	450	560	420	640	450	560
tensile strength - anchor rod	f_u	[N/mm²]	520	800	700	700	520	800	700	700	520	800	700	700

fischer Injection mortar FIS VT with RG MI

Anchor design according to ETA

1. Types

RG MI – Internal-threaded anchor (gvz)

RG MI A4 – Internal-threaded anchor (A4)

Injection mortar FIS VT

European Technical Approval - Option 7 for non-cracked concrete

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 7.
- Suitable for non-cracked concrete.
- Universal fixing system for a broad range of applications on building sites.
- The resin anchoring is free of expansion forces and permits low spacings and edge distances.
- Extensive range of accessories for a wide variety of applications.

Materials

Internal-threaded anchor:	Carbon steel, zinc plated (5 µm) and passivated (gvz) Stainless steel of the corrosion resistance class III, e.g. A4
Injection mortar:	Vinylester resin (styrene-free), quartz sand and hardener

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

Mean values

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	
	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4
non-cracked concrete temperature range - 40 °C to + 50 °C										
tension load C 20/25 N_u [kN]	19.0*)	26.0*)	30.0*)	41.0*)	44.0*)	59.0*)	80.0		126.7	
tension load C 50/60 N_u [kN]	19.0*)	26.0*)	30.0*)	41.0*)	44.0*)	59.0*)	82.0*)	100.8	127.0*)	159.6
shear load ≧ C 20/25 V_u [kN]	9.5*)	12.8*)	15.1*)	20.3*)	21.9*)	29.5*)	40.7*)	54.8*)	63.6*)	85.7*)

*) Steel failure decisive

1) The values apply to screws with the strength classification 5.8

2) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

fischer FIXING SYSTEMS

Status 05/2010

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube\,(150)}$ [N/mm²]	Influence factor $f_{b,p}$ [-]	$f_{b,c}$ [-]
C 20/25	20	25	1.00	1.00
C 25/30	25	30	1.05	1.10
C 30/37	30	37	1.10	1.22
C 40/50	40	50	1.19	1.41
C 45/55	45	55	1.22	1.48
C 50/60	50	60	1.26	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [3)]

Characteristic loads

Anchor type				FIS VT RG M 8 I gvz[1)]	FIS VT RG M 8 I A4	FIS VT RG M 10 I gvz[1)]	FIS VT RG M 10 I A4	FIS VT RG M 12 I gvz[1)]	FIS VT RG M 12 I A4	FIS VT RG M 16 I gvz[1)]	FIS VT RG M 16 I A4	FIS VT RG M 20 I gvz[1)]	FIS VT RG M 20 I A4
non-cracked concrete temperature range - 40 °C to + 50 °C													
tension load	C 20/25	N_{Rk}	[kN]	19.0	25.0	30.0	35.0	44.0	50.0	60.0	60.0	95.0	95.0
	C 50/60	N_{Rk}	[kN]	19.0	26.0	30.0	41.0	44.0	59.0	75.6	75.6	119.7	119.7
shear load	≧ C 20/25	V_{Rk}	[kN]	9.5	12.8	15.1	20.3	21.9	29.5	40.7	54.8	63.6	85.7

Design loads

Anchor type				FIS VT RG M 8 I gvz[1)]	FIS VT RG M 8 I A4	FIS VT RG M 10 I gvz[1)]	FIS VT RG M 10 I A4	FIS VT RG M 12 I gvz[1)]	FIS VT RG M 12 I A4	FIS V T RG M 16 I gvz[1)]	FIS V T RG M 16 I A4	FIS VT RG M 20 I gvz[1)]	FIS VT RG M 20 I A4
non-cracked concrete temperature range - 40 °C to + 50 °C													
tension load	C 20/25	N_{Rd}	[kN]	12.8	13.9	19.4	19.4	27.8	27.8	33.3	33.3	52.8	52.8
	C 50/60	N_{Rd}	[kN]	12.8	13.9	20.3	21.9	29.7	31.6	42.0	42.0	66.5	66.5
shear load	≧ C 20/25	V_{Rd}	[kN]	7.6	8.2	12.1	13.0	17.5	18.9	32.6	35.1	50.9	54.9

Permissible loads [2)]

Anchor type				FIS VT RG M 8 I gvz[1)]	FIS VT RG M 8 I A4	FIS VT RG M 10 I gvz[1)]	FIS VT RG M 10 I A4	FIS VT RG M 12 I gvz[1)]	FIS VT RG M 12 I A4	FIS VT RG M 16 I gvz[1)]	FIS VT RG M 16 I A4	FIS VT RG M 20 I gvz[1)]	FIS VT RG M 20 I A4
non-cracked concrete temperature range - 40 °C to + 50 °C													
tension load	C 20/25	N_{perm}	[kN]	9.2	9.9	13.9	13.9	19.8	19.8	23.8	23.8	37.7	37.7
	C 50/60	N_{perm}	[kN]	9.2	9.9	14.5	15.7	21.2	22.5	30.0	30.0	47.5	47.5
shear load	≧ C 20/25	V_{perm}	[kN]	5.4	5.9	8.6	9.3	12.5	13.5	23.3	25.1	36.3	39.2

1) The values apply to steel with the strength classification 5.8
2) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.
3) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

fischer Injection mortar FIS VT with RG MI

Anchor design according to ETA

4. Load direction: tension

4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

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		
			gvz		A4	gvz		A4	gvz		A4	gvz		A4	gvz		A4
			5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8	
characteristic resistance	$N_{Rk,s}$	[kN]	19.0	29.0	26.0	30.0	46.0	41.0	44.0	67.0	59.0	82.0	109.0	110.0	127.0	182.0	171.0
design resistance	$N_{Rd,s}$	[kN]	12.8	19.3	13.9	20.3	30.7	21.9	29.7	44.7	31.6	55.4	72.7	58.8	85.8	121.3	91.4

4.2 Pull-out/pull-through failure for the highest loaded anchor [1)]

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

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
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
non-cracked concrete temperature range -40 °C to +50 °C							
characteristic resistance	$N^0_{Rk,p}$	[kN]	25.0	35.0	50.0	60.0	95.0
Design resistance	$N^0_{Rd,p}$	[kN]	13.9	19.4	27.8	33.3	52.8

1) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details“).

4.3 Concrete cone failure and splitting for the most unfavourable anchor [1)]

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

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
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
non-cracked concrete temperature range -40 °C to +50 °C							
characteristic resistance	$N^0_{Rk,c}$	[kN]	43.1	43.1	70.6	102.2	142.8
design resistance	$N^0_{Rd,c}$	[kN]	24.0	24.0	39.2	56.8	79.4

1) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details“).

4.3.1 Concrete cone failure
4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm]	Influence factor f_s [-] 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
40	0.57				
45	0.58	0.58			
60	0.61	0.61	0.58		
80	0.65	0.65	0.61	0.58	
100	0.69	0.69	0.63	0.60	
125	0.73	0.73	0.67	0.63	0.60
150	0.78	0.78	0.70	0.66	0.63
200	0.87	0.87	0.77	0.71	0.67
250	0.96	0.96	0.83	0.76	0.71
270	1.00	1.00	0.86	0.78	0.73
300			0.90	0.81	0.75
375			1.00	0.89	0.81
480				1.00	0.90
600					1.00
s_{min} [mm]	40	45	60	80	125
$s_{cr,N}$ [mm]	270	270	375	480	600

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s^2_{cr,N}}$$

Edge distance c [mm]	Influence factor f_c [-] 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
40	0.51				
45	0.53	0.53			
60	0.60	0.60	0.53		
80	0.70	0.70	0.59	0.53	
100	0.80	0.80	0.66	0.58	
125	0.94	0.94	0.75	0.65	0.58
135	1.00	1.00	0.79	0.68	0.61
150			0.85	0.72	0.64
170			0.93	0.78	0.68
190			1.00	0.84	0.73
200				0.87	0.75
240				1.00	0.85
300					1.00
c_{min} [mm]	40	45	60	80	125
$c_{cr,N}$ [mm]	135	135	188	240	300

Intermediate values by linear interpolation.

4

4.3.2 Concrete splitting
4.3.2.1 Influence of spacing

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

Spacing s	Influence factor $f_{s,sp}$ [-]				
[mm]	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
40	0.56				
45	0.56	0.56			
60	0.58	0.58	0.57		
80	0.61	0.61	0.59	0.57	
100	0.64	0.64	0.61	0.59	
125	0.67	0.67	0.64	0.62	0.59
150	0.71	0.71	0.67	0.64	0.61
200	0.78	0.78	0.73	0.69	0.64
300	0.92	0.92	0.84	0.78	0.71
360	1.00	1.00	0.91	0.83	0.76
400			0.95	0.87	0.79
440			1.00	0.91	0.81
500				0.96	0.86
540				1.00	0.89
600					0.93
700					1.00
s_{min} [mm]	40	45	60	80	125
$s_{cr,sp}$ [mm]	360	360	440	540	700

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c	Influence factor $f_{c,sp}$ [-]				
[mm]	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
40	0.47				
45	0.48	0.48			
60	0.53	0.53	0.50		
80	0.60	0.60	0.55	0.51	
100	0.67	0.67	0.61	0.56	
125	0.77	0.77	0.68	0.61	0.55
150	0.87	0.87	0.76	0.67	0.59
180	1.00	1.00	0.86	0.75	0.65
200			0.93	0.80	0.68
220			1.00	0.86	0.72
270				1.00	0.82
300					0.89
350					1.00
c_{min} [mm]	40	45	60	80	125
$c_{cr,sp}$ [mm]	180	180	220	270	350

Intermediate values by linear interpolation.

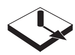
4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{\frac{2}{3}} \leq \left(\frac{2 \cdot h_{ef}}{h_{min}}\right)^{\frac{2}{3}}$$

Thickness h [mm]	**Influence factor f_h [-]** 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
120	1.00				
125	1.03	1.00			
150	1.16	1.13			
165	1.24	1.20	1.00		
200			1.14		
205			1.16	1.00	
220			1.21	1.05	
230			1.25	1.08	
250			1.32	1.14	
260				1.17	1.00
300				1.29	1.10
310				1.32	1.12
380					1.29
400					1.33
h_{min} [mm]	120	125	165	205	260
h_{ef} [mm]	90	90	125	160	200

Intermediate values by linear interpolation.

5. Load direction: shear



5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type	**FIS VT RG M 8 I**			**FIS VT RG M 8 I**			**FIS VT RG M 12 I**			**RG M 16 I**			**RG M 20 I**		
	gvz		**A4**	**gvz**		**A4**	**gvz**		**A4**	**gvz**		**A4**	**gvz**		**A4**
	5.8	**8.8**		**5.8**	**8.8**		**5.8**	**8.8**		**5.8**	**8.8**		**5.8**	**8.8**	
characteristic resistance $V_{Rk,s}$ [kN]	9.5	14.6	12.8	15.1	23.2	20.3	21.9	33.7	29.5	40.7	62.7	54.8	63.6	91.1	85.7
design resistance $V_{Rd,s}$ [kN]	7.6	11.7	8.2	12.1	18.6	13.0	17.5	27.0	18.9	32.6	50.2	35.1	50.9	72.9	54.9

5.2 Pryout-failure for the most unfavourable anchor [1)]

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot f_s \cdot f_c \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C 20/25

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**
eff. anchorage depth h_{ef} [mm]	90	90	125	160	200
non-cracked concrete **temperature range - 40 °C to + 50 °C**					
characteristic resistance $N^0_{Rk,cp}$ (c) [kN]	43.1	43.1	70.6	102.2	142.8
design resistance $N^0_{Rd,cp}$ (c) [kN]	28.7	28.7	47.1	68.1	95.2
characteristic resistance $N^0_{Rk,cp}$ (p) [kN]	25.0	35.0	50.0	60.0	95.0
design resistance $N^0_{Rd,cp}$ (p) [kN]	16.7	23.3	33.3	40.0	63.3

1) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor [1)]

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

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
non-cracked concrete temperature range - 40 °C to + 50 °C							
minimum edge distance	c_{min}	[mm]	40	45	60	80	125
characteristic resistance	$V^0_{Rk,c}$	[kN]	6.3	7.8	12.4	19.8	38.0
design resistance	$V^0_{Rd,c}$	[kN]	4.2	5.2	8.3	13.2	25.3

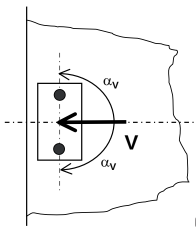
1) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 50°C (see also „Installation details").

4

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



0° ≤ α_V ≤ 90°

In case of α_V > 90° it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 **Single anchor** influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$

$$f_{sc,V}^{\;n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$

$$f_{sc,V}^{\;n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\;n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 **Anchor pair** influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$
and spacing $\mathbf{s \leqq 3 \cdot c}$

$$f_{sc,V}^{\;n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for $s > 3 \cdot c$

$$f_{sc,V}^{\;n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$
and spacing $\mathbf{s \leqq 4.5 \cdot h}$

$$f_{sc,V}^{\;n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for $s > 4.5 \cdot h$

$$f_{sc,V}^{\;n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\;n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

6. Summary of required proof:

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

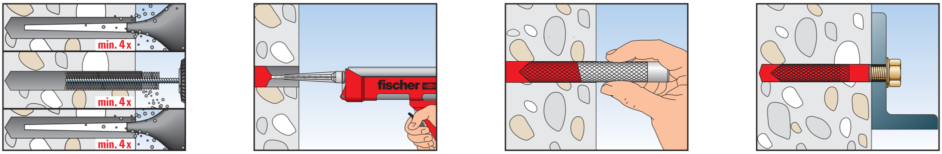
6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

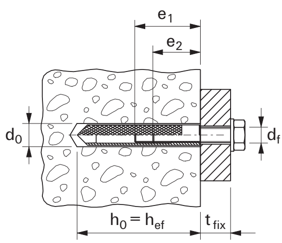
N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

7. Installation details



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]	12	15	18	24	30
	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 RG MI

Anchor design according to ETA

9. Gelling and curing times

Cartridge temperature (minimum + 5 °C)	Gelling time FIS VT	Temperature at anchoring base	Curing time 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 wet concrete the curing time must be doubled.

10. Mechanical 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		
			gvz		A4	gvz		A4	gvz		A4	gvz		A4	gvz		A4
			5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8	
stressed cross sectional area - screw	A_s	[mm^2]	36.6			58.0			84.3			157.0			245.0		
resisting moment - screw	W	[mm^3]	31.2			62.3			109.2			277.5			540.9		
yield strength - screw	f_y	[N/mm^2]	400	640	450	400	640	450	400	640	450	400	640	450	400	640	450
tensile strength - screw	f_u	[N/mm^2]	500	800	700	500	800	700	500	800	700	500	800	700	500	800	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm^2]	72.5			137.1			161.8			210.4			350.5		
resisting moment - internal-threaded anchor	W	[mm^3]	147.8			361.4			496.6			836.9			1755.3		
yield strength - internal-threaded anchor	f_y	[N/mm^2]	420		450	420		450	420		450	420		450	420		450
tensile strength - internal-threaded anchor	f_u	[N/mm^2]	520		700	520		700	520		700	520		700	520		700

fischer Injection mortar FIS EM

Anchor design according to ETA

1. Types

RG M 8 - M 20 - threaded rod (gvz)
with external hexagon head

RG M 8 - M 20 - threaded rod (A4 and C)
with external hexagon head

RG M 24 - M 30 - threaded rod (gvz)
straight cut

RG M 24 - M 30 - threaded rod (A4 and C)
straight cut

FIS EM - Injection mortar FIS EM 390 S, FIS EM 1100 S

ETA
European Technical Approval – Option 1 for cracked concrete

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 1.
- Very good bonding of the mortar ensures high loads in concrete.
- Suitable for underwater installations.
- Suitable for diamond drilled holes guarantees highest flexibility on site.
- Longer curing time for simple installation.
- Low shrinkage of the mortar.

Materials

Threaded rod :	Carbon steel, zinc plated (5 µm) and passivated (gvz)
	Stainless steel of the corrosion resistance class III, e.g. A4
	Stainless steel of the corrosion resistance class IV, e.g. 1.4529 (C)
Injection mortar:	Epoxy resin, cement and hardener

2. Ultimate loads of single anchors with large spacing and edge distance [1)]

Mean values

Anchor type	FIS EM M 8		FIS EM M 8		FIS EM M 10		FIS EM M 10		FIS EM M 12		FIS EM M 12	
	gvz	A4 | C	gvz	A4 | C	gvz	A4 | C	gvz	A4 | C	gvz	A4 | C	gvz	A4 | C
h_{ef} [mm]	60		160		60		200		70		240	
non-cracked concrete, temperature range - 40 °C to + 35 °C												
tension load C 20/25 N_u [kN]	19.0*)	26.0*)	19.0*)	26.0*)	29.0*)	31.4	29.0*)	41.0*)	39.5		43.0*)	59.0*)
C 50/60 N_u [kN]	19.0*)	26.0*)	19.0*)	26.0*)	39.0*)	41.0*)	29.0*)	41.0*)	43.0*)	57.5	43.0*)	59.0*)
shear load ≧ C 20/25 V_u [kN]	9.0*)	13.0*)	9.0*)	13.0*)	15.0*)	20.0*)	15.0*)	20.0*)	21.0*)	30.0*)	21.0*)	30.0*)
cracked concrete, temperature range - 40 °C to + 35 °C												
tension load C 20/25 N_u [kN]	14.1		19.0*)	26.0*)	17.6		29.0*)	41.0*)	24.6		43.0*)	59.0*)
C 50/60 N_u [kN]	15.3		19.0*)	26.0*)	19.2		29.0*)	41.0*)	26.8		43.0*)	59.0*)
shear load ≧ C 20/25 V_u [kN]	9.0*)	13.0*)	9.0*)	13.0*)	15.0*)	20.0*)	15.0*)	20.0*)	21.0*)	30.0*)	21.0*)	30.0*)

Anchor type	FIS EM M 16		FIS EM M 16		FIS EM M 20		FIS EM M 20		FIS EM M 24		FIS EM M 24	
	gvz	A4 | C	gvz	A4 | C	gvz	A4 | C	gvz	A4 | C	gvz	A4 | C	gvz	A4 | C
h_{ef} [mm]	80		320		90		400		96		480	
non-cracked concrete, temperature range - 40 °C to + 35 °C												
tension load C 20/25 N_u [kN]	48.3		79.0*)	110.0*)	57.6		123.0*)	172.0*)	63.5		177.0*)	247.0*)
C 50/60 N_u [kN]	74.9		79.0*)	110.0*)	89.3		123.0*)	172.0*)	98.4		177.0*)	247.0*)
shear load ≧ C 20/25 V_u [kN]	39.0*)	55.0*)	39.0*)	55.0*)	61.0*)	86.0*)	61.0*)	86.0*)	89.0*)	124.0*)	89.0*)	124.0*)
cracked concrete, temperature range - 40 °C to + 35 °C												
tension load C 20/25 N_u [kN]	34.5		79.0*)	110.0*)	41.2		123.0*)	172.0*)	45.4		177.0*)	247.0*)
C 50/60 N_u [kN]	40.9		79.0*)	110.0*)	57.5		123.0*)	172.0*)	70.3		177.0*)	247.0*)
shear load ≧ C 20/25 V_u [kN]	39.0*)	55.0*)	39.0*)	55.0*)	61.0*)	82.3*)	61.0*)	86.0*)	89.0*)	90.7	89.0*)	124.0*)

Anchor type	FIS EM M 27		FIS EM M 27		FIS EM M 30		FIS EM M 30	
	gvz	A4 | C	gvz	A4 | C	gvz	A4 | C	gvz	A4 | C
h_{ef} [mm]	108		540		120		600	
non-cracked concrete, temperature range - 40 °C to + 35 °C								
tension load C 20/25 N_u [kN]	75.8		230.0*)	322.0*)	88.7		281.0*)	393.0*)
C 50/60 N_u [kN]	117.4		230.0*)	322.0*)	137.5		281.0*)	393.0*)
shear load ≧ C 20/25 V_u [kN]	115.0*)	151.5	115.0*)	161.0*)	141.0*)	177.5	141.0*)	197.0*)
cracked concrete, temperature range - 40 °C to + 35 °C								
tension load C 20/25 N_u [kN]	54.1		230.0*)	322.0*)	63.4		281.0*)	393.0*)
C 50/60 N_u [kN]	83.9		230.0*)	322.0*)	98.2		281.0*)	393.0*)
shear load ≧ C 20/25 V_u [kN]	108.2		115.0*)	161.0*)	126.8		141.0*)	197.0*)

1) The loads apply to fischer threaded rods with strength classification 5.8, dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details").

*) Steel failure decisive

4

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube\,(150)}$ [N/mm²]	Influence factor $f_{b,p}$ [-]	Influence factor $f_{b,c}$ [-]
C 20/25	20	25	1.00	1.00
C 25/30	25	30	1.02	1.10
C 30/37	30	37	1.04	1.22
C 40/50	40	50	1.07	1.41
C 45/55	45	55	1.08	1.48
C 50/60	50	60	1.09	1.55

fischer Injection mortar FIS EM

Anchor design according to ETA

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [1)]

Characteristic loads

Anchor type		FIS EM M 8		FIS EM M 8		FIS EM M 10		FIS EM M 10		FIS EM M 12		FIS EM M 12	
		gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C
h_{ef}	[mm]	60		160		60		200		70		240	
non-cracked concrete, temperature range - 40 °C to + 35 °C													
tension load	C 20/25 N_{Rk} [kN]	19.0	23.4	19.0	26.0	23.4		29.0	41.0	29.5		43.0	59.0
	C 50/60 N_{Rk} [kN]	19.0	26.0	19.0	26.0	29.0	30.8	29.0	41.0	43.0	43.1	43.0	59.0
shear load	C 20/25 V_{Rk} [kN]	9.0	13.0	9.0	13.0	15.0	20.0	15.0	20.0	21.0	30.0	21.0	30.0
	C 50/60 V_{Rk} [kN]	9.0	13.0	9.0	13.0	15.0	20.0	15.0	20.0	21.0	30.0	21.0	30.0
cracked concrete, temperature range - 40 °C to + 35 °C													
tension load	C 20/25 N_{Rk} [kN]	10.6		19.0	26.0	11.2		29.0	41.0	18.5		43.0	59.0
	C 50/60 N_{Rk} [kN]	11.5		19.0	26.0	14.4		29.0	41.0	20.1		43.0	59.0
shear load	C 20/25 V_{Rk} [kN]	9.0	13.0	9.0	13.0	15.0	20.0	15.0	20.0	21.0	30.0	21.0	30.0
	C 50/60 V_{Rk} [kN]	9.0	13.0	9.0	13.0	15.0	20.0	15.0	20.0	21.0	30.0	21.0	30.0

Anchor type		FIS EM M 16		FIS EM M 16		FIS EM M 20		FIS EM M 20		FIS EM M 24		FIS EM M 24	
		gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C
h_{ef}	[mm]	80		320		90		400		96		480	
non-cracked concrete, temperature range - 40 °C to + 35 °C													
tension load	C 20/25 N_{Rk} [kN]	36.1		79.0	110.0	43.0		123.0	172.0	47.4		177.0	247.0
	C 50/60 N_{Rk} [kN]	55.9		79.0	110.0	66.7		123.0	172.0	73,4		177.0	247.0
shear load	C 20/25 V_{Rk} [kN]	39.0	55.0	39.0	55.0	61.0	86.0	61.0	86.0	89.0	94.8	89.0	124.0
	C 50/60 V_{Rk} [kN]	39.0	55.0	39.0	55.0	61.0	86.0	61.0	86.0	89.0	124.0	89.0	124.0
cracked concrete, temperature range - 40 °C to + 35 °C													
tension load	C 20/25 N_{Rk} [kN]	25.8		79.0	110.0	30.7		123.0	172.0	33.9		177.0	247.0
	C 50/60 N_{Rk} [kN]	30.7		79.0	110.0	43.1		123.0	172.0	52.5		177.0	247.0
shear load	C 20/25 V_{Rk} [kN]	39.0	51.5	39.0	55.0	61.0	61.5	61.0	86.0	67.7		89.0	124.0
	C 50/60 V_{Rk} [kN]	39.0	55.0	39.0	55.0	61.0	86.0	61.0	86.0	89.0	104.9	89.0	124.0

Anchor type		FIS EM M 27		FIS EM M 27		FIS EM M 30		FIS EM M 30	
		gvz	A4 / C	gvz	A4 / C	gvz	A4 / C	gvz	A4 / C
h_{ef}	[mm]	108		540		120		600	
cracked concrete, temperature range - 40 °C to + 35 °C									
tension load	C 20/25 N_{Rk} [kN]	56.6		230.0	322.0	66.3		281.0	393.0
	C 50/60 N_{Rk} [kN]	87.6		230.0	322.0	102.6		281.0	393.0
shear load	C 20/25 V_{Rk} [kN]	113.1		115.0	161.0	132.5		141.0	197.0
	C 50/60 V_{Rk} [kN]	115.0	161.0	115.0	161.0	141.0	197.0	141.0	197.0
non-cracked concrete, temperature range - 40 °C to + 35 °C									
tension load	C 20/25 N_{Rk} [kN]	40.4		230.0	320.6	47.3		281.0	393.0
	C 50/60 N_{Rk} [kN]	62.6		230.0	322.0	73.3		281.0	393.0
shear load	C 20/25 V_{Rk} [kN]	80.8		115.0	161.0	94.6		141.0	197.0
	C 50/60 V_{Rk} [kN]	115.0	125.2	115.0	161.0	141.0	146.6	141.0	197.0

1) The loads apply to fischer threaded rods with strength classification 5.8, dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details“).

Design- and permissible loads see next pages

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [1)]

Design loads

Anchor type		FIS EM M 8			FIS EM M 8			FIS EM M 10			FIS EM M 10			FIS EM M 12			FIS EM M 12		
		gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef}	[mm]	60			160			60			200			70			240		
non-cracked concrete, temperature range - 40 °C to + 35 °C																			
tension load	C 20/25 N_{Rd} [kN]	12.7	13.9	15.6	12.7	13.9	17.3	15.6			19.3	21.9	27.3	19.7			28.7	31.6	39.3
	C 50/60 N_{Rd} [kN]	12.7	13.9	17.3	12.9	13.9	17.3	19.3	20.5		19.3	21.9	27.3	28.7	28.8		28.7	31.6	39.3
shear load	C 20/25 V_{Rd} [kN]	7.2	8.3	10.4	7.2	8.3	10.4	12.0	12.8	16.0	12.0	12.8	16.0	16.8	19.2	24.0	16.8	19.2	24.0
	C 50/60 V_{Rd} [kN]	7.2	8.3	10.4	7.2	8.3	10.4	12.0	12.8	16.0	12.0	12.8	16.0	16.8	19.2	24.0	16.8	19.2	24.0
cracked concrete, temperature range - 40 °C to + 35 °C																			
tension load	C 20/25 N_{Rd} [kN]	7.0			12.7	13.9	17.3	8.8			19.3	21.9	27.3	12.3			28.7	31.6	39.3
	C 50/60 N_{Rd} [kN]	7.7			12.7	13.9	17.3	9.6			19.3	21.9	27.3	13.4			28.7	31.6	39.3
shear load	C 20/25 V_{Rd} [kN]	7.2	8.3	10.4	7.2	8.3	10.4	12.0	12.8	16.0	12.0	12.8	16.0	16.8	19.2	24.0	16.8	19.2	24.0
	C 50/60 V_{Rd} [kN]	7.2	8.3	10.4	7.2	8.3	10.4	12.0	12.8	16.0	12.0	12.8	16.0	16.8	19.2	24.0	16.8	19.2	24.0

4

Anchor type		FIS EM M 16			FIS EM M 16			FIS EM M 20			FIS EM M 20			FIS EM M 24			FIS EM M 24		
		gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef}	[mm]	80			320			90			400			96			480		
non-cracked concrete, temperature range - 40 °C to + 35 °C																			
tension load	C 20/25 N_{Rd} [kN]	20.0			52.7	58.8	73.3	23.9			82.0	92.0	114.7	26.3			118.0	132.1	164.7
	C 50/60 V_{Rd} [kN]	31.0			52.7	58.8	73.3	37.0			82.0	92.0	114.7	40.8			118.0	132.1	164.7
shear load	C 20/25 V_{Rd} [kN]	31.2	35.3	44.0	31.2	35.3	44.0	48.8	55.1	57.4	48.8	55.1	68.8	63.2			71.2	79.5	99.2
	C 50/60 V_{Rd} [kN]	31.2	35.3	44.0	31.2	35.3	44.0	48.8	55.1	68.8	48.8	55.1	68.8	71.2	79.5	97.9	71.2	79.5	99.2
cracked concrete, temperature range - 40 °C to + 35 °C																			
tension load	C 20/25 N_{Rd} [kN]	14.3			52.7	58.8	62.6	17.1			82.0	92.0	97.7	18.8			118.0	132.1	140.7
	C 50/60 V_{Rd} [kN]	17.0			52.7	58.8	68.2	24.0			82.0	92.0	106.5	29.1			118.0	132.1	153.4
shear load	C 20/25 V_{Rd} [kN]	31.2	34.3		31.2	35.3	44.0	41.0			48.8	55.1	68.8	45.1			71.2	79.5	99.2
	C 50/60 V_{Rd} [kN]	31.2	35.3	40.9	31.2	35.3	44.0	48.8	55.1	57.5	48.8	55.1	68.8	69.9			71.2	79.5	99.2

Anchor type		FIS EM M 27			FIS EM M 27			FIS EM M 30			FIS EM M 30		
		gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef}	[mm]	108			540			120			600		
non-cracked concrete, temperature range - 40 °C to + 35 °C													
tension load	C 20/25 N_{Rd} [kN]	31.4			153.3	172.2	214.7	36.8			187.3	210.2	262.0
	C 50/60 V_{Rd} [kN]	48.7			153.3	172.2	214.7	57.0			187.3	210.2	262.0
shear load	C 20/25 V_{Rd} [kN]	75.4			92.0	103.2	128.8	88.3			112.8	126.3	157.6
	C 50/60 V_{Rd} [kN]	92.0	103.2	116.8	92.0	103.2	128.8	112.8	126.3	136.9	112.8	126.3	157.6
cracked concrete, temperature range - 40 °C to + 35 °C													
tension load	C 20/25 N_{Rd} [kN]	22.4			153.3	172.2	178.1	26.3			187.3	210.2	219.9
	C 50/60 V_{Rd} [kN]	34.8			153.3	172.2	194.2	40.7			187.3	210.2	239.7
shear load	C 20/25 V_{Rd} [kN]	53.9			92.0	103.2	128.8	63.1			112.8	126.3	157.6
	C 50/60 V_{Rd} [kN]	83.5			92.0	103.2	128.8	97.8			112.8	126.3	157.6

[1)] The loads apply to fischer threaded rods with strength classification 5.8, dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details").

Permissible loads see next page.

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [1)]

Permissible loads [2)]

Anchor type		FIS EM M 8			FIS EM M 8			FIS EM M 10			FIS EM M 10			FIS EM M 12			FIS EM M 12		
		gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef}	[mm]	60			160			60			200			70			240		
non-cracked concrete, temperature range - 40 °C to + 35 °C																			
tension load	C 20/25 N_{perm} [kN]	9.0	9.9	11.2	9.0	9.9	12.4	11.2			13.8	15.7	19.5	14.1			20.5	22.5	28.1
	C 50/60 N_{perm} [kN]	9.0	9.9	12.4	9.0	9.9	12.4	13.8	14.7		13.8	15.7	19.5	20.5			20.5	22.5	28.1
shear load	C 20/25 V_{perm} [kN]	5.1	6.0	7.4	5.1	6.0	7.4	8.6	9.2	11.4	8.6	9.2	11.4	12.0	13.7	17.1	12.0	13.7	17.1
	C 50/60 V_{perm} [kN]	5.1	6.0	7.4	5.1	6.0	7.4	8.6	9.2	11.4	8.6	9.2	11.4	12.0	13.7	17.1	12.0	13.7	17.1
cracked concrete, temperature range - 40 °C to + 35 °C																			
tension load	C 20/25 N_{perm} [kN]	5.0			9.0	9.9	12.4	6.3			13.8	15.7	19.5	8.8			20.5	22.5	28.1
	C 50/60 N_{perm} [kN]	5.5			9.0	9.9	12.4	6.8			13.8	15.7	19.5	9.6			20.5	22.5	28.1
shear load	C 20/25 V_{perm} [kN]	5.1	6.0	7.4	5.1	6.0	7.4	8.6	9.2	11.4	8.6	9.2	11.4	12.0	13.7	17.1	12.0	13.7	17.1
	C 50/60 V_{perm} [kN]	5.1	6.0	7.4	5.1	6.0	7.4	8.6	9.2	11.4	8.6	9.2	11.4	12.0	13.7	17.1	12.0	13.7	17.1

4

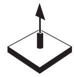
Anchor type		FIS EM M 16			FIS EM M 16			FIS EM M 20			FIS EM M 20			FIS EM M 24			FIS EM M 24		
		gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef}	[mm]	80			320			90			400			96			480		
non-cracked concrete, temperature range - 40 °C to + 35 °C																			
tension load	C 20/25 N_{perm} [kN]	14.3			37.6	42.0	52.4	17.1			58.6	65.7	81.9	18.8			84.3	94.3	117.6
	C 50/60 N_{perm} [kN]	22.2			37.6	42.0	52.4	26.5			58.6	65.7	81.9	29.1			84.3	94.3	117.6
shear load	C 20/25 V_{perm} [kN]	22.3	25.2	31.4	22.3	25.2	31.4	34.9	39.4	41.0	34.9	39.4	49.1	45.1			50.9	56.8	70.9
	C 50/60 V_{perm} [kN]	22.3	25.2	31.4	22.3	25.2	31.4	34.9	39.4	49.1	34.9	39.4	49.1	50.9	56.8	69.9	50.9	56.8	70.9
cracked concrete, temperature range - 40 °C to + 35 °C																			
tension load	C 20/25 N_{perm} [kN]	10.2			37.6	42.0	44.7	12.2			58.6	65.7	69.8	13.4			84.3	94.3	100.5
	C 50/60 N_{perm} [kN]	12.2			37.6	42.0	48.7	17.1			58.6	65.7	76.1	20.8			84.3	94.3	109.6
shear load	C 20/25 V_{perm} [kN]	22.3	24.5		22.3	25.2	31.4	29.3			34.9	39.4	49.1	32.2			50.9	56.8	70.9
	C 50/60 V_{perm} [kN]	22.3	25.2	29.2	22.3	25.2	31.4	34.9	39.4	41.1	34.9	39.4	49.1	50.0			50.9	56.8	70.9

Anchor type		FIS EM M 27			FIS EM M 27			FIS EM M 30			FIS EM M 30		
		gvz	A4	C	gvz	A4	C	gvz	A4	C	gvz	A4	C
h_{ef}	[mm]	108			540			120			600		
non-cracked concrete, temperature range - 40 °C to + 35 °C													
tension load	C 20/25 N_{perm} [kN]	22.4			109.5	123.0	153.3	26.3			133.8	150.1	187.1
	C 50/60 N_{perm} [kN]	34.8			109.5	123.0	153.3	40.7			133.8	150.1	187.1
shear load	C 20/25 V_{perm} [kN]	35.9			65.7	73.7	92.0	63.1			80.6	90.2	112.6
	C 50/60 V_{perm} [kN]	65.7	73.7	83.5	65.7	73.7	92.0	80.6	90.2	97.8	80.6	90.2	112.6
cracked concrete, temperature range - 40 °C to + 35 °C													
tension load	C 20/25 N_{perm} [kN]	16.0			109.5	123.0	127.2	18.8			133.8	150.1	157.1
	C 50/60 N_{perm} [kN]	24.8			109.5	123.0	138.7	29.1			133.8	150.1	171.2
shear load	C 20/25 V_{perm} [kN]	38.5			65.7	73.7	92.0	45.1			80.6	90.2	112.6
	C 50/60 V_{perm} [kN]	59.6			65.7	73.7	92.0	69.8			80.6	90.2	112.6

1) The loads apply to fischer threaded rods with strength classification 5.8, dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details").

2) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type	FIS EM M 8				FIS EM M10				FIS EM M12			
	gvz		A4	C	gvz		A4	C	gvz		A4	C
	5.8	8.8			5.8	8.8			5.8	8.8		
characteristic resistance $N_{Rk,s}$ [kN]	19.0	30.0	26.0	26.0	29.0	47.0	41.0	41.0	43.0	68.0	59.0	59.0
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

Anchor type	FIS EM M16				FIS EM M20				FIS EM M24			
	gvz		A4	C	gvz		A4	C	gvz		A4	C
	5.8	8.8			5.8	8.8			5.8	8.8		
characteristic resistance $N_{Rk,s}$ [kN]	79.0	126.0	110.0	110.0	123.0	196.0	172.0	172.0	177.0	282.0	247.0	247.0
design resistance $N_{Rd,s}$ [kN]	52.7	84.0	58.8	73.3	82.0	130.7	92.0	114.7	118.0	188.0	132.1	164.7

Anchor type	FIS EM M27				FIS EM M30			
	gvz		A4	C	gvz		A4	C
	5.8	8.8			5.8	8.8		
characteristic resistance $N_{Rk,s}$ [kN]	230.0	368.0	322.0	322.0	281.0	449.0	393.0	393.0
design resistance $N_{Rd,s}$ [kN]	153.3	245.3	172.2	214.7	187.3	299.3	210.2	262.0

4.2 Pull-out/pull-through failure for the highest loaded anchor [1)]

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type	FIS EM M 8		FIS EM M 10		FIS EM M 12		FIS EM M 16	
eff. anchorage depth h_{ef} [mm]	60	160	60	200	70	240	80	320
non-cracked concrete, temperature range - 40 °C to + 35 °C								
characteristic resistance $N^0_{Rk,p}$ [kN]	24.1	64.3	28.3	94.2	39.6	135.7	56.3	225.2
Design resistance $N^0_{Rd,p}$ [kN]	16.1	42.9	18.8	62.8	26.4	90.5	31.3	125.1
cracked concrete, temperature range - 40 °C to + 35 °C								
characteristic resistance $N^0_{Rk,p}$ [kN]	10.6	28.1	13.2	44.0	18.5	63.3	28.1	112.6
Design resistance $N^0_{Rd,p}$ [kN]	7.0	18.8	8.8	29.3	12.3	42.2	15.6	62.6

Anchor type	FIS EM M 20		FIS EM M 24		FIS EM M 27		FIS EM M 30	
eff. anchorage depth h_{ef} [mm]	90	400	96	480	108	540	120	600
non-cracked concrete, temperature range - 40 °C to + 35 °C								
characteristic resistance $N^0_{Rk,p}$ [kN]	73.5	326.7	94.1	470.5	119.1	595.5	135.7	678.6
Design resistance $N^0_{Rd,p}$ [kN]	40.8	181.5	52.3	261.4	66.2	330.8	75.4	377.0
cracked concrete, temperature range - 40 °C to + 35 °C								
characteristic resistance $N^0_{Rk,p}$ [kN]	39.6	175.9	50.7	253.3	64.1	320.6	79.2	395.8
Design resistance $N^0_{Rd,p}$ [kN]	22.0	97.7	28.1	140.7	35.6	178.1	44.0	219.9

[1)] The loads apply to fischer threaded rods with strength classification 5.8, dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details").

