PRESTATIEVERKLARING

DoP-BS-020

voor fischer C-Fiber Force Strengthening System NL

1. Unieke identificatiecode van het producttype: **DoP-BS-020**

2. Beoogd(e) gebruik(en): **Kits voor de versterking van betonelementen met extern verlijmde en in sleuven verlijmde CFRP-lamellen Zie bijlage, met name de bijlagen B1-B6.**

3. Fabrikant: **fischerwerke GmbH & Co. KG, Klaus-Fischer-Str. 1, 72178 Waldachtal, Duitsland**

4. Gemachtigde: **–**

5. Het systeem of de systemen voor de beoordeling en verificatie van de prestatiebestendigheid **1+**

6. Europees beoordelingsdocument: **EAD 160086-01-0301**
   Europese technische beoordeling: **ETA-24/0281; 2024-12-06**
   Technische beoordelingsinstantie: **DIBt- Deutsches Institut für Bautechnik**
   Aangemelde instantie(s): **2837, TU Darmstadt**

7. Aangegeven prestatie(s):

Mechanische weerstand en stabiliteit (BWR 1)

1) Glasovergangstemperatuur van het structurele lijmmiddel: zie bijlage, met name bijlage C2
2) Glasovergangstemperatuur van de reparatiemortel: zie bijlage, met name bijlage C4
3) buig- en druksterkte van het structurele hechtmiddel: zie bijlage, met name de bijlagen C5-C6
4) Buig- en druksterkte van de reparatiemortel: zie bijlage, met name de bijlagen C7-C8
5) Buig- en druksterkte van het structurele hechtmiddel, uitgehard bij de minimale installatietemperatuur afhankelijk van de uithardingstijd: zie bijlage, met name de bijlagen C5-C6
6) Buig- en druksterkte van de reparatiemortel, uitgehard bij de minimale installatietemperatuur afhankelijk van de uithardingstijd: zie bijlage, met name de bijlagen C7-C8
7) Elasticiteitsmodulus, treksterkte en rek bij breuk van CFRP-lamellen: zie bijlage, met name de bijlagen C10-C11
8) Bestand van CFRP-lamellen na opslag in een alkalische omgeving bij de maximale gebruikstemperatuur: zie bijlage, met name de bijlagen C12-C15
9) Bestand van CFRP-lamellen in een alkalische omgeving onder langdurige belasting bij de maximale gebruikstemperatuur: - NPD
10) Hechtheidssterkte (treksterkte bij afsplijting) van de set die onder standaardklimaat is uitgehard: zie bijlage, met name bijlage C17
11) Afscheursterkte van de set na laagcyclische vermoeiingsbelasting: zie bijlage, met name bijlage C18
12) Afscheursterkte van de set na langdurige belasting onder zware klimatologische omstandigheden: NPD
13) Afscheursterkte van de set die is uitgehard bij de minimale installatietemperatuur afhankelijk van de uithardingstijd: zie bijlage, met name bijlage C19

Verdere essentiële kenmerken uitsluitend voor sets met extern verlijmde CFRP-lamellen

14) Afschuifweerstand van de hechtingsverankering van extern op beton verlijmde CFRP-lamellen: zie bijlage, met name de bijlagen C20 - C28
15) Vermoeiingsgedrag van de hechtingsverankering van extern op beton verlijmde CFRP-lamellen: NPD

Verdere essentiële kenmerken uitsluitend voor sets met in sleuven verlijmde CFRP-lamellen

16) Breuklasten van de eindverankering van in sleuven verlijmde CFRP-lamellen: zie bijlage, met name bijlage C29
17) Langdurige belasting van de eindverankering van in sleuven verlijmde CFRP-lamellen: NPD

Veiligheid in geval van brand (BWR 2)

18) Reactie op brand: NPD

8. Geëigende technische documentatie en/of specifieke technische documentatie: **–**

De prestaties van het hierboven omschreven product zijn conform de aangegeven prestaties. Deze prestatieverklaring wordt in overeenstemming met Verordening (EU) nr. 305/2011 onder de exclusieve verantwoordelijkheid van de hierboven vermelde fabrikant verstrekt.

Ondertekend voor en namens de fabrikant door:

Dr. Ronald Mihala, Algemeen directeur Onderzoek en Ontwikkeling

Dieter Pfaff, Hoofd van de Internationale Productiefederatie en Kwaliteitsbeheer

Deze DoP is opgesteld in meerdere talen. In het geval van geschillen over de interpretatie zal de Engelse tekst altijd prevaleren.

Het aanhangsel bevat vrijwillige en aanvullende informatie in het Engels die de (taal-neutraal gespecificeerde) wettelijke vereisten overschrijdt.

Translation guidance Essential Characteristics and Performance Parameters for Annexes

