fischer

Installation Manual.

C-Fiber Force Strengthening System:
Carbon Fiber Spike Anchor FRS-FC.

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Safety Instructions
Please read the Safety Data Sheets (SDS) and Technical Data Sheets (TDS) before using the products! When working with chemical products, use suitable protective clothing, protective gloves and safety glasses. IMPORTANT: Please follow the application instructions, which are included in every package.

 These application instructions were created with care. However, fischerwerke GmbH & Co.KG does not take over any liability for any errors in these application instructions and their consequences. There is also no liability for direct or consequential damage taken from incorrect use of the products.

Performance of construction materials (Epoxy resins) vary with external conditions (e.g. project site conditions such as temperature or humidity).

The suitability of the strengthening kit must be checked and confirmed by the responsible planer. All product names and brand names used belong to the owner, even if not explicitly marked as such. The content is subject to changes.

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Content

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1 Introduction

This installation manual describes the installation of the fischer FRS-FC Carbon Fiber Spike Anchor for the end anchorage of FRS-W Carbon Fiber Fabric (CF Fabric). This document must be used or referred to in conjunction with all relevant Technical Data Sheets (TDS), Safety Data Sheets (SDS), Technical Assessments and project specifications. Structural strengthening works shall only be carried out by experienced and trained specialists. For professional product trainings and in case of any questions about our design software REINFORCE-FIX©, please consult the technical team of the national fischer subsidiaries. Note that the inadequate choice on the strengthening or retrofitting method, incorrect structural design, inadequate installation might cause significant risks.

2 System description

2.1 Intended use

The primary intended use of the fischer C-Fiber Force Strengthening System with CF fabric in combination with spike anchors is the strengthening of reinforced concrete or prestressed concrete structures. Various installation scenarios and spike anchor arrangements are possible. The FRS-FC Carbon Fiber Spike Anchor can be used as end anchorage of FRS-W CF Fabric used for shear strengthening or flexural strengthening. Furthermore, anchorage of FRS-W CF Fabric in confinement of rectangular columns with high aspect ratios or even confinement of columns with wall joints can be realized. The fischer C-Fiber Force Strengthening System was developed for safety relevant applications. The design and application of CF fabric on base materials such as timber or masonry require additional engineering judgement.

The manufacturer strongly recommends the use of the fischer C-Fiber Force Strengthening System as a whole. Combined applications with products from other manufacturers are out of the responsibility range of the fischer group.

2.2 References

This installation manual was written in accordance with the recommendations of fib Bulletin 90 – Externally applied FRP reinforcement for concrete structures and based on best practice.

2.3 Restrictions

This product shall only be used for its intended purpose. Further design details or design information are to be found in the structural design, technical drawings, specifications and risk assessments of the corresponding design engineer or specialist contractor.

3 fischer C-Fiber Force Strengthening System

The primary intended application scope of the fischer C-Fiber Force Strengthening System is to strengthen reinforced or prestressed concrete members. The FRS-W U300, FRS-W U600 CF Fabric and FRS-FC Spike Anchors are system components of the fischer C-Fiber Force Strengthening System.

Table 1: Constituents of the fischer C-Fiber Force Strengthening System with corresponding short product descriptions

Product name	Description
FRS-L-S & FRS-L-H FRS-L-S NSM	Pultruded, precured carbon fiber reinforced polymer (CFRP) Laminates for the structural strengthening
FRS-CS	Thixotropic, 2-component epoxy mortar for the installation of CFRP Laminates and steel plates
FRS-W U300 FRS-W U600	Unidirectional Carbon Fiber (CF) Fabric with 300 g/m^2 or 600 g/m^2 area density
FRS-FC	Unidirectional CF filament high-strength carbon-fiber anchor for optimal end anchorage of FRS-W CF Fabric
FRS-CF	Thixotropic, 2-component epoxy-based saturating resin for the application of FRS-W and FRS-FC
FRS-PC 11	Thixotropic, high-viscosity, low-shrinkage, 3-component epoxy-based concrete repair mortar for reprofiling, surface levelling and for increasing or restoring concrete cover
FRS-BA	2-component, epoxy-based, solvent-free high performance bonding agent for optimal adhesion between different concrete repair mortars and existing concrete as well as corrosion protection for embedded steel reinforcing bars
FRS-CP red FRS-CP grey	Low viscosity, 2-component, epoxy-based corrosion protection primer for exposed steel surfaces as well as embedded steel rebars in two colour versions, red and grey
FRS-SF	Highly UV resistant and water repellant, waterborne protective coating with high durability against environmental exposure for CFRP reinforcement in outdoor applications
FRS-FP	Waterborne, intumescent coating for CFRP strengthening systems against fire and smoke development
FRS-CA	Universal cleaning agent for the FRS-L-S and FRS-L-H CFRP Laminate and tools

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4 Storage conditions

The materials shall be stored in closed and undamaged original packaging in a dry environment at ambient temperature. Please note the minimum and maximum storage temperature and the shelf life in the corresponding product data sheets (TDS) and product labels.