4.3 Concrete cone failure and splitting for the most unfavourable anchor[1)]

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FIS EM M 8		FIS EM M 10		FIS EM M 12		FIS EM M 16	
eff. anchorage depth	h_{ef}	[mm]	60	160	60	200	70	240	80	320
non-cracked concrete, temperature range - 40 °C to + 35 °C										
characteristic resistance	$N^0_{Rk,c}$	[kN]	23.4	102.0	23.4	142.6	29.5	187.4	36.1	288.5
design resistance	$N^0_{Rd,c}$	[kN]	15.6	68.0	15.6	95.0	19.7	124.9	20.0	160.3
cracked concrete, temperature range - 40 °C to + 35 °C										
characteristic resistance	$N^0_{Rk,c}$	[kN]	16.7	72.9	16.7	101.8	21.1	133.9	25.8	206.1
design resistance	$N^0_{Rd,c}$	[kN]	11.2	48.6	11.2	67.9	14.1	89.2	14.3	114.5

Anchor type			FIS EM M 20		FIS EM M 24		FIS EM M 27		FIS EM M 30	
eff. anchorage depth	h_{ef}	[mm]	90	400	96	480	108	540	120	600
non-cracked concrete, temperature range - 40 °C to + 35 °C										
characteristic resistance	$N^0_{Rk,c}$	[kN]	43.0	403.2	47.4	530.0	56.6	632.4	66.3	740.7
design resistance	$N^0_{Rd,c}$	[kN]	23.9	224.0	26.3	294.5	31.4	351.4	36.8	411.5
cracked concrete, temperature range - 40 °C to + 35 °C										
characteristic resistance	$N^0_{Rk,c}$	[kN]	30.7	288.0	33.9	378.6	40.4	451.7	47.3	529.1
design resistance	$N^0_{Rd,c}$	[kN]	17.1	160.0	18.8	210.3	22.4	251.0	26.3	293.9

[1)] The loads apply to fischer threaded rods with strength classification 5.8, dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details").

Intermediate values for $N^0_{Rd,c}$ depending on $h_{ef,var}$ can be determined according:

$$N^0_{Rd,c\,(h_{ef,var})} = N^0_{Rd,c\,(h_{ef,min})} \cdot \left(\frac{h_{ef,var}}{h_{ef,min}}\right)^{1.5}$$

4

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm] ↓	Influence factor f_s [-]															
	FIS EM M8		FIS EM M10		FIS EM M12		FIS EM M16		FIS EM M20		FIS EM M24		FIS EM M27		FIS EM M30	
h_{ef} [mm]	**60**	**160**	**60**	**200**	**70**	**240**	**80**	**320**	**90**	**400**	**96**	**480**	**108**	**540**	**120**	**600**
40	0.61	0.54														
45	0.63	0.55	0.63	0.54												
55	0.65	0.56	0.65	0.55	0.63	0.54										
65	0.68	0.57	0.68	0.55	0.65	0.55	0.63	0.54								
85	0.74	0.59	0.74	0.57	0.70	0.56	0.68	0.54	0.66	0.54						
105	0.79	0.61	0.79	0.59	0.75	0.57	0.72	0.55	0.69	0.54	0.68	0.54				
120	0.83	0.63	0.83	0.60	0.79	0.58	0.75	0.56	0.72	0.56	0.71	0.54	0.69	0.54		
140	0.89	0.65	0.89	0.62	0.83	0.60	0.79	0.57	0.76	0.56	0.74	0.55	0.72	0.54	0.69	0.54
160	0.94	0.67	0.94	0.63	0.88	0.61	0.83	0.58	0.80	0.57	0.78	0.56	0.75	0.55	0.72	0.54
180	1.00	0.69	1.00	0.65	0.93	0.63	0.88	0.59	0.83	0.58	0.81	0.56	0.78	0.56	0.75	0.55
210		0.72		0.68	1.00	0.65	0.94	0.61	0.89	0.59	0.86	0.57	0.82	0.56	0.79	0.56
240		0.75		0.70		0.67	1.00	0.63	0.94	0.60	0.92	0.58	0.87	0.57	0.83	0.57
270		0.78		0.73		0.69		0.64	1.00	0.61	0.97	0.59	0.92	0.58	0.88	0.58
290		0.80		0.74		0.70		0.65		0.62	1.00	0.60	0.95	0.59	0.90	0.58
325		0.84		0.77		0.73		0.67		0.64		0.61	1.00	0.60	0.95	0.59
360		0.88		0.80		0.75		0.69		0.65		0.63		0.61	1.00	0.60
430		0.95		0.86		0.80		0.72		0.68		0.65		0.63		0.62
480		1.00		0.90		0.83		0.75		0.70		0.67		0.65		0.63
540				0.95		088		0.78		0.73		0.69		0.67		0.65
600				1.00		0.92		0.81		0.75		0.71		0.69		0.67
720						1.00		0.87		0.80		0.75		0.72		0.70
960								1.00		0.90		0.83		0.79		0.77
1200										1.00		0.92		0.87		0.83
1440												1.00		0.94		0.90
1620														1.00		0.95
1800																1.00
s_{min} [mm]	40	40	45	45	55	55	65	65	85	85	105	105	120	120	140	140
$s_{cr,N}$ [mm]	180	480	180	600	210	720	240	960	270	1200	288	1440	324	1620	360	1800

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c [mm] ↓ h_{ef} [mm]	Influence factor f_c [-] FIS EM M8		FIS EM M10		FIS EM M12		FIS EM M16		FIS EM M20		FIS EM M24		FIS EM M27		FIS EM M30	
	60	160	60	200	70	240	80	320	90	400	96	480	108	540	120	600
40	0.60	0.44														
45	0.64	0.45	0.64	0.43												
55	0.71	0.47	0.71	0.45	0.65	0.43										
65	0.79	0.50	0.79	0.47	0.72	0.45	0.66	0.42								
85	0.96	0.55	0.96	0.50	0.85	0.48	0.78	0.44	0.72	0.42						
90	1.00	0.56	1.00	0.51	0.89	0.48	0.81	0.45	0.75	0.43						
105		0.60		0.54	1.00	0.51	0.90	0.47	0.83	0.44	0.79	0.43				
120		0.64		0.57		0.53	1.00	0.48	0.91	0.46	0.87	0.44	0.80	0.43		
135		0.68		0.61		0.56		0.50	1.00	0.47	0.95	0.45	0.87	0.44		
140		0.69		0.62		0.57		0.51		0.47	0.98	0.45	0.89	0.44	0.83	0.43
165		0.76		0.67		0.61		0.54		0.50		0.47	1.00	0.46	0.93	0.45
180		0.81		0.70		0.64		0.56		0.51		0.48		0.47	1.00	0.46
200		0.87		0.75		0.67		0.58		0.53		0.50		0.48		0.47
220		0.93		0.80		0.71		0.61		0.55		0.52		0.50		0.48
240		1.00		0.85		0.75		0.64		0.57		0.53		0.51		0.49
270				0.92		0.81		0.68		0.61		0.56		0.53		0.51
300				1.00		0.87		0.72		0.64		0.58		0.56		0.53
360						1.00		0.81		0.70		0.64		0.60		0.57
420								0.91		0.78		0.69		0.65		0.62
480								1.00		0.85		0.75		0.70		0.67
600										1.00		0.88		0.81		0.76
660												0.94		0.87		0.81
720												1.00		0.92		0.86
810														1.00		0.93
900																1.00
c_{min} [mm]	40	40	45	45	55	55	65	65	85	85	105	105	120	120	140	140
$c_{cr,N}$ [mm]	90	240	90	300	105	360	120	480	135	600	144	720	167	810	180	900

Intermediate values by linear interpolation.

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s	Influence factor $f_{s,sp}$ [-]															
[mm]	FIS EM M8		FIS EM M10		FIS EM M12		FIS EM M16		FIS EM M20		FIS EM M24		FIS EM M27		FIS EM M30	
↓ h_{ef} [mm]	60	160	60	200	70	240	80	320	90	400	96	480	108	540	120	600
40	0.57	0.53														
45	0.58	0.53	0.58	0.52												
55	0.60	0.54	0.60	0.53	0.59	0.53										
65	0.62	0.54	0.62	0.54	0.60	0.53	0.59	0.52								
85	0.66	0.56	0.66	0.55	0.63	0.54	0.62	0.53	0.60	0.52						
105	0.69	0.57	0.69	0.56	0.67	0.55	0.65	0.54	0.63	0.53	0.62	0.52				
120	0.72	0.58	0.72	0.57	0.69	0.56	0.67	0.54	0.65	0.53	0.64	0.53	0.62	0.52		
140	0.76	0.60	0.76	0.58	0.72	0.56	0.69	0.55	0.67	0.54	0.66	0.53	0.64	0.53	0.63	0.53
160	0.79	0.61	0.79	0.59	0.75	0.57	0.72	0.56	0.70	0.54	0.68	0.54	0.66	0.53	0.65	0.53
175	0.82	0.62	0.82	0.60	0.78	0.58	0.74	0.56	0.72	0.55	0.70	0.54	0.68	0.54	0.66	0.53
190	0.85	0.63	0.85	0.61	0.80	0.59	0.76	0.57	0.73	0.55	0.72	0.54	0.69	0.54	0.68	0.54
270	1.00	0.69	1.00	0.65	0.93	0.62	0.87	0.59	0.83	0.57	0.81	0.56	0.78	0.56	0.75	0.55
315		0.72		0.67	1.00	0.65	0.94	0.61	0.89	0.59	0.86	0.57	0.82	0.56	0.79	0.56
355		0.75		0.70		0.66	0.99	0.62	0.94	0.60	0.90	0.58	0.86	0.57	0.82	0.56
405		0.78		0.72		0.69		0.64	1.00	0.61	0.96	0.59	0.91	0.58	0.87	0.57
430		0.80		0.74		0.70		0.65		0.62	1.00	0.60	0.94	0.59	0.90	0.58
485		0.83		0.77		0.72		0.67		0.63		0.61	1.00	0.60	0.95	0.59
540		0.87		0.80		0.75		0.68		0.65		0.62		0.61	0.99	0.60
725		1.00		0.90		0.83		0.75		0.70		0.67		0.65		0.63
895				1.00		0.91		0.81		0.75		0.71		0.68		0.66
1020						0.97		0.85		0.78		0.74		0.71		0.69
1080						1.00		0.87		0.80		0.75		0.72		0.70
1180								0.91		0.83		0.77		0.74		0.72
1280								0.94		0.86		0.79		0.76		0.74
1380								0.98		0.88		0.82		0.78		0.75
1445								1.00		0.90		0.83		0.80		0.77
1810										1.00		0,92		0.87		0.83
2170												1.00		0.95		0.90
2440														1.00		0.95
2715																1.00
s_{min} [mm]	40	40	45	45	55	55	65	65	85	85	105	105	120	120	140	140
$s_{cr,sp}$ [mm]	272	724	272	904	316	1084	362	1446	406	1808	434	2170	488	2440	542	2712

Intermediate values by linear interpolation.

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4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s^2_{cr,sp}}$$

Spacing s [mm] ↓	Influence factor $f_{s,sp}$ [-]															
	FIS EM M8		FIS EM M10		FIS EM M12		FIS EM M16		FIS EM M20		FIS EM M24		FIS EM M27		FIS EM M30	
h_{ef} [mm]	60	160	60	200	70	240	80	320	90	400	96	480	108	540	120	600
40	0.51	0.41														
45	0.53	0.41	0.53	0.40												
55	0.58	0.43	0.58	0.41	0.54	0.40										
65	0.62	0.44	0.62	0.43	0.58	0.41	0.55	0.40								
85	0.72	0.48	0.72	0.45	0.66	0.43	0.62	0.41	0.59	0.40						
105	0.83	0.51	0.83	0.47	0.75	0.45	0.69	0.43	0.65	0.41	0.63	0.40				
120	0.91	0.53	0.91	0.49	0.82	0.47	0.75	0.44	0.70	0.42	0.67	0.41	0.63	0.40		
135	0.99	0.56	0.99	0.51	0.89	0.48	0.81	0.45	0.75	0.43	0.72	0.41	0.67	0.41		
140		0.57		0.52	0.91	0.49	0.83	0.45	0.77	0.43	0.74	0.42	0.69	0.41	0.65	0.40
160		0.60		0.55	1.00	0.51	0.91	0.47	0.84	0.44	0.80	0.43	0.74	0.42	0.70	0.41
180		0.64		0.57		0.53	1.00	0.48	0.91	0.46	0.87	0.44	0.80	0.43	0.75	0.42
205		0.68		0.61		0.56		0.50	1.00	0.47	0.96	0.45	0.88	0.44	0.81	0.43
220		0.71		0.63		0.58		0.52		0.48	1.00	0.46	0.92	0.45	0.85	0.44
245		0.76		0.67		0.61		0.54		0.50		0.47	1.00	0.46	0.92	0.45
270		0.81		0.70		0.64		0.56		0.52		0.48		0.47	1.00	0.46
300		0.87		0.75		0.68		0.59		0.54		0.50		0.48		0.47
330		0.93		0.80		0.71		0.61		0.56		0.52		0.50		0.48
365		1.00		0.85		0.75		0.64		0.58		0.54		0.52		0.50
400				0.91		0.80		0.68		0.60		0.55		0.53		0.51
425				0.95		0.83		0.70		0.62		0.57		0.54		0.52
455				1.00		0.88		0.72		0.64		0.59		0.56		0.54
500						0.94		0.77		0.68		0.61		0.58		0.55
545						1.00		0.81		0.71		0.64		0.61		0.58
620								0.89		0.77		0.68		0.64		0.61
660								0.93		0.79		0.71		0.66		0.63
725								1.00		0.85		0.75		0.70		0.66
905										1.00		0.87		0.81		0.75
1190												1.00		0.98		0.91
1220														1.00		0.92
1360																1.00
c_{min} [mm]	40	40	45	45	55	55	65	65	85	85	105	105	120	120	140	140
$c_{cr,sp}$ [mm]	136	362	136	452	158	542	181	723	203	904	217	1085	244	1220	271	1356

Intermediate values by linear interpolation.

fischer Injection mortar FIS EM

Anchor design according to ETA

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{\frac{2}{3}} \leq \left(\frac{2 \cdot h_{ef}}{h_{min}}\right)^{\frac{2}{3}}$$

Thickness h	Influence factor f_h [-]															
[mm]	FIS EM M8		FIS EM M10		FIS EM M12		FIS EM M16		FIS EM M20		FIS EM M24		FIS EM M27		FIS EM M30	
↓ h_{ef} [mm]	60	160	60	200	70	240	80	320	90	400	96	480	108	540	120	600
100	1.00		1.00		1.00											
105	1.03		1.03		1.03											
110	1.07		1.07		1.07											
120	1.13		1.13		1.13		1.02									
125					1.16		1.05									
135					1.22		1.11									
145							1.16		1.03							
155							1.21		1.08		1.02					
165									1.13		1.06					
175									1.17		1.11		1.04			
185											1.15		1.07			
195		1.02											1.11		1.02	
205		1.05											1.15		1.06	
215		1.09													1.09	
225		1.12													1.13	
235		1.15		1.01											1.16	
245		1.18		1.04												
255		1.22		1.07												
275		1.28		1.13		1.01										
295		1.34		1.18		1.06										
315		1.40		1.23		1.11										
335				1.28		1.15										
365				1.36		1.22		1.02								
385				1.41		1.27		1.05								
425						1.35		1.13								
465						1.44		1.19		1.03						
505								1.26		1.08						
535								1.32		1.13		1.00				
615								1.44		1.24		1.10		1.02		
625								1.46		1.25		1.11		1.03		
675										1.32		1.17		1.08		1.01
785										1.45		1.29		1.20		1.11
835												1.35		1.25		1.16
935												1.45		1.35		1.25
1035														1.44		1.34
1185																1.46
h_{min} [mm]	100	190	100	230	100	270	116	356	138	448	152	536	168	600	190	670
h_{ef} [mm]	60	160	60	200	70	240	80	320	90	400	96	480	108	540	120	600

Intermediate values by linear interpolation.

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5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type	FIS EM M 8				FIS EM M10				FIS EM M12			
	gvz		A4	C	gvz		A4	C	gvz		A4	C
	5.8	8.8			5.8	8.8			5.8	8.8		
characteristic resistance $V_{Rk,s}$ [kN]	9.0	15.0	13.0	13.0	15.0	23.0	20.0	20.0	21.0	34.0	30.0	30.0
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

Anchor type	FIS EM M16				FIS EM M20				FIS EM M24			
	gvz		A4	C	gvz		A4	C	gvz		A4	C
	5.8	8.8			5.8	8.8			5.8	8.8		
characteristic resistance $V_{Rk,s}$ [kN]	39.0	63.0	55.0	55.0	61.0	98.0	86.0	86.0	89.0	141.0	124.0	124.0
design resistance $V_{Rd,s}$ [kN]	31.2	50.4	35.3	44.0	48.8	78.4	55.1	68.6	71.2	112.8	79.5	99.2

Anchor type	FIS EM M27				FIS EM M30			
	gvz		A4	C	gvz		A4	C
	5.8	8.8			5.8	8.8		
characteristic resistance $V_{Rk,s}$ [kN]	115.0	184.0	161.0	161.0	141.0	225.0	197.0	197.0
design resistance $V_{Rd,s}$ [kN]	92.0	147.2	103.2	128.8	112.8	180.0	126.3	157.6

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5.2 Pryout-failure for the most unfavourable anchor [1)]

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot f_s \cdot f_c \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type	FIS EM M 8		FIS EM M 10		FIS EM M 12		FIS EM M 16	
eff. anchorage depth h_{ef} [mm]	60	160	60	200	70	240	80	320
non-cracked concrete, temperature range - 40 °C to + 35 °C								
characteristic resistance $N^0_{Rk,cp}$ (c) [kN]	23.4	102.0	23.4	142.6	29.5	187,4	36,1	288,5
design resistance $N^0_{Rd,cp}$ (c) [kN]	15.6	68.0	15.6	95.0	19.7	124,9	24,0	192,3
characteristic resistance $N^0_{Rk,cp}$ (p) [kN]	24.1	64.3	28.3	94.2	39.6	135,7	56,3	225,2
design resistance $N^0_{Rd,cp}$ (p) [kN]	16.1	42.9	18.8	62.8	26.4	90,5	37,5	150,1
cracked concrete, temperature range - 40 °C to + 35 °C								
characteristic resistance $N^0_{Rk,cp}$ (c) [kN]	16.7	72.9	16.7	101.8	21.1	133,9	25,8	206,1
design resistance $N^0_{Rd,cp}$ (c) [kN]	11.2	48.6	11.2	67.9	14.1	89,2	17,2	137,4
characteristic resistance $N^0_{Rk,cp}$ (p) [kN]	10.6	28.1	13.2	44.0	18.5	63,3	28,1	112,6
design resistance $N^0_{Rd,cp}$ (p) [kN]	7.0	18.8	8.8	29.3	12.3	42,2	18,8	75,1

1) The loads apply to fischer threaded rods with strength classification 5.8, dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details").

2) Intermediate values for $N^0_{Rd,cp}$ (p) depending on $h_{ef,var}$ can be determined by linear interpolation.

3) Intermediate values for $N^0_{Rd,cp}$ (c) depending on $h_{ef,var}$ can be determined according: $N^0_{Rd,cp\,(c)\,(h_{ef,var})} = N^0_{Rd,cp\,(c)\,(h_{ef,min})} \cdot \left(\frac{h_{ef,var}}{h_{ef,min}}\right)^{1.5}$

continued next page

fischer Injection mortar FIS EM

Anchor design according to ETA

Anchor type			FIS EM M 20		FIS EM M 24		FIS EM M 27		FIS EM M 30	
eff. anchorage depth	h_{ef}	[mm]	90	400	96	480	108	540	120	600
non-cracked concrete, temperature range - 40 °C to + 35 °C										
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	43,0	403,2	47.7	530.0	55.6	632.4	66.3	740.7
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	28,7	268,8	31.6	353.3	37.7	421.6	44.2	493.8
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	73,5	326,7	94.1	470.5	119.1	595.5	135.7	678.6
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	49,0	217,8	62.7	313.7	79.4	397.0	90.5	452.4
cracked concrete, temperature range - 40 °C to + 35 °C										
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	30,7	288,0	33.9	378.6	40.4	451.7	47.3	529.1
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	20,5	192,0	22.6	252.4	26.9	301.2	31.5	352.7
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	39,6	175,9	50.7	253.3	64.1	320.6	79.2	395.8
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	26,4	117,3	33.8	168.9	42.8	213.8	52.8	263.9

[1] The loads apply to fischer threaded rods with strength classification 5.8, dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details").

[2] Intermediate values for $N^0_{Rd,cp}$ (p) depending on $h_{ef,var}$ can be determined by linear interpolation.

[3] Intermediate values for $N^0_{Rd,cp}$ (c) depending on $h_{ef,var}$ can be determined according: $N^0_{Rd,cp\,(c)\,(h_{ef,var})} = N^0_{Rd,cp\,(c)\,(h_{ef,min})} \cdot \left(\frac{h_{ef,var}}{h_{ef,min}}\right)^{1.5}$

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5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor [1]

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,V} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

Anchor type			FIS EM M 8		FIS EM M 10		FIS EM M 12		FIS EM M 16	
			60	**160**	**60**	**200**	**70**	**240**	**80**	**320**
non-cracked concrete, temerature range - 40 °C to + 35 °C										
minimum edge distance	c_{min}	[mm]	40	40	45	45	55	55	65	65
characteristic resistance	$V^0_{Rk,c}$	[kN]	5.3	6.6	6.4	8.7	8.9	12.3	11.9	18.0
design resistance	$V^0_{Rd,c}$	[kN]	3.5	4.4	4.3	5.8	5.9	8.2	7.9	12.0
cracked concrete, temerature range - 40 °C to + 35 °C										
minimum edge distance	c_{min}	[mm]	40	40	45	45	55	55	65	65
characteristic resistance	$V^0_{Rk,c}$	[kN]	3.7	4.7	4.5	6.2	6.3	8.7	8.4	12.7
design resistance	$V^0_{Rd,c}$	[kN]	2.5	3.1	3.0	4.1	4.2	5.8	5.6	8.5

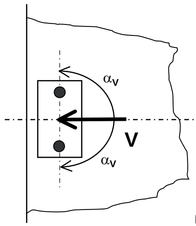
Anchor type			FIS EM M 20		FIS EM M 24		FIS EM M 27		FIS EM M 30	
			90	**400**	**96**	**480**	**108**	**540**	**120**	**600**
non-cracked concrete, temerature range - 40 °C to + 35 °C										
minimum edge distance	c_{min}	[mm]	85	85	105	105	120	120	140	140
characteristic resistance	$V^0_{Rk,c}$	[kN]	17.9	28.2	24.6	40.3	30.5	50.6	38.7	64.3
design resistance	$V^0_{Rd,c}$	[kN]	12.0	18.8	16.4	26.9	20.3	33.7	25.8	42.9
cracked concrete, temerature range - 40 °C to + 35 °C										
minimum edge distance	c_{min}	[mm]	85	85	105	105	120	120	140	140
characteristic resistance	$V^0_{Rk,c}$	[kN]	12.7	20.0	17.4	28.6	21.6	35.9	27.4	45.6
design resistance	$V^0_{Rd,c}$	[kN]	8.5	13.3	11.6	19.0	14.4	23.9	18.3	30.4

[1] The loads apply to fischer threaded rods with strength classification 5.8, dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details").
Intermediate values by linear interpolation.

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 **Single anchor** influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$

$$f_{sc,V}^{\;n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$

$$f_{sc,V}^{\;n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\;n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 Anchor pair influenced only by one edge

for concrete thickness h ≧ 1.5 · c
and spacing **s ≦ 3 · c**

$$f_{sc,V}^{\;n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for s > 3 · c

$$f_{sc,V}^{\;n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c
and spacing **s ≦ 4.5 · h**

$$f_{sc,V}^{\;n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for s > 4.5 · h

$$f_{sc,V}^{\;n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\;n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2,89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

6. Summary of required proof:

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

6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = **lowest value of** $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

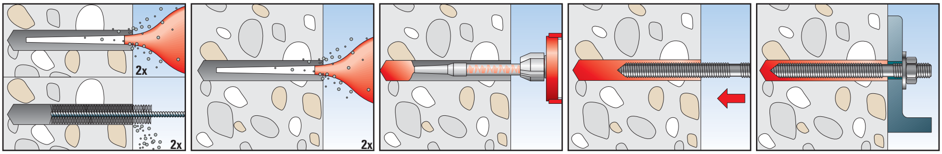
$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leq 1.2$$

N^h_{Sd} ; V^h_{Sd} = **tension/shear components of the load for single anchor**

N_{Rd} ; V_{Rd} = **design resistance including safety factors**

4

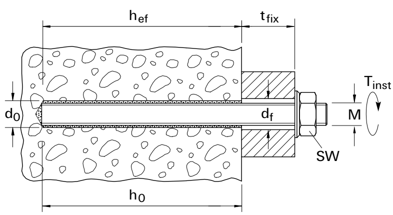
7. Installation details



8. Anchor characteristics

Anchor type			FIS EM M 8		FIS EM M 10		FIS EM M 12		FIS EM M 16	
	h_{ef}	[mm]	60	160	60	200	70	240	80	320
diameter of thread			M 8		M 10		M 12		M 16	
nominal drill hole diameter	d_0	[mm]	12	12	14	14	14	14	18	18
drill depth	h_0	[mm]	60	160	60	200	70	240	80	320
clearance-hole in fixture to be attached	d_f	[mm]	≦ 9	≦9	≦ 12	≦ 12	≦ 14	≦ 14	≦ 18	≦ 18
wrench size	SW	[mm]	13	13	17	17	19	19	24	24
required torque	T_{inst}	[Nm]	10	10	20	20	40	40	60	60
minimum thickness of concrete member	h_{min}	[mm]	100	190	100	230	100	270	116	356
minimum spacing	s_{min}	[mm]	40	40	45	45	55	55	65	65
minimum edge distances	c_{min}	[mm]	40	40	45	45	55	55	65	65
mortar filling quantity		[scale units]	3	8	4	13	4	13	5	21

Anchor type			FIS EM M 20		FIS EM M 24		FIS EM M 27		FIS EM M 30	
	h_{ef}	[mm]	90	400	96	480	108	540	120	600
diameter of thread			M 20		M 24		M 27		M 30	
nominal drill hole diameter	d_0	[mm]	24	24	28	28	30	30	35	35
drill depth	h_0	[mm]	90	400	96	480	108	540	120	600
clearance-hole in fixture to be attached	d_f	[mm]	≦ 22	≦ 22	≦ 26	≦ 26	≦ 30	≦ 30	≦ 33	≦ 33
wrench size	SW	[mm]	30	30	36	36	41	41	46	46
required torque	T_{inst}	[Nm]	120	120	150	150	200	200	300	300
minimum thickness of concrete member	h_{min}	[mm]	138	448	152	536	168	600	190	670
minimum spacing	s_{min}	[mm]	85	85	105	105	120	120	140	140
minimum edge distances	c_{min}	[mm]	85	85	105	105	120	120	140	140
mortar filling quantity		[scale units]	11	53	15	75	17	81	28	139



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9. Gelling and curing times

Cartridge temperature (mortar)	Gelling time FIS EM	Temperature at anchoring base	Curing time FIS EM
– 5 °C – + 5 °C	4 h	– 5 °C – + 5 °C	80 h
+ 5 °C – + 10 °C	2 h	+ 5 °C – + 10 °C	40 h
+ 10 °C – + 20 °C	30 min.	+ 10 °C – + 20 °C	18 h
+ 20 °C – + 30 °C	14 min.	+ 20 °C – + 30 °C	10 h
+ 30 °C – + 40 °C	7 min.	+ 30 °C – + 40 °C	5 h

The above times apply from the moment of contact between resin and hardener in the static mixer.
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 should be replaced.

10. Mechanical characteristics

Anchor type			FIS EM M 8				FIS EM M10				FIS EM M12			
			gvz		A4	C	gvz		A4	C	gvz		A4	C
			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			
resisting moment anchor rod	W	[mm²]	31.2				62.3				109.2			
yield strength anchor rod	f_y	[N/mm²]	420	640	450	560	420	640	450	560	420	540	450	560
tensile strength anchor rod	f_u	[N/mm²]	520	800	700	700	520	800	700	700	520	800	700	700

Anchor type			FIS EM M16				FIS EM M20				FIS EM M24			
			gvz		A4	C	gvz		A4	C	gvz		A4	C
			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			
resisting moment anchor rod	W	[mm²]	277.5				540.9				935.5			
yield strength anchor rod	f_y	[N/mm²]	420	640	450	560	420	640	450	560	420	640	450	560
tensile strength anchor rod	f_u	[N/mm²]	520	800	700	700	520	800	700	700	520	800	700	700

Anchor type			FIS EM M27				FIS EM M30			
			gvz		A4	C	gvz		A4	C
			5.8	8.8			5.8	8.8		
stressed cross sectional area anchor rod	A_s	[mm²]	459.0				561.0			
resisting moment anchor rod	W	[mm²]	1387.0				1874.2			
yield strength anchor rod	f_y	[N/mm²]	420	640	450	560	420	640	450	560
tensile strength anchor rod	f_u	[N/mm²]	520	800	700	700	520	800	700	700

fischer Injection mortar FIS EM with RG MI

Anchor design according to ETA

1. Types

RG MI – Internal-threaded anchor (gvz)

RG MI A4 – Internal-threaded anchor (A4)

FIS EM - Injection mortar FIS EM 390 S, FIS EM 1100 S

4

European Technical Approval – Option 1 for cracked concrete

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval option 1.
- Very good bonding of the mortar ensures high loads in concrete.
- Suitable for underwater installations.
- Suitable for diamond drilled holes guarantees highest flexibility on site.
- Longer curing time for simple installation.
- Low shrinkage of the mortar.

Materials

Internal-threaded anchor: Carbon steel grade 5.8, zinc plated (5 µm) and passivated (gvz)
Stainless steel of the corrosion resistance class III, e.g. A4

Injection mortar: Epoxy resin, cement and hardener

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

Mean values

Anchor type				FIS EM RG M 8 I		FIS EM RG M 10 I		FIS EM RG M 12 I		FIS EM RG M 16 I		FIS EM RG M 20 I	
				gvz[1]	A4	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4
non-cracked concrete, temperature range - 40 °C to + 50 °C													
tension load	C 20/25	N_u	[kN]	19.0*)	27.0*)	29.0*)	41.0*)	43.0*)	59.0*)	79.0*)	110.0*)	123.0*)	172.0*)
	C 50/60	N_u	[kN]	19.0*)	27.0*)	29.0*)	41.0*)	43.0*)	59.0*)	79.0*)	110.0*)	123.0*)	172.0*)
shear load	≧ C 20/25	V_u	[kN]	9.2*)	12.8*)	14.5*)	20.3*)	21.1*)	29.5*)	39.2*)	54.8*)	62.0*)	86.0*)
cracked concrete concrete, temperature range - 40 °C to + 50 °C													
tension load	C 20/25	N_u	[kN]	19.0*)	26.7	29.0*)	33.3	43.0*)	53.3	79.0*)	80.0	123.0*)	126.7
	C 50/60	N_u	[kN]	19.0*)	27.0*)	29.0*)	36.3*)	44.0*)	58.1	79.0*)	87.2	123.0*)	138.1
shear load	≧ C 20/25	V_u	[kN]	9.2*)	12.8*)	14.5*)	20.3*)	21.5*)	29.5*)	39.2*)	54.8*)	62.0*)	86.0*)

*) Steel failure decisive

1) The values apply to screws with the strength classification 5.8

2) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 72°C (see also „Installation details").

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube\,(150)}$ [N/mm²]	Influence factor $f_{b,p}$ [-]	Influence factor $f_{b,c}$ [-]
C 20/25	20	25	1.00	1.00
C 25/30	25	30	1.04	1.10
C 30/37	30	37	1.10	1.22
C 40/50	40	50	1.21	1.41
C 45/55	45	55	1.26	1.48
C 50/60	50	60	1.30	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [3]

Characteristic loads

Anchor type				FIS EM RG M 8 I		FIS EM RG M 10 I		FIS EM RG M 12 I		FIS EM RG M 16 I		FIS EM RG M 20 I	
				gvz[1]	A4	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4
non-cracked concrete, temperature range - 40 °C to + 50 °C													
tension load	C 20/25	N_{Rk}	[kN]	19.0	27.0	29.0	41.0	43.0	59.0	79.0	102.4	123.0	143.1
	C 50/60	N_{Rk}	[kN]	19.0	27.0	29.0	41.0	43.0	59.0	79.0	110.0	123.0	172.0
shear load	≥ 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
cracked concrete concrete, temperature range - 40 °C to + 50 °C													
tension load	C 20/25	N_{Rk}	[kN]	19.0	26.7	25.0		40.0		60.0		95.0	
	C 50/60	N_{Rk}	[kN]	19.0	26.7	27.3		43.0	43.6	65.4		103.6	
shear load	≥ 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

Design loads

Anchor type				FIS EM RG M 8 I		FIS EM RG M 10 I		FIS EM RG M 12 I		FIS EM RG M 16 I		FIS EM RG M 20 I	
				gvz[1]	A4	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4	gvz[1]	A4
non-cracked concrete, temperature range - 40 °C to + 50 °C													
tension load	C 20/25	N_{Rd}	[kN]	12.7	14.4	19.3	21.9	28.7	31.6	52.7	56.9	79.5	
	C 50/60	N_{Rd}	[kN]	12.7	14.4	19.3	21.9	28.7	31.6	52.7	58.8	82.0	92.0
shear load	≥ 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
cracked concrete concrete, temperature range - 40 °C to + 50 °C													
tension load	C 20/25	N_{Rd}	[kN]	12.7	13.3	16.7		26.7		33.3		52.8	
	C 50/60	N_{Rd}	[kN]	12.7	14.4	18.2		28.7	29.1	36.3		57.5	
shear load	≥ 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

Permissible loads see next page.

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [3)]

Permissible loads [2)]

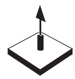
Anchor type				FIS EM RG M 8 I		FIS EM RG M 10 I		FIS EM RG M 12 I		FIS EM RG M 16 I		FIS EM RG M 20 I	
				gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4	gvz[1)]	A4
non-cracked concrete, temperature range - 40 °C to + 50 °C													
tension load	C 20/25	N_{perm}	[kN]	9.0	10.3	13.8	15.7	20.5	22.5	37.6	40.6	56.8	
	C 50/60	N_{perm}	[kN]	9.0	10.3	13.8	15.7	20.5	22.5	37.6	42.0	58.6	65.7
shear load	≧ C 20/25	V_{perm}	[kN]	5.3	5.9	8.3	9.3	12.1	13.5	22.4	25.1	35.4	39.4
cracked concrete concrete, temperature range - 40 °C to + 50 °C													
tension load	C 20/25	N_{perm}	[kN]	9.0	9.5	11.9		19.0		23.8		37.7	
	C 50/60	N_{perm}	[kN]	9.0	10.3	13.0		20.5	20.8	26.0		41.1	
shear load	≧ C 20/25	V_{perm}	[kN]	5.3	5.9	8.3	9.3	12.1	13.5	22.4	25.1	35.4	39.4

1) The values apply to screws with the strength classification 5.8

2) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

3) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 72°C (see also „Installation details").

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			FIS EM RG M 8 I			FIS EM RG M 10 I			FIS EM RG M 12 I			FIS EM RG M 16 I			FIS EM RG M 20 I		
			gvz		A4	gvz		A4	gvz		A4	gvz		A4	gvz		A4
			5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8	
characteristic resistance	$N_{Rk,s}$	[kN]	19.0	27.0	27.0	29.0	47.0	41.0	43.0	68.0	59.0	79.0	108.0	110.0	123.0	179.0	172.0
design resistance	$N_{Rd,s}$	[kN]	12.7	18.0	14.4	19.3	31.3	21.9	28.7	45.3	31.6	52.7	72.0	58.8	82.0	119.3	92.0

4.2 Pull-out/pull-through failure for the highest loaded anchor [1)]

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FIS EM RG M 8 I	FIS EM RG M 10 I	FIS EM RG M 12 I	FIS EM RG M 16 I	FIS EM RG M 20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
non-cracked concrete, temperature range - 40 °C to + 50 °C							
characteristic resistance	$N^0_{Rk,p}$	[kN]	40.0	50.0	75.0	115.0	170.0
Design resistance	$N^0_{Rd,p}$	[kN]	26.7	33.3	50.0	63.9	94.4
cracked concrete concrete, temperature range - 40 °C to + 50 °C							
characteristic resistance	$N^0_{Rk,p}$	[kN]	20.0	25.0	40.0	60.0	95.0
Design resistance	$N^0_{Rd,p}$	[kN]	13.3	16.7	26.7	33.3	52.8

1) The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 72°C (see also „Installation details").

fischer Injection mortar FIS EM with RG MI

Anchor design according to ETA

4.3 Concrete cone failure and splitting for the most unfavourable anchor [1)]

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FIS EM RG M 8 I	FIS EM RG M 10 I	FIS EM RG M 12 I	FIS EM RG M 16 I	FIS EM RG M 20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
non-cracked concrete, temperature range - 40 °C to + 50 °C							
characteristic resistance	$N^0_{Rk,c}$	[kN]	43.2	43.2	70.7	102.4	143.1
design resistance	$N^0_{Rd,c}$	[kN]	28.8	28.8	47.1	56.9	79.5
cracked concrete concrete, temperature range - 40 °C to + 50 °C							
characteristic resistance	$N^0_{Rk,c}$	[kN]	30.7	30.7	50.3	72.9	101.8
design resistance	$N^0_{Rd,c}$	[kN]	20.5	20.5	33.5	40.5	56.6

[1)] The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar $T \leqq +72°C$ (see also „Installation details").