Prestatie

Mechanical resistance and stability (BWR 1) **Mechanische weerstand en stabiliteit (BWR 1)**		
1	Glass transition temperature of the structural bonding agent: **Glasovergangstemperatuur van het structurele lijmmiddel**	T_{Gg} [°C], t_{GTn} [S]
2	Glass transition temperature of the repair mortar: **Glasovergangstemperatuur van de reparatiemortel**	T_{Mg} [°C], t_{MTn} [S]
3	Flexural and compressive strength of the structural bonding agent: **buig- en druksterkte van het structurele hechtmiddel**	f_{Gfli}, $f_{Gtflm,}$ f_{Gflk}, [MPa], f_{Gci}, f_{Gcm}, f_{Gck} [MPa]
4	Flexural and compressive strength of the repair mortar: **Buig- en druksterkte van de reparatiemortel**	f_{Mfli}, $f_{Mflm,}$ f_{Mflk}, [MPa], f_{Mci}, f_{Mcm}, f_{Mck} [MPa]
5	Flexural and compressive strength of the structural bonding agent cured at minimum temperature of installation depending on the curing time: **Buig- en druksterkte van het structurele hechtmiddel, uitgehard bij de minimale installatietemperatuur afhankelijk van de uithardingstijd**	f_{Gflij}, $f_{Gtflmj,}$ f_{Gflkj}, [MPa], f_{Gcij}, f_{Gcmj}, f_{Gckj} [MPa]
6	Flexural and compressive strength of repair mortar cured at minimum temperature of installation depending on the curing time: **Buig- en druksterkte van de reparatiemortel, uitgehard bij de minimale installatietemperatuur afhankelijk van de uithardingstijd**	f_{Mflij}, $f_{Mflmj,}$ f_{Mflkj}, [MPa], f_{Mcij}, f_{Mcmj}, f_{Mckj} [MPa]
7	Modulus of elasticity, tensile strength and strain at failure of CFRP strips: **Elasticiteitsmodulus, treksterkte en rek bij breuk van CFRP-lamellen**	E_{Li}, E_{Lm} [MPa]; f_{Li}, f_{Lm}, f_{Lk} [MPa] ε_{Lui}, ε_{Lum} [mm/mm] // E_{fi}, E_{fm} [MPa], f_{fi}, f_{fm}, f_{fk} [MPa]
8	Resistance of CFRP strips after storage in alkaline environment at maximum temperature for the intended use: **Bestand van CFRP-lamellen na opslag in een alkalische omgeving bij de maximale gebruikstemperatuur**	E_{LAi}, [MPa]; f_{Lai} [MPa] ε_{Luai} [mm/mm], E_{lam} [MPa], f_{lam} [MPa] ε_{luam} [mm/mm], R_{LEa}, R_{Lfa} // $R_{L\varepsilon ua}$
9	Resistance of CFRP strips in alkaline environment under long-term load at maximum temperature for the intended use: **Bestand van CFRP-lamellen in een alkalische omgeving onder langdurige belasting bij de maximale gebruikstemperatuur**	E_{Llti}, [MPa]; f_{Llti} [MPa] ε_{Lulti} [mm/mm], E_{Lltm} [MPa], f_{Lltm} [MPa] ε_{Lultm} [mm/mm], R_{LElt}, R_{Lflt} // $R_{L\varepsilon ult}$
10	Bond strength of specimens cured at standard environmental conditions: **Hechtheidssterkte (treksterkte bij afsplijting) van de set die onder standaardklimaat is**	$f_{Cti,surf}$, $f_{Ctm,surf,}$ $f_{Ctk,surf}$ [MPa]
11	Bond strength after low-cycle fatigue action for robustness: **Afscheursterkte van de set na laagcyclische vermoeiingsbelasting**	$f_{Cti,surf,fat}$, $f_{Ctm,surf,fat,}$ $f_{Ctk,surf,fat}$ [MPa] $R_{fat,m}$
12	Bond strength after long-term loading under harsh climatic conditions: **Afscheursterkte van de set na langdurige belasting onder zware klimatologische**	$f_{Cti,surf,lt}$ [MPa]
13	Bond strength of specimens cured at minimum temperature of installation depending on the curing time: **Afscheursterkte van de set die is uitgehard bij de minimale installatietemperatuur afhankelijk van de uithardingstijd**	$f_{Cti,surf,Tmin}$, $f_{Ctm,surf,Tmin,}$ $f_{Ctk,surf,Tmin}$ [MPa] $R_{Tmin,m}$
Further essential characteristics only for kits with externally bonded (EB) CFRP strips **Verdere essentiële kenmerken uitsluitend voor sets met extern verlijmde CFRP-lamellen**		
14	Shear resistance of the bond anchorage of CFRP strips externally bonded to concrete: **Afschuifweerstand van de hechtingsverankering van extern op beton verlijmde CFRP-lamellen**	$f_{Ctim,surf}$, $f_{Ctik,surf,}$ f_{Ccm}, f_{Cck} [MPa] F_{bLi}, F_{bLm}, F_{bLk} [kN]
15	Fatigue behaviour of the bond anchorage of CFRP strips externally bonded to concrete: **Vermoeiingsgedrag van de hechtingsverankering van extern op beton verlijmde CFRP-lamellen**	$f_{Ctim,surf}$, $f_{Ctik,surf,}$ f_{Ccm}, f_{Cck} [MPa] $\Delta F_{bLi} = F^{u}_{bLi} - F^{l}_{bLi}$ [kN]
Further essential characteristics only of near surface mounted (NSM) CFRP strips **Verdere essentiële kenmerken uitsluitend voor sets met in sleuven verlijmde CFRP-lamellen**		
16	Ultimate anchorage load of near surface mounted CFRP strips **Breuklasten van de eindverankering van in sleuven verlijmde CFRP-lamellen**	$F_{b(NSM)Li}$, $F_{b(NSM)Lm,}$ $F_{b(NSM)Lk}$ [kN]
17	Long-term ultimate anchorage load: **Langdurige belasting van de eindverankering van in sleuven verlijmde CFRP-lamellen**	t_j [s], $F_{b(NSM)Lm,}$ $F_{b(NSM)l,lt,j}$ [kN]
Safety in case of fire (BWR 2)		
18	Reaction to fire: **Reactie op brand:**	Class Klasse

Deutsches Institut für Bautechnik

Public-law institution jointly founded by the federal states and the Federation

European Technical Assessment Body for construction products

Member of EOTA
www.eota.eu

Designated according to Article 29 of Regulation (EU) No 305/2011 and member of EOTA (European Organisation for Technical Assessment)

European Technical Assessment ETA-24/0281 of 6 December 2024

English translation prepared by DIBt - Original version in German language

General Part

Technical Assessment Body issuing the European Technical Assessment:	Deutsches Institut für Bautechnik
Trade name of the construction product	fischer C-Fiber Force Strengthening System
Product family to which the construction product belongs	Kits for the strengthening of concrete elements by externally bonded and near surface mounted CFRP strips
Manufacturer	fischerwerke GmbH & Co. KG Klaus-Fischer-Straße 1 72178 Waldachtal DEUTSCHLAND
Manufacturing plant	
This European Technical Assessment contains	46 pages including 40 annexes which form an integral part of this assessment
This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of	EAD 160086-01-0301

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Specific part

1 Technical description of the product

Subject matter of regulation of this European Technical Assessment (ETA) is the “fischer C-Fiber Force Strengthening System" for the strengthening of concrete elements by externally bonded (EB) CFRP strips and by near surface mounted (NSM) CFRP strips (in the following referred to as kit). The kit is used for the strengthening of concrete elements by bonded reinforcements to increase the flexural capacity of the elements either to compensate for design deficiencies, execution flaws and aging induced loss of capacity of the existing structure or increase of capacity in case of increased loads or repurposing of the existing structure.

The kit for the strengthening of concrete elements by externally bonded or near surface mounted carbon fiber reinforced polymer strips consists of the following components:

A Two types of unidirectional carbon fiber reinforced polymer (CFRP) strips for EB:
- FRS-L-H and FRS-L-S,

One type of unidirectional carbon fiber reinforced polymer (CFRP) strips for NSM:
- FRS-L-S NSM (same type of strips as FRS-L-S for EB)

B Structural bonding agent acc. to EN 1504-4, EN 1504-3, EN 1504-6 for CFRP strips FRS-CS

C Repair mortar with polymer binder FRS-PC 11 acc. to EN 1504-3,

D Bonding agent for the repair mortar FRS-BA acc. to EN 1504-7,

E Cleaning agent for the CFRP strips FRS-CA.