The FRS-FC shall only be transported in the original packaging or with other adequate protection against mechanical and chemical damage.

5 Recommended equipment

5.1 Equipment, devices, tools and accessories

For the adequate installation of the fischer FRS-FC Carbon Fiber Spike Anchor, it is recommended to have the following equipment on site for proper installation:

- Thermometer for air and surface temperatures
- Handheld agitator suitable for mixing the chemical products, with a rotation speed (≤ 300 rpm)
- Application equipment (painting roller, spatula, cleaning cloth, etc.)
- Ruler and visible marker
- Wet film thickness gauge
- Rotary hammer drill and drill bit (14 or 16 mm diameter, for FRS-FC 10 and FRS-FC 12, respectively)
- Caliper (for drillhole depth measurement)
- Compressed air wand
- Router bit
- Router
- Brushes for hole cleaning (based on the installation instructions of the used injection system)
- Mortar dispenser (based on the installation instructions of the used injection system)
- Vacuum cleaner
- FRS-CA Cleaning Agent or acetone

5.2 Cleaning of tools and accessories

All tools and processing accessories must be cleaned immediately after use with FRS-CA Cleaning Agent or another suitable solvent. Cured materials can only be removed mechanically.

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6 Health and safety

6.1 Risk assessment

All health and safety risks must be assessed and adequate countermeasures shall be defined. This includes the very condition of the structure and the resulting risks thereof, the processing of all materials used on site as well as working methods.

All work and working procedures must be carried out in full compliance with the relevant local safety and environmental regulations in force on site.

6.2 Personal safety

During the installation, safety shoes, safety gloves and other suitable skin protection must always be worn. It is strongly recommended to use adequate disposable safety equipment during the processing and application of the materials. Since epoxy adhesives or impregnating resins can cause skin irritation, always wear protective gloves e.g. nitrile-based hand gloves when working with them. Unprotected skin must always be covered with protective cream before starting work.

Always wear suitable eye protection during processing, mixing and installation of the products. It is recommended to carry eye wash with you at all times. Always wash hands with suitable soap and clean water after processing the materials.

The work area must be well ventilated and workers should take regular breaks in the fresh air, to avoid health problems. The developing dust and quartz sand during drilling, grinding or sandblasting the concrete can be hazardous. Avoid the inhalation of concrete of CFRP dust. To protect yourself and others, use e.g. vacuum cleaner or other adequate suction techniques. Always wear a dust mask or respirator when grinding concrete or cutting the CFRP Laminate. For detailed health and safety information, see the relevant Safety Data Sheets (SDS).

6.3 First aid

If the epoxy mortar-based chemicals come into contact with the eyes or mucous membranes, the contact lenses must be removed and the eyes must be rinsed immediately with clean, warm water for 10–15 min. and a medical doctor should be consulted

If chemicals come into contact with the skin, it must be cleaned immediately and carefully rinsed with clean warm water.

In case an accident happens, despite all the preventive measures, the corresponding Safety Data Sheet must be immediately handed over to the emergency services. This helps the emergency services to select the appropriate medical treatment(s). For detailed health and safety information, refer to the relevant Safety Data Sheet of the individual products.

6.4 Waste disposal

Excess materials must not be poured down in drains or into water supplies. Waste and packaging must be disposed by specialized waste management companies or partners in accordance with local legislation and official requirements. Furthermore, chemical materials must not be allowed to enter the soil, watercourses, drains or sewers. Chemical waste in uncured form or leaking adhesive must be disposed as hazardous waste.

Waste in the form of cured adhesive can be safely disposed off as normal construction waste in accordance with local legislation. For detailed environmental and safety information, refer to the relevant Safety Data Sheet (SDS).