4

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm]		Influence factor f_s [-] FIS EM RG M 8 I	FIS EM RG M 10 I	FIS EM RG M 12 I	FIS EM RG M 16 I	FIS EM RG M 20 I
40		0.57				
45		0.58	0.58			
55		0.60	0.60	0.57		
65		0.62	0.62	0.59	0.57	
90		0.67	0.67	0.62	0.59	0.58
125		0.73	0.73	0.67	0.63	0.60
150		0.78	0.78	0.70	0.66	0.63
200		0.87	0.87	0.77	0.71	0.67
250		0.96	0.96	0.83	0.76	0.71
270		1.00	1.00	0.86	0.78	0.73
330				0.94	0.84	0.78
375				1.00	0.89	0.81
430					0.95	0.86
480					1.00	0.90
540						0.95
600						1.00
s_{min}	[mm]	40	45	55	65	90
$s_{cr,N}$	[mm]	270	270	375	480	600

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c [mm]	Influence factor f_c [-] FIS EM RG M 8 I	FIS EM RG M 10 I	FIS EM RG M 12 I	FIS EM RG M 16 I	FIS EM RG M 20 I
40	0.51				
45	0.53	0.53			
55	0.58	0.58	0.51		
65	0.63	0.63	0.54	0.50	
90	0.75	0.75	0.62	0.56	0.51
125	0.94	0.94	0.75	0.65	0.58
135	1.00	1.00	0.79	0.68	0.61
150			0.85	0.72	0.64
170			0.93	0.78	0.68
190			1.00	0.84	0.73
200				0.87	0.75
220				0.93	0.80
240				1.00	0.85
300					1.00
c_{min} [mm]	40	45	55	65	90
$c_{cr,N}$ [mm]	135	135	198	240	270

Intermediate values by linear interpolation.

4

4.3.2 Concrete splitting
4.3.2.1 Influence of spacing

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

Spacing s [mm]	Influence factor $f_{s,sp}$ [-] FIS EM RG M 8 I	FIS EM RG M 10 I	FIS EM RG M 12 I	FIS EM RG M 16 I	FIS EM RG M 20 I
40	0.55				
45	0.56	0.56			
55	0.57	0.57	0.55		
65	0.58	0.58	0.56	0.54	
90	0.61	0.61	0.58	0.56	0.55
125	0.65	0.65	0.61	0.59	0.57
150	0.68	0.68	0.63	0.60	0.58
200	0.75	0.75	0.68	0.64	0.61
300	0.88	0.88	0.77	0.71	0.67
405	1.00	1.00	0.86	0.78	0.72
515			0.95	0.86	0.78
565			1.00	0.89	0.81
600				0.92	0.83
725				1.00	0.90
815					0.95
905					1.00
s_{min} [mm]	40	45	55	65	90
$s_{cr,sp}$ [mm]	406	406	566	724	904

Intermediate values by linear interpolation.

fischer Injection mortar FIS EM with RG MI

Anchor design according to ETA

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c [mm]	Influence factor $f_{c,sp}$ [-] FIS EM RG M 8 I	FIS EM RG M 10 I	FIS EM RG M 12 I	FIS EM RG M 16 I	FIS EM RG M 20 I
40	0.45				
45	0.47	0.47			
55	0.50	0.50	0.45		
65	0.53	0.53	0.47	0.44	
90	0.60	0.60	0.52	0.48	0.46
125	0.71	0.71	0.60	0.54	0.50
150	0.80	0.80	0.66	0.58	0.53
205	1.00	1.00	0.79	0.68	0.61
285			1.00	0.84	0.72
325				0.92	0.79
365				1.00	0.85
405					0.92
452					1.00
c_{min} [mm]	40	45	55	60	90
$c_{cr,sp}$ [mm]	203	203	283	362	452

Intermediate values by linear interpolation.

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{\frac{2}{3}} \leq \left(\frac{2 \cdot h_{ef}}{h_{min}}\right)^{\frac{2}{3}}$$

Thickness h [mm]	Influence factor f_h [-] FIS EM RG M 8 I	FIS EM RG M 10 I	FIS EM RG M 12 I	FIS EM RG M 16 I	FIS EM RG M 20 I
120	1.00				
125	1.03	1.00			
150	1.16	1.13			
165	1.24	1.20	1.00		
200	1.41	1.37	1.14		
205	1.43	1.39	1.16	1.00	
220	1.50	1.46	1.21	1.05	
230		1.50	1.25	1.08	
250			1.32	1.14	
260			1.35	1.17	1.00
300			1.49	1.29	1.10
310			1.50	1.32	1.12
380				1.50	1.29
400					1.33
480					1.50
h_{min} [mm]	120	125	165	205	260
$h_{ef,sp}$ [mm]	90	90	125	160	200

Intermediate values for h_{min} by linear interpolation.

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			FIS EM RG M 8 I			FIS EM RG M 8 I			FIS EM RG M 12 I			FISS EM RG M 16 I			FIS EM RG M 20 I		
			gvz		A4	gvz		A4	gvz		A4	gvz		A4	gvz		A4
			5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8	
characteristic resistance	$V_{Rk,s}$	[kN]	9.2	14.6	12.8	14.5	23.2	20.3	21.1	33.7	29.5	39.2	54.0	54.8	62.0	90.0	86.0
design resistance	$V_{Rd,s}$	[kN]	7.4	11.7	8.2	11.6	18.6	13.0	16.9	27.0	18.9	31.4	43.2	35.1	49.6	72.0	55.1

5.2 Pryout-failure for the most unfavourable anchor [1)]

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot f_s \cdot f_c \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C 20/25

Anchor type			FIS EM RG M 8 I	FIS EM RG M 10 I	FIS EM RG M 12 I	FIS EM RG M 16 I	FIS EM RG M 20 I
eff. anchorage depth	h_{ef}	[mm]	90	90	125	160	200
non-cracked concrete, temperature range - 40 °C to + 50 °C							
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	86.4	86.4	141.4	204.8	268.2
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	57.6	57.6	94.3	136.5	190.8
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	80.0	100.0	150.0	230.0	340.0
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	53.3	66.7	100.0	153.3	226.7
cracked concrete concrete, temperature range - 40 °C to + 50 °C							
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	61.5	61.5	100.6	145.7	203.6
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	41.0	41.0	67.1	97.1	135.8
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	40.0	50.0	80.0	120.0	190.0
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	26.7	33.3	53.3	80.0	126.7

[1)] The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 72°C (see also „Installation details“).

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor [1)]

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

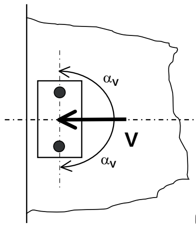
Anchor type			FIS EM RG M 8 I	FIS EM RG M 10 I	FIS EM RG M 12 I	FIS EM RG M 16 I	FIS EM RG M 20 I
non-cracked concrete, temperature range - 40 °C to + 50 °C							
minimum edge distance	c_{min}	[mm]	40	45	55	65	90
characteristic resistance	$V^0_{Rk,c}$	[kN]	5.7	7.0	10.2	14.3	23.7
design resistance	$V^0_{Rd,c}$	[kN]	3.8	4.7	6.8	9.5	15.8
cracked concrete concrete, temperature range - 40 °C to + 50 °C							
minimum edge distance	c_{min}	[mm]	40	45	55	65	90
characteristic resistance	$V^0_{Rk,c}$	[kN]	4.1	5.0	7.2	10.1	16.8
design resistance	$V^0_{Rd,c}$	[kN]	2.7	3.3	4.8	6.7	11.2

[1)] The loads apply to fischer internal-threaded anchor RGMI, drill hole cleaning according ETA-approval and temperature in the substrate in the area of the mortar T ≦ + 72°C (see also „Installation details").

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos\alpha_V)^2 + \left(\frac{\sin\alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example

5.3.2 Influence of spacing and edge distance

5.3.2.1 Single anchor influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}{}^{n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}{}^{n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}{}^{n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 Anchor pair influenced only by one edge

for concrete thickness $h \geqq 1.5 \cdot c$
and spacing $\mathbf{s \leqq 3 \cdot c}$

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for $s > 3 \cdot c$

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness $h < 1.5 \cdot c$
and spacing $\mathbf{s \leqq 4.5 \cdot h}$

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for $s > 4.5 \cdot h$

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

4

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2,89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

6. Summary of required proof:

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

6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

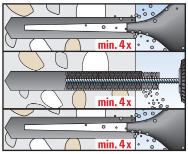
$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leq 1.2$$

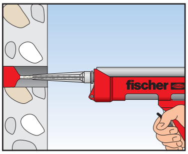
N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

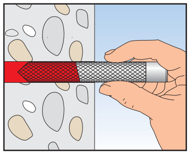
fischer Injection mortar FIS EM with RG MI

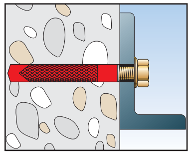
Anchor design according to ETA

7. Installation details



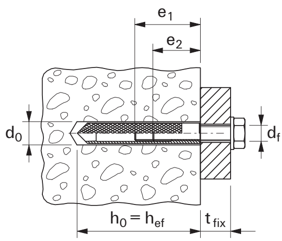






8. Anchor characteristics

Anchor type			FIS EM RG M 8 I	FIS EM RG M 10 I	FIS EM RG M 12 I	FIS EM RG M 16 I	FIS EM 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]	12	15	18	24	30
	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	55	65	90
minimum edge distances	c_{min}	[mm]	40	45	55	65	90
mortar filling quantity		[scale units]	5	7	11	17	48



9. Gelling and curing times

Cartridge temperature (mortar)	Gelling time FIS EM
– 5 °C – + 5 °C	4 h
+ 5 °C – + 10 °C	2 h
+ 10 °C – + 20 °C	30 min.
+ 20 °C – + 30 °C	14 min.
+ 30 °C – + 40 °C	7 min.

Temperature at anchoring base	Curing time FIS EM
– 5 °C – + 5 °C	80 h
+ 5 °C – + 10 °C	40 h
+ 10 °C – + 20 °C	18 h
+ 20 °C – + 30 °C	10 h
+ 30 °C – + 40 °C	5 h

The above times apply from the moment of contact between resin and hardener in the static mixer.
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 should be replaced.

10. Mechanical characteristics

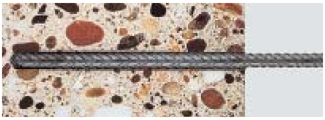
Anchor type			FIS EM RG M 8 I			FIS EM RG M 10 I			FIS EM RG M 12 I			FIS EM RG M 16 I			FIS EM RG M 20 I		
			gvz		A4	gvz		A4	gvz		A4	gvz		A4	gvz		A4
			5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8		5.8	8.8	
stressed cross sectional area - screw	A_s	[mm²]	36.6			58.0			84.3			157.0			245.0		
resisting moment - screw	W	[mm³]	31.2			62.3			109.2			277.5			540.9		
yield strength - screw	f_y	[N/mm²]	400	640	450	400	640	450	400	640	450	400	640	450	400	640	450
tensile strength - screw	f_u	[N/mm²]	500	800	700	500	800	700	500	800	700	500	800	700	500	800	700
stressed cross sectional area - internal-threaded anchor	A_s	[mm²]	72.5			137.1			161.8			210.4			350.5		
resisting moment - internal-threaded anchor	W	[mm³]	147.8			361.4			496.6			836.9			1755.3		
yield strength - internal-threaded anchor	f_y	[N/mm²]	420		450	420		450	420		450	420		450	420		450
tensile strength - internal-threaded anchor	f_u	[N/mm²]	520		700	520		700	520		700	520		700	520		700

Notes

fischer Injection mortar FIS EM with rebars

Anchor design according to ETA

1. Types



Reinforcement bars

FIS EM - Injection mortar FIS EM 390 S, FIS EM 1100 S

Features and Advantages

- European Technical Approval option 1.
- Very good bonding of the mortar ensures high loads in concrete.
- Suitable for underwater installations.
- Suitable for diamond drilled holes guarantees highest flexibility on site.
- Longer curing time for simple installation.
- Low shrinkage of the mortar.

European Technical Approval – Option 1 for cracked concrete

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Materials

Reinforcing steel : f_{yk} = 500 N/mm², f_{uk} = 550 N/mm²
Injection mortar: Epoxy resin, cement and hardener

2. Ultimate loads of single anchors with large spacing and edge distance[1)]

Mean values

Anchor type	FIS EM ⌀ 8		FIS EM ⌀ 10		FIS EM ⌀ 12		FIS EM ⌀ 14		FIS EM ⌀ 16		FIS EM ⌀ 20	
h_{ef} [mm]	60	160	60	200	70	240	75	280	80	320	90	400
non-cracked concrete, temperature range - 40 °C to + 35 °C												
tension load C 20/25 N_u [kN]	28.0 *)	28.0 *)	31.4	44.0 *)	39.5	63.0 *)	43.8	85.0 *)	48.3	111.0 *)	57.6	173.0 *)
C 50/60 N_u [kN]	28.0 *)	28.0 *)	41.1 *)	44.0 *)	57.5	63.0 *)	67.1	85.0 *)	74.9	111.0 *)	89.3	173.0 *)
shear load ≧ C 20/25 V_u [kN]	13.8 *)	13.8 *)	21.6 *)	21.6 *)	31.1 *)	31.1 *)	42.4 *)	42.4 *)	55.3 *)	55.3 *)	87.0 *)	87.0 *)
cracked concrete, temperature range - 40 °C to + 35 °C												
tension load C 20/25 N_u [kN]	14.1	28.0 *)	17.6	44.0 *)	24.6	63.0 *)	30.8	85.0 *)	34.5	111.0 *)	41.2	173.0 *)
C 50/60 N_u [kN]	15.3	28.0 *)	19.2	44.0 *)	26.8	63.0*)	33.6	85.0 *)	40.9	111.0 *)	57.5	173.0 *)
shear load ≧ C 20/25 V_u [kN]	13.8 *)	13.8 *)	21.6 *)	21.6 *)	31.1 *)	31.1 *)	42.4 *)	42.4 *)	55.3 *)	55.3 *)	82.3*)	87.0 *)

Anchor type	FIS EM ⌀ 25		FIS EM ⌀ 28		FIS EM ⌀ 32		FIS EM ⌀ 36		FIS EM ⌀ 40	
h_{ef} [mm]	100	500	112	560	128	640	144	720	160	800
non-cracked concrete, temperature range - 40 °C to + 35 °C										
tension load C 20/25 N_u [kN]	67.5	270.0 *)	80.0	339.0 *)	97.8	443.0 *)	116.6	560.0 *)	136.6	691.0 *)
C 50/60 N_u [kN]	104.6	270.0 *)	129.0	339.0 *)	151.5	443.0 *)	180.8	560.0 *)	211.7	691.0 *)
shear load ≧ C 20/25 V_u [kN]	135.0 *)	135.0 *)	160.0	170.0 *)	195.5	221.0 *)	233.3	280.0 *)	273.2	346.0 *)
cracked concrete, temperature range - 40 °C to + 35 °C										
tension load C 20/25 N_u [kN]	48.2	270.0 *)	57.1	339.0 *)	69.8	428.9	83.3	542.9	97.6	670.2
C 50/60 N_u [kN]	74.7	270.0 *)	88.6	339.0 *)	93.5	443.0 *)	118.3	560.0 *)	146.1	691.0 *)
shear load ≧ C 20/25 V_u [kN]	96.4	135.0 *)	114.3	170.0 *)	139.6	221.0 *)	166.6	280.0 *)	195.2	346.0 *)

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm², dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details").

*) Steel failure decisive

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube(150)}$ [N/mm²]	Influence factor $f_{b,p}$ [-]	Influence factor $f_{b,c}$ [-]
C 20/25	20	25	1.00	1.00
C 25/30	25	30	1.02	1.10
C 30/37	30	37	1.04	1.22
C 40/50	40	50	1.07	1.41
C 45/55	45	55	1.08	1.48
C 50/60	50	60	1.09	1.55

4

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [1)]

Characteristic loads

Anchor type				FIS EM ⌀ 8		FIS EM ⌀ 10		FIS EM ⌀ 12		FIS EM ⌀ 14		FIS EM ⌀ 16		FIS EM ⌀ 20	
h_{ef}			[mm]	60	160	60	200	70	240	75	280	80	320	90	400
non-cracked concrete, temperature range -40 °C to +35 °C															
tension load	C 20/25	N_{Rk}	[kN]	23.4	28.0	23.4	44.0	29.5	63.0	32.7	85.0	36.1	111.0	43.0	173.0
	C 50/60	N_{Rk}	[kN]	26.3	28.0	30.8	44.0	43.1	63.0	50.3	85.0	55.9	111.0	66.7	173.0
shear load	C 20/25	V_{Rk}	[kN]	13.8	13.8	21.6	21.6	31.1	31.1	42.4	42.4	55.3	55.3	86.1	87.0
	C 50/60	V_{Rk}	[kN]	13.8	13.8	21.6	21.6	31.1	31.1	42.4	42.4	55.3	55.3	87.0	87.0
cracked concrete, temperature range -40 °C to +35 °C															
tension load	C 20/25	N_{Rk}	[kN]	10.6	28.0	13.2	44.0	18.5	63.0	23.1	85.0	25.8	111.0	30.7	173.0
	C 50/60	N_{Rk}	[kN]	11.5	28.0	14.4	44.0	20.1	63.0	25.2	85.0	30.7	111.0	43.1	173.0
shear load	C 20/25	V_{Rk}	[kN]	13.8	13.8	21.6	21.6	31.1	31.1	42.4	42.4	51.5	55.3	61.5	87.0
	C 50/60	V_{Rk}	[kN]	13.8	13.8	21.6	21.6	31.1	31.1	42.4	42.4	55.3	55.3	86.3	87.0

Anchor type				FIS EM ⌀ 25		FIS EM ⌀ 28		FIS EM ⌀ 32		FIS EM ⌀ 36		FIS EM ⌀ 40	
h_{ef}			[mm]	100	500	112	560	128	640	144	720	160	800
non-cracked concrete, temperature range -40 °C to +35 °C													
tension load	C 20/25	N_{Rk}	[kN]	50.4	270.0	59.7	339.0	73.0	443.0	87.1	560.0	102.0	691.0
	C 50/60	N_{Rk}	[kN]	78.1	270.0	92.5	339.0	113.1	443.0	134.9	560.0	158.0	691.0
shear load	C 20/25	V_{Rk}	[kN]	100.8	135.0	119.5	170.0	146.0	221.0	174.2	280.0	204.0	346.0
	C 50/60	V_{Rk}	[kN]	135.0	135.0	170.0	170.0	221.0	221.0	269.8	280.0	316.0	346.0
cracked concrete, temperature range -40 °C to +35 °C													
tension load	C 20/25	N_{Rk}	[kN]	36.0	270.0	42.7	339.0	52.1	321.7	62.2	407.2	52.1	502.7
	C 50/60	N_{Rk}	[kN]	55.8	270.0	66.1	339.0	70.1	350.7	88.8	443.8	80.8	547.9
shear load	C 20/25	V_{Rk}	[kN]	72.0	135.0	85.3	170.0	104.3	221.0	124.4	280.0	104.3	346.0
	C 50/60	V_{Rk}	[kN]	111.5	135.0	132.2	170.0	140.3	221.0	177.5	280.0	161.5	346.0

Design and permissible loads see next pages.

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance [1)]

Design loads

Anchor type				FIS EM ⌀ 8		FIS EM ⌀ 10		FIS EM ⌀ 12		FIS EM ⌀ 14		FIS EM ⌀ 16		FIS EM ⌀ 20	
h_{ef}			[mm]	60	160	60	200	70	240	75	280	80	320	90	400
non-cracked concrete, temperature range - 40 °C to + 35 °C															
tension load	C 20/25	N_{Rd}	[kN]	15.6	20.0	15.6	31.4	19.7	45.0	21.8	60.7	20.0	79.3	23.9	123.6
	C 50/60	N_{Rd}	[kN]	17.5	20.0	20.5	31.4	28.8	45.0	33.6	60.7	31.0	79.3	37.0	123.6
shear load	C 20/25	V_{Rd}	[kN]	9.2	9.2	14.4	14.4	20.7	20.7	28.3	28.3	36.9	36.9	57.4	58.0
	C 50/60	V_{Rd}	[kN]	9.2	9.2	14.4	14.4	20.7	20.7	28.3	28.3	36.9	36.9	58.0	58.0
cracked concrete, temperature range - 40 °C to + 35 °C															
tension load	C 20/25	N_{Rd}	[kN]	7.0	18.8	8.8	29.3	12.3	42.2	15.4	57.5	14.3	62.6	17.1	97.7
	C 50/60	N_{Rd}	[kN]	7.7	20.0	9.6	31.4	13.4	45.0	16.8	60.7	17.0	68.2	24.0	106.5
shear load	C 20/25	V_{Rd}	[kN]	9.2	9.2	14.4	14.4	20.7	20.7	28.3	28.3	34.3	36.9	41.0	58.0
	C 50/60	V_{Rd}	[kN]	9.2	9.2	14.4	14.4	20.7	20.7	28.3	28.3	36.9	36.9	57.5	58.0

4

Anchor type				FIS EM ⌀ 25		FIS EM ⌀ 28		FIS EM ⌀ 32		FIS EM ⌀ 36		FIS EM ⌀ 40	
h_{ef}			[mm]	100	500	112	560	128	640	144	720	160	800
non-cracked concrete. temperature range - 40 °C to + 35 °C													
tension load	C 20/25	N_{Rd}	[kN]	28.0	192.9	33.2	242.1	40.5	316.4	48.4	400.0	56.7	493.6
	C 50/60	N_{Rd}	[kN]	43.4	192.9	51.4	242.1	62.8	316.4	75.0	400.0	87.8	493.6
shear load	C 20/25	V_{Rd}	[kN]	67.2	90.0	79.7	113.3	97.3	147.3	116.1	186.7	136.0	230.7
	C 50/60	V_{Rd}	[kN]	90.0	90.0	113.3	113.3	147.3	147.3	179.9	186.7	210.7	230.7
cracked concrete. temperature range - 40 °C to + 35 °C													
tension load	C 20/25	N_{Rd}	[kN]	20.0	152.7	23.7	191.6	29.0	178.7	34.6	226.2	29.0	279.3
	C 50/60	N_{Rd}	[kN]	31.0	166.5	36.7	208.8	39.0	194.8	49.3	246.6	44.9	304.4
shear load	C 20/25	V_{Rd}	[kN]	48.0	90.0	56.9	113.3	69.5	147.3	82.9	186.7	69.5	230.7
	C 50/60	V_{Rd}	[kN]	74.4	90.0	88.1	113.3	93.5	147.3	118.3	186.7	107.7	230.7

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm², dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details").

2) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.

fischer Injection mortar FIS EM with rebars

Anchor design according to ETA

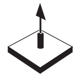
Permissible loads [2)]

Anchor type		FIS EM ⌀ 8		FIS EM ⌀ 10		FIS EM ⌀ 12		FIS EM ⌀ 14		FIS EM ⌀ 16		FIS EM ⌀ 20	
h_{ef}	[mm]	60	160	60	200	70	240	75	280	80	320	90	400
non-cracked concrete, temperature range - 40 °C to + 35 °C													
tension load	C 20/25 N_{perm} [kN]	11.2	14.3	11.2	22.4	14.1	32.1	15.6	43.4	14.3	56.6	17.1	88.3
	C 50/60 N_{perm} [kN]	12.5	14.3	14.7	22.4	20.5	32.1	24.0	43.4	22.2	56.6	26.5	88.3
shear load	C 20/25 V_{perm} [kN]	6.6	6.6	10.3	10.3	14.8	14.8	20.2	20.2	26.3	26.3	41.0	41.4
	C 50/60 V_{perm} [kN]	6.6	6.6	10.3	10.3	14.8	14.8	20.2	20.2	26.3	26.3	41.4	41.4
cracked concrete, temperature range - 40 °C to + 35 °C													
tension load	C 20/25 N_{perm} [kN]	5.0	13.4	6.3	20.9	8.8	30.2	11.0	41.1	10.2	44.7	12.2	69.8
	C 50/60 N_{perm} [kN]	5.5	14.3	6.8	22.4	9.6	32.1	12.0	43.4	12.2	48.7	17.1	76.1
shear load	C 20/25 V_{perm} [kN]	6.6	6.6	10.3	10.3	14.8	14.8	20.2	20.2	24.5	26.3	29.3	41.4
	C 50/60 V_{perm} [kN]	6.6	6.6	10.3	10.3	14.8	14.8	20.2	20.2	26.3	26.3	41.1	41.4

Anchor type		FIS EM ⌀ 25		FIS EM ⌀ 28		FIS EM ⌀ 32		FIS EM ⌀ 36		FIS EM ⌀ 40	
h_{ef}	[mm]	100	500	112	560	128	640	144	720	160	800
non-cracked concrete, temperature range - 40 °C to + 35 °C											
tension load	C 20/25 N_{perm} [kN]	20.0	137.8	23.7	173.0	29.0	226.0	34.6	285.7	40.5	352.6
	C 50/60 N_{perm} [kN]	31.0	137.8	36.7	173.0	44.9	226.0	53.5	285.7	62.7	352.6
shear load	C 20/25 V_{perm} [kN]	48.0	64.3	56.0	81.0	69.5	105.2	82.9	133.3	97.1	164.8
	C 50/60 V_{perm} [kN]	64.3	64.3	81.0	81.0	105.2	105.2	128.5	133.3	150.5	164.8
cracked concrete, temperature range - 40 °C to + 35 °C											
tension load	C 20/25 N_{perm} [kN]	14.3	109.1	16.9	136.8	20.7	127.7	24.7	161.6	20.7	199.5
	C 50/60 N_{perm} [kN]	22.1	118.9	25.2	149.1	27.8	139.1	35.2	176.1	32.0	217.4
shear load	C 20/25 V_{perm} [kN]	34.3	64.3	40.6	81.0	49.7	105.2	59.2	133.3	49.7	164.8
	C 50/60 V_{perm} [kN]	53.1	64.3	63.0	81.0	66.8	105.2	84.5	133.3	76.9	164.8

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm², dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details").

2) Material safety factors γ_M and safety factor for load γ_L = 1.4 are included. Material safety factor γ_M depends on type of anchor.



4. Load direction: tension

4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			FIS EM ⌀ 8	FIS EM ⌀ 10	FIS EM ⌀ 12	FIS EM ⌀ 14	FIS EM ⌀ 16	FIS EM ⌀ 20	FIS EM ⌀ 25	FIS EM ⌀ 28	FIS EM ⌀ 32	FIS EM ⌀ 36	FIS EM ⌀ 40
characteristic resistance	$N_{Rk,s}$	[kN]	28.0	44.0	63.0	85.0	111.0	173.0	270.0	339.0	443.0	560.0	691.0
design resistance	$N_{Rd,s}$	[kN]	20.0	31.4	45.0	60.7	79.3	123.6	192.9	242.1	316.4	400.0	493.6

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

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FIS EM ⌀ 8		FIS EM ⌀ 10		FIS EM ⌀ 12		FIS EM ⌀ 14		FIS EM ⌀ 16		FIS EM ⌀ 20		FIS EM ⌀ 25		FIS EM ⌀ 28		FIS EM ⌀ 32		FIS EM ⌀ 36		FIS EM ⌀ 40	
eff. anchorage depth	h_{ef}	[mm]	60	160	60	200	70	240	75	280	80	320	90	400	100	500	112	560	128	640	144	720	160	800
non-cracked concrete, temperature range - 40 °C to + 35 °C																								
characteristic resistance	$N^0_{Rk,p}$	[kN]	24.1	64.3	28.3	94.2	39.6	135.7	46.2	172.4	56.3	225.2	73.5	326.7	102.1	510.5	128.1	640.4	154.4	772.1	195.4	977.2	241.3	1206.4
Design resistance	$N^0_{Rd,p}$	[kN]	16.1	42.9	18.8	62.8	26.4	90.5	30.8	114.9	31.3	125.1	40.8	181.5	56.7	283.6	71.2	355.8	85.8	428.9	108.6	542.9	134.0	670.2
cracked concrete, temperature range - 40 °C to + 35 °C																								
characteristic resistance	$N^0_{Rk,p}$	[kN]	10.6	28.1	13.2	44.0	18.5	63.3	23.1	86.2	28.1	112.6	39.6	175.9	55.0	274.9	69.0	344.8	64.3	321.7	81.4	407.2	100.5	502.7
Design resistance	$N^0_{Rd,p}$	[kN]	7.0	18.8	8.8	29.3	12.3	42.2	15.4	57.5	15.6	62.8	22.0	97.7	30.5	152.7	38.3	191.6	35.7	178.7	45.2	226.2	55.9	279.3

Intermediate values for $N^0_{Rd,p}$ by linear interpolation.

4.3 Concrete cone failure and splitting for the most unfavourable anchor[1)]

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FIS EM ⌀ 8		FIS EM ⌀ 10		FIS EM ⌀ 12		FIS EM ⌀ 14		FIS EM ⌀ 16		FIS EM ⌀ 20	
eff. anchorage depth	h_{ef}	[mm]	60	160	60	200	70	240	75	280	80	320	90	400
non-cracked concrete, temperature range - 40 °C to + 35 °C														
characteristic resistance	$N^0_{Rk,c}$	[kN]	23.4	102.0	23.4	142.6	29.5	187.4	32.7	236.1	36.1	288.5	43.0	403.2
design resistance	$N^0_{Rd,c}$	[kN]	15.6	68.0	15.6	95.0	19.7	124.9	21.8	157.4	20.0	160.3	23.9	224.0
cracked concrete, temperature range - 40 °C to + 35 °C														
characteristic resistance	$N^0_{Rk,c}$	[kN]	16.7	72.9	16.7	101.8	21.1	133.9	23.4	168.7	25.8	206.1	30.7	288.0
design resistance	$N^0_{Rd,c}$	[kN]	11.2	48.6	11.2	67.9	14.1	89.2	15.6	112.4	14.3	114.5	17.1	160.0

Anchor type			FIS EM ⌀ 25		FIS EM ⌀ 28		FIS EM ⌀ 32		FIS EM ⌀ 36		FIS EM ⌀ 40	
eff. anchorage depth	h_{ef}	[mm]	100	500	112	560	128	640	144	720	160	800
non-cracked concrete, temperature range - 40 °C to + 35 °C												
characteristic resistance	$N^0_{Rk,c}$	[kN]	50.4	563.5	59.7	667.5	73.0	816.0	87.1	973.7	102.0	1140.4
design resistance	$N^0_{Rd,c}$	[kN]	28.0	313.0	33.2	371.1	40.5	453.3	48.4	540.9	56.7	633.6
cracked concrete, temperature range - 40 °C to + 35 °C												
characteristic resistance	$N^0_{Rk,c}$	[kN]	36.0	402.5	42.7	477.1	52.1	582.9	62.2	695.5	52.1	814.6
design resistance	$N^0_{Rd,c}$	[kN]	20.0	223.6	23.7	265.0	29.0	323.8	34.6	386.4	29.0	452.5

[1)] The loads apply to reinforcing steel with f_{yk} = 500 N/mm², dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details“).

Intermediate values for $N^0_{Rd,c}$ depending on $h_{ef,var}$ can be determined according:

$$N^0_{Rd,c\,(h_{ef,var})} = N^0_{Rd,c\,(h_{ef,min})} \cdot \left(\frac{h_{ef,var}}{h_{ef,min}}\right)^{1.5}$$

4.3.1 Concrete cone failure
4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm]	Influence factor f_s [-]																					
	FIS EM Ø 8		FIS EM Ø 10		FIS EM Ø 12		FIS EM Ø 14		FIS EM Ø 16		FIS EM Ø 20		FIS EM Ø 25		FIS EM Ø 28		FIS EM Ø 32		FIS EM Ø 36		FIS EM Ø 40	
↓ h_{ef} [mm]	60	160	60	200	70	240	75	280	80	320	90	400	100	500	112	560	128	640	144	720	160	800
40	0.61	0.54																				
45	0.63	0.55	0.63	0.54																		
50	0.64	0.55	0.64	0.54	0.62	0.53																
60	0.67	0.56	0.67	0.55	0.64	0.54	0.63	0.54														
65	0.68	0.57	0.68	0.55	0.65	0.55	0.64	0.54	0.64	0.53												
85	0.74	0.59	0.74	0.57	0.70	0.56	0.69	0.55	0.68	0.54	0.66	0.54										
110	0.81	0.61	0.81	0.59	0.76	0.58	0.74	0.57	0.73	0.56	0.70	0.55	0.68	0.54								
130	0.86	0.64	0.86	0.61	0.81	0.59	0.79	0.58	0.77	0.57	0.74	0.55	0.72	0.54	0.69	0.54						
160	0.94	0.67	0.94	0.63	0.88	0.61	0.86	0.60	0.83	0.58	0.80	0.57	0.77	0.55	0.74	0.55	0.71	0.54				
180	1.00	0.69	1.00	0.65	0.93	0.63	0.90	0.61	0.88	0.59	0.83	0.58	0.80	0.56	0.77	0.55	0.73	0.55	0.71	0.54		
200		0.72		0.68	1.00	0.65	0.97	0.63	0.94	0.61	0.89	0.59	0.85	0.57	0.81	0.56	0.77	0.55	0.74	0.55	0.72	0.54
225		0.73		0.69		0.66	1.00	0.63	0.97	0.62	0.92	0.59	0.88	0.58	0.83	0.57	0.79	0.56	0.76	0.55	0.73	0.55
240		0.75		0.70		0.67		0.64	1.00	0.63	0.94	0.60	0.90	0.58	0.86	0.57	0.81	0.56	0.78	0.56	0.75	0.55
270		0.78		0.73		0.69		0.66		0.64	1.00	0.61	0.95	0.59	0.90	0.58	0.85	0.57	0.81	0.56	0.78	0.56
300		0.81		0.75		0.71		0.68		0.66		0.63	1.00	0.60	0.95	0.59	0.89	0.58	0.85	0.57	0.81	0.56
335		0.85		0.78		0.73		0.70		0.67		0.64		0.61	1.00	0.60	0.94	0.59	0.89	0.58	0.85	0.57
385		0.90		0.82		0.77		0.73		0.70		0.66		0.63		0.61	1.00	0.60	0.95	0.59	0.90	0.58
430		0.95		0.86		0.80		0.76		0.72		0.68		0.64		0.63		0.61	1.00	0.60	0.95	0.59
480		1.00		0.90		0.83		0.79		0.75		0.70		0.66		0.64		0.63		0.61	1.00	0.60
600				1.00		0.92		0.86		0.81		0.75		0.70		0.68		0.66		0.64		0.63
720						1.00		0.93		0.88		0.80		0.74		0.71		0.69		0.69		0.65
840								1.00		0.94		0.85		0.78		0.75		0.72		0.70		0.68
960										1.00		0.90		0.82		0.79		0.75		0.72		0.70
1200												1.00		0.90		0.86		0.81		0.78		0.75
1500														1.00		0.95		0.89		0.85		0.81
1680																1.00		0.93		0.89		0.85
1920																		1.00		0.95		0.90
2160																				1.00		0.95
2400																						1.00
s_{min} [mm]	40		45		50		60		65		85		110		130		160		180		200	
$s_{cr,N}$ [mm]	180	480	180	600	210	720	225	840	240	960	270	1200	300	1500	336	1680	384	1920	432	2160	480	2400

Intermediate values by linear interpolation.

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s_{cr,N}^2}$$

Edge distance c [mm]	Influence factor f_c [-]																					
	FIS EM ∅ 8		FIS EM ∅ 10		FIS EM ∅ 12		FIS EM ∅ 14		FIS EM ∅ 16		FIS EM ∅ 20		FIS EM ∅ 25		FIS EM ∅ 28		FIS EM ∅ 32		FIS EM ∅ 36		FIS EM ∅ 40	
↓ h_{ef} [mm]	60	160	60	200	70	240	75	280	80	320	90	400	100	500	112	560	128	640	144	720	160	800
40	0.60	0.44																				
45	0.64	0.45	0.64	0.43																		
50	0.67	0.46	0.67	0.44	0.62	0.42																
60	0.75	0.48	0.75	0.46	0.68	0.44	0.66	0.42														
65	0.79	0.50	0.79	0.47	0.72	0.45	0.69	0.43	0.66	0.42												
85	0.96	0.55	0.96	0.50	0.85	0.48	0.81	0.46	0.78	0.44	0.72	0.42										
90	1.00	0.56	1.00	0.51	0.89	0.48	0.85	0.46	0.81	0.45	0.75	0.43										
105		0.60		0.54	1.00	0.51	0.95	0.48	0.90	0.47	0.83	0.44										
110		0.61		0.55		0.52	0.98	0.49	0.93	0.47	0.86	0.45	0.80	0.43								
115		0.62		0.56		0.53		0.50	0.97	0.48	0.88	0.45	0.82	0.43								
120		0.64		0.57		0.53		0.51	1.00	0.48	0.91	0.46	0.85	0.43								
130		0.66		0.59		0.55		0.52		0.50	0.97	0.47	0.90	0.44	0.83	0.43						
135		0.68		0.61		0.56		0.53		0.50	1.00	0.47	0.92	0.44	0.85	0.43						
150		0.72		0.64		0.58		0.55		0.52		0.48	1.00	0.46	0.92	0.44						
160		0.75		0.66		0.60		0.56		0.53		0.49		0.46	0.96	0.45	0.87	0.44				
170		0.78		0.68		0.62		0.58		0.55		0.50		0.47	1.00	0.46	0.91	0.44				
180		0.81		0.70		0.64		0.59		0.56		0.51		0.48		0.46	0.95	0.45	0.87	0.44		
190		0.84		0.73		0.66		0.61		0.57		0.52		0.49		0.47	1.00	0.45	0.91	0.44		
200		0.87		0.75		0.67		0.62		0.58		0.53		0.49		0.48		0.46	0.94	0.45	0.87	0.44
215		0.92		0.79		0.70		0.65		0.60		0.55		0.51		0.49		0.47	1.00	0.46	0.92	0.44
240		1.00		0.85		0.75		0.68		0.64		0.57		0.53		0.51		0.48		0.47	1.00	0.46
300				1.00		0.87		0.78		0.72		0.64		0.57		0.55		0.52		0.50		0.48
360						1.00		0.89		0.81		0.70		0.62		0.59		0.56		0.53		0.51
420								1.00		0.90		0.77		0.68		0.64		0.60		0.57		0.54
480										1.00		0.85		0.73		0.68		0.64		0.60		0.57
600												1.00		0.85		0.78		0.72		0.67		0.64
750														1.00		0.92		0.83		0.77		0.72
840																1.00		0.90		0.83		0.77
960																		1.00		0.91		0.85
1080																				1.00		0.92
1200																						1.00
c_{min} [mm]	40		45		50		60		65		85		110		130		160		180		200	
$c_{cr,N}$ [mm]	90	240	90	300	105	360	113	420	120	480	135	600	150	750	168	840	192	960	216	1080	240	1200

Intermediate values by linear interpolation.