Furthermore, the manufacturer recommends the coating FRS-SF in case of exposure scenarios with increased UV-exposure as mentioned in the manufacturers product installation manual (MPII) and national regulations which is not part of the kit.

The following information on the kit and its components are given in the annexes to this ETA:

An overview of the kit and its components is given in annex A1 - A3 and its installed condition in annex A4 and A5.

A detailed description of the components of the kit is given in:
- Annex C9 for the CFRP strips (comp. A),
- Annex C1 for the structural bonding agent FRS-CS (comp. B),
- Annex C3 for the repair mortar FRS PC 11 (comp. C),
- Annex C16 for the bonding agent of the repair mortar FRS-BA (comp. D),

- The description of the intended use, design, installation of the kit and curing conditions of the structural bonding agent, repair mortar and bonding agent for the repair mortar is given in annex B1 and B2.
- Instruction of strengthening of concrete structures with externally bonded CFRP strips and near surface mounted CFRP strips is given annex B3 - B6.
- The results of the essential characteristics from assessment procedures according to EAD 160086-01-0301 are given in annex C:
  - Annex C10 – C15 for the CFRP strips (comp. A),
  - Annex C2, C5 and C6for the structural bonding agent FRS-CS (comp. B),
  - Annex C4, C7 and C8 for the repair mortar FRS PC 11 (comp. C),
- The essential characteristics of the system resulting of from the assessment procedures according to EAD 160086-01-0301 are given in annex C17 – C29.

2 Specification of the intended use in accordance with the applicable European Assessment Document

The kit is used for strengthening the tensile area of concrete elements like beams, slabs, walls and columns. It is intended to contribute to the increase of the structural capacity for static and quasi-static loaded concrete elements according to the design rules. The kit covers two different types of strengthening methods, as depicted in annex A4 and A5, in which CFRP strips are either applied externally onto the prepared concrete surface (EB) or in milled slots perpendicular to the concrete surface (NSM) in accordance with the manufacturer´s product installation instructions (MPII).

In case the surface conditions required are not fulfilled due to defects and damages of the concrete element the repair mortar (components C and D), normal concrete or shotcrete (both not part of the kit) may be used to improve the concrete surface condition prior to the application of the CFRP strips to the repaired concrete surface in accordance with the MPII and national regulations.

The performances given in section 3 are only valid if the kit is used in compliance with the specifications and conditions given in annex B and the MPII. Irrespective of annex B and the MPII, national regulations need to be respected.

The verifications and assessment methods on which this ETA is based lead to the assumption of a working life of the kit of at least 25 years when installed, provided that the kit is subject to appropriate installation and use. These provisions are based upon the current state of the art and the available knowledge and experience. The indications given as to the working life of the construction product cannot be interpreted as a guarantee neither given by the product manufacturer nor by the Technical Assessment Body issuing this ETA but are regarded only as a means for expressing the expected economically reasonable working life of the construction product.

3 Performance of the product and references to the methods used for its assessment

3.1 Mechanical resistance and stability (BWR 1)

No.	Essential characteristic	Assessment method according to EAD 160086-01-0301	Performance
1	Glass transition temperature of the structural bonding agent	2.2.1	See Annex C2
2	Glass transition temperature of the repair mortar	2.2.1	See Annex C4
3	Flexural and compressive strength of the structural bonding agent	2.2.2	See Annex C5 and C6
4	Flexural and compressive strength of the repair mortar	2.2.2	See Annex C7 and C8
5	Flexural and compressive strength of the structural bonding agent cured at minimum temperature of installation in depending on the curing time	2.2.3	See Annex C5 and C6
6	Flexural and compressive strength of the repair mortar cured at minimum temperature of installation in depending on the curing time	2.2.3	See Annex C7 and C8
7	Modulus of elasticity, tensile strength and strain at failure of CFRP strips	2.2.4	See Annex C10 and C11
8	Resistance of CFRP strips after storage in alkaline environment at maximum temperature according to the intended use	2.2.5	See Annex C12 to C15
9	Resistance of CFRP strips in alkaline environment under long-term load at maximum temperature according to the intended use	2.2.6	No performance assessed
10	Bond strength of specimens cured at standard environmental conditions	2.2.7	See Annex C17
11	Bond strength after low-cycle fatigue action	2.2.8	see Annex C18
12	Bond strength after long-term loading under harsh climatic conditions	2.2.9	No performance assessed
13	Bond strength of specimens cured at minimum temperature of installation depending on the curing time	2.2.10	See Annex C19
Further essential characteristics only of externally bonded (EB) CFRP strips			
14	Shear resistance of the anchorage of CFRP strips externally bonded to concrete	2.2.11	See Annex C20 to C28
15	Fatigue behaviour of the anchorage of CFRP strips externally bonded to concrete	2.2.12	No performance assessed

No.	Essential characteristic	Assessment method according to EAD 160086-01-0301	Performance
Further essential characteristics only of near surface mounted (NSM) CFRP strips			
16	Ultimate anchorage load of near surface mounted CFRP strips	2.2.13	See Annex C29
17	Long-term ultimate anchorage load	2.2.14	No performance assessed

3.2 Safety in case of fire (BWR 2)

No.	Essential characteristic	Assessment method according to EAD 160086-01-0301	Performance
18	Reaction to fire	2.2.15	No performance assessed

4 Assessment and verification of constancy of performance (AVCP) system applied, with reference to its legal base

In accordance with EAD 160086-01-0301 the applicable European legal act is: 2000/606/EC.
The system to be applied is: 1+

5 Technical details necessary for the implementation of the AVCP system, as provided for in the applicable EAD

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited with Deutsches Institut für Bautechnik.