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7 Products for installation at a glance

Product name	Description
FIS EM Plus	Recommended epoxy injection system to install the precured part of the FRS-FC Carbon Fiber Spike Anchor in the concrete substrate
FRS-CF	Primer for the substrate, saturating and adhering of the CF filaments of FRS-FC as well as FRS-W U300 and FRS-W U600 CF Fabric
FRS-FC 10 170/280	Carbon Fiber Spike Anchor Diameter: 10 mm Total length: 450 mm Length of precured part: 170 mm Length of CF filaments: 280 mm
FRS-FC 12 170/280	Carbon Fiber Spike Anchor Diameter: 12 mm Total length: 450 mm Length of precured part: 170 mm Length of CF filaments: 280 mm

8 Installation steps

8.1 Preparation works, substrate and environmental conditions

Requirements and preparation

Environmental conditions

- Verify the permitted temperature range of the member with a thermometer.
- Verify that the chemicals are stored at the permitted storage temperature before use.

- Underground temperature of the member to be strengthened should be higher than +10 °C and at least 3 K above dew point during and after application throughout the curing time.
- The maximum temperature should not exceed 40 °C and the relative humidity should be below 75 %. Check the humidity with an adequate humidity measurement device.

8.2 General instructions on the installation of the FRS-FC

The intended use of the Carbon Fiber Spike Anchor FRS-FC is to enhance the adhesion between the Carbon Fiber Fabric FRS-CF and the concrete surface. In the different layouts and installations arrangements in the practice, the beneficial effect of FRS-FC on the anchorage of CF-Fabric has been proven and can be taken into account in the design.

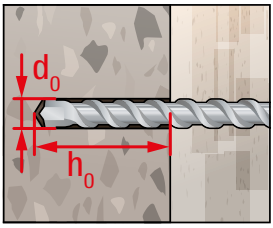
The precured part of the Carbon Fiber Spike Anchor FRS-FC is to be installed as a bonded anchor system into a properly prepared concrete drillhole. For the installation a suitable injection system should be used, e.g. FIS EM Plus. The loose part of the carbon fiber spike carbon filaments should be presaturated by using the Saturating Resin FRS-CF. During the installation process, the pot life of the used chemicals FRS-CF and FIS EM Plus should be taken into account.

The installation process starts with the drillhole preparation (drilling & cleaning). After the preparation works, the injection mortar is injected into the drillhole using the a mortar dispenser. In the final installation step, the loose carbon fiber filaments of FRS-FC are submerged into the FRS-CF Saturating Resin and saturated completely with a brush or manually. The impregnated spike anchot is then inserted into the drillhole, which was previously drilled, cleaned and injected with FIS EM Plus. The presaturated loose carbon fiber filaments are finally spread over the surface using a roller in the desired arrangement depending on the application, e.g. fan shape or circular shape.

8.3 Drillhole preparation

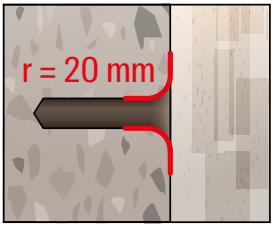
The FRS-FC Spike Anchor shall be installed into the concrete substrate with its precured end, for which the drillhole should be prepared according to the MPII of the chosen injection system. In the following, the drillhole preparation is shown based on the MPII of our FIS EM Plus injection system.

Drillhole preparation



Drillholes with a diameter d = 14 mm for FRS-FC 10 and d = 16 mm for FRS-FC 12 should be drilled into the concrete member. The drillhole depth should be in the range of $h_{0,min}$ = 190 mm and $h_{0,max}$ = 210 mm.

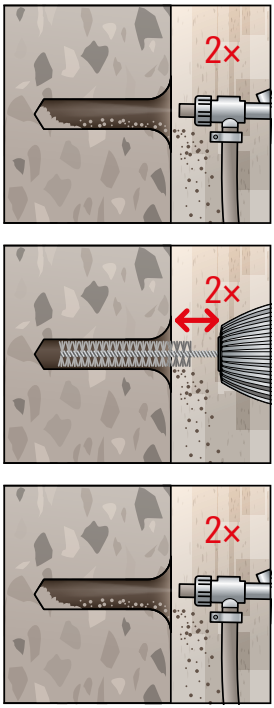
The angle of the drillhole depends on the method of application and should be defined by an experienced engineer in the design drawings since the embedment angle will affect the maximum capacity and failure mode.



The edges of the drillhole should be rounded to a radius of at least 20 mm with a handheld router, countersink or a router bit to avoid damage of the fibers under load.

Instead of a router, a router bit attached to a conventional drilling machine can also be used to round the corners.

Make sure the corners are smooth prior to continuing installation works. Sharp corners can damage the CF filaments.