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s [mm]	Influence factor $f_{s,sp}$ [-]																					
	FIS EM ⌀ 8		FIS EM ⌀ 10		FIS EM ⌀ 12		FIS EM ⌀ 14		FIS EM ⌀ 16		FIS EM ⌀ 20		FIS EM ⌀ 25		FIS EM ⌀ 28		FIS EM ⌀ 32		FIS EM ⌀ 36		FIS EM ⌀ 40	
↓ h_{ef} [mm]	60	160	60	200	70	240	75	280	80	320	90	400	100	500	112	560	128	640	144	720	160	800
40	0.57	0.53																				
45	0.58	0.53	0.58	0.52																		
50	0.59	0.53	0.59	0.53	0.58	0.52																
60	0.61	0.54	0.61	0.53	0.59	0.53	0.59	0.52														
65	0.62	0.54	0.62	0.54	0.60	0.53	0.60	0.53	0.59	0.52												
85	0.66	0.56	0.66	0.55	0.63	0.54	0.63	0.53	0.62	0.53	0.60	0.52										
110	0.70	0.58	0.70	0.56	0.67	0.55	0.66	0.54	0.65	0.54	0.64	0.53	0.62	0.52								
130	0.74	0.59	0.74	0.57	0.71	0.56	0.69	0.55	0.68	0.54	0.66	0.54	0.64	0.53	0.63	0.53						
160	0.79	0.61	0.79	0.59	0.75	0.57	0.74	0.56	0.72	0.56	0.70	0.54	0.68	0.54	0.663	0.53	0.64	0.53				
180	0.83	0.62	0.83	0.60	0.78	0.58	0.76	0.57	0.75	0.56	0.72	0.55	0.70	0.54	0.68	0.54	0.66	0.53	0.64	0.53		
200	0.87	0.64	0.87	0.61	0.82	0.59	0.79	0.58	0.78	0.57	0.75	0.56	0.72	0.54	0.70	0.54	0.67	0.53	0.65	0.53	0.64	0.53
220	0.90	0.65	0.90	0.62	0.85	0.60	0.82	0.59	0.80	0.58	0.77	0.56	0.74	0.55	0.72	0.54	0.69	0.54	0.67	0.53	0.65	0.53
240	0.94	0.67	0.94	0.63	0.88	0.61	0.85	0.59	0.83	0.58	0.80	0.57	0.77	0.55	0.74	0.55	0.71	0.54	0.68	0.54	0.67	0.53
250	0.96	0.67	0.96	0.64	0.90	0.62	0.87	0.60	0.85	0.59	0.81	0.57	0.78	0.56	0.75	0.55	0.72	0.54	0.69	0.54	0.67	0.53
270	1.00	0.69	1.00	0.65	0.94	0.63	0.90	0.61	0.88	0.60	0.84	0.58	0.80	0.56	0.77	0.55	0.74	0.55	0.71	0.54	0.69	0.54
315		0.72		0.67	1.00	0.65	0.96	0.62	0.94	0.61	0.89	0.59	0.85	0.57	0.81	0.56	0.77	0.55	0.74	0.55	0.72	0.54
340		0.73		0.69		0.66	1.00	0.63	0.97	0.62	0.92	0.59	0.88	0.58	0.84	0.57	0.79	0.56	0.76	0.55	0.73	0.55
360		0.75		0.70		0.67		0.64	1.00	0.62	0.94	0.60	0.90	0.58	0.86	0.57	0.81	0.56	0.78	0.56	0.75	0.55
405		0.78		0.72		0.69		0.66		0.64	1.00	0.61	0.95	0.59	0.90	0.58	0.85	0.57	0.81	0.56	0.78	0.56
450		0.81		0.75		0.71		0.68		0.66		0.62	1.00	0.60	0.94	0.59	0.89	0.58	0.85	0.57	0.81	0.56
505		0.85		0.78		0.73		0.70		0.67		0.64		0.61	1.00	0.60	0.94	0.59	0.89	0.58	0.85	0.57
580		0.90		0.82		0.77		0.73		0.70		0.66		0.63		0.61	1.00	0.60	0.95	0.59	0.90	0.58
650		0.95		0.86		0.80		0.76		0.72		0.68		0.64		0.63		0.61	1.00	0.60	0.95	0.59
725		1.00		0.90		0.92		0.79		0.75		0.70		0.66		0.64		0.63		0.61	1.00	0.60
900				1.00		1.00		0.85		0.81		0.75		0.70		0.68		0.66		0.64		0.62
1085								0.93		0.88		0.80		0.74		0.71		0.69		0.67		0.65
1265								1.00		0.94		0.85		0.78		0.75		0.72		0.69		0.67
1445										1.00		0.90		0.82		0.79		0.75		0.72		0.70
1800												1.00		0.90		0.86		0.81		0.78		0.75
2260														1.00		0.85		0.89		0.85		0.81
2530																1.00		0.94		0.89		0.85
2900																		1.00		0.95		0.90
3250																				1.00		0.95
3600																						1.00
s_{min} [mm]	40		45		50		60		65		85		110		130		160		180		200	
$s_{cr,sp}$ [mm]	272	724	272	904	316	1084	340	1266	362	1446	406	1808	452	2260	506	2532	578	2892	650	3254	724	3616

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c [mm]	Influence factor $f_{c,sp}$ [-]																					
	FIS EM Ø 8		FIS EM Ø 10		FIS EM Ø 12		FIS EM Ø 14		FIS EM Ø 16		FIS EM Ø 20		FIS EM Ø 25		FIS EM Ø 28		FIS EM Ø 32		FIS EM Ø 36		FIS EM Ø 40	
↓ h_{ef} [mm]	60	160	60	200	70	240	75	280	80	320	90	400	100	500	112	560	128	640	144	720	160	800
40	0.51	0.41																				
45	0.53	0.41	0.53	0.40																		
50	0.55	0.42	0.55	0.41	0.52	0.40																
60	0.60	0.44	0.60	0.42	0.56	0.41	0.55	0.40														
65	0.62	0.44	0.62	0.43	0.58	0.41	0.56	0.40	0.55	0.40												
85	0.72	0.48	0.72	0.45	0.66	0.43	0.64	0.42	0.62	0.41	0.59	0.40										
110	0.85	0.52	0.85	0.48	0.77	0.46	0.74	0.44	0.71	0.43	0.66	0.41	0.63	0.40								
130	0.96	0.55	0.96	0.51	0.86	0.48	0.82	0.46	0.79	0.44	0.73	0.43	0.69	0.41	0.65	0.40						
140	1.00	0.57	1.00	0.52	0.91	0.49	0.86	0.47	0.83	0.45	0.77	0.43	0.72	0.41	0.67	0.41						
160		0.60		0.55	1.00	0.51	0.95	0.49	0.91	0.47	0.84	0.44	0.78	0.42	0.73	0.42	0.67	0.41				
170		0.62		0.56		0.52	1.00	0.50	0.95	0.48	0.87	0.45	0.81	0.43	0.75	0.42	0.70	0.41				
180		0.64		0.57		0.53		0.50	1.00	0.48	0.91	0.46	0.84	0.43	0.78	0.42	0.72	0.41	0.67	0.41		
200		0.67		0.60		0.55		0.52		0.50	0.99	0.47	0.91	0.44	0.84	0.43	0.77	0.42	0.71	0.41	0.67	0.41
225		0.72		0.64		0.58		0.55		0.52		0.48	1.00	0.46	0.91	0.44	0.83	0.43	0.77	0.42	0.72	0.41
250		0.77		0.67		0.61		0.57		0.54		0.50		0.47	0.99	0.45	0.89	0.44	0.82	0.43	0.77	0.42
290		0.85		0.73		0.66		0.61		0.57		0.53		0.49		0.47	1.00	0.46	0.92	0.44	0.85	0.43
325		0.92		0.79		0.70		0.62		0.61		0.55		0.51		0.49		0.47	1.00	0.46	0.92	0.44
360		1.00		0.84		0.75		0.68		0.64		0.57		0.52		0.50		0.48		0.47	1.00	0.46
450				1.00		0.87		0.78		0.72		0.64		0.57		0.55		0.52		0.50		0.48
540						1.00		0.89		0.81		0.70		0.62		0.59		0.56		0.53		0.51
630								1.00		0.90		0.77		0.68		0.64		0.60		0.57		0.54
720										1.00		0.84		0.73		0.68		0.64		0.60		0.57
800												0.91		0.78		0.73		0.67		0.63		0.60
900												1.00		0.84		0.78		0.72		0.67		0.64
1130														1.00		0.92		0.83		0.77		0.72
1270																1.00		0.90		0.83		0.78
1450																		1.00		0.91		0.85
1630																				1.00		0.92
1810																						1.00
c_{min} [mm]	40		45		50		60		65		85		110		130		160		180		200	
$c_{cr,sp}$ [mm]	136	362	136	452	158	542	170	633	181	723	203	904	226	1130	253	1266	289	1446	325	1627	362	1808

Intermediate values by linear interpolation.

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{h_{min}}\right)^{\frac{2}{3}} \leq \left(\frac{2 \cdot h_{ef}}{h_{min}}\right)^{\frac{2}{3}}$$

Thickness h [mm] ↓	Influence factor f_h [-]																					
	FIS EM ⌀ 8		FIS EM ⌀ 10		FIS EM ⌀ 12		FIS EM ⌀ 14		FIS EM ⌀ 16		FIS EM ⌀ 20		FIS EM ⌀ 25		FIS EM ⌀ 28		FIS EM ⌀ 32		FIS EM ⌀ 36		FIS EM ⌀ 40	
h_{ef} [mm]	60	160	60	200	70	240	75	280	80	320	90	400	100	500	112	560	128	640	144	720	160	800
100	1.00		1.00																			
110	1.07		1.07		1.05																	
115	1.10		1.10		1.08		1.02															
120	1.13		1.13		1.11		1.05		1.00													
135					1.21		1.14		1.08													
145							1.19		1.13		1.02											
155									1.19		1.07											
165											1.12		1.02									
175											1.16		1.06									
185													1.10		1.01							
190		1.00											1.14		1.05							
215		1.09													1.12		1.02					
235		1.15		1.01													1.08		1.00			
255		1.22		1.07													1.15		1.06			
275		1.28		1.13		1.01													1.11		1.01	
290		1.33		1.17		1.04															1.05	
320		1.42		1.25		1.11		1.01													1.12	
330				1.27		1.14		1.03														
360				1.35		1.21		1.09		1.00												
400				1.45		1.29		1.17		1.07												
450						1.40		1.27		1.16		1.00										
630										1.45		1.25		1.08		1.00						
720												1.37		1.18		1.09		1.00				
810														1.28		1.18		1.08		1.00		
910														1.38		1.28		1.17		1.08		1.00
1000														1.47		1.36		1.24		1.15		1.06
1100																1.45		1.33		1.23		1.13
1200																		1.41		1.30		1.20
1300																				1.37		1.27
1400																				1.44		1.33
1600																						1.46
h_{min} [mm]	100	190	100	230	102	272	111	316	120	360	140	450	160	560	182	630	208	720	234	810	270	910
h_{ef} [mm]	60	160	60	200	70	240	75	280	80	320	90	400	100	500	112	560	128	640	144	720	160	800

Intermediate values by linear interpolation.

4

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			FIS EM ⌀ 8	FIS EM ⌀ 10	FIS EM ⌀ 12	FIS EM ⌀ 14	FIS EM ⌀ 16	FIS EM ⌀ 20	FIS EM ⌀ 25	FIS EM ⌀ 28	FIS EM ⌀ 32	FIS EM ⌀ 36	FIS EM ⌀ 40
characteristic resistance	$V_{Rk,s}$	[kN]	13.8	21.6	31.1	42.4	55.3	87.0	135.0	170.0	221.0	280.0	346.0
design resistance	$V_{Rd,s}$	[kN]	9.2	14.4	20.7	28.3	36.9	58.0	90.0	113.3	147.3	186.7	230.7

5.2 Pryout-failure for the most unfavourable anchor [1)]

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot f_s \cdot f_c \cdot k$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			FIS EM ⌀ 8		FIS EM ⌀ 10		FIS EM ⌀ 12		FIS EM ⌀ 14		FIS EM ⌀ 16		FIS EM ⌀ 20	
eff. anchorage depth	h_{ef}	[mm]	60	160	60	200	70	240	75	280	80	320	90	400
non-cracked concrete, temperature range - 40 °C to + 35 °C														
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	23.4	102.0	23.4	142.6	29.5	187.4	32.7	236.1	36.1	288.5	43.0	403.2
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	15.6	68.0	15.6	95.0	19.7	124.9	21.8	157.4	24.0	192.3	28.7	268.8
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	24.1	64.3	28.3	94.2	39.6	135.7	46.2	172.4	56.3	225.2	73.5	326.7
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	16.1	42.9	18.8	62.8	26.4	90.5	30.8	114.9	37.5	150.1	49.0	217.8
cracked concrete, temperature range - 40 °C to + 35 °C														
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	16.7	72.9	16.7	101.8	21.1	133.9	23.4	168.7	25.8	206.1	30.7	288.0
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	11.2	48.6	11.2	67.9	14.1	89.2	15.6	112.4	17.2	137.4	20.5	192.0
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	10.6	28.1	13.2	44.0	18.5	63.3	23.1	86.2	28.1	112.6	39.6	175.9
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	7.0	18.8	8.8	29.3	12.3	42.2	15.4	57.5	18.8	75.1	26.4	117.3

Anchor type			FIS EM ⌀ 25		FIS EM ⌀ 28		FIS EM ⌀ 32		FIS EM ⌀ 36		FIS EM ⌀ 40	
eff. anchorage depth	h_{ef}	[mm]	100	500	112	560	128	640	144	720	160	800
non-cracked concrete, temperature range - 40 °C to + 35 °C												
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	50.4	563.5	59.7	667.9	73.0	816.0	87.1	973.7	102.0	1140.4
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	33.6	375.7	39.8	445.3	48.7	544.0	58.1	649.1	68.0	760.3
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	102.1	510.5	128.1	640.4	154.4	772.0	195.4	977.2	241.3	1206.4
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	68.1	340.3	85.4	426.9	102.9	514.7	130.3	651.4	160.8	804.2
cracked concrete, temperature range - 40 °C to + 35 °C												
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	36.0	402.5	42.7	477.1	52.1	582.9	62.2	695.5	52.1	814.6
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	24.0	268.3	28.4	318.0	34.8	388.6	41.5	463.7	34.8	543.1
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	55.0	274.9	69.0	344.8	64.3	321.7	81.4	407.2	100.5	502.7
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	36.7	183.3	46.0	229.9	42.9	214.5	54.3	271.4	67.0	335.1

1) The loads apply to reinforcing steel with f_{yk} = 500 N/mm², dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details").

2) Intermediate values for $N^0_{Rd,cp}$ (p) depending on $h_{ef,var}$ can be determined by linear interpolation.

3) Intermediate values for $N^0_{Rd,cp}$ (c) depending on $h_{ef,var}$ can be determined according: $N^0_{Rd,cp\,(c)\,(h_{ef,var})} = N^0_{Rd,cp\,(c)\,(h_{ef,min})} \cdot \left(\frac{h_{ef,var}}{h_{ef,min}}\right)^{1.5}$

5.2.1 Influence of anchorage depth

h_{ef}	k
< 60 mm	1.0
≧ 60 mm	2.0

5.3 Concrete edge failure for the most unfavourable anchor [1)]

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

Characteristic resistance and design resistance for single anchors in concrete C20/25 for edge distances c_{min}

Anchor type			FIS EM ⌀ 8		FIS EM ⌀ 10		FIS EM ⌀ 12		FIS EM ⌀ 14		FIS EM ⌀ 16		FIS EM ⌀ 20		FIS EM ⌀ 25		FIS EM ⌀ 28		FIS EM ⌀ 32		FIS EM ⌀ 36		FIS EM ⌀ 40	
h_{ef}		**[mm]**	**60**	**160**	**60**	**200**	**70**	**240**	**75**	**280**	**80**	**320**	**90**	**400**	**100**	**500**	**112**	**560**	**128**	**640**	**144**	**720**	**160**	**800**
non-cracked concrete, temperature range - 40 °C to + 35 °C																								
minimum edge distance	c_{min}	[mm]	40		45		50		60		65		85		110		130		160		180		200	
characteristic resistance	$V^0_{Rk,c}$	[kN]	5.3	6.6	6.4	8.7	7.8	11.0	10.3	15.0	11.9	18.0	17.9	28.2	26.5	43.7	34.3	56.6	47.1	77.6	57.2	95.6	68.2	115.2
design resistance	$V^0_{Rd,c}$	[kN]	3.5	4.4	3.5	5.8	5.2	7.4	6.9	10.0	7.9	12.0	12.0	18.8	17.7	29.1	22.9	37.7	31.4	51.7	38.2	63.7	45.5	76.8
cracked concrete, temperature range - 40 °C to + 35 °C																								
minimum edge distance	c_{min}	[mm]	40		45		50		60		65		85		110		130		160		180		200	
characteristic resistance	$V^0_{Rk,c}$	[kN]	3.7	4.7	4.5	6.2	5.5	7.8	7.3	10.6	8.4	12.7	12.7	20.0	18.8	30.9	24.3	40.1	33.3	55.0	40.5	67.7	48.3	81.6
design resistance	$V^0_{Rd,c}$	[kN]	2.5	3.1	3.0	4.1	3.7	5.2	4.9	7.1	5.6	8.5	8.5	13.3	12.5	20.6	16.2	26.7	22.2	36.6	27.0	45.1	32.2	54.4

[1)] The loads apply to reinforcing steel with f_{yk} = 500 N/mm², dry and wet anchoring base and careful drill hole cleaning acc. ETA-approval, carried out with a steel brush and blow-out tool and temperatures in the substrate in the area of the mortar T ≦ + 35°C (see also „Installation details“).

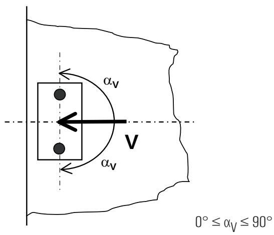
Intermediate values by linear interpolation.

4

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	**Influence factor $f_{\alpha,V}$ [-]**
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.3.2 Influence of spacing and edge distance

5.3.2.1 Single anchor influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}^{\,n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\,n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	4.19	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.3.2.2 Anchor pair influenced only by one edge

for concrete thickness h ≧ 1.5 · c
and spacing **s ≦ 3 · c**

$$f_{sc,V}^{\,n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for s > 3 · c

$$f_{sc,V}^{\,n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c
and spacing **s ≦ 4.5 · h**

$$f_{sc,V}^{\,n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for s > 4.5 · h

$$f_{sc,V}^{\,n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\,n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2,89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.31	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.30	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

fischer Injection mortar FIS EM with rebars

Anchor design according to ETA

6. Summary of required proof:

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

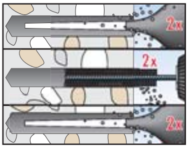
6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

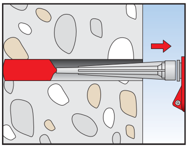
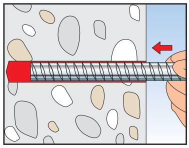
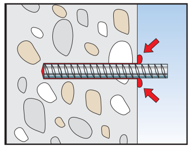
6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

7. Installation details

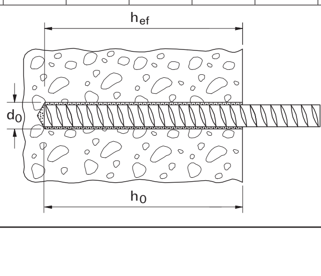


8. Anchor characteristics

Anchor type			FIS EM ⌀ 8		FIS EM ⌀ 10		FIS EM ⌀ 12		FIS EM ⌀ 14		FIS EM ⌀ 16		FIS EM ⌀ 20	
	h_{ef}	[mm]	60	160	60	200	70	240	75	280	80	320	90	400
diameter of rebar		[mm]	8		10		12		14		16		20	
nominal drill hole diameter	d_0	[mm]	12		14		16		18		20		25	
drill depth	h_0	[mm]	60	160	60	200	70	240	75	280	80	320	90	400
effective anchorage depth	h_{ef}	[mm]	60	160	60	200	70	240	75	280	80	320	90	400
minimum thickness of concrete member	h_{min}	[mm]	100	190	100	230	102	272	111	316	120	360	140	450
minimum spacing	s_{min}	[mm]	40		45		50		60		65		85	
minimum edge distances	c_{min}	[mm]	40		45		50		60		65		85	
mortar filling quantity		[ml]	3	7	3	10	4	14	5	18	6	24	10	45

Anchor type			FIS EM ⌀ 25		FIS EM ⌀ 28		FIS EM ⌀ 32		FIS EM ⌀ 36		FIS EM ⌀ 40	
	h_{ef}	[mm]	100	500	112	560	128	640	144	720	160	800
diameter of rebar		[mm]	25		28		32		36		40	
nominal drill hole diameter	d_0	[mm]	30		35		40		45		50	
drill depth	h_0	[mm]	100	500	112	560	128	640	144	720	160	800
effective anchorage depth	h_{ef}	[mm]	100	500	112	560	128	640	144	720	160	800
minimum thickness of concrete member	h_{min}	[mm]	160	560	182	630	208	720	234	810	270	910
minimum spacing	s_{min}	[mm]	110		130		160		180		200	
minimum edge distances	c_{min}	[mm]	110		130		160		180		200	
mortar filling quantity		[ml]	15	65	23	115	35	173	52	255	90	448



9. Gelling and curing times

Cartridge temperature (minimum + 5 °C)	**Gelling time FIS EM**
- 5 °C to	4 h
+ 10 °C	2 h
+ 20 °C	30 min.
+ 30 °C	14 min.
+ 40 °C	7 min.

Temperature at anchoring base	**Curing time FIS EM**
- 5 °C	80 h
+ 5 °C	40 h
+ 10 °C	18 h
+ 20 °C	10 h
+ 30 °C	5 h
+ 40 °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 should be replaced.

10. Mechanical characteristics

Anchor type			**FIS EM ⌀ 8**	**FIS EM ⌀ 10**	**FIS EM ⌀ 12**	**FIS EM ⌀ 14**	**FIS EM ⌀ 16**	**FIS EM ⌀ 20**	**FIS EM ⌀ 25**	**FIS EM ⌀ 28**	**FIS EM ⌀ 32**	**FIS EM ⌀ 36**	**FIS EM ⌀ 40**
stressed cross sectional area reinforcing steel	A_s	[mm^2]	50.3	78.5	113.1	153.9	201.1	314.2	490.9	615.8	804.2	1017.9	1256.6
resisting moment reinforcing steel	W	[mm^3]	50.3	98.2	169.6	269.4	402.1	785.4	1534.0	2155.1	3217.0	4580.4	6283.2
yield strength reinforcing steel	f_y	[N/mm^2]	500										
tensile strength reinforcing steel	f_u	[N/mm^2]	550										

Notes

fischer Long-shaft fixing SXS

Anchor design according to ETA

1. Types

SXS-T – with zinc plated CO-NA screw and countersunk head

SXS-F US – with zinc plated CO-NA hexagon-head screw with integrated washer

SXS-SS – with zinc plated CO-NA hexagon-head screw

SXS-T A4 – with CO-NA hexagon-head screw in A4 stainless steel with countersunk washer

SXS-F US A4 – with CO-NA hexagon-head screw in A4 stainless steel with integrated washer

SXS-SS A4 – with CO-NA hexagon-head screw in A4 stainless steel

Features and Advantages

- German Approval, design according to Annex C of the ETAG.
- Suitable for cracked and non-cracked concrete.
- First Nylon fixing approved for cracked concrete.
- Specially developed fischer CO-NA screw ensures high loads and bending moments.
- fischer CO-NA screw pre-assembled.
- Integral hammer-in stop prevents the fixing from expanding prematurely during installation.
- The SXS-F US version does not require additional washers and prevents contact corrosion.
- Wide range of head designs for different applications.

Materials

Screw:	Carbon steel, zinc plated (5 µm) and passivated (gvz)
	Stainless steel of the corrosion resistance class III, e.g. A4
Anchor sleeve:	Polyamide

fischer Long-shaft fixing SXS

Anchor design according to ETA

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

Mean values

Anchor type				SXS 10 gvz		SXS 10 A4	
Temperature range: short-term/long-term			[°C]	30/50	50/80	30/50	50/80
non-cracked concrete							
tension load	C 20/25	N_u	[kN]	12.8	8.3	12.8	8.3
shear load	≥ C 20/25	V_u	[kN]	13.8 *)	11.7	13.8 *)	11.7
cracked concrete							
tension load	C 20/25	N_u	[kN]	10.4	6.7	10.4	6.7
shear load	≥ C 20/25	V_u	[kN]	13.8 *)	11.7	13.8 *)	11.7

*) Steel failure decisive

2.1 Influence of concrete strength

$$f_{b,c} = \sqrt{\frac{f_{ck,cube(150)}}{25}}$$

Concrete strength classes	Cylinder compressive strength $f_{ck,cyl}$ [N/mm²]	Cube compressive strength $f_{ck,cube(150)}$ [N/mm²]	Influence factor $f_{b,p}$ [-]	Influence factor $f_{b,c}$ [-]
C 20/25	20	25	1.00	1.00
C 25/30	25	30	1.00	1.10
C 30/37	30	37	1.00	1.22
C 40/50	40	50	1.00	1.41
C 45/55	45	55	1.00	1.48
C 50/60	50	60	1.00	1.55

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Characteristic loads

Anchor type				SXS 10 gvz		SXS 10 A4	
Temperature range: short-term/long-term			[°C]	30/50	50/80	30/50	50/80
non-cracked concrete							
tension load	C 20/25	N_{Rk}	[kN]	6.0	4.0	6.0	4.0
shear load	≥ C 20/25	V_{Rk}	[kN]	9.0	7.5	9.0	7.5
cracked concrete							
tension load	C 20/25	N_{Rk}	[kN]	5.0	3.0	5.0	3.0
shear load	≥ C 20/25	V_{Rk}	[kN]	9.0	6.0	9.0	6.0

Design loads and permissible loads see next page.

fischer Long-shaft fixing SXS

Anchor design according to ETA

3. Characteristic, design and permissible loads of single anchors with large spacing and edge distance

Design loads

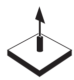
Anchor type	SXS 10 gvz		SXS 10 A4	
Temperature range: short-term/long-term [°C]	30/50	50/80	30/50	50/80
non-cracked concrete				
tension load C 20/25 N_{Rd} [kN]	2.8	1.9	2.8	1.9
shear load ≧ C 20/25 V_{Rd} [kN]	4.2	3.5	4.2	3.5
cracked concrete				
tension load C 20/25 N_{Rd} [kN]	2.3	1.4	2.3	1.4
shear load ≧ C 20/25 V_{Rd} [kN]	4.2	3.3	4.2	3.3

Permissible loads [1]

Anchor type	SXS 10 gvz		SXS 10 A4	
Temperature range: short-term/long-term [°C]	30/50	50/80	30/50	50/80
non-cracked concrete				
tension load C 20/25 N_{perm} [kN]	2.0	1.3	2.0	1.3
shear load ≧ C 20/25 V_{perm} [kN]	3.0	2.5	3.0	2.5
cracked concrete				
tension load C 20/25 N_{perm} [kN]	1.7	1.0	1.7	1.0
shear load ≧ C 20/25 V_{perm} [kN]	3.0	2.4	3.0	2.4

[1] Material safety factors γ_M and safety factor for load γ_L = 1.4 are included.
Material safety factor γ_M depends on type of anchor.

4. Load direction: tension



4.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type	SXS 10 gvz	SXS 10 A4
characteristic resistance $N_{Rk,s}$ [kN]	16.1	15.6
design resistance $N_{Rd,s}$ [kN]	10.7	10.4

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

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

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type	SXS 10 gvz		SXS 10 A4	
Temperature range: short-term/long-term [°C]	30/50	50/80	30/50	50/80
non-cracked concrete				
characteristic resistance $N^0_{Rk,p}$ [kN]	6.0	4.0	6.0	4.0
design resistance $N^0_{Rd,p}$ [kN]	2.8	1.9	2.8	1.9
cracked concrete				
characteristic resistance $N^0_{Rk,p}$ [kN]	5.0	3.0	5.0	3.0
design resistance $N^0_{Rd,p}$ [kN]	2.3	1.4	2.3	1.4

4.3 Concrete cone failure and splitting for the most unfavourable anchor

$$N_{Rd,c} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_s \cdot f_c$$

$$N_{Rd,sp} = N^0_{Rd,c} \cdot f_{b,c} \cdot f_{s,sp} \cdot f_{c,sp} \cdot f_h$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			SXS 10 gvz	SXS 10 A4
eff. anchorage depth	h_{ef}	[mm]	35	35
non-cracked concrete				
characteristic resistance	$N^0_{Rk,c}$	[kN]	10.4	10.4
design resistance	$N^0_{Rd,c}$	[kN]	4.8	4.8
cracked concrete				
characteristic resistance	$N^0_{Rk,c}$	[kN]	7.5	7.5
design resistance	$N^0_{Rd,c}$	[kN]	3.5	3.5

4.3.1 Concrete cone failure

4.3.1.1 Influence of spacing

$$f_s = \left(1.0 + \frac{s}{s_{cr,N}}\right) \cdot 0.5$$

Spacing s [mm]		Influence factor f_s [-] SXS 10
55		0.76
60		0.79
65		0.81
70		0.83
75		0.86
80		0.88
85		0.90
90		0.93
95		0.95
100		0.98
105		1.00
s_{min}	[mm]	55
$s_{cr,N}$	[mm]	105

Intermediate values by linear interpolation

4.3.1.2 Influence of edge distance

$$f_c = 0.35 + \frac{c}{s_{cr,N}} + 0.6 \cdot \frac{c^2}{s^2_{cr,N}}$$

Edge distance c [mm]		Influence factor f_c [-] SXS 10
50		0.96
52.5		1.00
c_{min}	[mm]	50
$c_{cr,N}$	[mm]	52.5

Intermediate values by linear interpolation.

4.3.2 Concrete splitting

4.3.2.1 Influence of spacing

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

Spacing s [mm]		Influence factor $f_{s,sp}$ [-] SXS 10
55		0.64
70		0.68
85		0.71
100		0.75
115		0.79
130		0.83
145		0.86
160		0.90
175		0.94
190		0.98
200		1.00
s_{min}	[mm]	55
$s_{cr,sp}$	[mm]	200

Intermediate values by linear interpolation.

4.3.2.2 Influence of edge distance

$$f_{c,sp} = 0.35 + \frac{c}{s_{cr,sp}} + 0.6 \cdot \frac{c^2}{s_{cr,sp}^2}$$

Edge distance c [mm]		Influence factor $f_{c,sp}$ [-] SXS 10
50		0.64
55		0.67
60		0.70
65		0.74
70		0.77
75		0.81
80		0.85
85		0.88
90		0.92
95		0.96
100		1.00
c_{min}	[mm]	50
$c_{cr,sp}$	[mm]	100

Intermediate values by linear interpolation.

4.3.2.3 Influence of concrete thickness

$$f_h = \left(\frac{h}{2 \cdot h_{nom}}\right)^{\frac{2}{3}} \leq 1.5$$

Thickness h [mm]	Influence factor f_h [-] SXS 10
100	1.00
110	1.07
120	1.13
140	1.25
160	1.37
170	1.42
180	1.48
190	1.50
h_{nom} [mm]	50
h_{min} [mm]	100

Intermediate values by linear interpolation.

4

5. Load direction: shear

5.1 Steel failure for the highest loaded anchor

Characteristic resistance and design resistance for single anchors

Anchor type			SXS 10 gvz	SXS 10 A4
characteristic resistance	$V_{Rk,s}$	[kN]	12.9	12.5
design resistance	$V_{Rd,s}$	[kN]	10.3	10.0

5.2 Pull-out failure for the the highest loaded anchor

$$V_{Rd,p} = V^0_{Rd,p} \cdot f_{b,p}$$

Characteristic resistance and design resistance for single anchors in concrete C20/25

Anchor type			SXS 10 gvz		SXS 10 A4	
Temperature range: short-term/long-term		[°C]	30/50	50/80	30/50	50/80
non-cracked concrete						
characteristic resistance	$V^0_{Rk,p}$	[kN]	9.0	7.5	9.0	7.5
design resistance	$V^0_{Rd,p}$	[kN]	4.2	3.5	4.2	3.5
cracked concrete						
characteristic resistance	$V^0_{Rk,p}$	[kN]	9.0	7.5	9.0	7.5
design resistance	$V^0_{Rd,p}$	[kN]	4.2	3.5	4.2	3.5

5.2.1 Influence of anchorage depth

h_{ef}	k
SXS 10	2.0

5.3 Pryout-failure for the most unfavourable anchor

$$V_{Rd,cp}(c) = N^0_{Rd,cp}(c) \cdot f_{b,c} \cdot f_s \cdot f_c \cdot k$$

$$V_{Rd,cp}(p) = N^0_{Rd,cp}(p) \cdot f_{b,p} \cdot k$$

Characteristic resistance and design restance for single anchors in concrete C20/25

Anchor type			SXS 10	SXS 10
Temperature range: short-term/long-term		[°C]	30/50	50/80
eff. anchorage depth	h_{ef}	[mm]	35	35
non-cracked concrete				
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	10.4	10.4
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	5.8	5.8
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	6.0	4.0
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	3.3	2.2
cracked concrete				
characteristic resistance	$N^0_{Rk,cp}$ (c)	[kN]	7.5	7.5
design resistance	$N^0_{Rd,cp}$ (c)	[kN]	4.1	4.1
characteristic resistance	$N^0_{Rk,cp}$ (p)	[kN]	5.0	3.0
design resistance	$N^0_{Rd,cp}$ (p)	[kN]	2.8	1.7

5.4 Concrete edge failure for the most unfavourable anchor

$$V_{Rd,c} = V^0_{Rd,c} \cdot f_{b,c} \cdot f_{\alpha,V} \cdot f_{sc,V}{}^n$$

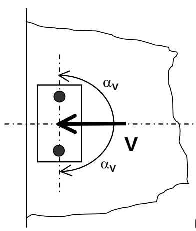
Characteristic resistance and design restance for single anchors in concrete C20/25 for edge distances c_{min}

Anchor type			SXS 10 gvz	SXS 10 A4
non-cracked concrete				
minimum edge distance	c_{min}	[mm]	60	60
characteristic resistance	$V^0_{Rk,c}$	[kN]	8.5	8.5
design resistance	$V^0_{Rd,c}$	[kN]	4.7	4.7
cracked concrete				
minimum edge distance	c_{min}	[mm]	50	50
characteristic resistance	$V^0_{Rk,c}$	[kN]	4.7	4.7
design resistance	$V^0_{Rd,c}$	[kN]	2.6	2.6

5.3.1 Influence of load direction

$$f_{\alpha,V} = \sqrt{\frac{1}{(\cos \alpha_V)^2 + \left(\frac{\sin \alpha_V}{2.5}\right)^2}} \geq 1.0$$

Angle α_V	Influence factor $f_{\alpha,V}$ [-]
0°	1.00
15°	1.03
30°	1.13
45°	1.31
60°	1.64
75°	2.15
90°	2.50



$0° \leq \alpha_V \leq 90°$

In case of $\alpha_V > 90°$ it is assumed that only the component of the shear load parallel to the edge is acting on the anchor. The component acting away from the edge may be neglected for the proof of concrete edge failure. Example of anchor group see chapter 4, example 4.

5.4.2 Influence of spacing and edge distance

5.4.2.1 **Single anchor** influenced only by one edge

for concrete thickness h ≧ 1.5 · c

$$f_{sc,V}^{\ n=1} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c

$$f_{sc,V}^{\ n=1} = \frac{\frac{h}{1.5}}{c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

	single anchor factor $f_{sc,V}^{\ n=1}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
	1.00	1.31	1.66	2.02	2.41	2.83	3.26	3.72	41.9	4.69	5.20	5.72	6.27	6.83	7.41	8.00

Intermediate values by linear interpolation.

5.4.2.2 **Anchor pair** influenced only by one edge

for concrete thickness h ≧ 1.5 · c
and spacing **s ≦ 3 · c**

$$f_{sc,V}^{\ n=2} = \frac{3 \cdot c + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for s > 3 · c

$$f_{sc,V}^{\ n=2} = \frac{c}{c_{min}} \cdot \sqrt{\frac{c}{c_{min}}}$$

for concrete thickness h < 1.5 · c
and spacing **s ≦ 4.5 · h**

$$f_{sc,V}^{\ n=2} = \frac{2 \cdot h + s}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

for s > 4.5 · h

$$f_{sc,V}^{\ n=2} = \frac{6.5 \cdot h}{6 \cdot c_{min}} \cdot \sqrt{\frac{\frac{h}{1.5}}{c_{min}}}$$

spacing s/c_{min}	anchor pair factor $f_{sc,V}^{\ n=2}$ edge distance = c/c_{min} or $(h/1.5)/c_{min}$															
	1.0	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**	**3.0**	**3.2**	**3.4**	**3.6**	**3.8**	**4.0**
1.0	0.67	0.84	1.03	1.22	1.43	1.65	1.88	2.12	2.36	2.62	2.89	3.16	3.44	3.73	4.03	4.33
1.5	0.75	0.93	1.12	1.33	1.54	1.77	2.00	2.25	2.50	2.76	3.03	3.31	3.60	3.89	4.19	4.50
2.0	0.83	1.02	1.22	1.43	1.65	1.89	2.13	2.38	2.63	2.90	3.18	3.46	3.75	4.05	4.35	4.67
2.5	0.92	1.11	1.32	1.54	1.77	2.00	2.25	2.50	2.77	3.04	3.32	3.61	3.90	4.21	4.52	4.83
3.0	1.00	1.20	1.42	1.64	1.88	2.12	2.37	2.63	2.90	3.18	3.46	3.76	4.06	4.36	4.68	5.00
3.5		1.30	1.52	1.75	1.99	2.24	2.50	2.76	3.04	3.32	3.61	3.91	4.21	4.52	4.84	5.17
4.0			1.62	1.86	2.10	2.36	2.62	2.89	3.17	3.46	3.75	4.05	4.36	4.68	5.00	5.33
4.5				1.96	2.21	2.47	2.74	3.02	3.31	3.60	3.90	4.20	4.52	4.84	5.17	5.50
5.0					2.33	2.59	2.87	3.15	3.44	3.74	4.04	4.35	4.67	5.00	5.33	5.67
5.5						2.71	2.99	3.28	3.57	3.88	4.19	4.50	4.82	5.15	5.49	5.83
6.0						2.83	3.11	3.41	3.71	4.02	4.33	4.65	4.98	5.13	5.65	6.00
6.5							3.24	3.54	3.84	4.16	4.47	4.80	5.13	5.47	5.82	6.17
7.0								3.67	3.98	4.29	4.62	4.95	5.29	5.63	5.98	6.33
7.5									4.11	4.43	4.76	5.10	5.44	5.79	6.14	6.50
8.0										4.57	4.91	5.25	5.59	5.95	6.330	6.67
8.5											5.05	5.40	5.75	6.10	6.47	6.83
9.0											5.20	5.55	5.90	6.26	6.63	7.00
9.5												5.69	6.05	6.42	6.79	7.17
10.0													6.21	6.58	6.95	7.33
11.0															7.28	7.67
12.0																8.00

Intermediate values by linear interpolation.