Issued in Berlin on 6. December 2024 by Deutsches Institut für Bautechnik

LBD Dipl.-Ing. Andreas Kummerow
Head of Department

beglaubigt:
Alex

Deutsches Institut für Bautechnik DIBt

Overview of the fischer C-Fiber Force Strengthening System – System components (Part I)							
Components acc. to EAD	Comp. A			Comp. B	Comp. C	Comp. D	Comp. E
Product name	CFRP CFRP strip FRS-L-H	CFRP CFRP strip FRS-L-S	CFRP CFRP strip FRS-L-S NSM	Epoxy mortar FRS-CS	Epoxy repair mortar FRS-PC 11	Bonding Agent FRS-BA	Cleaning Agent FRS-CA
Function	Unidirectional carbon fiber reinforced polymer (CFRP) strips			Structural bonding agent for CFRP strips	Repair mortar with polymer binder	Bonding agent for the repair mortar	Cleaning agent for the CFRP strips
Material	Precured composite from carbon fibers embedded in an epoxy matrix			Cold curing epoxy with mineral fillers	Cold curing epoxy with mineral fillers	Cold curing epoxy with mineral fillers	Solvent / Mixture of solvents
Type of application*	EB	EB	NSM	EB & NSM	EB & NSM	EB & NSM	EB & NSM
Packaging	100 m coil or 150 m coil**			5 kg can 10 kg can 585 ml injection cartridge	11 kg can	5 kg can	500 ml spray can
Shelf life	Infinite (if stored UV-protected)			36 months	36 months	36 months	36 months
Storage conditions	5 to 50 °C, dry environment and UV-protectet			5 to 40 °C	5 to 40 °C	5 to 40 °C	5 to 40 °C
Application temp.	10 to 40 °C			10 to 40 °C	10 to 40 °C	10 to 40 °C	10 to 40 °C
Temp. range in use	- 25 to 40 °C			- 25 to 40 °C	- 25 to 40 °C	- 25 to 40 °C	Not applicable

*EB: Externally bonded CFRP strips; NSM: Near surface mounted CFRP strips.
**Coil lengths for the different cross-section product variants are specified in the corresponding technical datasheets.

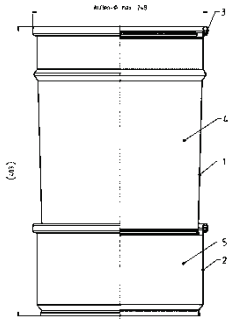
fischer C-Fiber Force Strengthening System	**Annex A1**
Product description System components and technical details	

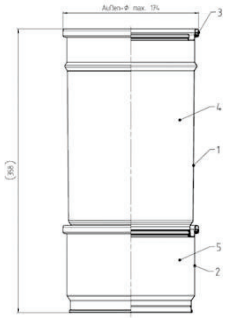
Deutsches Institut für Bautechnik DIBt

Overview of the fischer C-Fiber Force Strengthening System – System components (Part II)

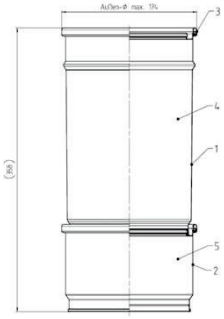
Epoxy Mortar FRS-CS (Component B, Structural Bonding Agent)

10 kg Can **5 kg Can**

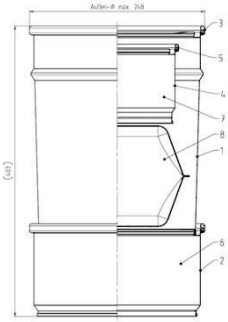




Bonding agent FRS-BA (Component D) **5 kg Can**



Repair mortar FRS-PC 11 (Comp. C) **11 kg Can**



Cleaning agent FRA-CA (Comp. E) **500 ml aerosol spray can**

fischer C-Fiber Force Strengthening System	**Annex A2**
Product description System components and technical details	

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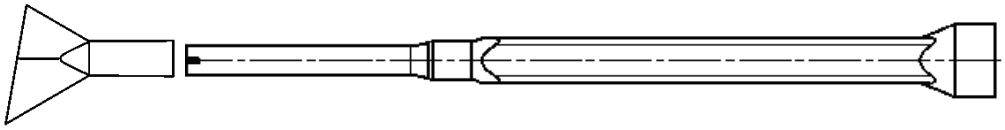
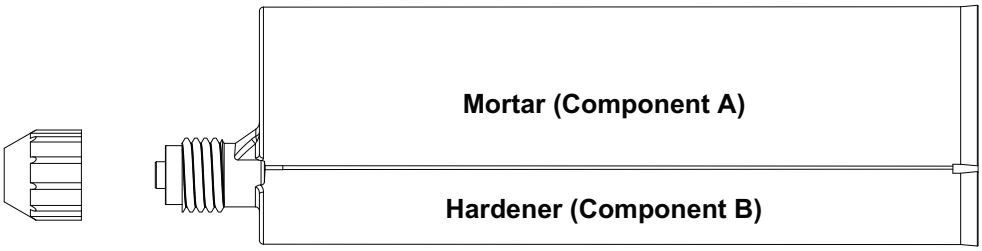
Overview of the fischer C-Fiber Force Strengthening System – System components (Part III)

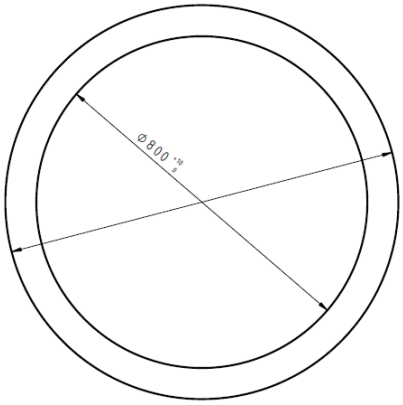
Static mixing nozzle FIS UMR for cartridges with FRS-GA injection adapter



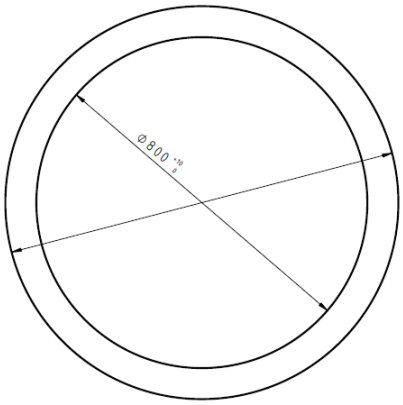
Structural bonding agent FRS-CS 585 ml cartridges



Coils of externally bonded CFRP strips FRS-L-S, FRS-L-H (Component A)



Coils of near surface mounted CFRP strips FRS-L-S-NSM (Component A)



fischer C-Fiber Force Strengthening System	**Annex A3**
Product description System components and technical details	

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Overview of the fischer C-Fiber Force Strengthening System – strengthening techniques (Part I)