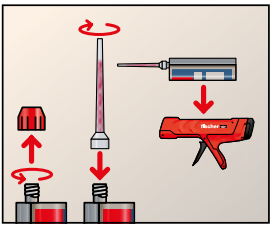


The drillhole should be properly cleaned with compressed air > 6 bar twice, followed by cleaning twice with a steel brush with a diameter preferably 2 mm larger than the diameter of the drillhole and subsequently twice again with compressed air. The drillhole must be free of dust and loose particles.

8.4 Preparation of FIS EM Plus

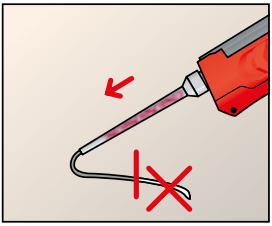
It's important to prepare FIS EM Plus after drillhole preparation and impregnation of the concrete surface. It's necessary to be within the pot life of FIS EM Plus between the extruding of material and the injection into the drillhole.

Preparation of FIS EM Plus



Open the cartridge of injection mortar FIS EM Plus. Screw the mixing nozzle onto the cartridge.

Place the cartridge into the dispenser.

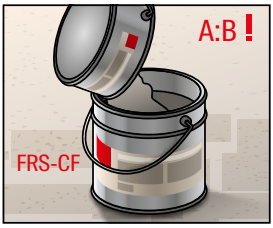


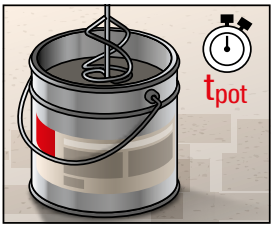
Extrude approximately 10 cm of material until the epoxy mortar is evenly grey in color. Don't use epoxy mortar that isn't uniformly grey.

8.5 Preparation of FRS-CF

It's necessary to be within the pot life of FRS-CF between the mixing and the saturation of the CF filaments of the FRS-FC Carbon Fiber Spike Anchor.

Preparation of saturating resin FRS-CF





The FRS-CF Satirating Resin must be prepared by following the processing steps in accordance with the Technical Data Sheet (TDS) of FRS-CF. Note the required mixing ratio, pot life, storage temperature and the proper mixing procedure.

Special care should be taken on work safety while working with FRS-CF.

If phase separation is observed after opening the can components, the individual can components should be homogenized by stirring them separately, before mixing them. This is especially recommended when partial quantities are taken.

Add component B to component A and mix with a handheld agitator for 3 minutes with 300 rpm without air bubbles until a homogeneous and uniform grey tone is achieved.

If partial quantities are taken, please pay attention on the correct mixing ratio by weight of component A and component B (3:1). Using weighing scale is recommended to adhere to the mixing ratio.

The intended use of FRS-CF is within a temperature range from 10 °C to 40 °C.

The pot life (working time) is min. 60 minutes at 23 °C and depends on environment temperature. Precooled material and smaller quantities can help to prolong the pot life.

8.6 Carbon Fiber Spike Anchors for Anchorage of CF Fabric

Single Open-End CFRP (Carbon Fiber Reinforced Polymer) Connectors are widely used for anchoring CF fabric in a variety of structural strengthening applications. In principle, the same anchorage concept applies across all applications: the precured end of the connector is bonded into the concrete substrate, while the loose filaments are bonded to the CF fabric.

Among the various configurations available, the most common applications are listed below:

- Spike anchors may be applied at the end of CF fabric either on or in between or below layers of CF fabric for end anchorage of the fabric in shear or flexural strengthening with splay angles between 30° and 60°. Typical inclination angles are between 15° and 90°.
- Spike anchors may be applied in concave sections of elements strengthened with CF fabric either on or in between or below layers of CF fabric to allow for intermediate anchorage to the substrate. Splay angles of 360° and inclination angles of 90° are typical.
- Spike anchors may be applied in half distance of the long side of rectangular columns with large diameter or high aspect ratio to improve the confinement of the section by intermediate anchorage of the CF fabric. Splay angles of 360° and inclination angles of 90° are typical.

Piercing the fabric to allow for application on or in between layers of fabric is common, but care should be taken not to cause undulations or weaken the CF fabric unnecessarily.

The anchorage layout is responsibility of a structural engineer and requires expert judgement.