6. Summary of required proof:

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

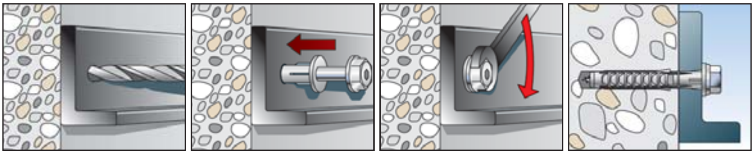
6.2 Shear: $V^h_{Sd} \leqq V_{Rd}$ = lowest value of $V_{Rd,s}$; $V_{Rd,p}$; $V_{Rd,cp}$ (c) ; $V_{Rd,cp}$ (p) ; $V_{Rd,c}$

6.3 Combined tension and shear load:

$$\frac{N^h_{Sd}}{N_{Rd}} + \frac{V^h_{Sd}}{V_{Rd}} \leqq 1.2$$

N^h_{Sd} ; V^h_{Sd} = tension/shear components of the load for single anchor
N_{Rd} ; V_{Rd} = design resistance including safety factors

7. Installation details

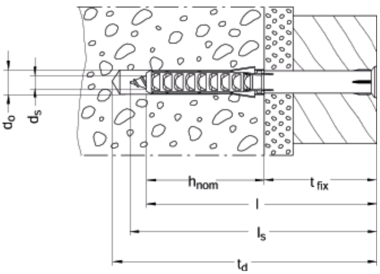


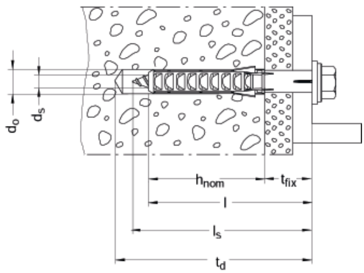
fischer Long-shaft fixing SXS

Anchor design according to ETA

8. Anchor characteristics

Anchor type			SXS 10 gvz	SXS 10 A4
nominal drill hole diameter	d_0	[mm]	10	
drill depth	h_1	[mm]	60	
anchorage depth	h_{nom}	[mm]	50	
clearance-hole in fixture to be attached	d_f	[mm]	≦ 12	
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		[-]	T 40	
min. thickness of concrete member	h_{min}	[mm]	100	
non-cracked concrete				
minimum spacing for required edge distances	s_{min}	[mm]	55	
	for c	[mm]	100	
minimum edge distances for required spacing	c_{min}	[mm]	60	
	for s	[mm]	250	
cracked concrete				
minimum spacing for required edge distances	s_{min}	[mm]	55	
	for c	[mm]	100	
minimum edge distances for required spacing	c_{min}	[mm]	50	
	for s	[mm]	250	





9. Mechanical 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
yield strength screw	f_y	[N/mm²]	480	450
tensile strength screw	f_u	[N/mm²]	600	580

fischer Frame fixing SXR

Anchor design according to ETA

1. Types

SXR-T – with zinc-plated fischer safety screw

SXR-Z – with zinc-plated fischer safety screw for cross drive PZ 4

SXR-FUS – with zinc-plated CO-NA hexagon-head screw

European Technical Approval – for concrete and masonry

Fire resistance classification R 90

Anchor types see test report

CALCULATION WITH CC COMPUFIX CALCULATION SOFTWARE

Features and Advantages

- European Technical Approval for concrete and masonry.
- Suitable under pure axial loads in cracked and non-cracked concrete.
- Unique on the market - the decisive factor here is a comparatively low thigtheningtorque in relation to a very high overtorque during the setting process.
- With distinct anti-rotation lock that wirks optimally even in critical building materials.
- The SXR can easily be hammerd in without bending.
- Wide range of head designs for different applications.

Materials

Screw:	Carbon steel, zinc plated (5 µm) and passivated (gvz)
	Carbon steel, hot-dip galvanised to min. 40 µm (fvz)
	Stainless steel of the corrosion resistance class III, e.g. A4
Anchor sleeve:	Polyamide

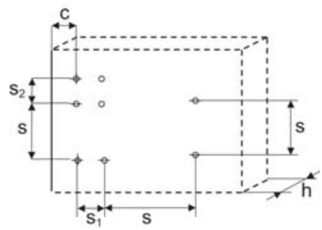
fischer Frame fixing SXR

Anchor design according to ETA

Maximum permissible loads[1)] of one fixing point[2)] in concrete.
For the design the complete approval ETA-07/0121 is to be observed.

Fixing type					SXR 8		SXR 10	
					gvz	A4	gvz	A4
Effective anchorage depth			h_{ef}	[mm]	50		50	
Drill hole depth			$h_1 \geqq$	[mm]	60		60	
Minimum structural component thickness			h_{min}	[mm]	100		100	
Nominal drill hole diameter			d_0	[mm]	8		10	
Clearance-hole in fixture to be attached			d_f	[mm]	8.5		10.5	
Permissible bending moment			M_{perm}	[Nm]	7.1	5.8	10.1	9.5
Permissible tensile load Nperm[1)] of one fixing point 2) in concrete (use category "a")								
Concrete C12/15	Temperatue range ϑ 3)		30 ° / 50 °C	[kN]	1.0		2.0	
			50 ° / 80 °C	[kN]	1.0		1.8	
Permissible shear load Vperm[1)] of one fixing point 2) in concrete (use category "a")								
Concrete C12/15	Temperatue range ϑ 3)		30 ° / 50 °C	[kN]	4.2	3.4	5.4	5.0
			50 ° / 80 °C	[kN]				
Spacings and edge distances in concrete (use category "a")								
Concrete C12/15	Minimum spacing		s_{min}	[mm]	70		70	
			for $c_{min} \geqq$	[mm]	70		210	
	Minimum edge distance		c_{min}	[mm]	70		85	
			for $s_{min} \geqq$	[mm]	70		100	
	Characteristic edge distance		$c_{cr, N}$	[mm]	70		140	
Concrete C16/20 - C50/60	Minimum spacing		s_{min}	[mm]	50		50	
			for $c_{min} \geqq$	[mm]	50		150	
	Minimum edge distance		c_{min}	[mm]	580		60	
			for $s_{min} \geqq$	[mm]	50		70	
	Characteristic edge distance		$c_{cr, N}$	[mm]	50		100	

1) Material safety factors according to approval and safety factor for load γ_F = 1.4 are considered. For combined tension and shear please observe the ETA approval and the design method (ETAG 020, Annex C).
2) A fixing point can consist of a single anchor, a group of two anchors with $s_1 \geq s_{1,min}$ or a group of four anchors with $s_1 \geq s_{1,min}$ and $s_2 \geq s_{2,min}$.
3) In the temperature ranges ϑ = (30°/50° C) and ϑ = (50°/80° C) the first value indicates the maximum long-term temperature and the second value indicates the maximum short-term temperature."



4

fischer Frame fixing SXR

Anchor design according to ETA

Permissible load F_{perm}[1)] of one fixing point [2)] in solid masonry (use category "b") for tension, shear or combined shear and tension.

Type of brick	Supplier / Trade name of the brick	Brick size [-]	Brick size [mm]	Bulk density class [kg/dm³]	Min. compressive strength [N/mm²]		SXR 8 Temperature range ϑ [3)] 50°/80° C
Terracotta solid brick **MZ** e.g. DIN 105, DIN EN 771-1	e.g. Wienerberger *Mz*, Schlagmann *Mz*	DF	240 x 115 x 52	≧ 1.8	28	[kN]	0.7
					20		0.6
					10		0.4
		NF	240 x 115 x 71	≧ 1.8	20	[kN]	0.6
					10		0.3 (0.4) [4)]
		2 DF	240 x 115 x 113	≧ 1.0	12	[kN]	0.2
					8		0.1
		3 DF	240 x 175 x 113	≧ 1.8	20	[kN]	0.7
					10		0.6
Sand-lime solid brick **KS** e.g. DIN 106, DIN EN 771-2	e.g. KS Wemding *KS*	NF	240 x 115 x 71	≧ 1.8	20	[kN]	0.7
					10		0.6
		-	175 x 500 x 235	≧ 2.0	20	[kN]	0.7
					10		0.4 (0.6) [4)]
Solid brick of light-weight concrete e.g. DIN 18152, DIN EN 771-3	e.g. KLB *V*	2 DF	240 x 115 x 113	≧ 1.2	2	[kN]	0.3
		-	240 x 490 x 115	≧ 1.0	2	[kN]	0.4
		-	250 x 240 x 245	≧ 1.8	8	[kN]	0.7
					4		0.4
		-	240 x 490 x 115	≧ 1.4	6	[kN]	0.3
					4		0.2
Solid brick of normal-weight concrete **VBN** e.g. DIN 18153, DIN EN 771-3	e.g. Adolf Blatt *VBN*	-	246 x 240 x 245	≧ 1.8	12	[kN]	0.7
					8		0.6
					4		0.3
Terracotta solid brick **BS** e.g. EN 771-1: 2003 + A1: 2005	e.g. Wienerberger *Mz*, *BS Røde*	DF	228 x 108 x 54	≧ 1.8	28	[kN]	0.7
					20		0.6
					10		0.4

Continued next page.

fischer Frame fixing SXR

Anchor design according to ETA

Permissible load F_{perm}[1)] of one fixing point [2)] in hollow or perforated masonry (use category "c") for tension, shear or combined shear and tension.

Type of brick	Supplier / *Trade name of the brick*	Brick characteristics [-]	Brick size [mm]	Bulk density class [kg/dm³]	Min. compressive strength [N/mm²]		SXR 8 Temperature range ϑ [3)] 50°/80° C
Vertical perforated brick Form B **Hlz** e.g. DIN 105, DIN EN 771-1	e.g. Wienerberger *Hlz*	2 DF	240 x 115 x 113	≧ 1.2	20	[kN]	0.3
					10		0.1
	e.g. Schlagmann	12 DF	380 x 240 x 240	≧ 0.9	8	[kN]	0.2
					6		0.2
					4		0.1
	e.g. Schlagmann *Plan-füllziegel*			≧ 0.7	6	[kN]	0.3
					4		0.2
					2		0.1
Vertical perforated brick Form B **Hlz** e.g. EN 771-1, A1: 2005	e.g. Wienerberger *BS*	DF	240 x 115 x 52	≧ 1.5	28	[kN]	0.6
					20		0.3 (0.4) [4)]
					10		0.2
Vertical perforated brick **Hlz** e.g. EN 771-1		NF	240 x 115 x 71	≧ 1.8	20	[kN]	0.7
					10		0.6
Perforated sand-lime brick **KSL** e.g. DIN 106, DIN EN 771-2	e.g. KS Wemding *KSL*	2 DF	240 x 115 x 113	≧ 1.4	12	[kN]	0.6
					6		0.3
		3 DF	240 x 175 x 113	≧ 1.4	16	[kN]	0.3 (0.49) [4)]
					6		0.1 (0.2) [4)]
		5 DF	300 x 240 x 115	≧ 1.4	16	[kN]	0.6
					6		0.2
		P10	495 x 98 x 248	≧ 1.2	6	[kN]	0.3 (0.49) [4)]
					2		0.1 (0.2) [4)]
Hollow block of lightweight concrete **Hbl** e.g. DIN 18151, DIN EN 771-3	e.g. KLB *Hbl*	-	240 x 240 x 360	≧ 1.0	6	[kN]	0.4
Hollow block of lightweight concrete e.g. NF-P 14-301, EN 771-3	e.g. Sepa *Parpaing*	-	500 x 200 x 200	≧ 0.9	4	[kN]	0.1
Hollow block of lightweight concrete e.g. EN 771-3	e.g. Roadstone masonry	-	440 x 210 x 215	≧ 1.2	10	[kN]	0.7
					6		0.4
Vertical perforated brick **MS** e.g. EN 771-1: 2003 + A1: 2005	e.g. Wienerberger *MS Rød glat hulsten*	DF	228 x 108 x 54	≧ 1.4	28	[kN]	0.6
					20		0.3 (0.4) [4)]
					10		0.2

Spacings and edge distances in masonry (use category "b" and "c")

Minimum interspacing (between single anchors or groups of anchors)	s_{min}	[mm]	250
Minimum spacing within a group of anchors, perpendicular to the free edge	$s_{1, min}$	[mm]	100
Minimum spacing within a group of anchors, prarallel to the free edge	$s_{2, min}$	[mm]	100
Minimum edge distance	c_{min}	[mm]	100
Minimum thickness of member	h_{min}	[mm]	100

1) Material safety factors according to approval and safety factor for load γ_F = 1.4 are considered.
For combined tension and shear please observe the ETA approval and the design method (ETAG 020, Annex C).

2) A fixing point can consist of a single anchor, a group of two anchors with $s_1 \geq s_{1,min}$ or a group of four anchors with $s_1 \geq s_{1,min}$ and $s_2 \geq s_{2,min}$.

3) In the temperature ranges ϑ = (30°/50° C) and ϑ = (50°/80° C) the first value indicates the maximum long-term temperature and the second value indicates the maximum short-term temperature.

4) The value in brackets is valid for temperature range 30/50 °C only.

fischer Frame fixing SXR

Anchor design according to ETA

Permissible load F_{perm} [1] of one fixing point [2] in solid masonry (use category "b") for tension, shear or combined shear and tension.

Type of brick	Supplier / *Trade name of the brick*	Brick characteristics [-]	Brick size [mm]	Bulk density class [kg/dm³]	Min. compressive strength [N/mm²]		SXR 10 Temperature range ϑ [3] 30°/50° C	SXR 10 Temperature range ϑ [3] 50°/80° C
Terracotta solid brick **MZ** e.g. DIN 105, DIN EN 771-1	e.g. Vollmeter *Mz*, Schlagmann *Mz*	NF	240 x 115 x 71	≧ 1.8	20 (10) [4]	[kN]	1.0	0.9
					36		1.4	1.4
		3 DF	240 x 115 x 113	≧ 1.8	20 (10) [4]	[kN]	0.6	0.6
							1.3 [5]	1.1 [5]
Sand-lime solid brick **KS** e.g. DIN 106, DIN EN 771-2	e.g. KS Wemding *KS*	NF	240 x 115 x 71	≧ 1.8	20 (10) [4]	[kN]	0.7	0.7
							1.1 [5]	1.1 [5]
		NF	240 x 115 x 71	≧ 2.0	20 (10) [4]	[kN]	1.0	0.9
					36		1.4	1.4
		-	175 x 500 x 235	≧ 2.0	20 (10) [4]	[kN]	1.3	1.3
					28		1.4	1.4
Solid brick of light-weight concrete e.g. DIN 18152, DIN EN 771-3	e.g. KLB *V*	2 DF	240 x 115 x 113	≧ 1.2	2	[kN]	0.2	0.2
							0.3 [5]	0.3 [5]
		-	240 x 490 x 115	≧ 1.2	2	[kN]	0.3	0.3
		-	250 x 240 x 245	≧ 1.6	6	[kN]	0.7	0.7
		-	240 x 490 x 115	≧ 1.6	8	[kN]	0.9	0.9
Solid brick of normal-weight concrete **VBN** e.g. DIN 18153, DIN EN 771-3	e.g. Adolf Blatt *VBN*	-	246 x 240 x 245	≧ 1.8	20 (10) [4]	[kN]	1.3	1.3
Solid brick of normal-weight concrete **VBN**	*e.g.* Tamac	-	440 x 215 x 100	≧ 1.8	20 (10) [4]	[kN]	1.3	1.1
Solid brick of normal-weight concrete **VBL**	*e.g.* Tamac	-	440 x 215 x 100	≧ 1.4	6	[kN]	0.6	0.6
							0.7 [5]	0.7 [5]
Heat insulation block	*e.g.* Gisoton *WDB*	-	390 x 240 x 250	≧ 0.7	2	[kN]	0.4	0.4
Terracotta solid brick **BS** e.g. EN 771-1: 2003 + A1: 2005	e.g. Wienerberger *Mz*, *MS Rød glst hulsten*	DF	228 x 108 x 54	≧ 1.5	28	[kN]	0.9	0.9
					20		0.6	0.6
					10		0.4	0.4

Continued next page.

fischer Frame fixing SXR

Anchor design according to ETA

Permissible load F_{perm}[1)] of one fixing point [2)] in hollow or perforated masonry (use category "c") for tension, shear or combined shear and tension.

Type of brick	Supplier	Brick characteristics					SXR 10	
		Brick size		Bulk density class	Min. compressive strength		Temperature range ϑ [3)]	
	Trade name of the brick	[-]	[mm]	[kg/dm³]	[N/mm²]		30°/50° C	50°/80° C
Vertical perforated brick Form B **Hlz** e.g. DIN 105, DIN EN 771-1	e.g. Wienerberger *Hlz*	2 DF	240 x 115 x 113	≧ 1.0	20 (10) [4)]	[kN]	0.6	0.6
				≧ 1.2			0.9 [5)]	0.7
	e.g. Schlagmann *Plan-füllziegel*	12 DF	380 x 240 x 240	≧ 0.7	6	[kN]	0.6	0.6
	e.g. Schlagmann *Poroton T14*	-	300 x 240 x 240	≧ 0.7	6	[kN]	0.1	0.1
Vertical perforated brick Form B **Hlz** e.g. NF-P 13-301, EN 771-	e.g. Wienerberger *Porotherm GF R20*	-	500 x 200 x 299	≧ 0.7	10	[kN]	0.2	0.2
Vertical perforated brick **Hlz** e.g. NF-P 13-301, EN 771-	e.g. Imerys *Gelimatic*	-	270 x 200 x 500	≧ 0.6	6	[kN]	0.2	0.2
	e.g. Terreal *Calibric*	-	500 x 200 x 314	≧ 0.7	8	[kN]	0.2	0.2
	e.g. Bouyer Leroux *BGV*	-	570 x 200 x 314	≧ 0.6	6	[kN]	0.2	0.2
							0.3 [5)]	0.3 [5)]
	e.g. Wienerberger *Porotherm 30 R*	-	370 x 300 x 249	≧ 0.7	10	[kN]	0.1	0.1
							0.2 [5)]	0.2 [5)]
Perforated sand-lime brick **KSL** e.g. DIN 106, DIN EN 771-2	e.g. KS Wemding *KSL*	5 DF	300 x 240 x 115	≧ 1.4	16 (10) [4)]	[kN]	1.0 [5)]	0.9
		P 10	495 x 98 x 248	≧ 1.2	6	[kN]	0.4	0.4
							0.7 [5)]	0.6 [5)]
Hollow block of lightweight concrete **Hbl** e.g. DIN 18151, DIN EN 771-3	e.g. KLB *Hbl*	-	-	≧ 1.2	2	[kN]	0.4	0.4
Hollow block of lightweight concrete e.g. NF-P 14-301, EN 771-3	e.g. Sepa *Parpaing*	-	500 x 200 x 200	≧ 0.9	4	[kN]	0.3	0.3
							0.4 [5)]	
Hollow block of lightweight concrete **Hbn** e.g. DIN 18153, DIN EN 771-3	e.g. Adolf Blatt *Hbn*	10 DF	300 x 240 x 240	≧ 1.6	6	[kN]	0.7	0.7
Vertical perforated brick **MS** e.g. EN 771-1: 2003 + A1: 2005	e.g. Wienerberger *BS Røde*	DF	228 x 108 x 54	≧ 1.5	28	[kN]	0.9	0.6
					20		0.6	0.3
					12		0.3	0.3
					8		0.3	0.3

4

Spacings and edge distances in masonry (use category "b" and "c")

Minimum interspacing (between single anchors or groups of anchors)	s_{min}	[mm]	250
Minimum spacing within a group of anchors, perpendicular to the free edge	$s_{1,\ min}$	[mm]	100
Minimum spacing within a group of anchors, pralallel to the free edge	$s_{2,\ min}$	[mm]	100
Minimum edge distance	c_{min}	[mm]	100

1) Material safety factors according to approval and safety factor for load $\gamma F = 1.4$ are considered.
For combined tension and shear please observe the ETA approval and the design method (ETAG 020, Annex C).
2) A fixing point can consist of a single anchor, a group of two anchors with $s_1 \geq s_{1,min}$ or a group of four anchors with $s_1 \geq s_{1,min}$ and $s_2 \geq s_{2,min}$.
3) In the temperature ranges ϑ = (30°/50° C) and ϑ = (50°/80° C) the first value indicates the maximum long-term temperature and the second value indicates the maximum short-term temperature.
4) For a minimum compressive strength of the the brick between 10 N/mm² and 20 N/mm²: $F'_{perm} = 0{,}7 \times F_{perm}$.
5) Valid for an edge distance of c ≥ 200 mm only; Intermediate values by linear interpolation.

Notes

Post-installed rebar connections with Injection mortar FIS V and FIS EM

Post-installed rebar connections

with Injection mortar FIS V and FIS EM

5.1 Types

Injection mortar
FIS V 360 S

Injection mortar
FIS VS 360 S

Injection mortar
FIS V 950 S,
FIS VS 950 S

Injection mortar
FIS EM 390S

Injection mortar
FIS EM 1100 S

Static mixer FIS S

Static mixer FIS SE

Mit allgemeiner bauaufsichtlicher Zulassung

European Technical Approval – for rebar connections.

Features and Advantages

- High temperature resistance
- Improved chemical resistance
- Reduced shrinkage
- Less sensitive to hole cleaning
- Resin is alkaline, providing improved corrosion resistance
- High and more consistent loadbearing capacity

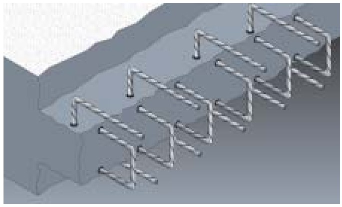
Advantages over mineral mortars

- Short curing time
- Easy installation due to cartridge form

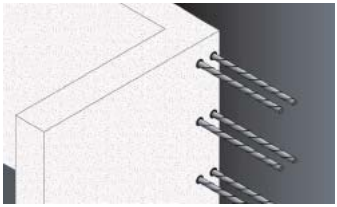
5.2 Applications

Extension of cantilevered slabs and refurbishment of slab edges.

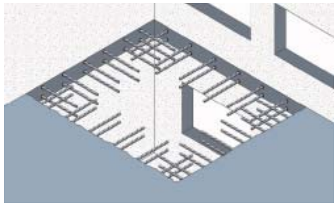
Bent reinforcement can be easily installed using FIS V or FIS EM.



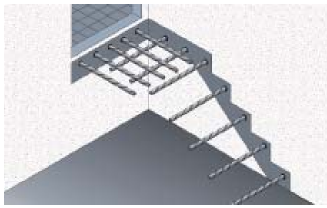
Starter bars for extending concrete walls.



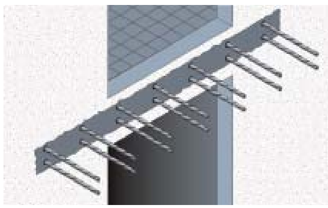
Starter bars for closing openings.



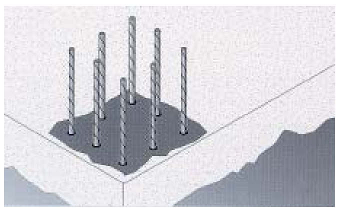
Anchoring of staircase landings.



Connection of a cantilevered slab to the edge of a concrete floor using spliced bars.



Starter bars for concrete columns.



5.3 Features and advantages

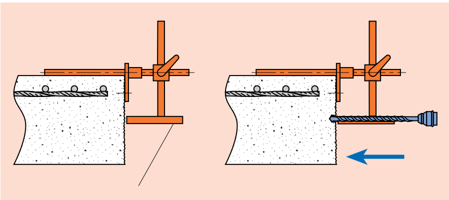
- Time and cost savings compared to traditional break-out and making good of concrete elements
- Subsequent flexible planning resulting in easy change of use or easy extension of buildings
- Defined performance in accordance with assessments and approval documents
- Design in accordance with EC2 like cast-in rebars
- Resin is alkaline, providing improved corrosion resistance

5.4 Installation

- Drilling process

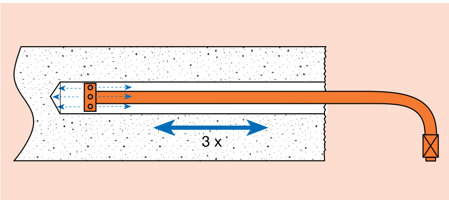
Position of drill hole should be provided by the design engineer.

For precise drilling parallel to an existing surface a drilling aid is available from the fischer range to ensure deviations ≦ 2 %.



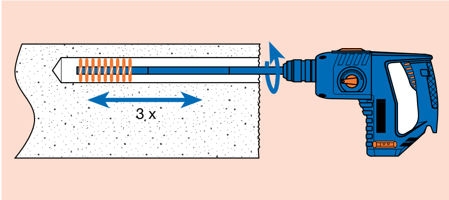
- Blowing-out of the drill hole

The drill hole must be blown-out 3 times (FIS V) from the bottom of the hole using the compressed air lance from the fischer range (oil free compressed air ≧ 6 bar).



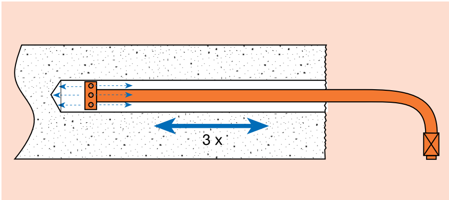
- Brushing of the drill hole

The drill hole must be brushed out 3 times (FIS V) using the stainless steel brush from the fischer range.



- Blowing-out of the drill hole

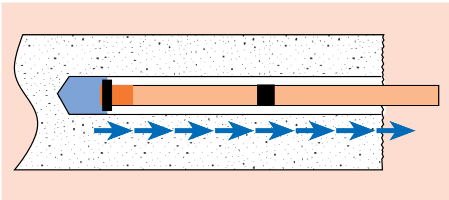
The drill hole must be blown-out 3 times (FIS V) from the bottom of the hole using the compressed air lance from the fischer range (oil free compressed air ≧ 6 bar).



- Injection of the FIS V or FIS EM mortar

Filling the drill hole from the bottom with mortar.

The fischer injection aid is attached to the end of the extension nozzle. Back pressure is created to avoid any air bubbles being present.



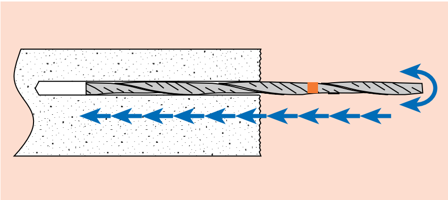
- Inserting the rebar

With strong pressure and simultanous twisting action the rebar is inserted into the hole.

Post-installed rebar connections

with Injection mortar FIS V and FIS EM

After curing the rebar may be loaded.



For optimum installation fischer offers a comprehensive range of equipment.

- FIS rebar case

...contains all the important equipment for correct installation.

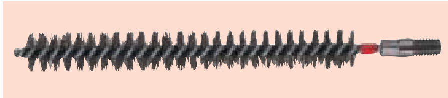
The FIS rebar case contains a drilling guide, extensions for the steel brush, injection aid, cleaning lance, steel brushes and further useful equipment. It also contains the installation instructions and a check list for documentation of the installation process.

- The drilling guide

...is part of the system kit. It is an aid to ensure minimum deviation from the desired position (see first figure of the installation instructions).

- The cleaning brushes

...ensure properly cleaned drill hole walls. The use of stainless steel brushes guarantees a perfect removal of the drill dust.



- Injection guns

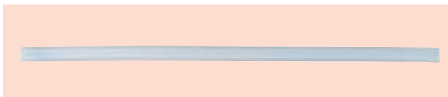
...guaranteed no-tiredness injection by offering a hand operated gun for small jobs and a pneumatic gun for professional high volume use.

- The injection aid

...makes it easy to fill the holes without air bubbles. The aid is attached to the end of the extension nozzle. Using this enables the back pressure to be felt easily.

- The extension tube

...enables the hybrid mortar to be transferred to the bottom of the drill hole.



- The SDS-max scabbler

...is used to remove the carbonated concrete surface, in order to expose the aggregates to provide a good keying surface for transmitting shear loads.

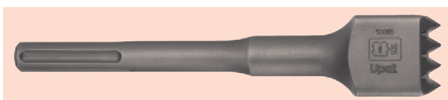


Table 5.1:
Gelling time

Concrete temperature	Setting time [min]		
	FIS V	FIS VS	FIS EM
+ 5 °C	9	-	240
+ 10 °C	6	18	120
+ 15 °C	4	12	60
+ 20 °C	3	9	30
+ 25 °C	2.5	7	14
+ 40 °C *)	2 *)	4	7

*) With temperatures above 30 °C to 40 °C the cartridges have to be cooled down to 15 °C ... 20 °C (water bath or cool box).

Table 5.2:
Curing time

Concrete temperature	Curing time		
	FIS V [min]	FIS VS [min]	FIS EM [h]
- 5 °C	360	-	80
0 °C	180	360	80
+ 5 °C	90	180	40
+ 10 °C	80	120	18
+ 15 °C	60	90	18
+ 20 °C	50	60	10
+ 25 °C	40	45	10
+ 30 °C	35	35	5
+ 40 °C	25	25	5

Required volume of resin

$$V_{FIS} = \frac{p}{4} \cdot \left(d_0^2 - d_s^2\right) \cdot l_v = k \cdot l_v$$

Where:

V_{FIS} = mortar volume [ml]
l_v = anchorage length [cm]
d_0 = drill diameter [mm]
d_s = rebar diameter [mm]

Example:

A rebar with a diameter of d_s = 20 mm should be installed with an anchorage length of 850 mm. The required volume of resin is:

$V_{FIS\ V/EM} = k \cdot l_v = 1.77\ ^{ml}/_{cm} \cdot 85\ cm = 150.45\ ml$

5.5. Design
5.5.1 Basics

For the assessment of post-installed rebars under tension two methods are available:

- Design in non-reinforced concrete (anchor theorie)

The loads are transmitted to the concrete using its tensile strength. Possible modes of failure are concrete failure, pull-out of the anchor from the drill hole and steel failure. The design can be done in accordance with the CC-Method (see Annex A).

- Design in reinforced concrete

The load is transmitted to the existing reinforcement by compression struts. The design is done similarly to the design of cast-in rebars. The following parts of this design guide deal exclusively with the design in reinforced concrete based on EC2.

The equations and the construction guidance are based on the assumption that the transmission of loads, e. g. to the supports, follows requirements of the reinforced concrete regulations. Possible national regulations have to be observed.

Extensive test series show that the bonding behaviour of post-installed rebars using fischer FIS V/EM in concrete with a strength class up to C50/60 does not differ compared with cast-in rebars, provided that the installation of the rebars is done in accordance with the fischer installation instructions.

Table 5.3:
Factor k for calculation of the mortar volume $V_{FIS\ V/EM}$

Rebar diameter d_s [1]	[mm]	8	10	12	14	16	20	25	28	32
Drill diameter d_0	[mm]	12	14	16	18	20	25	30	35	40
Faktor k for the required volume of resin	[ml/cm]	0.63	0.75	0.88	1.01	1.13	1.77	2.16	3.46	4.52

[1] Further diameter see approval

Generally the design of post-installed rebars and lap splices can be done in accordance with EC2. There are some minor deviations regarding the condition of application, e.g. minimum anchorage length, behaviour under fire and minimum concrete cover.

Design with higher bond strength than those recommended in the national regulations is not recommended because a significant increase in displacement of the bar has to be expected.

5.5.2 Partial safety factors for actions

The partial safety factors for actions may be taken in accordance with EC2:

Table 5.4:
Partial safety factor

		Favourable (reducing of loading)	Unfavourable (increasing of loading)
Dead loads	γ_G	1.0	1.35
Variable loads	γ_Q	0	1.5

5.5.3 Steel values of resistance

The value of resistance of a rebar under tension depends on the material properties (yield strength, tensile strength) and on the cross-sectional area of the bar.

$$N_{Rd,s} = \frac{\pi}{4} \cdot d_s^2 \cdot \frac{f_{yk}}{\gamma_s} \qquad (5.1)$$

Where:

$N_{Rd,s}$ = design value of the tensile resistance for steel failure

d_s = diameter of the rebar

f_{yk} = yield strength of the rebar

γ_s = partial safety factor of the material = 1.15

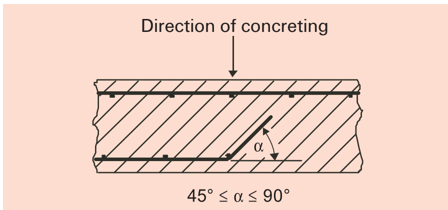
5.5.4 Bond strength - required anchorage length

5.5.4.1 Bond conditions

The bond strength of cast-in rebars depends mainly on the surface profile of the bar, the dimensions of the structural component and the inclination of the bar during concreting.

Good bond conditions exist (EC2, Section 8.4.2):

a) When the rebar has an inclination of 45° to 90°.



b) When the rebar has an inclination of 0° to 45° and the thickness of the structural component in the direction of concreting is not greater than 250 mm.

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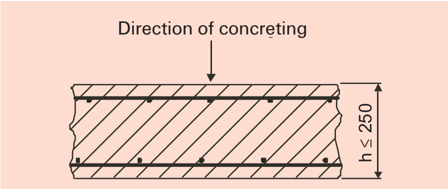
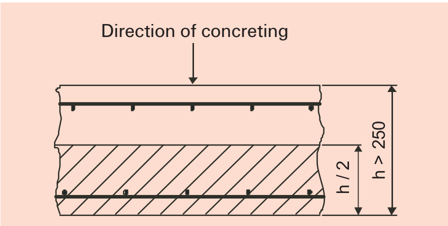
Table 5.5:
Design value $N_{Rd,s}$ of the tensile resistance as a function of the nominal yield strength

Diameter of rebar d_s [mm] [1)]		8	10	12	14	16	20	25	28	32	40
Design value $N_{Rd,s}$ of the tensile resistance for steel failure [kN]											
f_{yk} [N/mm²]	400	17.5	27.3	39.3	53.5	69.9	109.3	170.7	214.2	279.7	437.1
	420	18.4	28.7	41.3	56.2	73.4	114.7	179.3	224.9	293.7	458.9
	460	20.1	31.4	45.2	61.6	80.4	125.7	196.3	246.3	321.7	502.7
	500	21.9	34.1	49.2	66.9	87.4	136.6	213.4	267.7	349.7	546.4
	550	24.0	37.6	54.1	73.6	96.2	150.3	234.8	294.5	384.6	601.0

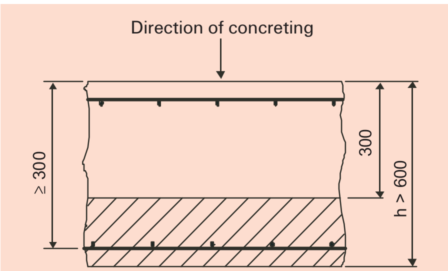
[1)] Further diameter see approval



c) When the thickness of the structural component is greater than 250 mm and the rebar is located in the lower half of the component.



d) When the thickness of the structural component is greater than 600 mm and the rebar is located at least 300 mm from the upper surface of the component



Good bond conditions for rebars in the **hatched** areas.

Poor bond conditions for rebars in the **un-hatched** areas.

5.5.4.2 Design resistance of the bond strength

The load bearing capacity and the displacement behaviour of a post-installed rebar using FIS V/EM is similar to that of a cast-in rebar up to a concrete compressive strength of 30 N/mm², measured with cylinders.

$$f_{bd} = 2.25\,\eta_1 \cdot \eta_2 \cdot f_{ctd} \qquad (5.2)$$

Where:

η_1 = 1.0 for good bonding conditions
= 0.7 for all other conditions

η_2 = 1.0 for $d_s \leq 32$ mm
= $(132 - d_s)/100$ for $d_s > 32$ mm

f_{ctd} = $(\alpha_{ct} \cdot f_{ctk,0.05}/\gamma_c)$

α_{ct} = influence of long-term performance
= 1.0

$f_{ctk,\,0.05}$ = lower limit of characteristic tensile strength of concrete (5% fractile)

γ_c = safety coefficient for the concrete
= 1.5

With post-installed rebars the correct installation (drilling, cleaning, injection, inserting the rebar) has a strong effect on the load bearing capacity and the displacement behaviour.

Table 5.6:
Design values of the bond strength for fischer injection mortar FIS V. FIS EM is sometimes different. See approval.