Externally bonded CFRP strips

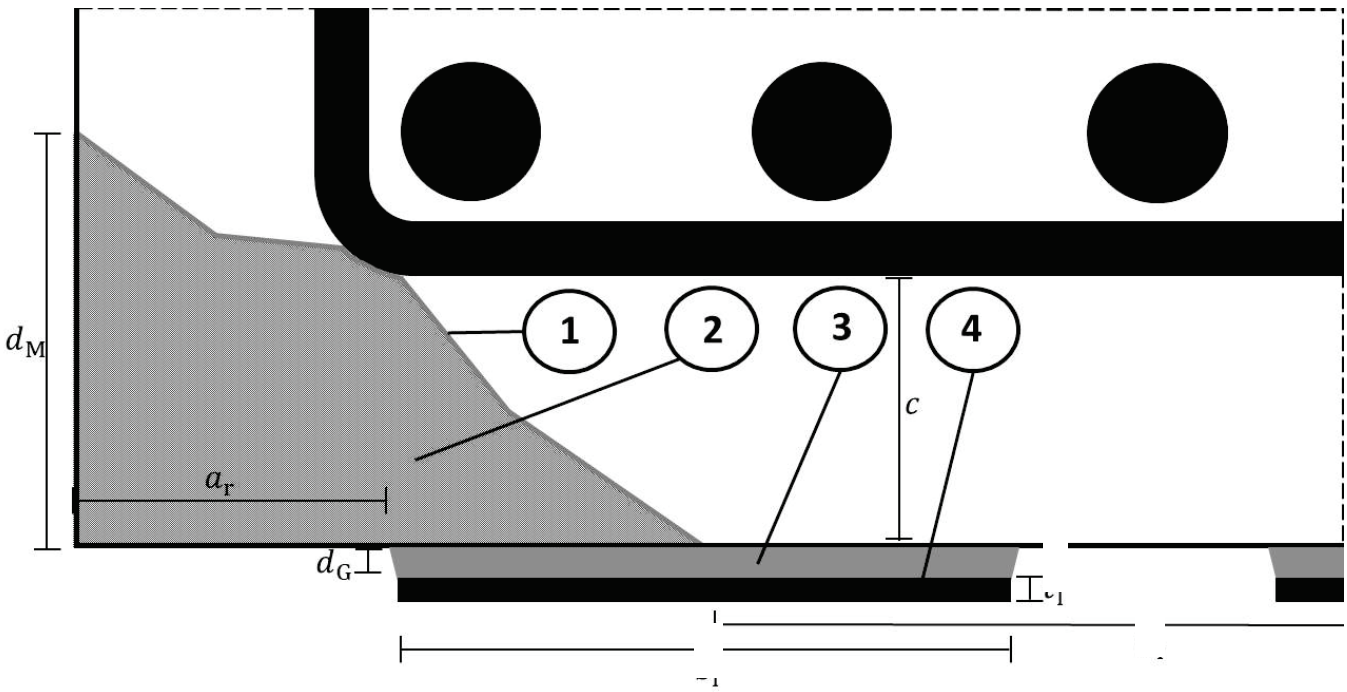


Figure A4.1: Strengthening layout with externally bonded FRS-L-S and FRS-L-H CFRP strips using the Epoxy Mortar FRS-CS with (optional) preceding concrete repair using the Epoxy Repair Mortar FRS-PC 11 with the Bonding Agent FRS-BA.

Legend

c	Concrete Cover of the internal reinforcement
a_r	Edge distance of the externally bonded reinforcements
a_l	Center to center distance of externally bonded CFRP strips
d_B	Layer thickness or consumption of the Bonding Agend FRS-BA
d_M	Layer thickness of the Epoxy Repair Mortar FRS-PC 11
d_G	Layer thickness of the structural bonding agent, the Epoxy Mortar FRS-CS
t_l	Thickness of the externally bonded CFRP strips
b_l	Width of the externally bonded CFRP strips

1	**Component D - Bonding Agent FRS-BA:**	**Consumption d_D: 500 g/m² - 800 g/m²**
2	Component C - Epoxy Repair Mortar FRS-PC 11:	Layer thickness d_M: 4 mm - 30 mm
3	Component B - Structural bonding agent FRS-CS:	Layer thickness d_G: 1 mm - 5 mm
4	Component A - CFRP strip FRS-L-S / FRS-L-H:	thickness of CFRP strips t_L: 1,2 mm / 1,4 mm (≤ 2 layers)

fischer C-Fiber Force Strengthening System	**Annex A4**
Product description Installed condition – externally bonded CFRP strips	

Overview of the fischer C-Fiber Force Strengthening System – strengthening techniques (Part II)

Near surface mounted CFRP strips

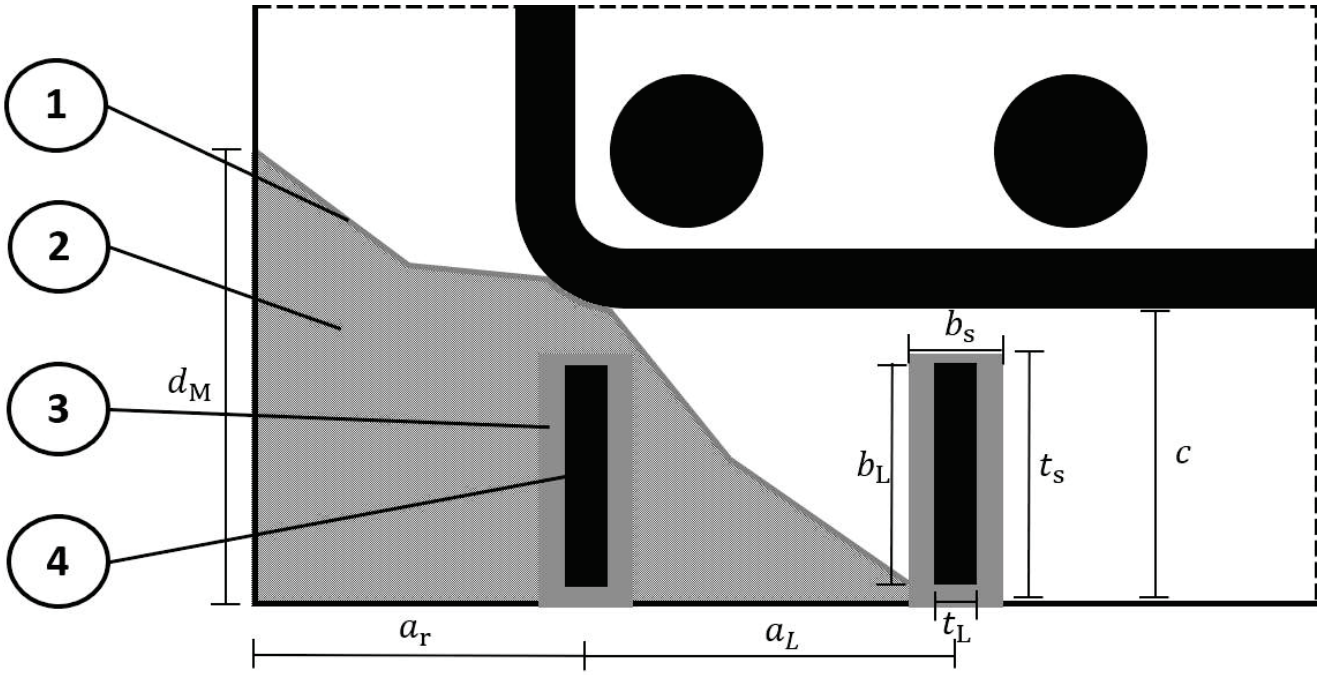


Figure A5.1: Strengthening layout with Near Surface Mounted FRS-L-S NSM CFRP strips using the Epoxy Mortar FRS-CS with preceding concrete repair using the Epoxy Repair Mortar FRS-PC 11 with the Bonding Agent FRS-BA.