The following guidelines may provide guidance in designing and calculating FRP strengthening with FRS-FC Carbon Fiber Spike Anchors:

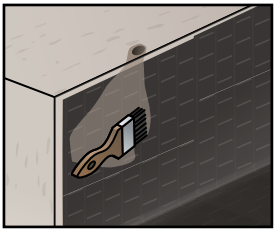
1. fib Bulletin 90 Chapters 9.2.1.1, 9.2.1.2, 9.2.2.1 and 9.2.2.2.
2. ACI 440.2-23 Chapters 14.1.4 and 16.6.
3. CNR 200-DT R2/2025 Chapters 4.1.5, 4.3.1, 4.3.2, 4.9.2.2, 14.1.4, 14.3.2.

The following installation steps shows a representative application for end anchorage of CF fabric for shear strengthening of a t-beam.

8.7 FRS-FC Spike Anchor as parallel connector for end anchorage of CF Fabric for shear strengthening

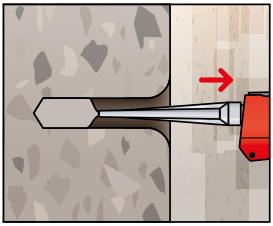
The FRS-FC Carbon Fiber Spike Anchor can also be applied as anchorage for FRS-W CF Fabric as a parallel connector with the CF filaments spread in a V-shape below, between or on top of FRS-W CF Fabric layers.

Anchor installation

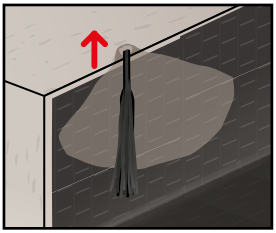


It is recommended to apply the FRS-FC Carbon Fiber Spike Anchors wet-in-wet on the CF fabric. Apply a layer of around 500 - 750 g/m2 of FRS-CF Saturating Reson to the layer of FRS-W CF fabric if not already done as topcoat during application of the CF fabric. If the CF filaments are to be applied on cured FRS-W CF fabric, lightly sand the surface and clean it with FRS-CA Cleaning Agent or acetone to improve adhesion.

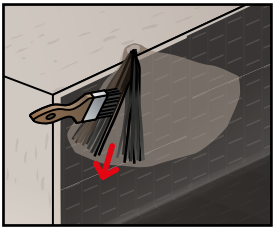
Manually separate and saturate the loose CF filaments of the FRS-FC until complete wetting of the filaments is achieved.



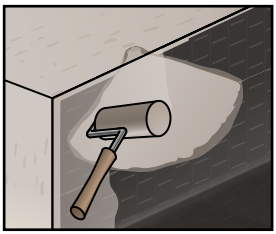
Use FIS EM Plus to bond the precured section of the FRS-FC Carbon Fiber Spike Anchor into the concrete. Fill the cleaned drillhole with FIS EM Plus, starting from the bottom of the hole up to an extend of around ⅔ of the drillhole. Make sure there are no air inclusions.

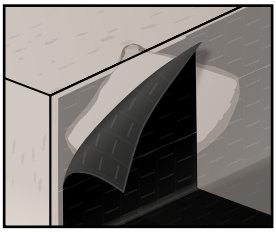


Keep the FRS-FC Carbon Fiber Spike Anchor clean until the moment of application. Insert the spike anchor into the drillhole, turning it while doing so. FIS EM Plus should be extruded from the annular gap or the drillhole.



Spread the saturated CF filaments on the substrate at the desired angle evenly. Take care to work in direction of the fibers and align them linearly until the fibers are spread evenly and the filaments are straight without undulations.





Further layers or a transverse sheet of FRS-W CF Fabric (in accordance with ACI 440.2-23 Chapter 14) may be applied over the FRS-FC Carbon Fiber Spike Anchor. If this is the case apply at least 750 g/m² of FRS-CF Saturating Resin over the impregnated and aligned filaments before adding the next layer of CF fabric according to the installation manual "Installation Manual C-Fiber Force Strengthening System with externally bonded CF Fabrics" and follow the conventional application procedure.

Further layers of CF fabric must be applied within the pot life of the FRS-CF Saturating Resin. If the CF fabric is applied after exceeding the pot life, let the FRS-CF cure for 24 h, sand and clean the surface with FRS-CA Cleaning Agent prior to the application of the next layer of CF fabric.

Inspection and quality control after the installation

Please conduct the typical quality control as described in the FRS-W installation manual "Installation Manual C-Fiber Force Strengthening System with externally bonded CF Fabrics" if the FRS-FC was installed as anchorage for FRS-W Laminates as usual without any major changes.

The concept of the quality inspection plan of the strengthened structure or structural member is the duty of the responsible structural engineer, following the national and international regulations.