Concrete strength class [1]		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
Characteristic compressive strength (measured with cylinders) f_{ck}	[N/mm²]	12	16	20	25	30	35	40	45	50
Lower limit of the characteristic concrete tensile strength $f_{ctk;\,0.05}$	[N/mm²]	1.1	1.3	1.5	1.8	2.0	2.2	2.5	2.7	2.9
Design value of the bond strength f_{bd} (good bond conditions) [2) 3)]	[N/mm²]	1.6	2.0	2.3	2.7	3.0	3.4	3.7	4.0	4.3

1) Information on national parameters can be found in Section 2 „Basic principles of fixing technology“, table 2.2
2) For ribbed bars with a diameter $d_s \leq 32$ mm
3) For poor bond conditions the values f_{bd} shall be multiplied by 0.7

5.5.4.3 Basic value of the required anchorage length

The basic required anchorage length $l_{b,rqd}$ is needed to anchor the force ($A_s \cdot \sigma_{sd}$) in a bar assuming constant bond stress. For $\sigma_{sd} = f_{yd}$ the maximum steel capacity can be gained. Thus steel failure is decisive and a further increase in anchorage length does not result in an increase in capacity.

$$l_{b,rqd} = \frac{d_s}{4} \cdot \frac{\sigma_{sd}}{f_{bd}} \quad (5.3)$$

Where:

$l_{b,rqd}$ = basic value of the required anchorage length

d_s = diameter of the rebar

σ_{sd} = design value of the tensile steel strength in the bar at the position from where the anchorage is measured from

f_{bd} = design value of the bond strength (see Equation (5.2) and Table (5.6))

5.5.4.4 Anchorages
5.5.4.4.1 Required anchorage length

The design value of the anchorage length is calculated as follows:

$$l_{bd} = \alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \alpha_4 \cdot \alpha_5 \cdot l_{b,rqd} \geq l_{b,min} \quad (5.4)$$

Where:

α_1 = influence of the bar shape

α_2 = influence of the concrete cover

α_3 = influence of the transverse reinforcement (not welded)

α_4 = influence of the transverse reinforcement (welded)

α_5 = influence of transverse pressure

$l_{b,rqd}$ = basic value of anchorage length

$l_{b,min}$ = minimum anchorage length

Where: $\alpha_2 \cdot \alpha_3 \cdot \alpha_5 \cdot \geq 0.7$

5

Table 5.7:
Values of α_1, α_2, α_3, α_3, α_4 and α_5 coefficients

Influence factor	Type of anchorage	Reinforcement bar in tension	Reinforcement bar in compression
Shape of bars	straight	$\alpha_1 = 1.0$	$\alpha_1 = 1.0$
	other than straight (see pr EN 1992-1-1: 2003 figure 8.1 (b), (c) and (d))	$\alpha_1 = 0.7$ if $c_d > 3\ d_s$ otherwise $\alpha_1 = 1.0$ (see pr EN 1992-1-1: 2003 figure 8.3 for values of c_d)	$\alpha_1 = 1.0$
Concrete cover	straight	$\alpha_2 = 1 - 0.15\ (c_d - d_s) / d_s$ ≥ 0.7 ≤ 1.0	$\alpha_2 = 1.0$
	other than straight (see pr EN 1992-1-1: 2003 figure 8.1 (b), (c) and (d))	$\alpha_2 = 1 - 0.15\ (c_d - 3\ d_s) / d_s$ ≥ 0.7 ≤ 1.0 (see pr EN 1992-1-1: 2003 figure 8.3 for values of c_d)	$\alpha_2 = 1.0$
Confinement by transverse reinforcement not welded to main reinforcement	all types	$\alpha_3 = 1 - K\lambda$ ≥ 0.7 ≤ 1.0	$\alpha_3 = 1.0$
Confinement by welded transverse reinforcement	all types, position and size as specified in pr EN 1992-1-1: 2003 figure 8.1 (e)	$\alpha_4 = 0.7$	$\alpha_4 = 0.7$
Confinement by transverse pressure	all types	$\alpha_5 = 1 - 0.04\ p$ ≥ 0.7 ≤ 1.0	-

Legend see next page

Where:

λ = $(\Sigma A_{st} - \Sigma A_{st, min})/A_s$

ΣA_{st} = cross-sectional area of the transverse reinforcement along the design anchorage length l_{bd}

$\Sigma A_{st, min}$ = cross-sectional area of the minimum transverse reinforcement
= 0.25 A_s for beams and 0 for slabs

A_s = area of a single anchored bar with maximum bar diameter

K = values see pr EN 1992-1-1: 2003 in figure 8.4

p = transverse pressure [MPa] at ultimate limit state along l_{bd}

5

Minimum anchorage length

- for rebars in tension

FIS EM [1)]
$$l_{b, min} = \{\max 0.3\, l_{b, rqd}\,;\, 10\, d_s\,;\, 100\text{ mm}\}$$

FIS V
$$l_{b, min} = 1.5\,\{\max 0.3\, l_{b, rqd}\,;\, 10\, d_s\,;\, 100\text{ mm}\} \quad (5.4\text{ a})$$

[1)] In case of diamond drilling multiply the values for $l_{b, min}$ by 1.3

- for rebars in compression

FIS EM [1)]
$$l_{b, min} = \{\max 0.6\, l_{b, rqd}\,;\, 10\, d_s\,;\, 100\text{ mm}\}$$

FIS V
$$l_{b, min} = 1.5\,\{\max 0.6\, l_{b, rqd}\,;\, 10\, d_s\,;\, 100\text{ mm}\} \quad (5.4\text{ b})$$

Where:

$l_{b, min}$ = minimum anchorage length

$l_{b, rqd}$ = basic value of the required anchorage length (Equation (5.3))

d_s = diameter of the rebar

5.5.4.4.2 Lap length

The spacing of the spliced rebars shall be $s \leq 4 \cdot d_s$. For spacings $s > 4 \cdot d_s$ the lap length l_0 shall be increased by $s - 4 \cdot d_s$.

$$l_0 = \alpha_1 \cdot \alpha_2 \cdot \alpha_3 \cdot \alpha_4 \cdot \alpha_5 \cdot \alpha_6 \cdot l_{b,rqd} \geq l_{0, min} \quad (5.5)$$

Where:

l_0 = required lap length

$l_{b, rqd}$ = basic value of the required anchorage length (Equation (5.4))

α_1 = influence of the bar shape

α_2 = influence of the concrete cover

α_3 = influence of the transverse reinforcement (not welded) ≤ 1

α_5 = influence of transverse pressure ≤ 1

α_4 = influence of the transverse reinforcement (welded) ≤ 1

α_6 = influence of the proportion of the overlapping bars ot the cross-section
= 1.5, if all bars are overlapping in cross-section

Minimum lap length

FIS EM [1)]
$$l_{0, min} = \{\max 0.3\, \alpha_6\, l_{b, rqd}\,;\, 15\, d_s\,;\, 200\text{ mm}\}$$

FIS V [1)]
$$l_{0, min} = 1.5\,\{\max 0.3\, \alpha_6\, l_{b, rqd}\,;\, 15\, d_s\,;\, 200\text{ mm}\} \quad (5.5\text{ a})$$

[1)] In case of diamond drilling multiply the values for $l_{0, min}$ and $l_{b, min}$ by 1.3.

Where:

$l_{0, min}$ = minimum lap length

α_6 = influence of the proportion of the overlapping bars of the cross-section
= 1.5, if all bars are overlapping in cross-section

$l_{b,rqd}$ = basic value of the required anchorage length (Equation (5.3))

d_s = diameter of rebar

Table 5.8:

Percentage of lapped bars relative to the total cross-section area	< 25%	33%	50%	> 50%
α_6	1	1.15	1.4	1.5

Note: Intermediate values may be determined by intepolation.

5.5.5 Concrete cover

5.5.5.1 Minimum concrete cover in accordance with environmental conditions

Table 5.9:
Minimum concrete cover according to environmental conditions

Exposure class [1]			Minimum concrete cover c in mm [2]
1	Dry environment		15
2a	Humid environment	without frost	20
2b		with frost	25
3	Humid environment with frost and de-icing salts		40
4a	Seawater environment	without frost	40
4b		with frost	40
5a	Aggressive chemical environment	slightly	25
5b		moderately	30
5c		high	40

1) For detailed information see EC2, Tables 4.1 and 4.2
2) A reduction of 5 mm may be considered for slabs in the exposure classes 2 to 5

5.5.5.2 Minimum concrete cover according to the type of drilling

With post-installed rebars tolerances may occur depending on the tools used (drilling guide). These tolerances may be considered by increasing the minimum concrete cover. The following table gives values based on various test series.

Table 5.10:
Minimum concrete cover according to the type of drilling and bar diameter ≦ 20mm

Type of drilling	without drilling guide	with drilling guide
Hammer drilling[1]	$c = 30\ mm + 0.06 \cdot l_v$	$c = 30\ mm + 0.02 \cdot l_v \geq 2 \cdot d_s$
Pneumatic hammer drilling	$c = 50\ mm + 0.08 \cdot l_v$	$c = 50\ mm + 0.02 \cdot l_v \geq 2 \cdot d_s$

1) FIS EM also in diamond-drilled holes
Bigger diameter see approval.

5.5.5.3 Load bearing capacity and minimum concrete cover in case of fire

Table 5.11 gives the design values of resistance of a rebar in case of fire as a function of the position of the post-installed rebar. The table is valid for anchorages perpendicular to the surface of the concrete exposed to fire. Table 5.12 gives the bond strength as a function of the concrete cover in case of fire for anchorages parallel to the surface of the concrete exposed to fire.

5.5.6 Transverse reinforcement

5.5.6.1 Required transverse reeinforcement for anchorages of rebars (EC 2 section 8.7.4.1, 8.7.4.2)

In beams transverse reinforcement should be provided:

- for anchorages of rebars in tension, if there is no transverse compression due to the support reaction (e.g. in case of indirect supports)
- for all anchorages of rebars in compression

The minimum cross-sectional area of the transverse reinforcement must be 25 % of the area of one anchored rebar. The reinforcement should be evenly distributed along the anchorage length.

For rebars in compression, the transverse reinforcement should surround the bars, being concentrated at the end of the anchorage and extend beyond it to a distance of at least 4 times the diameter of the anchored rebar.

5.5.6.2 Required transverse reinforcement for lap splices of rebars (EC2, Section 8.7.5.1)

With rebar diameters ≥16 mm the transverse reinforcement should have a total area of not less than the area A_s of one spliced bar.

5.6 Design tables

Design tables (tables 5.1 to 5.10) can be used as follows:

- Required anchorage length $l_{bd} \geq l_{b,\ min}$

The minimum anchorage length $l_{b,\ min}$ of anchorages in general and of anchorages at an end support (indirect support) can be calculated in accordance with equation (5.4a) for rebars in tension and (5.4b) for rebars in compression.

5

Example:

d_s = 10 mm, design action N_{Sd} = 15.0 kN, basic value of the anchorage length $l_{b,\ rqd}$ = 473 mm, anchorage length l_{bd} = 208 mm (Table 5.9)

- Rebar in tension

$l_{b,\ min} = 0.3 \cdot l_{b,rqd} = 0.3 \cdot 473$ mm
$= 142$ mm
$< l_{bd}$

$l_{b,\ min} = 10 \cdot d_s = 10 \cdot 10$ mm $= 100$ mm
$< l_{bd}$

$l_{b,\ min} = 100$ mm $< l_{bd}$

Anchorage length of the rebar l_{bd} = 208 mm.

- Rebar in compression

$l_{b,\ min} = 0.6 \cdot l_{b,\ rqd} = 0.6 \cdot 473$ mm
$= 284$ mm
$> l_{bd}$

$l_{b,\ min} = 10 \cdot d_s = 10 \cdot 10$ mm $= 100$ mm
$< l_{bd}$

$l_{b,\ min} = 100$ mm $< l_{bd}$

Anchorage length of the rebar $l_{b,\ min}$ = 284 mm.

- Required lap length l_0

The lap length l_0 of spliced rebars can be calculated in accordance with section 5.5.4.4.2.

Example:

d_s = 16 mm, design action N_{Sd} = 50.0 kN

basic value of the anchorage length $l_{b,\ rqd}$ = 756 mm, anchorage length l_{bd} = 433 mm (Table 5.9)

- Rebar with 50% lapped bars

$l_0 = l_{bd} \cdot \alpha_6 = 433$ mm $\cdot 1.4$
$= 606$ mm
$\geq l_{0,\ min}$

$l_{0,\ min} = 0.3 \cdot \alpha_6 \cdot l_{b,\ rqd} = 0.3 \cdot 1.4 \cdot 756$
$= 317$ mm

$l_{0,\ min} = 15 \cdot d_s = 15 \cdot 16$ mm
$= 240$ mm

$l_{0,\ min} = 200$ mm

Anchorage length of the rebar l_0 = 606 mm.

- The transmission of the loads to the supports of the concrete member should be given special consideration.
- Expertly done installation in accordance with the manufacturer's installation instructions with special consideration of exact drilling, proper cleaning of the drill hole and injection of resin without air bubbles.
- Yield strength of the steel
- Compressive strength of the concrete measured in cylinders f_{ck} = 20 N/mm²

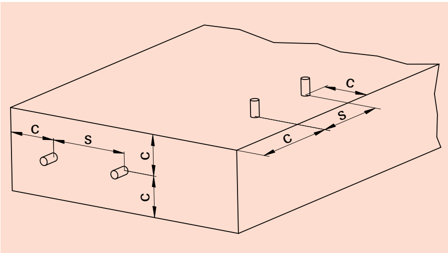
The following tables give the parameters depending on the diameter and the load of the rebar:

- Required anchorage length l_{bd}
- Minimum concrete cover c_{min} (compare section 5.5.5.2, minimum concrete cover according to the type of drilling) for precise

drilling parallel to an existing surface (deviations ≤ 2 %)

- Required edge distance and spacing according to Fig. 5.1 - 5.10.

Figure 5.1:
Definition of edge distance and spacing given in tables 5.1 - 5.10.



Design loads acc. Rebar Theory depending on the anchorage length in cracked concrete

Table 5.1: Metric sizes / Concrete C20/25, f_{ck} = 20 N/mm², steel: f_{yk} = 400 N/mm², **FIS V**

			8	10	12	14	16	20	25	28
Rebar size	d_s	[mm]	**8**	**10**	**12**	**14**	**16**	**20**	**25**	**28**
Drill diameter	d_0	[mm]	**12**	**14**	**16**	**18**	**20**	**25**	**30**	**35**
Cross section	A_s	[mm²]	50	79	113	154	201	314	491	616
Design yield force	$N_{yd,s}$	[N/mm²]	17.5	27.3	39.3	53.5	69.9	109.3	170.7	214.2
Length to develop yield	l_{b0}	[mm]	302	378	454	529	605	756	945	1059
Development length as multiple of d_s			38	38	38	38	38	38	38	38
Design bond strength	f_{bd}	[N/mm²]	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Edge distance	c	[cm]	edge distance (concrete cover) according to national regulations (e.g. EC 2)							
Spacing	s	[cm]	spacing according to national regulations (e.g. EC 2)							
Design load [kN] f_{yk} = 400 N/mm² concrete C20/25	**Anchorage length [mm]**	100	5.8	7.2						
		125	7.2	9.0	10.8					
		150	8.7	10.8	13.0	15.2				
		175	10.1	12.6	15.2	17.7	20.2			
		200	11.6	14.5	17.3	20.2	23.1	28.9		
		250	14.5	18.1	21.7	25.3	28.9	36.1	45.2	
		275	15.9	19.9	23.8	27.8	31.8	39.7	49.7	55.6
		325	17.5	23.5	28.2	32.9	37.6	47.0	58.7	65.8
		400		27.3	34.7	40.5	46.2	57.8	72.3	80.9
		500			39.3	50.6	57.8	72.3	90.3	101.2
		550				53.5	63.6	79.5	99.4	111.3
		600					69.4	86.7	108.4	121.4
		650						93.9	117.4	131.5
		700						101.2	126.4	141.6
		750						108.4	135.5	151.7
		800						109.3	144.5	161.9
		900							162.6	182.1
		950							170.7	192.2
		1000								202.3
		1100								214.2

Design loads acc. Rebar Theory depending on the anchorage length in cracked concrete

Table 5.2: Metric sizes / Concrete C20/25, f_{ck} = 20 N/mm², steel: f_{yk} = 420 N/mm², **FIS V**

			8	10	12	14	16	20	25	28
Rebar size	d_s	[mm]	**8**	**10**	**12**	**14**	**16**	**20**	**25**	**28**
Drill diameter	d_0	[mm]	**12**	**14**	**16**	**18**	**20**	**25**	**30**	**35**
Cross section	A_s	[mm²]	50	79	113	154	201	314	491	616
Design yield force	$N_{yd,s}$	[N/mm²]	18.4	28.7	41.3	56.2	73.4	114.7	179.3	224.9
Length to develop yield	l_{b0}	[mm]	318	397	476	556	635	794	992	1112
Development length as multiple of d_s			40	40	40	40	40	40	40	40
Design bond strength	f_{bd}	[N/mm²]	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Edge distance	c	[cm]	edge distance (concrete cover) according to national regulations (e.g. EC 2)							
Spacing	s	[cm]	spacing according to national regulations (e.g. EC 2)							
Design load [kN] f_{yk} = 420 N/mm² concrete C20/25	**Anchorage length [mm]**	100	5.8	7.2						
		125	7.2	9.0	10.8					
		150	8.7	10.8	13.0	15.2				
		175	10.1	12.6	15.2	17.7	20.2			
		200	11.6	14.5	17.3	20.2	23.1	28.9		
		225	13.0	16.3	19.5	22.8	26.0	32.5		
		250	14.5	18.1	21.7	25.3	28.9	36.1	45.2	
		275	15.9	19.9	23.8	27.8	31.8	39.7	49.7	55.6
		300	17.3	21.7	26.0	30.3	34.7	43.4	54.2	60.7
		325	18.4	23.5	28.2	32.9	37.6	47.0	58.7	65.8
		400		28.7	34.7	40.5	46.2	57.8	72.3	80.9
		500			41.3	50.6	57.8	72.3	90.3	101.2
		600				56.2	69.4	86.7	108.4	121.4
		650					73.4	93.9	117.4	131.5
		700						101.2	126.4	141.6
		800						114.7	144.5	161.9
		900							162.6	182.1
		1000							179.3	202.3
		1150								224.9

Post-installed rebar connections

with Injection mortar FIS V and FIS EM

Design loads acc. Rebar Theory depending on the anchorage length in cracked concrete

Table 5.3: Metric sizes / Concrete C20/25, f_{ck} = 20 N/mm², steel: f_{yk} = 460 N/mm², **FIS V**

Rebar size	d_s	[mm]		**8**	**10**	**12**	**14**	**16**	**20**	**25**	**28**
Drill diameter	d_0	[mm]		**12**	**14**	**16**	**18**	**20**	**25**	**30**	**35**
Cross section	A_s	[mm²]		50	79	113	154	201	314	491	616
Design yield force	$N_{yd,s}$	[N/mm²]		20.1	31.4	45.2	61.6	80.4	125.7	196.3	246.3
Length to develop yield	l_{b0}	[mm]		348	435	522	609	696	870	1087	1217
Development length as multiple of d_s				43	43	43	43	43	43	43	43
Design bond strength	f_{bd}	[N/mm²]		2.3	2.3	2.3	2.3	2.3	2.3	432.3	2.3
Edge distance	c	[cm]		edge distance (concrete cover) according to national regulations (e.g. EC 2)							
Spacing	s	[cm]		spacing according to national regulations (e.g. EC 2)							
Design load [kN] f_{yk} = 460 N/mm² concrete C20/25	Anchorage length [mm]		100	5.8	7.2						
			125	7.2	9.0	10.8					
			150	8.7	10.8	13.0	15.2				
			175	10.1	12.6	15.2	17.7	20.2			
			200	11.6	14.5	17.3	20.2	23.1	28.9		
			225	13.0	16.3	19.5	22.8	26.0	32.5		
			250	14.5	18.1	21.7	25.3	28.9	36.1	45.2	
			275	15.9	19.9	23.8	27.8	31.8	39.7	49.7	55.6
			300	17.3	21.7	26.0	30.3	34.7	43.4	54.2	60.7
			350	20.1	25.3	30.3	35.4	40.5	50.6	63.2	70.8
			400		28.9	34.7	40.5	46.2	57.8	72.3	80.9
			450		31.4	39.0	45.5	52.0	65.0	81.3	91.0
			500			43.4	50.6	57.8	72.3	90.3	101.2
			550			45.2	55.6	63.6	79.5	99.4	111.3
			650				61.6	75.1	93.9	117.4	131.5
			700					80.4	101.2	126.4	141.6
			800						115.6	144.5	161.9
			900						125.7	162.6	182.1
			1000							180.6	202.3
			1100							196.3	222.6
			1250								246.3

Design loads acc. Rebar Theory depending on the anchorage length in cracked concrete

Table 5.4: Metric sizes / Concrete C20/25, f_{ck} = 20 N/mm², steel: f_{yk} = 500 N/mm², **FIS V**

Rebar size	d_s	[mm]		**8**	**10**	**12**	**14**	**16**	**20**	**25**	**28**
Drill diameter	d_0	[mm]		**12**	**14**	**16**	**18**	**20**	**25**	**30**	**35**
Cross section	A_s	[mm²]		50	79	113	154	201	314	491	616
Design yield force	$N_{yd,s}$	[N/mm²]		21.9	34.1	49.2	66.9	87.4	136.6	213.4	267.7
Length to develop yield	l_{b0}	[mm]		378	473	567	662	756	945	1181	1323
Development length as multiple of d_s				47	47	47	47	47	47	47	47
Design bond strength	f_{bd}	[N/mm²]		2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Edge distance	c	[cm]		edge distance (concrete cover) according to national regulations (e.g. EC 2)							
Spacing	s	[cm]		spacing according to national regulations (e.g. EC 2)							
Design load [kN] f_{yk} = 500 N/mm² concrete C20/25	Anchorage length [mm]		100	5.8	7.2						
			125	7.2	9.0	10.8					
			150	8.7	10.8	13.0	15.2				
			175	10.1	12.6	15.2	17.7	20.2			
			200	11.6	14.5	17.3	20.2	23.1	28.9		
			225	13.0	16.3	19.5	22.8	26.0	32.5		
			250	14.5	18.1	21.7	25.3	28.9	36.1	45.2	
			275	15.9	19.9	23.8	27.8	31.8	39.7	49.7	55.6
			300	17.3	21.7	26.0	30.3	34.7	43.4	54.2	60.7
			400	21.9	28.9	34.7	40.5	46.2	57.8	72.3	80.9
			500		34.1	43.4	50.6	57.8	72.3	90.3	101.2
			600			49.2	60.7	69.4	86.7	108.4	121.4
			700				66.9	80.9	101.2	126.4	141.6
			800					87.4	115.6	144.5	161.9
			900						130.1	162.6	182.1
			950						136.6	171.6	192.2
			1100							198.7	222.6
			1200							213.4	242.8
			1350								267.7

Design loads acc. Rebar Theory depending on the anchorage length in cracked concrete

Table 5.5: Metric sizes / Concrete C20/25, f_{ck} = 20 N/mm², steel: f_{yk} = 550 N/mm², **FIS V**

Rebar size	d_s	[mm]	**8**	**10**	**12**	**14**	**16**	**20**	**25**	**28**
Drill diameter	d_0	[mm]	**12**	**14**	**16**	**18**	**20**	**25**	**30**	**35**
Cross section	A_s	[mm²]	50	79	113	154	201	314	491	616
Design yield force	$N_{yd,s}$	[N/mm²]	24.0	37.6	54.1	73.6	96.2	150.3	234.6	294.5
Length to develop yield	l_{b0}	[mm]	416	520	624	728	832	1040	1300	1456
Development length as multiple of d_s			52	52	52	52	52	52	52	52
Design bond strength	f_{bd}	[N/mm²]	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
Edge distance	c	[cm]	edge distance (concrete cover) according to national regulations (e.g. EC 2)							
Spacing	s	[cm]	spacing according to national regulations (e.g. EC 2)							
Design load [kN] f_{yk} = 550 N/mm² concrete C20/25	Anchorage length [mm]	100	5.8	7.2						
		125	7.2	9.0	10.8					
		150	8.7	10.8	13.0	15.2				
		175	10.1	12.6	15.2	17.7	20.2			
		200	11.6	14.5	17.3	20.2	23.1	28.9		
		250	14.5	18.1	21.7	25.3	28.9	36.1	45.2	
		300	17.3	21.7	26.0	30.3	34.7	43.4	54.2	60.7
		350	20.2	25.3	30.3	35.4	40.5	50.6	63.2	70.8
		400	23.1	28.9	34.7	40.5	46.2	57.8	72.3	80.9
		450	24.0	32.5	39.0	45.5	52.0	65.0	81.3	91.0
		550		37.6	47.7	55.6	63.6	79.5	99.4	111.3
		650			54.1	65.8	75.1	93.9	117.4	131.5
		750				73.6	86.7	108.4	135.5	151.7
		850					96.2	122.8	153.5	172.0
		950						137.3	171.6	192.2
		1050						150.3	189.7	212.4
		1150							207.7	232.7
		1300							234.8	263.0
		1400								283.2
		1500								294.5

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Design loads acc. Rebar Theory depending on the anchorage length in cracked concrete

Table 5.6: Metric sizes / Concrete C20/25, f_{ck} = 20 N/mm², steel: f_{yk} = 400 N/mm², **FIS EM**

Rebar size	d_s	[mm]	**8**	**10**	**12**	**14**	**16**	**20**	**25**	**28**	**32**	**36**	**40**
Drill diameter	d_0	[mm]	**12**	**14**	**16**	**18**	**20**	**25**	**30**	**35**	**40**	**46**	**50**
Cross section	A_s	[mm²]	50	79	113	154	201	314	491	616	804	1018	1257
Design yield force	$N_{yd,s}$	[N/mm²]	17.5	27.3	39.3	53.5	69.9	109.3	170.7	214.2	279.7	354.0	437.1
Length to develop yield	l_{b0}	[mm]	224	281	337	393	449	561	701	785	898	1010	1122
Development length as multiple of d_s			28	28	28	28	28	28	28	28	28	28	28
Design bond strength	f_{bd}	[N/mm²]	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Edge distance	c	[cm]	edge distance (concrete cover) according to national regulations (e.g. EC 2)										
Spacing	s	[cm]	spacing according to national regulations (e.g. EC 2)										
Design load [kN] f_{yk} = 400 N/mm² concrete C20/25	Anchorage length [mm]	100	7.8	9.7									
		125	9.7	12.2	14.6								
		150	11.7	14.6	17.5	20.5							
		175	13.6	17.0	20.5	23.9	27.3						
		200	15.6	19.5	23.4	27.3	31.2	39.0					
		225	17.5	21.9	26.3	30.7	35.1	43.8					
		250		24.3	29.2	34.1	39.0	48.7	60.9				
		275		26.8	32.1	37.5	42.9	53.6	67.0	75.0			
		300		27.3	35.1	40.9	46.7	58.4	73.0	81.8			
		325			38.0	44.3	50.6	63.3	79.1	88.6	101.3		
		350			39.3	47.7	54.5	68.2	85.2	95.4	109.1	122.7	
		400				53.5	62.3	77.9	97.4	109.1	124.7	140.2	155.8
		450					69.9	87.7	109.6	122.7	140.2	157.8	175.3
		500						97.4	121.7	136.3	155.8	175.3	194.8
		600						109.3	146.1	163.6	187.0	210.4	233.7
		750							170.7	204.5	233.7	263.0	292.2
		800								214.2	249.3	280.5	311.6
		900									279.7	315.5	350.6
		1050										354.0	409.0
		1150											437.1

Design loads acc. Rebar Theory depending on the anchorage length in cracked concrete

Table 5.7: Metric sizes / Concrete C20/25, f_{ck} = 20 N/mm², steel: f_{yk} = 420 N/mm², **FIS EM**

Rebar size	d_s	[mm]	**8**	**10**	**12**	**14**	**16**	**20**	**25**	**28**	**32**	**36**	**40**
Drill diameter	d_0	[mm]	**12**	**14**	**16**	**18**	**20**	**25**	**30**	**35**	**40**	**46**	**50**
Cross section	A_s	[mm²]	50	79	113	154	201	314	491	616	804	1018	1257
Design yield force	$N_{yd,s}$	[N/mm²]	18.4	28.7	41.3	56.2	73.4	114.7	179.3	224.9	293.7	371.7	458.9
Length to develop yield	l_{b0}	[mm]	236	295	353	412	471	589	736	825	942	1060	1178
Development length as multiple of d_s			29	29	29	29	29	29	29	29	29	29	29
Design bond strength	f_{bd}	[N/mm²]	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Edge distance	c	[cm]	edge distance (concrete cover) according to national regulations (e.g. EC 2)										
Spacing	s	[cm]	spacing according to national regulations (e.g. EC 2)										
Design load [kN] f_{yk} = 420 N/mm² concrete C20/25	Anchorage length [mm]	100	7.8	9.7									
		125	9.7	12.2	14.6								
		150	11.7	14.6	17.5	20.5							
		175	13.6	17.0	20.5	23.9	27.3						
		200	15.6	19.5	23.4	27.3	31.2	39.0					
		225	17.5	21.9	26.3	30.7	35.1	43.8					
		250	18.4	24.3	29.2	34.1	39.0	48.7	60.9				
		275		26.8	32.1	37.5	42.9	53.6	67.0	75.0			
		300		28.7	35.1	40.9	46.7	58.4	73.0	81.8			
		325			38.0	44.3	50.6	63.3	79.1	88.6	101.3		
		350			40.9	47.7	54.5	68.2	85.2	95.4	109.1	122.7	
		375			41.3	51.1	58.4	73.0	91.3	102.3	116.9	131.5	
		400				54.5	62.3	77.9	97.4	109.1	124.7	140.2	155.8
		450				56.2	70.1	87.7	109.6	122.7	140.2	157.8	175.3
		500					73.4	97.4	121.7	136.3	155.8	175.3	194.8
		600						114.7	146.1	163.6	187.0	210.4	233.7
		750							179.3	204.5	233.7	263.0	292.2
		850								224.9	264.9	298.0	331.1
		950									293.7	333.1	370.1
		1100										371.7	428.5
		1200											458.9

Design loads acc. Rebar Theory depending on the anchorage length in cracked concrete

Table 5.8: Metric sizes / Concrete C20/25, f_{ck} = 20 N/mm², steel: f_{yk} = 460 N/mm², **FIS EM**

Rebar size	d_s	[mm]	**8**	**10**	**12**	**14**	**16**	**20**	**25**	**28**	**32**	**36**	**40**
Drill diameter	d_0	[mm]	**12**	**14**	**16**	**18**	**20**	**25**	**30**	**35**	**40**	**46**	**50**
Cross section	A_s	[mm²]	50	79	113	154	201	314	491	616	804	1018	1257
Design yield force	$N_{yd,s}$	[N/mm²]	20.1	31.4	45.2	61.6	80.4	125.7	196.3	246.3	321.7	407.2	502.7
Length to develop yield	l_{b0}	[mm]	258	323	387	452	516	645	808	903	1032	1161	1290
Development length as multiple of d_s			32	32	32	32	32	32	32	32	32	32	32
Design bond strength	f_{bd}	[N/mm²]	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Edge distance	c	[cm]	edge distance (concrete cover) according to national regulations (e.g. EC 2)										
Spacing	s	[cm]	spacing according to national regulations (e.g. EC 2)										
Design load [kN] f_{yk} = 460 N/mm² concrete C20/25	Anchorage length [mm]	100	7.8	9.7									
		125	9.7	12.2	14.6								
		150	11.7	14.6	17.5	20.5							
		175	13.6	17.0	20.5	23.9	27.3						
		200	15.6	19.5	23.4	27.3	31.2	39.0					
		225	17.5	21.9	26.3	30.7	35.1	43.8					
		250	19.5	24.3	29.2	34.1	39.0	48.7	60.9				
		275	20.1	26.8	32.1	37.5	42.9	53.6	67.0	75.0			
		300		29.2	35.1	40.9	46.7	58.4	73.0	81.8	93.5		
		325		31.4	38.0	44.3	50.6	63.3	79.1	88.6	101.3		
		350			40.9	47.7	54.5	68.2	85.2	95.4	109.1	122.7	
		400			45.2	54.5	62.3	77.9	97.4	109.1	124.7	140.2	155.8
		500				61.6	77.9	97.4	121.7	136.3	155.8	175.3	194.8
		550					80.4	107.1	133.9	150.0	171.4	192.8	214.3
		650						125.7	158.3	177.2	202.6	227.9	253.2
		850							196.3	231.8	264.9	298.0	331.1
		950								246.3	296.1	333.1	370.1
		1050									321.7	368.1	409.0
		1200										407.2	467.5
		1300											502.7

Design loads acc. Rebar Theory depending on the anchorage length in cracked concrete

Table 5.9: Metric sizes / Concrete C20/25, f_{ck} = 20 N/mm², steel: f_{yk} = 500 N/mm², **FIS EM**

Rebar size	d_s	[mm]	8	10	12	14	16	20	25	28	32	36	40
Drill diameter	d_0	[mm]	12	14	16	18	20	25	30	35	40	46	50
Cross section	A_s	[mm²]	50	79	113	154	201	314	491	616	804	1018	1257
Design yield force	$N_{yd,s}$	[N/mm²]	21.9	34.1	49.2	66.9	87.4	136.6	213.4	267.7	349.7	442.6	546.4
Length to develop yield	l_{b0}	[mm]	281	351	421	491	561	701	877	982	1122	1262	1403
Development length as multiple of d_s			35	35	35	35	35	35	35	35	35	35	35
Design bond strength	f_{bd}	[N/mm²]	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Edge distance	c	[cm]	edge distance (concrete cover) according to national regulations (e.g. EC 2)										
Spacing	s	[cm]	spacing according to national regulations (e.g. EC 2)										
Design load [kN] f_{yk} = 500 N/mm² concrete C20/25	Anchorage length [mm]	100	7.8	9.7									
		125	9.7	12.2	14.6								
		150	11.7	14.6	17.5	20.5							
		175	13.6	17.0	20.5	23.9	27.3						
		200	15.6	19.5	23.4	27.3	31.2	39.0					
		250	19.5	24.3	29.2	34.1	39.0	48.7	60.9				
		275	21.4	26.8	32.1	37.5	42.9	53.6	67.0	75.0			
		300	21.9	29.2	35.1	40.9	46.7	58.4	73.0	81.8	93.5		
		350		34.1	40.9	47.7	54.5	68.2	85.2	95.4	109.1	122.7	
		400			46.7	54.5	62.3	77.9	97.4	109.1	124.7	140.2	155.8
		450			49.2	61.4	70.1	87.7	109.6	122.7	140.2	157.8	175.3
		500				66.9	77.9	97.4	121.7	136.3	155.8	175.3	194.8
		600					87.4	116.9	146.1	163.6	187.0	210.4	233.7
		700						136.3	170.4	190.9	218.2	254.4	272.7
		750						136.6	182.6	204.5	233.7	263.0	292.2
		900							213.4	245.4	280.5	315.5	350.6
		1000								267.7	311.6	350.6	389.6
		1150									349.7	403.2	448.0
		1300										442.6	506.4
		1400											545.4

Design loads acc. Rebar Theory depending on the anchorage length in cracked concrete

Table 5.10: Metric sizes / Concrete C20/25, f_{ck} = 20 N/mm², steel: f_{yk} = 550 N/mm², **FIS EM**

Rebar size	d_s	[mm]	8	10	12	14	16	20	25	28	32	36	40
Drill diameter	d_0	[mm]	12	14	16	18	20	25	30	35	40	46	50
Cross section	A_s	[mm²]	50	79	113	154	201	314	491	616	804	1018	1257
Design yield force	$N_{yd,s}$	[N/mm²]	24.0	37.6	54.1	73.6	96.2	150.3	234.8	294.5	384.6	486.8	601.0
Length to develop yield	l_{b0}	[mm]	309	386	463	540	617	771	964	1080	1234	1388	1543
Development length as multiple of d_s			39	39	39	39	39	39	39	39	39	39	39
Design bond strength	f_{bd}	[N/mm²]	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1
Edge distance	c	[cm]	edge distance (concrete cover) according to national regulations (e.g. EC 2)										
Spacing	s	[cm]	spacing according to national regulations (e.g. EC 2)										
Design load [kN] f_{yk} = 550 N/mm² concrete C20/25	Anchorage length [mm]	100	7.8	9.7									
		125	9.7	12.2	14.6								
		150	11.7	14.6	17.5	20.5							
		175	13.6	17.0	20.5	23.9	27.3						
		200	15.6	19.5	23.4	27.3	31.2	39.0					
		250	19.5	24.3	29.2	34.1	39.0	48.7	60.9				
		300	23.4	29.2	35.1	40.9	46.7	58.4	73.0	81.8	93.5		
		350	24.0	34.1	40.9	47.7	54.5	68.2	85.2	95.4	109.1	122.7	
		400		37.6	46.7	54.5	62.3	77.9	97.4	109.1	124.7	140.2	155.8
		500			54.1	68.2	77.9	97.4	121.7	136.3	155.8	175.3	194.8
		550				73.6	85.7	107.1	133.9	150.0	171.4	192.8	214.3
		650					96.2	126.6	158.3	177.2	202.6	227.9	253.2
		700						136.3	170.4	190.9	218.2	245.4	272.7
		800						150.3	194.8	218.2	249.3	280.5	311.6
		900							219.1	245.4	280.5	315.5	350.6
		1000							234.8	272.7	311.6	350.6	389.6
		1100								294.5	342.8	385.7	428.5
		1200									374.0	420.7	467.5
		1250									384.6	438.3	486.9
		1400										486.8	545.4
		1550											601.0

Post-installed rebar connections

with Injection mortar FIS V and FIS EM

Maximum permissible loads in the case of fire - FIS V [1)]

Rebar connection perpendicular to the surface exposed to fire

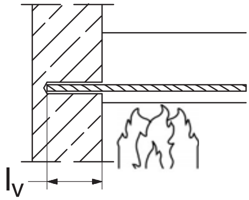


Table 5.11:

d_s [mm] ↓	d_0 [mm] ↓	max $N_{perm,s,T}$ [kN] ↓	l_V [mm] ↓	Max. permissible loads in the case of fire $N_{perm,s,T}$ [kN] Fire resistance classification				
				R 30	R 60	R 90	R120	R180
8	12	16.2	80	3.5	1.5	0.6	0.3	0.0
			120	10.6	5.0	2.8	1.9	0.7
			160	16.2	11.9	7.9	5.2	2.7
			190	-	16.2	13.2	10.4	4.7
			210	-	-	16.2	13.9	6.4
			230	-	-	-	16.2	8.5
			280	-	-	-	-	16.2
10	14	25.3	100	8.8	3.6	1.9	1.1	0.2
			150	19.8	12.7	7.7	5.1	2.6
			180	25.3	19.3	14.3	10.7	4.9
			210	-	26.3	20.6	17.3	7.6
			240	-	-	25.3	23.9	12.5
			250	-	-	-	25.3	14.4
			310	-	-	-	-	25.3
12	16	36.4	120	15.9	7.5	4.1	2.9	1.0
			180	31.7	23.1	17.1	12.9	5.9
			200	36.4	28.4	22.4	18.1	8.0
			240	-	36.4	32.9	28.7	14.4
			260	-	-	36.4	34.0	19.7
			270	-	-	-	36.4	22.3
			330	-	-	-	-	36.4
14	18	49.6	140	24.7	14.6	7.9	5.8	2.7
			210	44.0	36.2	29.2	24.2	10.6
			230	49.6	42.4	35.4	30.4	13.9
			260	-	49.6	44.0	39.6	23.0
			280	-	-	49.6	44.0	29.1
			300	-	-	-	49.6	32.2
			350	-	-	-	-	49.6
↑	↑	↑	↑	R 30	R 60	R 90	R120	R180
[mm] d_s	[mm] d_0	[kN] max $N_{perm,s,T}$	[mm] l_V	Fire resistance classification Max. permissible loads in the case of fire $N_{perm,s,T}$ [kN]				

d_s [mm] ↓	d_0 [mm] ↓	max $N_{perm,s,T}$ [kN] ↓	l_V [mm] ↓	Max. permissible loads in the case of fire $N_{perm,s,T}$ [kN] Fire resistance classification				
				R 30	R 60	R 90	R120	R180
16	20	64.8	160	35.2	23.8	15.8	10.4	5.3
			240	57.5	51.9	43.9	38.3	19.2
			250	64.8	55.5	47.5	41.8	22.7
			280	-	64.8	57.5	52.3	33.2
			300	-	-	64.8	57.5	40.3
			320	-	-	-	64.8	47.3
			370	-	-	-	-	64.8
20	25	101,2	200	61.3	47.1	37.1	29.8	13.2
			240	78.8	64.4	55.0	48.0	24.2
			280	101.2	82.6	73.2	66.0	42.4
			310	-	101.2	85.1	78.5	55.0
			350	-	-	101.2	95.8	72.3
			360	-	-	-	101.2	77.0
			420	-	-	-	-	101.2
25	30	158.1	250	104.5	86.6	74.1	65.3	35.4
			300	132.0	114.1	101.6	92.8	62.9
			350	158.1	141.6	129.1	120.2	90.4
			380	-	158.1	145.6	136.7	106.9
			410	-	-	158.1	153.2	123.4
			420	-	-	-	158.1	128.9
			480	-	-	-	-	158.1
28	35	198.3	280	135.6	115.5	101.5	91.6	58.1
			340	172.5	152.4	138.5	128.5	95.1
			390	198.3	183.2	169.2	159.3	125.9
			420	-	198.3	187.7	177.8	144.3
			440	-	-	198.3	190.1	156.7
			460	-	-	-	198.3	169.0
			510	-	-	-	-	198.3
↑	↑	↑	↑	R 30	R 60	R 90	R120	R180
[mm] d_s	[mm] d_0	[kN] max $N_{perm,s,T}$	[mm] l_V	Fire resistance classification Max. permissible loads in the case of fire $N_{perm,s,T}$ [kN]				

d_s .... diameter of the rebar, d_0 .... drill diameter, $N_{Rd,s,T}$ .... Design value of resistance in the case of fire, l_V .... required anchorage length
f_{yk} = 500 M/mm²; γ_S = 1,15; γ_G = 1,35

[1)] Not applicable for FIS EM

5

Bond strength depending on the concrete cover in the case of fire - FIS V[1)]

Rebar connection parallel to the surface exposed to fire

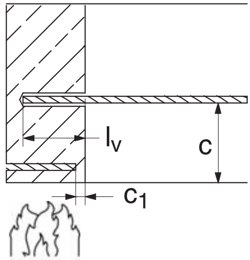


Table 5.12:

c [mm] ↓	max $f_{bd,T}$ [N/mm²] ↓	Bond strength in the case of fire $f_{bd,T}$ [N/mm²] Fire resistance classification [mm]					c [mm] ↓
		R 30	R 60	R 90	R120	R180	
30		1.4	0.2	-	-	-	30
35		1.7	0.4	-	-	-	35
40		1.9	0.7	-	-	-	40
45		2.2	1.0	-	-	-	45
50		-	1.2	0.4	-	-	50
55		-	1.4	0.5	-	-	55
60		-	1.7	0.7	0.3	-	60
65		-	1.9	0.9	0.5	-	65
70		-	2.2	1.2	0.7	-	70
75		-	-	1.4	0.8	-	75
80		-	-	1.7	1.0	0.2	80
85	2.2	-	-	1.8	1.3	0.3	85
90		-	-	2.0	1.5	0.5	90
95		-	-	2.2	1.7	0.6	95
100		-	-	-	1.9	0.7	100
105		-	-	-	2.2	0.9	105
110		-	-	-	-	1.2	110
115		-	-	-	-	1.4	115
120		-	-	-	-	1.6	120
125		-	-	-	-	1.7	125
130		-	-	-	-	1.9	130
135		-	-	-	-	2.1	135
140		-	-	-	-	2.2	140
↑	↑	R 30	R 60	R 90	R120	R180	↑
[mm] c	[N/mm²] max $f_{bd,T}$	Fire resistance classification [mm] Bond strength in the case of fire $f_{bd,T}$ [N/mm²]					[mm] c

c .... concrete cover of the post-installed rebar

$f_{bd,T}$ .... bond strength in the case of fire

f_{yk} = 500 M/mm²; γ_S = 1,15; γ_G = 1,35

[1)] Not applicable for FIS EM

Required proof:

$N_{Rd,s,T} \leq (l_v - c_1) \cdot d_s \cdot p \cdot f_{bd,T}$

with: $(l_v - c_1) \geq l_s$
$\leq 80 \cdot d_s$

$N_{Rd,s,T}$	Design value of resistance in the case of fire
$(l_v - c_1)$	Anchorage length
d_s	Diameter of the rebar
$f_{bd,T}$	Bond strength in the case of fire
l_s	Lap length of the splice

Fire Safety in the Fixing Technology

6.1 Introduction

Fire protection, why? The answer is:"It´s the law (building code) and basic human right in most countries!"