Legend

c	Concrete cover of the internal reinforcements
a_r	Edge distance of the externally bonded reinforcements
a_L	Center to center distance of externally bonded CFRP strips
d_B	Layer thickness or consumption of the Bonding Agent FRS-BA
d_M	Layer thickness of the Epoxy Repair Mortar FRS-PC 11
b_s	Width of the concrete slot $t_L + 1\text{mm} \leq b_s \leq t_L + 3\text{mm}$
t_s	Depth of the concrete slot $t_S \geq b_L + 3\text{mm}$
t_L	Thickness of the near-surface mounted CFRP strips
b_L	Width of the near-surface mounted CFRP strips

1	Component D - Bonding Agent FRS-BA:	Consumption ρ_D: 500 g/m² - 800 g/m²
2	Component C - Epoxy Repair Mortar FRS-PC 11:	Layer thickness d_M: 4 mm - 30 mm
3	Component B - Structural bonding agent FRS-CS:	Consumption ρ_B: 0,06 kg/m – 0,20 kg/m
4	Component A - CFRP strip FRS-L-S NSM:	thickness of CFRP strips t_L: 1,2 mm / 1,4 mm / 1,7 mm

fischer C-Fiber Force Strengthening System	**Annex A5**
Product description Installed condition – near surface mounted CFRP strips	

Overview of the fischer C-Fiber Force Strengthening System – Specifications

Intended use

The fischer C-Fiber Force Strengthening System is used for strengthening the tensile reinforcement area of concrete elements like beams, slabs, walls and columns. It is intended to contribute to the increase of the structural capacity for static, quasi-static and high cycle fatigue loading of concrete elements according to the design rules.

Structural design

The structural design of strengthening layouts with the fischer C-Fiber Force strengthening system by externally bonded CFRP strips and by near surface mounted CFRP strips is the responsibility of an experienced structural engineer according to the national or international guidelines and regulations, in conjunction with this technical assessment as well as technical drawings and the MPII.
The fischer REINFORCE-FIX® design software might provide design proposals for certain strengthening layouts for reinforced concrete elements.

Base materials

The intended use of the strengthening system as covered by this ETA covers concrete elements from normal weight reinforced concrete, whose properties enable assignment to concrete strength classes C12/15 to C50/60 according to EN 206-1:2000 or newer, with a mean surface tensile strength of at least ≥ 1,0 N/mm^2 with a sufficiently even and level surface. In case of the use of higher surface tensile strengths in the structural design, these values need to be verified on the concrete element to be strengthened by means of measurement of bond strength by pull-of tests acc. to EN 1542.
The decision on the suitability and adequate pretreatment of the concrete surface remains the responsibility of an experienced structural engineer.

Installation and use conditions

The installations shall be performed by appropriately qualified personnel under the supervision of the responsible structural engineer. Installation works shall be performed in accordance with the layout given in the structural design without allocation or exchange of defined materials and geometries. All materials covered in the C-Fiber Force Strengthening System shall be used without manipulations

The CFRP strips are only available in the widths according to Appendix B2. The width of the CFRP strips shall not be changed on the construction site. The CFRP strips shall be cut to the required length in accordance with the manufacturer´s product installation instructions (MPII).

Storage, transport, handling, preparation and mixing as well as installation works need to be performed according to the manufacturer's technical datasheets and manufacturer´s product installation instructions (MPII) and in alignment with national and international regulations.

The temperature range of use of the fischer C-Fiber Force Strengthening System is – 25 °C - + 40 °C after complete cure of the components. Reductions in load-bearing capacity due to the effects of temperature and other environmental conditions shall be taken into account in the structural design.

The fischer C-Fiber Force Strengthening System may be applied within an ambient temperature range of + 10 °C - + 40 °C if both surface temperature and ambient temperature are in range above dew point in accordance with the manufacturer´s product installation instructions (MPII) respectively manuals.

The curing times of the system components are listed below:

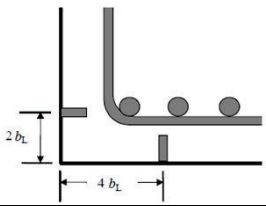
Temperature:	≥ 10 °C	≥ 20 °C	40 °C
FRS-BA	≥ 96 h	≥ 48 h	≥ 24 h
FRS-PC 11	≥ 96 h	≥ 48 h	≥ 24 h
FRS-CS	≥ 48 h	≥ 24 h	≥ 16 h

The kit should therefore cure for at least 48 h at standard conditions (21 °C) or at least 96 h at minimum installation temperature (10 °C) depending on the individual weather conditions.

Quality assurance of the application should be defined and performed by the responsible structural engineer to ensure correct design, surface preparation, installation and cure of the kit in alignment with the manufacturers MPII and national regulations if applicable.

fischer C-Fiber Force Strengthening System	**Annex B1**
Intended use Specifications and installation conditions	