8.7 Installation of the FRS-FC on masonry and timber

In addition to reinforced concrete, the fischer FRS-FC Carbon Fiber Spike Anchor can also be used for timber and masonry applications. Ensure that the masonry structure is suitable for the installation of the fischer FRS-FC Carbon Fiber Spike Anchor. The system can be installed on moderately cracked surface, whereas crumbling bricks and poor substrate quality will compromise the quality and effectiveness of the strengthening system. The responsible specialist engineer must carry out the necessary inspection and calculations, and conduct pull-off tests on site as needed to verify the assumptions met during the structural design. Your national fischer subsidiary provides you with consultancy if required. For installation, remove dust completely with oil-free compressed air or vacuum and remove loose masonry parts.

9 Legal notes

The above information, in particular the suggestions for processing and use of our products, are based on our knowledge and experience under normal conditions, provided the products have been stored and used properly. Due to the different materials, substrates and deviating working conditions, a guarantee of a work result or liability, from whatever legal relationship, can neither be justified from these instructions nor from verbal advice, unless we are charged with intent or gross negligence in this respect. In this context, the user must prove that he has in writing all knowledge required for a proper and reasonable assessment by fischer, has been communicated to fischer thoroughly and on time. The user must test the products regarding their suitability for the intended use.

The product specifications are subject to change without notice. Third party property rights must be observed. In all other respects, our respective terms and conditions of sale and delivery apply. Always the latest product data sheet (TDS) applies, which should be requested from us.

10 References

[1] fib Bulletin 90 “Externally applied FRP reinforcement for concrete structures”, fib Task Group 5.1, International Federation for Structural Concrete, Lausanne, Switzerland, **2019**.

[2] ACI PRC-440.2-23 "Design and Construction of Externally Bonded FRP Systems for Strengthening Concrete Structures”, ACI Committee 440, American Concrete Institute, Farmington Hills, United States of America, **2023**.

[3] DAfStb-Guideline “Strengthening of concrete members with adhesively bonded reinforcement”, W. Finckh, A. Ignatiadis, R. Niedermeier, U. Wiens, K. Zilch, Deutscher Ausschuss für Stahlbeton e. V. – DAfStb, Berlin, Germany, **2012**.

[4] ESR report 4774 according to AC125 Acceptance Criteria for Concrete and Reinforced and Unreinforced Masonry Strengthening using Externally Bonded Fiber-Reinforced Polymer (FRP) Composite Systems, ICC Evaluation Service, Brea, United States of America, **2024**.

[5] ACI PRC-546-14 “Guide to Concrete Repair”, ACI Committee 546, American Concrete Institute, Farmington Hills, United States of America, **2014**.

[6] ICRI 310.2R-2013 “Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, Polymer Overlays, and Concrete Repair”, International Concrete Repair Institute, Inc., Minnesota, United States of America, **2013**.

[7] ACI 224.1R-07 “Causes, Evaluation, and Repair of Cracks in Concrete Structures”, ACI Committee 224, American Concrete Institute, Farmington Hills, United States of America, **2007**.

[8] EN 1504-9:2008 “Products and systems for the protection and repair of concrete structures – Definitions, requirements, quality control and evaluation of conformity – Part 9: General principles for the use of products and systems”, European Committee for Standardization, Brussels, Belgium, **2008**.

[9] EN 206:2013+A2:2021 „Concrete – Specification, performance, production and conformity“, European Committee for Standardization, Brussels, Belgium, **2013**.

[10] DIN 1045-1:2023-08 “Concrete Structures – Part 1: Planning and design”, Deutsches Institut für Normung e. V., Berlin, Germany, **2023**.

[11] EN 14487-1:2022 “Sprayed concrete - Part 1: Definitions, specifications and conformity, European Committee for Standardization”, Brussels, Belgium, **2022**.

[12] DIN 18551:2014-08 “Sprayed concrete - National application rules for series DIN EN 14487 and rules for design of sprayed concrete constructions”, Deutsches Institut für Normung e. V., Berlin, Germany, **2014**.

[13] "Externally applied FRP reinforcement for concrete structures", Federation internationale du beton (fib), Stuttgart, Germany, **2019**.

[14] CNR-DT 200 R2/2025 "Guidelines for the Design, Execution, and Inspection of Structural Strengthening Interventions Using Fiber-Reinforced Composites" Consiglio Nazionale delle Ricerche (CNR), Roma, Italia, **2025**.

fischer stands for

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