- 4 million fires per year worldwide
- Cost for one year: 15.000 human lives and 70 billion $ of property damage and consequential damage
- 300.000 fires per year in Europe alone

All over the world fire protection is regulated through national and international standards which have to be complied with in the building and construction industry. Different parts of fire safety have to be considered. Fire safety is basically prevention against damage – preventive fire protection. Within the preventive fire protection we find structural fire protection which can be divided into the active part, sprinkler systems etc., and the passive part, walls and ceilings with different fire ratings. The fire protection in fixing technology belongs to the passive preventive fire protection.

Fasteners and anchors play an important role not only with regard to the connection of building elements, but also where durability, maintaining load capacity and safety is concerned. Often the stability of structural components in a fire will depend on the fastening element. The stability of structural components is essential for insuring that escape routes remain intact and that escape is possible. For this reason fischer has been working for years in collaboration with research institutes and material testing institutes in the area of "preventive fire protection".

Through their intensive involvement in this area, fischer contributes to the development of fastening technology for anchors exposed to extreme fire conditions. In addition we see it as an important contribution to safety when those responsible for the design and specification of building projects utilise our experience.

Choosing today's best solutions for preventive fire protection helps to limit damage and save lives.

Fire Protection first means personal security, which is regulated through the national building laws, and secondly it means the protection of property which is regulated through insurers and organisations which belong to the insurance business like VdS Schadenverhütung GmbH (VdS Loss Prevention) a company owned by the German Insurance Association (Gesamtverbands der deutschen Versicherungswirtschaft, GDV) or Factory Mutual (FM), an international group of insurance companies in the U. S.. The regulations of VdS and FM are required particularly for the design and installation of sprinkler systems. Anchors with FM-Certificate are listed in section 6.6.

6.2 Fire protection in Europe

Since implementation of the Construction Products Directive (CPD) – "Council Directive 89/106/EEC of 21 December 1988", fire protection within the European Union (EU) is a well-regulated subject. All members of the EU have to work according to this regulations. The main aim of the European Union is to avoid barriers to trade within the EC domestic market. For this the CPD gives "Essential Requirements" (ER) which must be satisfied by the buildings under construction . Such requirements must have an economically reasonable working life subject to normal maintenance.

6.2.1 Legal Basis

6.2.1.1 CPD and CE Conformity marking

The CPD should avoid barriers created by different national technical standards as well as barriers to trade. The CPD regulates how to bring products on the market, how to trade and how to use them. Documents based on the CPD give a clear specification of the Essential requirements (ER) for products and the development of harmonised technical standards.

Guidance Paper D – "CE Marking under the Construction Products Directive" is designed to show how to get the CE conformity marking for products. The CE marking shows that the approved product conforms to the requirements of the CPD.

Essential Requirements (ER) based on CPD - Article 3

The Essential Requirements for construction works are:

1. Mechanical resistance and stability
2. **Safety in case of fire**
3. Hygiene, health and the environment
4. Safety in use
5. Protection against noise
6. Energy economy and heat retention

Interpretative Document 2 – Safety in case of fire

This Interpretative document "Safety in case of fire" gives a interpretation of the Essential requirements "Safety in case of fire", which were written below:

The construction must be designed and built in such a way that in the event of an outbreak of fire:

- the load-bearing capacity of the construction can be assumed for a specific period of time
- the generation and spread of fire and smoke within the construction are limited
- the spread of the fire to neighbouring construction works is limited
- occupants can leave the works or be rescued by other means
- the safety of rescue teams is taken into consideration

In this case the Interpretative Document 2 is the basis for giving a mandate to publish European Technical Approvals (ETA) and gives also special requirements. This document gives a common understanding of the European Safety concept which is based on classifications and categories.

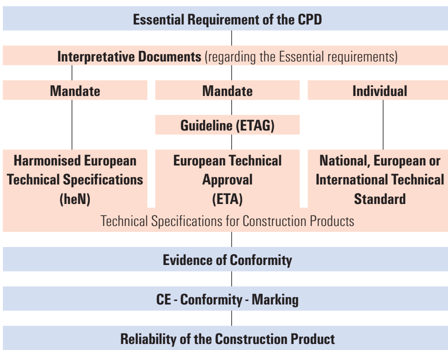
The common understanding is not always agreed through the national building laws and the national implementation of standards, especially in the field of fire protection.

The foundation of a common understanding of standards would be a European Building law, which is currently not realistic.

Conformity according the CPD

In the diagram below (figure 6.1) the structure given in the CPD shows establish the conformity of a product. European technical specifications give the possibility to certify the conformity of a product.

Figure 6.1:
Conformity according CPD



Product-related mandates were given by the European Commission to the European Committee for Standardization (CEN/CENELEC) to create harmonised European technical specifications (heN) and to the European Organisation for Technical Approvals (EOTA) to monitor and progress the drafting of ETA Guidelines (ETAG) as basis for European Technical Approvals (ETA).

6.2.1.2 Fire classification of construction products and building elements according EN 13501

In the field of fire protection the European technical specifications were not implemented as harmonised technical specifications (heN), but as identical standards nationally implemented, this also applies to DIN EN 13501, which is the common situation. On the tables of certified fasteners and anchors in section 6.7 tests according to DIN4102 as well as TR020 which is based on the EN13501 are included.

Table 6.1:
Construction product classes according EN 13501-1 and DIN 4102-1 in comparison

Euro classes DIN EN 13501-1	Capacity requirements for the Euro classes	Construction product classes DIN 4102-1
A 1	Non-combustible - no significant contribution to fire - no significant temperature increase -no flames	A 1
A2	Non-combustible - no significant contribution to fire - no significant temperature increase -short-term flames	A2
B	no significant contribution to fire	B 1
C	no significant contribution to fire	"bad" B 1
D	accepted contribution to fire	"good" B 2
E	accepted fire behaviour	B 2
F	no capacity listed	B 3

For the fire resistance rating the standard temperature/time curve (ETK) (Fig. 6.2), which is similar to ISO 834, is used in the EN 13501 and in the DIN 4102. The curve is characterised by a flat increase in temperature up to 1090 °C after 120 minutes. It is widely accepted as a basis for evaluation and as a result can be applied world wide.

Table 6.2:
Fire classification of building elements according DIN EN 13501-2 and the correlation to the German building law and the classifications according DIN4102

Building supervisional naming	structural element without brick partition	structural element withbrick partition	non-structural interior wall	non-structural exterior wall	raised floor	Suspended ceilings
fire retardent	R 30	REI 30	EI 30	E 30 (i→o) und EI 30 (i←o)	REI 30ETK (f)	EI 30 (a→b) EI 30 (a←b) EI 30 (a←→b)
	[F 30]	[F 30]	[F 30]	[W 30]	[F 30]	[F30 from above to below] [F30 from below to above] [F30 from both directions]
Highly fire retardant	R 60	REI 60	EI 60	E 60 (i→o) und EI 60 (i←o)	REI 60ETK (f)	EI 60 (a→b) EI 60 (a←b) EI 60 (a←→b)
	[F 60]	[F 60]	[F 60]	[W 60]	[F 60]	[F60 from above to below] [F60 from below to above] [F60 from both directions]
fire resistant	R 90	REI 90	EI 90	E 90 (i→o) und EI 90 (i←o)	REI 90ETK (f)	EI 90 (a→b) EI 90 (a←b) EI 90 (a←→b)
	[F 90]	[F 90]	[F 90]	[W 90]	[F 90]	[F90 from above to below] [F90 from below to above] [F90 from both directions]
fire resistance rating of 120 minutes	R 120	REI 120	-	-		-
	[F 120]	[F 120]	-	-		-
firewall / compartment wall	-	REI-M 90	EI-M 90	-		-

Table 6.3:
Definition of abbreviations according DIN EN 13501-2

Abbreviation	Legend classification	application criteria / area
R (Résitance) E (Étanchéité) I (Isolation) W (Radiation) M (Mechanical)	Loadbearing capacity Integrity Insulation Radiation Mechanical action	performance criteria for the fire resistance
S (Smoke)	Smoke leakage	limiting leakage rate
C (Closing)	Self-closing	self closure in the event of fire
i→o o←i i←→o (in - out)	Classification from inside to outsideClassification outside to insideClassification from inside to outside and from outside to inside	testing direction / doors
a→b a←b a←→b (above - below)	Classification from aboveClassification from belowClassification from both above and below	testing direction / suspended ceiling
ve ho ve,ho (vertical, horizontal)	vertical usehorizontal use-vertical and horizontal use	testing direction / fire dampers

6.2.2 Guidelines (ETAG) und Technical Reports (TR) in fixing technology

- ETAG 001 – Metal anchors for use in concrete:

Part 1 – Anchors in general
Part 2 – Torque-controlled expansion anchors
Part 3 – Undercut anchors
Part 4 – Deformation-controlled expansion anchors
Part 5 – Bonded anchors
Part 6 – Anchors for multiple use for non-structural applications
Annex A – Details of tests
Annex B – Tests for admissible service conditions – detailed information
Annex C – Design methods for anchorages

- Additional Technical reports (TR) related to ETAG 001 for special anchors and use in concrete:

TR 018 – Assessment for torque-controlled bonded anchors
TR 020 – Evaluation of anchorages in Concrete concerning resistance to fire
TR 029 – Design of bonded anchors

- ETICS fixing with plastic anchors:

ETAG 014 Plastic anchors for fixing of external thermal insulation composite systems with rendering

- ETAG 020 – Plastic anchors for multiple use in concrete and masonry for non-structural applications:

Part 1 - General
Part 2 – Plastic anchors for use in normal weight concrete
Part 3 - Plastic anchors for use in solid masonry material
Part 4 - Plastic anchors for use in hollow or perforated masonry
Part 5 - Plastic anchors for use in autoclaved aerated concrete (AAC)
Annex A – Details of tests
Annex B – Recommendations for tests to be carried out on construction works
Annex C – Design methods for anchorage

- Post-installed rebar connections:

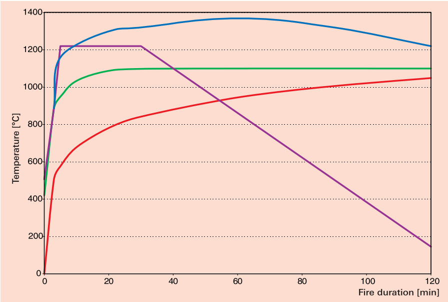
TR 023 - Assessment of post-installed rebar connections

6.2.2.1 Fire tests of Fasteners and anchors in concrete

The tests in the furnace take place in a C20/25 reinforced concrete slab, or masonry. The anchors are set into these building materials, loaded as defined and then exposed to flames. The duration of fire resistance indicates the time an anchor can resist without failure. As the load bearing capacity of an anchor essentially depends on its diameter, the elapsed time to failure is a function of the diameter. The results are on the conservative side as the tests are executed without protecting the fixing.

The temperature development must correspond to the standard temperature/time curve or to other curves (e.g. figure 6.2).

Figure 6.2:
Time/temperature curves [2] —— (ETK), —— Hydrocarbon curve, —— RABT Tunnel curve, —— Riikswaaterstaat Tunnel curve



Safety concept

In the ETA, and also in German DIBT approvals (ABZ), permissible and characteristic anchor loads and safety factors are given. Permissible anchor loads only show a fraction of the load of the anchor. This means that variations caused by irregularities in the building material, inaccurate assembly and unforeseen stresses in the structural member are accounted for.

In the fire test, the failure load is determined under fire conditions. Here the permissible load is determined from this failure load using a safety factor.

As different safety concepts are permitted for official fastener and anchor approvals and for fire test evaluation, it is possible that the permissible load determined for fire may be higher than that specified by the fastener or anchor approvals (ETA or ABZ). Nevertheless the prescribed maximum permissible load stated in the anchor approval must be respected.

Modes of failure

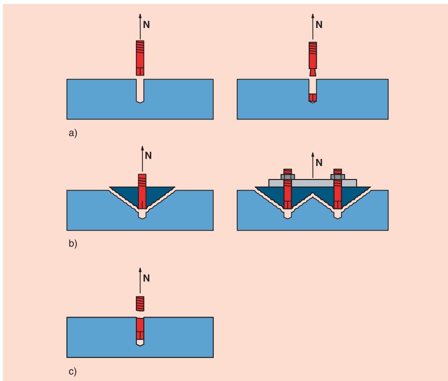
At high fire temperatures, tensile strength and yield strength of the steel and the compressive strength and tensile strength of the concrete are significantly reduced. During fire tests, using anchors installed in concrete, three different modes of failure can occur:

- Steel failure
- Concrete failure
- Pull out, pull through or bond failure of chemical anchor systems

Steel failure of fasteners and anchors

As the temperature rises, the strength of the steel is reduced. As soon as the ultimate strength has been reached steel failure occurs outside the base material (Fig. 6.3c) /3/. Figure 6.4 illustrates how temperature changes the load-bearing capacity of structural steels. At a temperature of 500 °C the yield strength corresponds to only 58% of the value measured at ambient temperature.

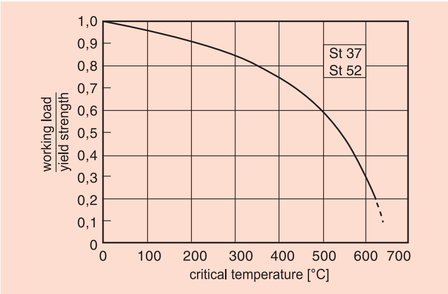
Figure 6.3:
Modes of failure under tension load



Two types of steel failure can be observed: steel failure within the cross section and the “shearing“ of threads of the threaded rod and/or the nut.

Test results /5/ reveal that the steel failure load depends upon the type of steel (carbon steel or stainless steel) and the diameter of the anchor. Accordingly stainless steels perform significantly better at comparable fire stresses than carbon steels. Anchors with smaller diameters fail more quickly than those with large diameters.

Figure 6.4:
Behavior of steel depending on the temperature, derived from/4/



Concrete failure

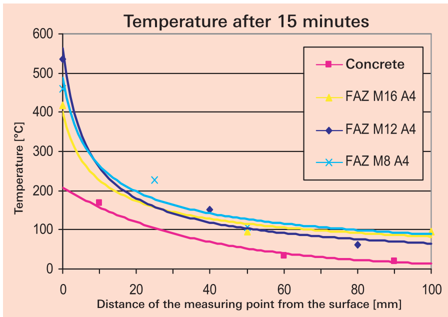
The different coefficients of expansion of the concrete components (aggregates, cement, water, reinforcement) as well as the high temperature differences between the flamed surface and the deeper layers produce strong stresses. In addition water, physically bound in concrete, vaporizes and thus stresses the concrete. This means particularly that spalling can occur in the layers close to the surface (Fig. 6.5).

Figure 6.5:
Spalling-off of the concrete cover /1/

Spalling is strongly influenced by the location and size of the reinforcement. A dense reinforcement of thin bars is more unfavourable than thicker reinforcement bars placed at greater distances from each other. The draft of the German regulation ZTV-DNG, part 5, section 4, requires a minimum embedment depth of 65 mm to allow for spalling of the concrete.

As illustrated in Figure 6.6, the temperature in the concrete decreases with increasing distance from the surface. The concrete cover represents temperature protection for the reinforcement. If the concrete cover spalls off, then reinforcement failure should be expected.

Figure 6.6:
fischer Anchor bolt FAZ A4 - temperatures over the length of the drill hole after 15 minutes of fire exposure /1/



New research results /5/ demonstrate that failure due to concrete break-out (Fig. 6.3b) of approved anchors with embedment depths > 40 mm is negligible. Exceptions are anchors that operate on the deformation-controlled principle via the setting of a cone (for example fischer Hammerset anchor EAII). This type of anchors is only approved for anchoring light ceiling claddings and for applications in non-cracked concrete. However in the case of fire, cracks occur in the concrete. Because of the lack of post expansion capacity, these anchors show a large displacement in cracked concrete. Hence the embedment depth is reduced to the extent that concrete break-out of the remaining concrete cover must be taken into consideration.

6

Pull out / pull through of metal expansion and undercut anchors

In fires of long duration, cracks will occur in the interior of the concrete that will run through the drill hole of the anchor. For torque-controlled anchors, suitable for use in cracked concrete, like the fischer Anchor bolt FAZ II, it has been identified that pull-out can only be observed shortly before failure of the concrete member. This is due to the fact that these anchors have a so called post-expansion behaviour: This means that if the drill hole is enlarged by a crack, then the load acting on the anchor pulls the expansion cone deeper into the expansion sleeve and so the transferable load remains high. Large displacements, as in the case of deformation-controlled anchors, does not occur.

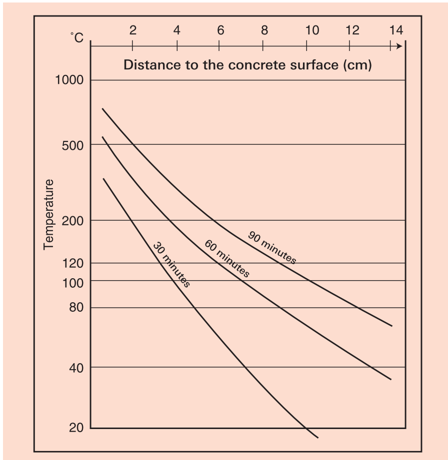
The same applies for undercut anchors like the fischer Zykon anchor FZA. The part of the anchor placed in the conical undercut of the drill hole has a significantly larger diameter than that within the cylindrical drill hole. This type of anchor remains largely unaffected by the formation of cracks.

Fire-induced cracks can become larger during or after cool down. In this case, post fire pull-out failure is possible.

to 120 °C. Polyester resin mortar has a short term temperature use of only 80 °C.

Further studies have shown that with bonded anchors, in direct contact with flames that are installed in concrete slabs, the heat advances only slowly along the embedment depth /2/. Figure 6.7 demonstrates how the temperature in the mortar develops depending on the distance to the concrete surface and the fire duration.

Figure 6.7:
Temperature in the area of the mortar of chemical anchors during a fire test (Upat UKA 3 Chemical anchor and fischer Resin anchor R)



Bond failure of chemical anchor systems

In the case of chemical anchor systems, capsule and injection systems, the mortar softens at high temperature which leads to a bond failure.

Hybrid systems based on vinyl ester resins with cement, as used by the fischer group of companies (Upat UPM 44 Injection mortar or fischer injection mortar FIS V), can be used up to 120 °C for short term use. Products based on pure vinyl ester resins (Upat UMV multi-cone, Upat UKA 3 resin anchor or fischer resin anchor R) may also be used, short term, up

Tests with the bonded expansion system, fischer Highbond anchor FHB, prove that the load-bearing capacity is only slightly reduced due to the supplemental expansion forces and that steel failure is decisive. Modern bonded expansion anchors, in the case of fire, have similar loads available to steel anchors.

Steel failure at temperature exposure up to 400 °C

In cases where fixings are exposed to temperatures up to 400 °C, a reduction in steel strength should be considered in the design procedure. This is covered by the draft of the tunnel regulation ZTV-DNG. Relatively high temperatures occur in the vicinity of the source of fire. Nevertheless equipment such as fans or fume extraction systems must remain usable. This is guaranteed by considering higher temperatures for both the equipment as well as the anchors. Table 6.4 shows the reduction of the yield strength of different stainless steels as a function of the temperature. Corresponding figures for carbon steel may be found in figure 6.4.

Table 6.4:
Minimum yield strengths [N/mm²] of stainless steels as a function of the temperature /6/

Material	20 °C	100 °C	200 °C	300 °C	400 °C
1.4401	200	175	145	127	115
1.4404	200	165	137	119	108
1.4571	200	185	165	145	135
1.4529	300	230	190	170	160

Generally stainless steels are safer in fires than carbon steels. For this reason the classification for anchors produced from stainless steel can be taken, without testing, from the results of carbon steel(the results are conservative). To illustrate, the test results are listed in table 6.5 for Upat UPM 44 Chemical mortar with ASTA M 16 and fischer Zykon anchor FZA M 12 for the fire rating class F 90.

Table 6.5:
Influence of the type of steel on the load capacity (examples for F90)

Designation		UPM 44 + ASTA M 16	FZA 18x80 M12
Zinc plated steel	[kN]	4.0	2.0
Stainless steel	[kN]	5.8	5.0

6.2.2.2 Design of anchorages in Concrete concerning resistance to fire

Not only do fasteners and anchors have to conform to the building regulations but it is necessary to have the fire certification with a specific rating according the construction element where it will be built . According the building laws the conformity marking "CE" could only be given based on an ETA. In Germany parallel with the conformity marking -Ü- by German DIBT approval (ABZ).

The classification of the fire resistance is not given in all ETA´s or German DIBT approvals (ABZ), so specific test reports will give the fire resistance rating. These test reports are written by authorised test institutes (see section 6.7 „Overview of certified fasteners and anchors", column „Test report and approval").

In their Technical Report TR 020, EOTA defined a fire rating guideline for metal anchors. Following ETAG 001, also in TR 020, the load directions axial tension and shear are proved separately and then in combination.

On the one hand TR 020 gives you a pure calculation method whose results are clearly on the safe side but do not use the whole capacity of the anchors.

On the other hand the calculation values can be increased enormously by making fire rating tests. These values are evaluated in a test report. The first time such a test report was issued was for the fischer Anchor bolt FAZ II.

6.2.2.3 Design of post-installed rebar connections according TR 023

The Technical report TR023 is in accordance with ETAG 001 – Part 1 and 5 and EN 1992-1-1:2004 Eurocode 2 (EC2). Design of anchorages in concrete concerning resistance to fire are not implemented in the TR 023.

In the German DIBT approvals (ABZ) mainly testing in accordance to DIN 4102-4 are integrated. (e.g. fischer FRA approval).

For further information regarding post-installed rebars see Chapter 5 of this Technical Handbook.

6.2.2.4 Fire resistance of plastic anchors according ETAG 020

For information regarding the fire resistance of plastic anchors, ETAG 020 Part 1 chapter 5.2 gives the following requirements:-

In part 5.2.1 the reaction of the anchor in fire is defined. Also given is the use of the anchors for fixing of a cladding or a component which is not class A 1 and the plastic parts are located in the drilled hole of the base material (concrete or masonry) and fixture. For this use of frame fixing anchors it is assumed that in case of fire, the cladding material and the substructures made of wood and metal will burn, before the anchors will collapse. In tests it is verified that the expansion part of the anchor in the base material will withstand the fire. The metal part (Screw) has to be construction product class A1 according EN 13501.

In the second part 5.2.2 a link to the Technical Report 020 "Evaluation of anchorages in Concrete concerning resistance to fire" and the part 2.2 with the simplified design method is given. In TR020 chapter 4 a similar remark is included. It is assumed that the fastening of claddings with plastic anchors for a fire resistance of at least 90 minutes (R90) and an admissible load (no permanent centric tension load) of <=0,8 kN have to fulfil the following conditions:

- Plastic anchor d =10mm
- Plastic sleeve made of Polyamid PA6
- Metal screw d ≥ 7mm
- Anchoring depth h_{ef} ≥ 50mm

6.2.2.5 Fire resistance of fixing with plastic anchors for external thermal insulation composite systems with rendering according ETAG 014 and ETAG 004

Regarding fire resistance the ETAG 014 has a link to ETAG 004.

In the ETAG 004 the following reaction to fire tests are required:

- test of the entire system (Kit)
- test of the insulation product alone (classification according Euro classes A1-E)

A relationship to the requirements of the Interpretative Document (ID) 2 is given. There is also a note concerning higher load requirements of the national building codes. In the ETA for external thermal insulation composite systems (ETICS) the fixing is included. The use of the system under fire conditions is only acceptable according the conditions written in the ETA.

In the ETAG 004, table 10 for anchors, a link to ETAG 020 "Plastic anchors for multiple use in concrete and masonry for non-structural applications" is given regarding the kind of tests required. Because of that the criteria of ETAG 020 can be used.

6.3. Fire protection in fixing technology according American standard

American standards are accepted not only in North- and South America, but also in the Arabic and in the Asian area.

6.3.1 Legal basis

The International Code Council (ICC) was established in 1994 as a nonprofit making organization dedicated to developing a single set of comprehensive and coordinated national model construction codes. The founders of the ICC are Building Officials and Code Administrators International, Inc. (BOCA), International Conference of Building Officials (ICBO), and Southern Building Code Congress International, Inc. (SBCCI). Since the early part of the last century, these organizations developed the three separate sets of model codes used throughout the United States. Although regional code development has been effective and responsive to our country's needs, the time came for a single set of codes. The nation's three model code groups responded by creating the International Code Council and by developing codes without regional limitations the International Codes.

These international Codes are implemented up to now in the most of the USA.

6.3.2 ICC – ES Guidelines

The ICC-ES (Evaluation Service INC.) are publishing, so called, „Acceptance – Criterias (AC)" which record the criteria, like codes and reference standards, for evaluating the different products. Based on this AC´s Evaluation reports (ESR) are published, which are comparable to an ETA or ABP.

6.3.2.1 Design procedure

According ACI 318-08 Appendix D.

6.3.2.2 Applicability of ES-Reports

Most of the USA has already introduced the International Codes, also other different countries will accept the standards.

6.4. Comparison of Test - Methods

Figure 6.6:
Comparison of test-methods according EN- and ICC-Standard

Standard	European Standard	ICC - ES Standard (ICC)
Guideline	ETAG 001 Teil 1 - 6	AC 193, AC 308
Fire resistance tested according to	EOTA TR 020	ASTM E 119
Temperature/time curve	ISO 834 (equivalent to ETK from DIN 4102-2)	ASTM E 119
Sign of conformity	CE – Zeichen	-
Design - Method	CC-Method	CCD-Method, equivalent to the CC-Method

6.5. Fire protection in fixing technology for the use in tunnel

6.5.1 Legal basis

The „EC-Tunnel Guidline" – „Directive 2004/54/EC on minimum safety requirements for tunnels in the trans-European road network" gives a standard. The other available Guidelines for this subject are national German Guidelines or standards as follows:

- Guidline for the equipment and handling of road tunnels (Richtlinie für die Ausstattung und den Betrieb von Straßentunnel - RABT 2006)

- Additional technical conditions of contract (Zusätzliche technische Vertragsbedingungen für Ingenieurbauwerke - ZTV-ING Teil 5 Abs. 4, Entwurf 2003)

- Model pipework Guidline (Muster-Leitungsanlagenrichtlinie - MLAR 2005)

6.5.2 Guidlines for design

6.5.2.1 Temperature/time curves

Besides the standard temperature/time curve, further temperature curves are accepted for special applications. The hydrocarbon curve describes fire damage with flammable liquids. In Germany tunnel fires are simulated according to the RABT/ZTV Tunnel curve. In the Netherlands they are simulated according to the Rijkswaterstaat Tunnel curve (Fig. 6.2).

The RABT/ZTV Tunnel curve is characterised by an increase in temperature up to

1200 °C within 5 minutes. An even more severe temperature action is required in accordance with the Rijkswaterstaat-Tunnelcurve: 1200 °C over a time of 120 minutes. The RWS-temprature-time-curve is becoming more and more acceptance worldwide.

6.5.2.2 Fire tests under real conditions

The fischer group of companies collaborates in international research projects on fire behaviour. In addition to analytical experiments and modelling calculations there is also a focus here on executing fire tests under real conditions. In this regard, the spectrum extends from small fire analysis of room fires and house fires to the fire test in a Brenner Motorway tunnel (Fig. 6.8). This fire test took place in July 2001 as part of a catastrophe-training program near Brixen, Italy.

Figure 6.8:
Tunnel fire test 2001 in a Brenner Motorway tunnel in cooperation with the Autostrada del Brennero S.P.A. Institute for Constructive Civil Engineering, Santa Automation Instruments and fischer fixing systems [1]

Three objectives were paramount during the execution of this trial: Determination of the temperature depending on the distance to the concrete surface (Fig. 6.9), the load bearing capacity of the anchors during and after the fire.

Figure 6.9:
Temperature measurement on the fischer Anchor bolt FAZ depending on the distance to the concrete surface

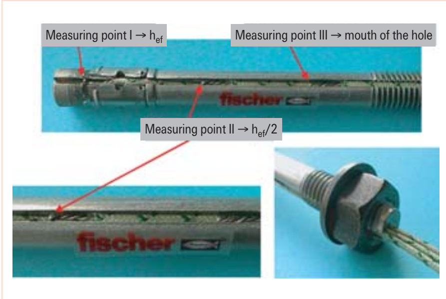
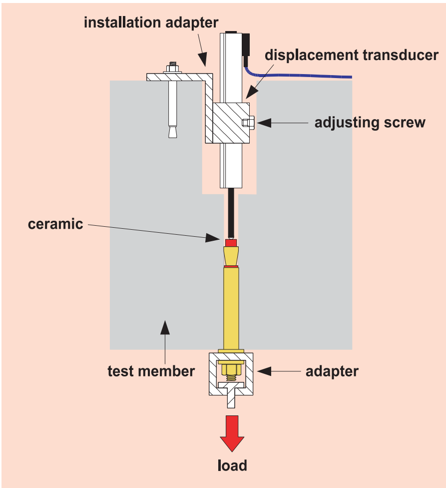


Figure 6.10 shows the test set up. Bergmeister and Rieder published the results of this fire test /2/.