Deutsches Institut für Bautechnik DIBt

Specifications and installation conditions of the strengthening system					
Concrete repair with FRS-PC 11 (Comp. C) and Bonding Agent FRS-BA (Comp. D)					
Concrete surface treatment	Removal of loose concrete particles and cleaning with a steel brush and vacuum or compressed air.				
System	Repair mortar FRS-PC 11 appl. wet in wet with bonding agent FRS-BA				
Recommended consumption of bonding agent FRS-BA d_B [kg/m²]	0,5 – 0,8				
Range of layer thickness of repair mortar FRS-PC 11 d_M [mm]	4 - 30				
Layer thickness of repair mortar FRS-PC 11 d_M [mm]	5	10	15	20	30
Corresponding consumption of repair mortar FRS-PC 11 [kg/m²]	10	20	30	40	60
Consumptions depend on the surface roughness of the concrete surface.					
Strengthening with externally bonded CFRP strips FRS-L-S / FRS-L-H (Comp. A) & FRS-CS (Comp. B)					
Concrete Surface treatment	Sand blasting	Shot peening	Grinding	Needle gun	
	Cleaning with vacuum or compressed air				
Recommended layer thickness d_G [mm]	1 - 5				
Approx. consumption of structural bonding agent FRS-CS [kg/m]	1 mm thickness	2 mm thickness	3 mm thickness	4 mm thickness	5 mm thickness
FRS-L-S / FRS-L-H b_l = 50 mm	0,10	0,20	0,30	0,40	0,50
FRS-L-S / FRS-L-H b_l = 75 mm	0,15	0,30	0,45	0,60	0,75
FRS-L-S / FRS-L-H b_l = 100 mm	0,20	0,40	0,60	0,80	1,00
Minimum edge distance a_r	At least equal to the concrete cover of the internal reinforcements				
Consumptions depend on the surface roughness of the concrete surface.					
Strengthening with near surface mounted CFRP strips FRS-L-S NSM (Comp. A) & FRS-CS (Comp. B)					
Surface treatment	Milling grooves				
	Cleaning of slots with compressed air				
Width and thickness of the CFRP strip [mm x mm]	10 x 1,7	15 x 1,4	20 x 1,2		
Recommended min. slot depth t_s [mm]	13	18	23		
Recommended slot width b_s [mm]	2,7 - 4,7	2,4 – 4,4	2,2 – 4,2		
Approx. consumption of structural bonding agent FRS-CS [kg/m]	0,060 – 0,075	0,075 – 0,090	0,090 – 0,200		
Minimum edge distance a_r	$a_r \geq min\begin{pmatrix} 2 \cdot b_f \\ 30\ mm \\ d_g \end{pmatrix}$ where b_f : width of CFRP strip; d_g: maximum aggregate size 				
Minimum slot-slot distance a_l	At least, $a_l \geq b_l$, without load reduction $a_l \geq 2 \cdot b_l$				
Minimum concrete cover c	At least $c \geq t_s$ + 5 mm, depending on the working and display accuracy of the devices used				
Consumptions depend on the surface roughness of the concrete surface.					

fischer C-Fiber Force Strengthening System	**Annex B2**
Intended use Specifications and installation conditions	

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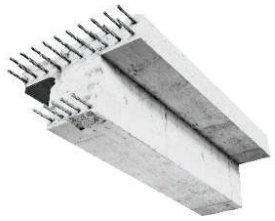
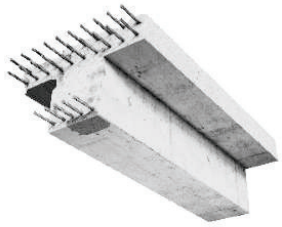
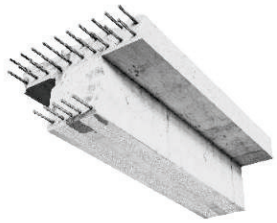
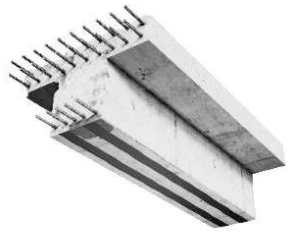
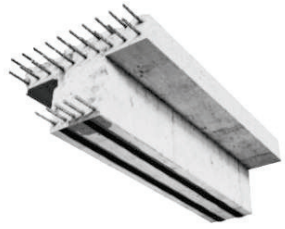
Graphic depictions of the strengthening method – Externally bonded CFRP strips (Part I)

Depiction of the stages of concrete repair and strengthening of concrete structures with the fischer C-Fiber Force Strengthening System with externally bonded CFRP strips

The hereby presented installation steps do not substitute the complete installation instruction manuals and might not be complete. For detailed application and processing information consult the corresponding Manufacturer´s Product Installation Instructions (MPII).

	Application of Bonding Agent FRS-BA as a thin layer on cleaned, fractured, or damaged areas of the concrete as well as on the rust-free, embedded steel reinforcing bars for corrosion protection if exposed. *(The necessity of concrete repair is dependent on the actual condition of the individual concrete element to be strengthened)*
	Application of the Epoxy Repair Mortar FRS-PC 11 on the damaged concrete, directly installed into the wet, non-cured bonding agent. *(The necessity of concrete repair is dependent on the actual condition of the individual concrete element to be strengthened)*
	Preparation and roughening of the concrete surface to be strengthened for the subsequent bonding of CFRP strips by either sand blasting, shot peening, grinding or similar in the areas, where the CFRP strips are to be applied. After the roughening, the coarse concrete aggregates ≥ 4 mm shall be visible.
	Application of a scratch coat of the structural bonding agent, the Epoxy Mortar FRS-CS on the prepared concrete surface as well as on the surface of the FRS-L-S and FRS-L-H CFRP strips in a roof shaped manner with hight from 2 mm to 10 mm.
	Application of the fischer FRS-L-S or FRS-L-H externally bonded CFRP strips to the surface of the concrete element to be strengthened. After the CFRP strips are placed on the concrete surface, the excess FRS-CS Epoxy Mortar shall be visible on the sides of the CFRP strips.

fischer C-Fiber Force Strengthening System	**Annex B3**
Overview of the stages of the repair and strengthening of concrete structures with externally bonded CFRP strips	

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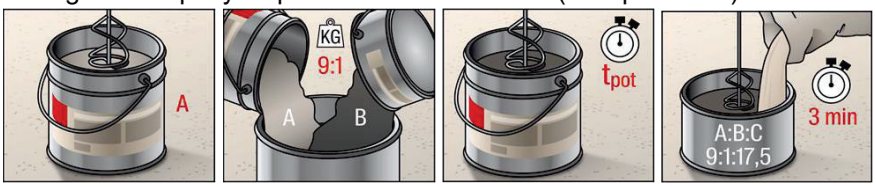
Graphic depictions of the strengthening method - Externally bonded CFRP strips (Part II)

Depiction of the stages of concrete repair and strengthening of concrete structures with the fischer C-Fiber Force Strengthening System with externally bonded CFRP strips

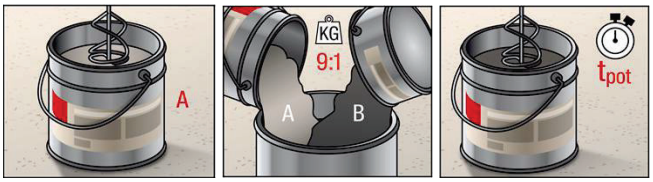
The hereby presented installation steps do not substitute the complete installation instruction manuals and might not be complete. For detailed application and processing information consult the corresponding Manufacturer´s Product Installation Instructions (MPII).