Figure 6.10:
Setup for the test in the Brenner Motorway tunnel /1/



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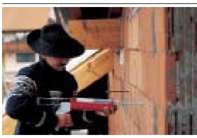
6.6. Anchor applications (examples)

Application		suitable fixing or anchor
	Ventilation ducts and ventilation dampers	fischer Nail anchor FNA II fischer Zykon hammerset anchor FZEA II fischer Anchor bolt FAZ II fischer Hammerset anchor EA II fischer Concrete screw FBS fischer Hollow ceiling anchor FHY fischer Ceiling nail FDN
	Lightweight suspended ceilings and similar systems in the intermediate ceiling area	fischer Hammerset anchor EA II fischer Nail anchor FNA II fischer Ceiling nail FDN fischer Concrete screw FBS
	Sprinkler systems	fischer Zykon anchor FZA fischer Zykon hammerset anchor FZEA II fischer Anchor bolt FAZ II fischer High performance anchor FH II fischer Hammerset anchor EA II
	Facade sub-constructions made of wood or metal	fischer Universal frame fixing FUR fischer Long-shaft fixing SXS fischer Frame fixing SXR
	Cable race ways	fischer Zykon anchor FZA fischer Zykon hammerset anchor FZEA II fischer Anchor bolt FAZ II fischer High performance anchor FH II fischer Hollow-ceiling anchor FHY fischer Hammerset anchor EA II fischer Nail anchor FNA II fischer Concrete screw FBS fischer Injection mortar FIS V
	Heavy pipelines and cable race ways	fischer Anchor bolt FAZ II fischer High performance anchor FH II fischer Zykon hammerset anchor FZEA II fischer Highbond anchor FHB II fischer Zykon anchor FZA fischer Injection mortar FIS V
	Steel constructions	fischer Anchor bolt FAZ II fischer Bolt FBN II fischer High performance anchor FH II fischer Highbond anchor FHB II fischer Zykon anchor FZA fischer Injection mortar FIS V Upat EXA Express anchor Upat UMV Vario injection anchor
	Anchorage in masonry	fischer Injection-System FIS V Upat UPM 44 chemical mortar

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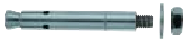
6.7 Overview of certified fasteners and anchors

6.7.1 Applications in cracked concrete

Designation	Anchor type	Material			Max. permissible loads in case of fire [kN]								Test report	Certifikate		Application
		gvz	A4	C (1.4529)	R 30/F 30		R 60/F 60		R 90/F 90		R 120/F 120		approval no. *	▲	FM	
					tension	shear	tension	shear	tension	shear	tension	shear				
fischer Highbond anchor FHB II	FHB II 8 x 60	●	●	●	2.3	2.8	1.8	2.1	1.2	1.4	0.9	1.0	PB III / B-06-065 (18.04.2006)			cracked and non-cracked concrete
	FHB II 10 x 60	●	●	●	3.4	4.1	2.4	2.9	1.4	1.8	0.9	1.2				
	FHB II 10 x 95	●	●	●	3.6	4.3	2.7	3.3	1.8	2.4	1.4	1.9				
	FHB II 12 x 75	●	●	●	4.4	4.9	3.5	4.0	2.6	3.1	2.1	2.7				
	FHB II 12 x 120	●	●	●	5.1	6.1	3.8	4.9	2.4	3.6	1.7	3.0				
	FHB II 16 x 95	●	●	●	8.3	9.2	6.6	7.5	4.8	5.9	4.0	5.0				
	FHB II 16 x 160	●	●	●	9.5	11.4	7.0	9.1	4.5	6.8	3.3	5.6				
	FHB II 20 x 210	●	●	●	14.9	17.8	11.0	14.2	7.1	10.6	5.2	8.8				
	FHB II 24 x 170	●	●	●	18.7	20.8	14.8	17.0	10.9	13.3	8.9	11.4				
fischer Highbond dynamic anchor FHB dyn	FHB-A dyn 12 x 100/25	●			7.0	-	4.0	-	2.5	-	-	-	3038/8141-1 (12.10.2001)			cracked and non-cracked concrete
	FHB-A dyn 12 x 100/50	●			7.0	-	4.0	-	2.5	-	-	-				
	FHB-A dyn 16 x 125/25	●			15.0	-	7.0	-	5.0	-	4.0	-				
	FHB-A dyn 16 x 125/50	●			15.0	-	7.0	-	5.0	-	4.0	-				
	FHB-A dyn 20 x 170/50	●			20.0	-	9.5	-	7.0	-	5.0	-				
	FHB-A dyn 24 x 220/50	●			25.0	-	12.0	-	9.5	-	7.5	-				
	FHB-A dyn 16 x 125/50C			●	15.0	-	7.0	-	5.0	-	4.0	-				
fischer Zykon bolt anchor FZA	FZA M6	●			1.0	-	0.5	-	0.35	-	0.25	-	3277/0531-1 (23.11.2001)			cracked and non-cracked concrete
	FZA M8	●			1.5	-	0.8	-	0.5	-	0.4	-		▲		
	FZA M10	●			4.5	-	2.2	-	1.3	-	0.9	-		▲	●	
	FZA M12	●			8.5	-	3.5	-	2.0	-	1.5	-		▲	●	
	FZA M16	●			13.5	-	6.5	-	4.0	-	3.0	-		▲	●	
	FZA M6 A4/C		●	●	2.1	-	1.2	-	0.85	-	0.7	-				
	FZA M8 A4/C		●	●	10.0	-	4.0	-	1.8	-	1.0	-		▲		
	FZA M10 A4/C		●	●	18.0	-	7.0	-	3.5	-	2.0	-		▲	●	
	FZA M12 A4/C		●	●	22.0	-	9.0	-	5.0	-	3.5	-		▲	●	
	FZA M16 A4/C		●	●	24.0	-	12.0	-	7.5	-	6.0	-		▲	●	
fischer Zykon through anchor FZA-D	FZA M8 D	●			1.5	-	0.8	-	0.5	-	0.4	-	3277/0531-1 (23.11.2001)	▲		cracked and non-cracked concrete
	FZA M10 D	●			4.5	-	2.2	-	1.3	-	0.9	-		▲	●	
	FZA M12 D	●			8.5	-	3.5	-	2.0	-	1.5	-		▲	●	
	FZA M16 D	●			13.5	-	6.5	-	4.0	-	3.0	-		▲	●	
	FZA M8 D A4/C		●	●	10.0	-	4.0	-	1.8	-	1.0	-		▲		
	FZA M10 D A4/C		●	●	18.0	-	7.0	-	3.5	-	2.0	-		▲	●	
	FZA M12 D A4/C		●	●	22.0	-	9.0	-	5.0	-	3.5	-		▲	●	
	FZA M16 D A4/C		●	●	24.0	-	12.0	-	7.5	-	6.0	-		▲	●	
fischer Zykon internally threaded anchor FZA-I	FZA M6 I	●			1.0	-	0.5	-	0.35	-	0.25	-	3277/0531-1 (23.11.2001)			cracked and non-cracked concrete
	FZA M8 I	●			1.5	-	0.8	-	0.5	-	0.4	-		▲		
	FZA M10 I	●			4.5	-	2.2	-	1.3	-	0.9	-		▲	●	
	FZA M12 I	●			8.5	-	3.5	-	2.0	-	1.5	-		▲	●	
	FZA M6 I A4/C		●	●	2.1	-	1.2	-	0.85	-	0.7	-				
	FZA M8 I A4/C		●	●	10.0	-	4.0	-	1.8	-	1.0	-		▲		
	FZA M10 I A4/C		●	●	18.0	-	7.0	-	3.5	-	2.0	-		▲	●	
	FZA M12 I A4/C		●	●	22.0	-	9.0	-	5.0	-	3.5	-		▲	●	
fischer Zykon hammerset anchor FZEA II	FZEA II 10 x 40 M8	●	●	●	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	ETA-06/0271 (05.01.2007)	▲		cracked and non-cracked concrete
	FZEA II 12 x 40 M10	●	●	●	1.8	2.3	1.8	1.7	1.6	1.1	1.2	0.9		▲	●	
	FZEA II 14 x 40 M12	●	●	●	1.8	2.4	1.8	2.1	1.8	1.4	1.5	1.0		▲	●	

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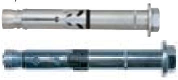
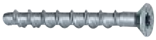
Designation	Anchor type	Material			Max. permissible loads in case of fire [kN]								Test report	Certifikate		Application
		gvz	A4	C (1.4529)	R 30/F 30		R 60/F 60		R 90/F 90		R 120/F 120		approval no. *	▲	FM	
					ten-sion	shear	ten-sion	shear	ten-sion	shear	ten-sion	shear				
fischer Anchor bolt FAZ	FAZ II M8	●	●	●	1.3	1.8	1.2	1.6	0.9	1.3	0.8	1.2	ETA-05/0069	▲		cracked
	FAZ II M10	●	●	●	2.3	3.6	2.3	2.9	1.9	2.2	1.6	1.9	(09.12.2008)	▲	●	and
	FAZ II M12	●	●	●	4.0	6.3	4.0	4.9	3.2	3.5	2.8	2.8		▲	●	non-
	FAZ II M16	●	●	●	9.4	11.7	7.7	9.1	6.0	6.6	5.2	5.3		▲	●	cracked
	FAZ II M20	●	●		14.0	18.0	12.0	14.0	9.0	10.0	8.0	8.0		▲	●	concrete
	FAZ II M24	●	●		21.0	26.0	17.0	20.0	13.0	14.0	11.0	11.0		▲	●	
fischer High performance anchor	FH II 10 B / S / H / SK	●			0.2	0.3	0.2	0.3	0.1	0.2	0.1	0.1	ETA-07/0025			cracked
FH/FH II	FH II 12 B / S / H / SK	●			2.0	2.0	1.3	1.3	0.6	0.6	0.2	0.2	(19.02.2009)	▲		and
	FH II 15 B / S / H / SK	●			3.2	3.2	2.3	2.3	1.4	1.4	1.0	1.0		▲	●	non-
	FH II 18 B / S / H / SK	●			4.8	4.8	3.9	3.9	3.0	3.0	2.6	2.6		▲	●	cracked
	FH II 24 B / S / H / SK	●			8.9	8.9	7.3	7.3	5.6	5.6	4.8	4.8		▲	●	concrete
	FH II 28 B / S / H / SK	●			13.0	13.9	11.3	11.3	8.8	8.8	7.5	7.5		▲		
	FH II 32 B / S / H / SK	●			20.0	20.0	16.3	16.3	12.6	12.6	10.8	10.8		▲		
fischer Concrete screw FBS	FBS 8	●			-	-	-	-	0.8	-	0.8	-	902 070 000			cracked
	FBS 10	●			-	-	-	-	1.0	-	1.0	-	(25.06.2002)			and
	FBS 10 A4		●		-	-	-	-	1.5	-	1.5	-				non-
																cracked
																concrete

* Detailed information about test reports and approvals please refer to: www.fischer.de/fixing systems/products/product online catalogue ...

▲ meets VdS requirements

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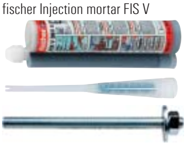
* Detailed information about test reports and approvals please refer to: www.fischer.de/fixing systems/products/product online catalogue ...

▲ meets VdS requirements

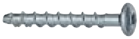
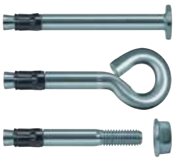
6.7.2 Applications in non-cracked concrete

Designation	Anchor type	Material gvz	Material A4	Material C (1.4529)	R 30/F 30 tension	R 30/F 30 shear	R 60/F 60 tension	R 60/F 60 shear	R 90/F 90 tension	R 90/F 90 shear	R 120/F 120 tension	R 120/F 120 shear	Test report approval no. *	Certifikate ▲	Certifikate FM	Application
					Max. permissible loads in case of fire [kN]											
fischer Bolt FBN 	FBN II 8	●			1.4[4]	1.8[4]	1.1[4]	1.8[4]	0.7[4]	1.8[4]	0.6[4]	1.1[4]	ETA-07/0211			non-cracked concrete
	FBN II 10	●			3.2[4]	3.2[4]	3.1[4]	3.2[4]	2.0[4]	3.2[4]	1.4[4]	2.5[4]	(30.11.2007)			
	FBN II 12	●			6.1[4]	9.8[4]	6.1[4]	7.9[4]	4.2[4]	6.1[4]	2.8[4]	5.1[4]	PB III/B-07-444			
	FBN II 16	●			10.3[4]	20.6[4]	10.3[4]	17.4[4]	7.8[4]	13.4[4]	5.3[4]	11.3[4]	(29.11.2007)			
	FBN II 20	●			20.3[4]	33.6[4]	19.9[4]	27.2[4]	12.2[4]	20.9[4]	8.4[4]	17.7[4]				
	FBN 8 A4		●		0.5	–	0.5	–	0.5	–	–	–	ETA-02/0037			
	FBN 10 A4		●		1.3	–	1.3	–	1.3	–	–	–	(15.12.2008)			
	FBN 12 A4		●		1.8	–	1.8	–	1.8	–	–	–	3355/0530-4			
	FBN 16 A4		●		4.0	–	4.0	–	4.0	–	–	–	(23.06.2000)			
Upat EXA Express anchor 	EXA M8	●			0.8	–	0.8	–	0.7	–	0.5	–	3268/1095-3			non-cracked concrete
	EXA M10	●			0.8	–	0.8	–	0.8	–	0.8	–	(21.02.1996)			
	EXA M12	●			0.8	–	0.8	–	0.8	–	0.8	–				
Upat UPM 44 Injection mortar 	UPM 44 M8	●			1.9	–	0.8	–	0.3	–	0.15	–	3253/0291-3			non-cracked concrete
	UPM 44 M10	●			4.5	–	2.1	–	1.0	–	0.6	–	(10.01.2002)			
	UPM 44 M12	●			8.5	–	3.6	–	2.1	–	1.5	–				
	UPM 44 M16	●			13.5	–	6.4	–	4.0	–	3.0	–				
	UPM 44 M20	●			21.0	–	10.0	–	6.0	–	4.5	–				
	UPM 44 M24	●			30.0	–	14.0	–	9.0	–	6.5	–				
	UPM 44 M30	●			45.0	–	22.0	–	14.0	–	10.0	–				
	UPM 44 M8 A4/C		●	●	4.3	–	0.8	–	0.3	–	0.15	–				
	UPM 44 M10 A4/C		●	●	7.5	–	2.1	–	1.0	–	0.6	–				
	UPM 44 M12 A4/C		●	●	11.0	–	5.7	–	3.9	–	3.0	–				
	UPM 44 M16 A4/C		●	●	25.0	–	10.0	–	5.8	–	4.0	–				
	UPM 44 M20 A4/C		●	●	32.0	–	15.0	–	9.0	–	6.0	–				
	UPM 44 M24 A4/C		●	●	45.0	–	22.0	–	13.0	–	9.0	–				
	UPM 44 M30 A4/C		●	●	70.0	–	35.0	–	20.0	–	14.0	–				
fischer Injection mortar FIS V 	FIS A M8	●			1.9	–	0.8	–	0.3	–	0.15	–	3038/8141-3			non-cracked concrete
	FIS A M10	●			4.5	–	2.1	–	1.0	–	0.6	–	(10.01.2002)			
	FIS A M12	●			8.5	–	3.6	–	2.1	–	1.5	–				
	FIS A M16	●			13.5	–	6.4	–	4.0	–	3.0	–				
	FIS A M20	●			21.0	–	10.0	–	6.0	–	4.5	–				
	FIS A M24	●			30.0	–	14.0	–	9.0	–	6.5	–				
	FIS A M30	●			45.0	–	22.0	–	14.0	–	10.0	–				
	FIS A M8 A4/C		●	●	4.3	–	0.8	–	0.3	–	0.15	–				
	FIS A M10 A4/C		●	●	7.5	–	2.1	–	1.0	–	0.6	–				
	FIS A M12 A4/C		●	●	11.0	–	5.7	–	3.9	–	3.0	–				
	FIS A M16 A4/C		●	●	25.0	–	10.0	–	5.8	–	4.0	–				
	FIS A M20 A4/C		●	●	32.0	–	15.0	–	9.0	–	6.0	–				
	FIS A M24 A4/C		●	●	45.0	–	22.0	–	13.0	–	9.0	–				
	FIS A M30 A4/C		●	●	70.0	–	35.0	–	20.0	–	14.0	–				
fischer Hollow-ceilling anchor FHY 	FHY M6	●			1.0	–	0.45	–	0.28	–	0.2	–	3566/3321			pre-stressed hollow-core concrete slab
	FHY M8	●			1.6	–	1.0	–	0.75	–	0.6	–	(21.06.2002)			
	FHY M10	●			2.5	–	1.65	–	1.3	–	1.1	–				
fischer Universal frame fixing FUR 	FUR 10[1]	●	●		1.6		–		0.8		–		Z-21.2-1204			non-cracked concrete
	FUR 10[2]	●	●		1.6		–		1.4		0.8		(27.04.2009)			
	FUR 10[3]	●	●		1.6		–		1.6		0.8		3705/4711 (23.11.2001)			

* Detailed information about test reports and approvals please refer to: www.fischer.de/fixing systems/products/product online catalogue ...

1) Angle of load 10° 2) Angle of load 70° 3) Angle of load 90° 4) Standard anchorage depth ▲ meets VdS requirements

6.7.3 For multiple fixings of non-structural applications and suspende ceilings

Designation	Anchor type	Material gvz	Material A4	Material C (1.4529)	Max. permissible loads in case of fire [kN] R 30/ F 30	R 60/ F 60	R 90/ F 90	R 120/ F 120	Test report approval no. *	Certificate ▲	Certificate FM	Application
fischer Concrete screw FBS 	FBS 5	●			–	–	0.2	0.2	902 070 000 (25.06.2002)			suspended ceillings
	FBS 6	●			–	–	0.5	0.3				
	FBS 8	●			–	–	0.8	0.8				
fischer Ceiling nail FDN 	FDN 6/35	●			0.45	0.35	0.25	0.25	ETA-07/0144 (03.07.2007)			suspended ceillings
	FDN 6/65	●			0.45	0.35	0.25	0.25				
fischer Nail anchor FNA II 	FNA II 6 x 25	●			0.6[1,2]	0.6[1,2]	0.5[1,2]	0.3[1,2]	ETA-06/0175 (16.07.2008)			multiple fixings of non-structural applica-tions
	FNA II 6 x 25 M6	●			0.4[1,2]	0.3[1,2]	0.3[1,2]	0.3[1,2]				
	FNA II 6 x 25 M8	●			0.4[1,2]	0.3[1,2]	0.3[1,2]	0.3[1,2]				
	FNA II 6 x 25 OE	●			0.3[1,2]	0.2[1,2]	0.2[1,2]	0.1[1,2]				
	FNA II 6 x 30	●	●	●	0.9[1,2]	0.9[1,2]	0.9[1,2]	0.7[1,2]				
	FNA II 6 x 30 M6	●	●	●	0.4[1,2]	0.3[1,2]	0.3[1,2]	0.3[1,2]				
	FNA II 6 x 30 M8	●	●	●	0.4[1,2]	0.3[1,2]	0.3[1,2]	0.2[1,2]				
fischer Hammerset anchor EA II 	EA II M6	●	●		0.6[3]	0.5[3]	0.4[3]	0.3[3]	ETA-07/0142 (06.02.2008)			multiple fixings of non-structural applica-tions
	EA II M8	●	●		0.9[3]	0.9[3]	0.6[3]	0.5[3]		▲		
	EA II M8 x 40	●	●		1.3[3]	0.9[3]	0.6[3]	0.5[3]		▲		
	EA II M10 x 30	●	●		0.9[3]	0.9[3]	0.9[3]	0.6[3]		▲	●	
	EA II M10	●	●		1.8[3]	1.5[3]	0.9[3]	0.6[3]		▲	●	
	EA II M12	●	●		2.3[3]	2.3[3]	2.0[3]	1.3[3]		▲	●	

* Detailed information about test reports and approvals please refer to: www.fischer.de/fixing systems/products/product online catalogue ...

1) The loads apply to the load directions tension, transverse tension and oblique tension at any angle with edge distances of at least 100 mm. For smaller edge distances, reduced loads have to be taken into consideration according to approval ETA-06/0175, ETA-06/0176 and ETA-06/0177 and test report no. PB III / B-06-267

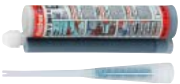
2) Permissible loading per fixation point. One fixation point can consist of a single anchor, a group of two with s ≥ 50 mm or a group of four with s ≥ 50 mm.

3) These loads apply to the load directions tension, transverse tension and oblique tension at any angle.

▲ meets VdS requirements

6

6.7.4 Fixings in masonry

Designation	Anchor type	Material gvz	Material A4	Material C (1.4529)	Max. permissible loads in case of fire [kN] R 30/F 30 tension	R 30/F 30 shear	R 60/F 60 tension	R 60/F 60 shear	R 90/F 90 tension	R 90/F 90 shear	R 120/F 120 tension	R 120/F 120 shear	Test report approval no. *	Application
fischer Injection mortar FIS V	FIS V M8	●	●		1.9	-	0.8	-	0.5	-	0.4	-	Z-21.3-1675 (14.06.2005) 3355/0530-5 (21.05.2001)	Masonry KS 12, Mz 12, Hlz 12, KSL 12 with internal threaded sockets (FIS E)
	FIS V M10	●	●		4.0	-	1.8	-	1.0	-	0.7	-		
	FIS V M12	●	●		5.0	-	2.7	-	1.5	-	1.0	-		
	FIS V M8	●	●		1.0[1]	1.0[1]	0.9[1]	1.0[1]	0.6[1]	1.0[1]	0.4[1]	0.7[1]	Z-21.3-1675 (14.06.2005) PB III/B-04-342 (22.12.2004)	Aerated concrete acc. approval
	FIS V M10	●	●		1.0[1]	1.0[1]	0.9[1]	1.0[1]	0.6[1]	1.0[1]	0.4[1]	0.7[1]		
	FIS V M12	●	●		1.0[1]	1.0[1]	0.9[1]	1.0[1]	0.6[1]	1.0[1]	0.4[1]	0.7[1]		
	FIS V M8	●	●		1.3[2]	1.4[2]	1.0[2]	1.3[2]	0.6[2]	1.0[2]	0.4[2]	0.9[2]		
	FIS V M10	●	●		1.3[2]	1.4[2]	1.0[2]	1.3[2]	0.6[2]	1.0[2]	0.4[2]	0.9[2]		
	FIS V M12	●	●		1.3[2]	1.4[2]	1.0[2]	1.3[2]	0.6[2]	1.0[2]	0.4[2]	0.9[2]		
Upat UPM 44 Injection mortar	UPM 44 M8	●	●		1.9	-	0.8	-	0.5	-	0.4	-	Z-21.3-1649 (14.06.2005) 3354/0520-5 (21.05.2001)	Masonry KS 12, Mz 12, Hlz 12, KSL 12 with internal threaded sockets (FIS E)
	UPM 44 M10	●	●		4.0	-	1.8	-	1.0	-	0.7	-		
	UPM 44 M12	●	●		5.0	-	2.7	-	1.5	-	1.0	-		
	UPM 44 M8	●	●		1.0[1]	1.0[1]	0.9[1]	1.0[1]	0.6[1]	1.0[1]	0.4[1]	0.7[1]	Z-21.3-1649 (14.06.2005) 3354/0520-5 (21.05.2001)	Aerated concrete acc. approval
	UPM 44 M10	●	●		1.0[1]	1.0[1]	0.9[1]	1.0[1]	0.6[1]	1.0[1]	0.4[1]	0.7[1]		
	UPM 44 M12	●	●		1.0[1]	1.0[1]	0.9[1]	1.0[1]	0.6[1]	1.0[1]	0.4[1]	0.7[1]		
	UPM 44 M8	●	●		1.3[2]	1.4[2]	1.0[2]	1.3[2]	0.6[2]	1.0[2]	0.4[2]	0.9[2]		
	UPM 44 M10	●	●		1.3[2]	1.4[2]	1.0[2]	1.3[2]	0.6[2]	1.0[2]	0.4[2]	0.9[2]		
	UPM 44 M12	●	●		1.3[2]	1.4[2]	1.0[2]	1.3[2]	0.6[2]	1.0[2]	0.4[2]	0.9[2]		
fischer Injection mortar FIS V	FIS V M6 K12 x 50	●	●		0.20		-		-		-		Z-21.3-1824 (03.07.2007) 3637/6346 (27.04.2007)	Masonry Hlz 12, KSL 4
	FIS V M6 K12 x 85	●	●		0.30		0.20		0.10		0.05			
	FIS V M8 K16 x 85	●	●		0.80		0.70		0.40		0.08			
	FIS V M10 K16 x 85	●	●		0.16		0.10		0.03		0.03			
	FIS V M12 K20 x 85	●	●		0.16		0.10		0.02		0.02			
	FIS V M8 K16 x 130	●	●		0.80		0.70		0.45		0.30		Z-21.3-1824 (03.07.2007) 3637/6346 (27.04.2007)	
	FIS V M10 K16 x 130	●	●		0.80		0.70		0.46		0.34			
	FIS V M12 K20 x 130	●	●		1.00		0.86		0.53		0.36			
	FIS V M12 K20 x 200	●	●		1.00[3]		1.00[3]		1.00[3]		1.00			
	FIS V M8 K20 x 85	●	●		0.10[4]		0.07[4]		0.04[4]		0.02[4]			
	FIS V M10 K20 x 85	●	●		0.12[4]		0.08[4]		0.04[4]		0.03[4]			
	FIS V M12 K20 x 85	●	●		0.12[4]		0.08[4]		0.04[4]		0.03[4]			

* Detailed information about test reports and approvals please refer to: www.fischer.de/fixing systems/products/product online catalogue ...

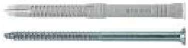
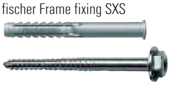
1) h_{ef} = 75 mm

2) h_{ef} = 95 mm

3) max. loads in KS and KSL up to 1.40 kN possible

4) with internal threaded socket FIS E

6.7.5 Fixings for claddings

Designation	Anchor type	Material: gvz	Material: A4	Material: C (1.4529)	Max. permissible loads in case of fire [kN]: R 30/ F 30	R 60/ F 60	R 90/ F 90	R 120/ F 120	Test report approval no. *	Application
fischer Universal frame fixing FUR 	FUR 8	●	●		–	–	0.8	–	Z-21.2-1204 (10.04.2000)	Claddings
	FUR 10	●	●		–	–	0.8	–		
					–	–				
					–	–				
fischer Frame fixing SXS 	SXS 10	●	●		–	–	0.8	–	Z-21.2-1695 (23.03.2001)	Claddings
fischer Frame fixing SXR 	SXR 10	●	●		–	–	0.8	–	Z-21.2-1862 (30.04.2009) ETA-07/0121 (30.01.2009)	Claddings

* Detailed information about test reports and approvals please refer to: www.fischer.de/fixing systems/products/product online catalogue ...

6.7.6 Fixing for tunnel applications

Designation	Anchor type	Material: gvz	Material: A4	Material: C (1.4529)	Max. permissible loads in case of fire [kN]	Test report approval no. *	Application
fischer Highbond anchor FHB II 	FHB II 8 x 60 C			●	1.0	PB III / B-06-139	cracked and non-cracked concrete
	FHB II 10 x 95 C			●	1.7		
	FHB II 12 x 120 C			●	2.8		
	FHB II 16 x 160 C			●	5.0		
	FHB II 20 x 210 C			●	7.2		
fischer Anchor bolt FAZ 	FAZ 8 C			●	1.2	PB III/B-04-289 (04.08.2003)	cracked and non-cracked concrete
	FAZ 10 C			●	2.3		
	FAZ 12 C			●	3.2		
	FAZ 16 C			●	6.2		
fischer Nail anchor FNA II 	FNA II 6 x 30 M6 A4 / C		●	●	0.1	PB III/B-07-114	multiple fixings of non-structural applications
	FNA II 6 x 30 A4 / C		●	●	0.1		
	FNA II 6 x 30 A4		●		0.1	Efectis 2006 R 0561 (90 min)	
	FNA II 6 x 30 M6 A4		●		0.1		
	FNA II 6 x 40		●		0.1		
	FNA II 6 x 40 M6		●		0.1		

* Detailed information about test reports and approvals please refer to: www.fischer.de/fixing systems/products/product online catalogue ...

6.8 References

/1/ Tunnelbrandversuch (Tunnel fire test 2001), unpublished presentation, fischer group of companies (in German)

/2/ Bergmeister K., Rieder A.,: Behaviour of post-installed anchors in case of fire. Connections between steel and concrete, Stuttgart, 12.09.2001

/3/ fischer, Technical Handbook, 4. edition 2001

/4/ DIN 4102 Teil 4, Ausgabe 1994 (in German)

/5/ Reick, M.: Brandverhalten von Befestigungen mit großem Randabstand in Beton bei zentrischer Zugbeanspruchung (Fire behaviour of fastenings with large edge distance in concrete under tensionload), Mitteilungen des Instituts für Werkstoffe im Bauwesen der Universität Stuttgart, 2001/4 (in German)

/6/ Euronorm EN 10088-3d

Corrosion

7.1 Basic principles

With the exception of noble metals such as gold, silver and platinium, all metal materials subjected to various atmospheric conditions react with oxygen. As a result of this reaction two phenomena occur.

1. The products of this reaction form an initial oxydized layer on the surface preventing further corrosion. Thus forming a passivated layer protecting the material from further negative influencees. Due to this mechanism metals with a less noble characteristic are very quickly oxydized through contact with the air and therefore have a very good long term durability. Typical examples are aluminium, chromium and titanium.

2. The products of this reaction are porous and do not form a protective layer against oxygen, water or carbon dioxide. This results in a continuing corrosion process which leads to complete break down of the material. An example of this mechanism is rust due to corrosion of iron in the air.

Metals referring to 1. do not require additional corrosion protection. Carbon steels as described in 2. require additional protection against atmospheric attack in order to sustain their long term performance.

7.2 Types of corrosion

I. Surface corrosion

The material's surface is continually in contact with the corrosive medium and corrodes at a constant rate. The rate of corrosion can be estimated over a certain duration of time and therefore can be considered in the overall life expectancy of the material. The best kown example of this type of corrosion is zinc and air.

II. Load corrosion - pitting and crevice corrosion

Pitting occurs when the surface passivation (e. g. aluminium or stainless steel) is damaged. In the region of the initial attack very aggressive zones are formed from which further damage of the material occurs. Also as in the above example when cracks or deposits are found localized electrolytes lead to very extreme corrosion.

III. Bimetallic corrosion

Bimetallic corrosion may occur when the dissimilar metals (Table 7.1) are in electrical contact in a common electrolyte (e. g. rain, condensation etc.). If a current flows between the two, the less noble metal (the anode) corrodes at a faster rate than would have occured if the metals were not in contact.

Alternativelly nobler metals can be protected from corrosion by connecting them electrically conductive to a less noble metal (typical examples are aluminium anodes for steel parts).

IV. Stress corrosion cracking

With stress corrosion cracking the agressive medium is insufficient for the products of corrosion to occur. A simultaneous presence of tensile stresses and specific environmental factors are required for this process to occur. The stresses can be due to external or internal imposed loading. Stress corrosion cracking is extremely dangerous as visible indication is not possible and therefore can lead to a spontaneous failure. A common form of this type of corrosion is where austenitic stainless steel is found in chlorine contaminated atmospheres such as indoor swimming pools.

Table 7.1 Potential (in [V]) of various metals

Aluminium	Titanium	Zinc	Chromium	Iron	Tin	Copper	Silver	Gold
-1.66	-0.95	-0.76	-0.74	-0.41	-0.14	+0.34	+0.80	+1.50

7.3 Corrosion protection

Two basic measures are available for the protection of materials which may be subjected to corrosion.

1. With suitable surface treatments of the material an attack of the corrosive medium is prevented. Examples of corrosion protections of steel are coatings and zinc plating or hot-dip galvanising. These methods are examples of economical protective coatings. The long term protection can only be achieved so long as no surface damage occurs.

2. Choosing materials that prevent the onset of corrosion is more effective than additional protective coatings. A popular measure is to add chromium or molybdenium. These additional materials insure long term performance even in severe conditions.

Subject to the installation environment steel anchors may be protected from corrosion by various means. fischer uses two standard protective coatings and further corrosion prohibitive materials which are sufficient for different applications. Should other national regulations exist in your country these must be taken into consideration as well.

I. Zinc plating

Due to the atmospheric conditions zinc forms a dense layer on the surface which provides further protection. In the electro-potential table (compare Table 7.1) zinc is found to have a considerably higher negative potential than iron i. e. zinc is the lesser noble of the two materials. These two phenomena make zinc an ideal corrosion protection partner for iron (technical: steel). This dense coating prevents the direct contact of the corrosive medium on steel. The lesser noble character of zinc offers a so-called cathodic protection with a self „healing“ effect. Sufficient corrosion protection is achieved even with small areas of damage of the coating.

a) Galvanised zinc plating

Galvanising is carried out by an electro-chemical process where a thin zinc layer is attached to the steel component. By controlling certain reaction parameters (e. g. pH-Value, temperature, concentration...) a definite characteristic in particular the coating thickness is possible. The type of passivation dictates the long term stability of the total coating. The darker the colour the better the protection.

fischer products have a minimum zinc plating 5 µm and yellow or blue passivation. This provides sufficient protection for transportation even in unfavourable conditions, also for long term protection for internal applications.

b) Hot-dip galvanising

Electro-chemical galvanising produces thicknesses of maximum 15 to 20 µm. For greater thicknesses where higher corrosion protection is required, further processes should be considered.

Generally to provide greater coating thickness (up to 80 µm, in certain cases more) the steel componets are dipped into liquid zinc (melting point 420 °C). Further treatments are not required and therefore the product may be used for the application. In certain cases due to capilliary action, zinc is collected in areas such as threads <10 mm which may influence the functioning of the anchor. For these situations mechanical zinc plating (e. g. sheradizing, Mc-Dermid-method) is used. Using this process provides similar coating thickness and thus similar protection as hot-dip galvanising. Negative collection of zinc by using this process is avoided. Hot-dip galvanised products can be used for external applications with reduced corrosion requirements. This provides an economical alternative to stainless steels.

All fischer products with hot-dip galvanising have a minimum coating thickness of 40 µm.

II. Corrosion resistant steels

a) Austenetic stainless steels
As long term corrosion-free material the construction industry uses a stainless steel grade 316 (A4) such as the material number 1.4401 or 1.4571 and 1.4404 (Table 7.2 und 7.3 /1/) offering optimum corrosion protection for general environmental conditons and also industrial atmospheres.

fischer standard products in stainless steel are available in the material number 1.4401 (grade 316, classification A4, DIN EN 10 088). Further stainless steels are available on request, e. g. material number 1.4571 and 1.4404.

b) Austenetic and ferritic steel
Another alternative material to the standard A4 is the Duplex-steel 1.4362. Due to the ferritic part in the material this "A4" steel is magnetic but with the same or better properties than the so far used steel types 1.4401 and 1.4571. The material is also integrated in the approvals (by DIN EN 10 088).

The materials described above are not suitable for chlorine contaminated atmospheres or off-store applications.

c) Special alloying metals

Should austenetic standard stainless steels not provide sufficient corrosion protection, special materials may be considered. Examples of where the previously described A4 stainless steels are unsuitable are chlorine contaminated atmospheres, traffic tunnels, power stations or water works. For applications such as these the fischer Technical services department can provide specific details for special applications. Examples are solutions for fixings in indoor swimming pools (chlorine contaminated atmosphere), using the following material numbers 1.4529 or 1.4565 or titanium anchors for power stations.

Table 7.2:
Steel grade according to corrosion resistance classes

Steel grade			Structure	Corrosion resistance class[2)]
No.	Short name	Material number		
1	X2CrNi12	1.4003	F	I - light
2	X6Cr17	1.4016	F	I - light
3	X5CrNi18-10	1.4301	A	II - moderate
4	X2CrNi18-9	1.4307	A	II - moderate
5	X3CrNiCu18-9-4	1.4567	A	II - moderate
6	X6CrNiTi18-10	1.4541	A	II - moderate
7	X2CrNiN18-7	1.4318	A	II - moderate
8	X5CrNiMo17-12-2	1.4401	A	III - medium
9	X2CrNiMo17-12-2	1.0040	A	III - medium
10	X3CrNiCuMo17-11-3-2	1.4578	A	III - medium
11	X6CrNiMoTi17-12-2	1.4571	A	III - medium
12	X2CrNiMoN17-13-5	1.4439	A	III - medium
13	X2CrNiN23-4	1.4362	FA	III - medium
14	X2NiCrMoCu22-5-3	1.4462	Fa	IV - strong
15	X1NiCrMoCu25-20-5	1.4539	A	IV - strong
16	X2CrNiMnMoNbN25-18-5	1.4565	A	IV - strong
17	X1NiCrMoCuN25-20-7	1.4529	A	IV - strong
18	X1CrNiMoCuN20-18-6	1.4547	A	IV - strong

1) F = ferritic
A = austenitic
FA = ferritic-austenitic (Duplex)

2) see table 7.3

Corrosion

Table 7.3:
Material selection at atmospheric exposure

Influence	Exposure		Criteria and examples	Corrosion resistance class			
				I	II	III	IV
Humidity, annual average value U of humidity	SF0	Dry	U < 60%	X			
	SF1	Rarely humid	60% ≤ U < 80%	X			
	SF2	Frequently humid	80% ≤ U < 95%	X			
	SF3	Permanent wet	95% < U		X		
Chloride content, distance M from sea, distance S from busy streets with use of de-icing salt	SC0	Low	Rural, urban M > 10 km U > 0,1 km	X			
	SC1	Medium	Industrial area 10 km ≥ M > 1 km 0,1 km ≥ S > 0,01 km		X		
	SC2	High	M ≤ 1 km S ≤ 0,01 km			X[1)]	
	SC3	Very high	Indoor swimming pools, street tunnels				X[2)]
Exposure with redox-active substances (e.g. SO2, HOCl; Cl2, H2O2)	SR0	Low	Rural, urban	X			
	SR1	Medium	Industrial area			X[1)]	
	SR2	High	Indoor swimming pools, street tunnels				X[2)]
pH-value at surface	SH0	Alkaline	9 < pH	X			
	SH1	Neutral	5 < pH ≤ 9	X			
	SH2	Lightly acidic	3 < pH ≤ 5		X		
	SH3	Acidic	pH ≤ 3			X	
Position of constructional element	SL0	Internal	Heated or unheated internal space	X			
	SL1	External, exposure to rain	Free standing constructions		X[3)]		
	SL2	External, roofed	Roofed constructions		X[3)]		
	SL3	External, inaccessible[4)], ambient air has access	Ventilated facades			X	

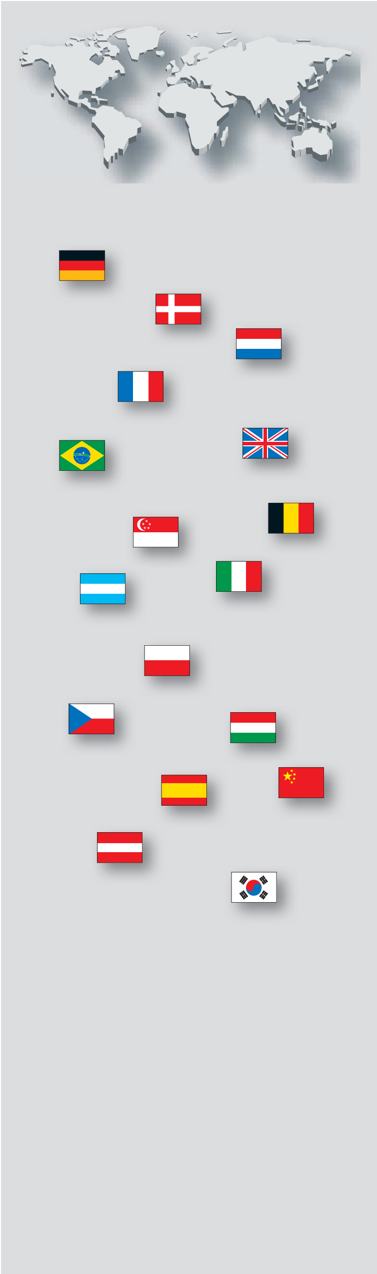
The influence which results in the highest corrosion resistance class, is decisive.
Combinations of different influences do not result in higher requirements

1) The corrosion exposure could be reduced considerably by means of regular cleaning of **accessible** constructions or exposed to rain. This leads to a reduction by one corrosion resistance class. With possible higher concentration of the substances on surfaces, a higher class must be chosen.
2) The corrosion exposure could be reduced considerably by means of regular cleaning of **accessible** constructions. This leads to a reduction by one corrosion resistance class.
3) If the life span is limited to 20 years, and if pitting corrosion up to 100 μm is tolerable (no aesthetic requirements), a reduction down to corrosion resistance class I is possible.
4) **Inaccessible** are constructions, whose condition can not, or only under complicated conditions, be controlled and if necessary can be rehabilitated only with extraordinary investments.

References

/1/ German Approval Z-30.3-6 for corrosion resistant steel.

Notes



Service / Contact

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International Technical Service (Support)

This Technical Manual gives you an insight into fixing engineering in general, and into the special products of fischerwerke in detail. The Technical Data will show you the efficiency of the products when properly selected and used under the defined parameters and ambient conditions.

Besides COMPUFIX design software, fischerwerke also offers you their world-wide application services. 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 at the headquaters in Germany.

We also offer training seminars which, suited to your individual needs and requirements, are designed to back your confidence in fischer products.

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CC-COMPUFIX
Design Software for anchors

- For design of steel and nylon anchors based on the CC-Method according to the fischer Specification or in accordance with European Technical Approvals
- Design of chemical anchors with variable embedment depth in accordance with the Technical Report TR 029
- For predominantly static and dynamic loads (pulsating and alternating)
- Considers single anchors and groups of two to eight anchors
- Allows the design of asymmetrical connections
- Permits bending of the anchors
- Covers design of anchors made of zinc plated and passivated steel, stainless steel of the corrosion resistance class III, e.g. A4 and highly corrosion-resistant steel of the corrosion resistance class IV. e.g. 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
- Offers the unique function “REMOTE-FIX®” which allows to exchange information via Internet such as up/download of projects, screenshots, text and comparison of applications

System requirements:

- IBM compatible PC, recommended: Pentium processor
- RAM: min 512 MB
- Graphic card: True colour (24/32 Bit)
- Minimum screen size: 1024 x 768 pixel
- CD-Rom drive
- Operating system: Windows 2000®, Windows XP® (32Bit/62Bit), Windows Vista® (32Bit/64Bit) and Windows 7®

SaMontec
Installationsystems

Pipe support system for the installation and mounting of pipes in commercial, industrial and residential buildings

Channels

Installationgrid

Pipe clamps

fischer Installation Grid System – Flexible installation choices for positioning machinery and equipment

- By using the fischer SaMontec Grid, a separate installation level can be constructed above the work space
- Fast installation, low assembly costs
- Highly flexible choices and options for changing machine layout
- User friendly media
- New viewing facility to aid optical designs
- Designed to support future alternations to the existing grid system
- Design, planning and creation is supported by qualified engineers from the technical sales support department

fischer SaMontec 3.0 design software

- Calculations for the complete installation of pipe work systems
- Accurate dimension calculations for different applications
- Technical installation dimensions for the fischer SaMontec system (pipe clamps, channels etc.)
- All the entered data is processed using the actual values

- Continuous background calculations are permanently carried out to ensure overall accuracy
- An individual project directory available
- Live internet access facility to update current programme
- Multi-language facility to calculate in one language and print in another

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 as well as 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 natural stone facade 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.

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 machines.

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