Concrete Repair using the Epoxy Repair Mortar FRS-PC 11 with the Bonding Agent FRS-BA:

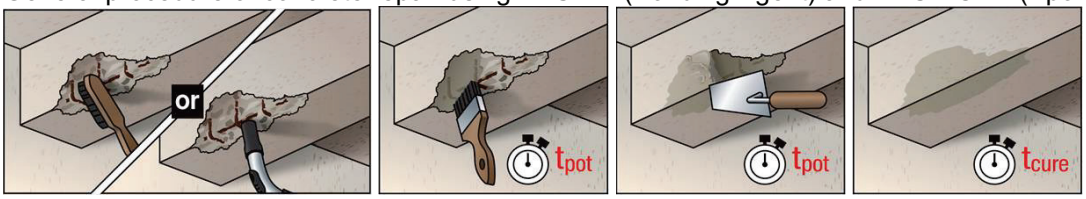
Mixing of the Epoxy Repair Mortar FRS-PC 11 (Component C):



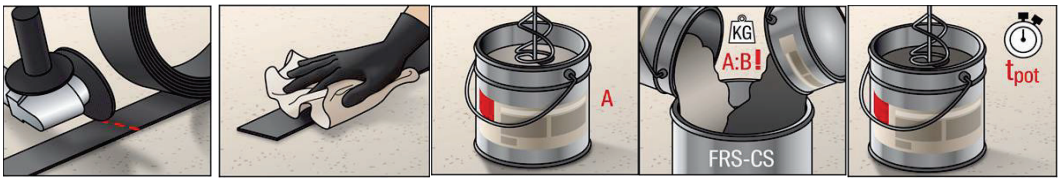
Mixing of the Bonding Agent FRS-BA (Component D):

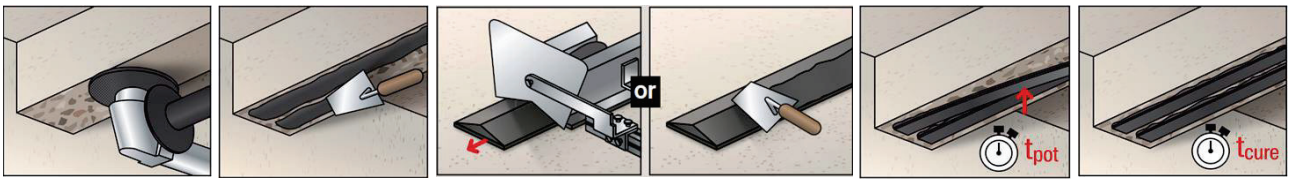


General procedure of concrete repair using FRS-BA (Bonding Agent) and FRS-PC 11 (Epoxy Repair Mortar):



Installation of FRS-L-S and FRS-L-H CFRP strips and mix of the Epoxy Mortar FRS-CS





For further information (e.g. on pot life, hardening time etc.) on the FRS-BA, FRS-PC 11, FRS-CS consult the corresponding technical data sheets, product labels, MPII.

fischer C-Fiber Force Strengthening System	
Overview of the stages of the repair and strengthening of concrete structures with externally bonded CFRP Strips	**Annex B4**

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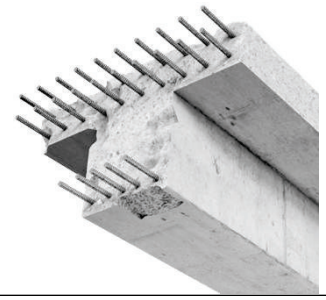
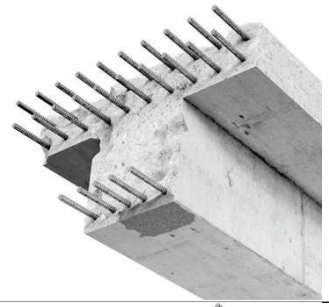
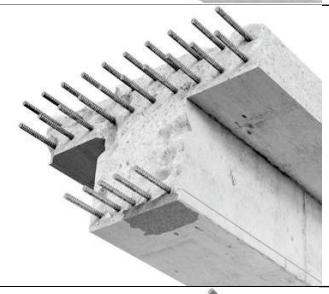
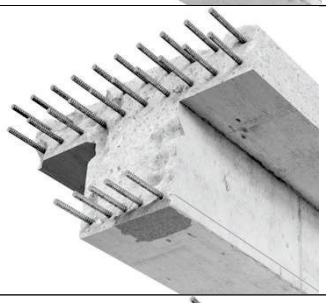
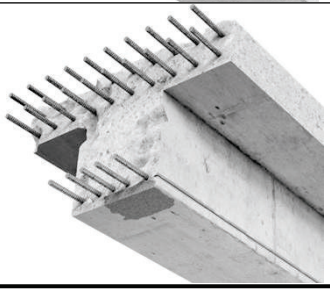
Graphic depictions of the strengthening method – Near surface mounted CFRP strips (Part I)

Depiction of the stages of concrete repair and strengthening of concrete structures with the fischer C-Fiber Force Strengthening System with near surface mounted CFRP strips

The hereby presented installation steps do not substitute the complete installation instruction manuals and might not be complete. For detailed application and processing information consult the corresponding Manufacturer´s Product Installation Instructions (MPII).

	Application of Bonding Agent FRS-BA as a thin layer on cleaned, fractured, or damaged areas of the concrete as well as on the rust-free, embedded steel reinforcing bars for corrosion protection if exposed. *(The necessity of concrete repair is dependent on the actual condition of the individual concrete element to be strengthened)*
	Application of the Epoxy Repair Mortar FRS-PC 11 on the damaged concrete, directly installed into the wet, non-cured bonding agent. *(The necessity of concrete repair is dependent on the actual condition of the individual concrete element to be strengthened)*
	Preparation of the concrete surface to be strengthened for bonding by cutting slots with adequate depth and width into the concrete cover and subsequent thorough cleaning of the slot with compressed air.
	The slots are completely filled with adhesive from the bottom of the slots and free of air pockets along their entire length until glue emerges from the slot.
	The CFRP strip is inserted into the middle of the slot until it is completely embedded flush in the slot. The surface is peeled off to remove excess adhesive and to ensure a flat component surface.

fischer C-Fiber Force Strengthening System	**Annex B5**
Overview of the stages of the repair and strengthening of concrete structures with near surface mounted CFRP strips	

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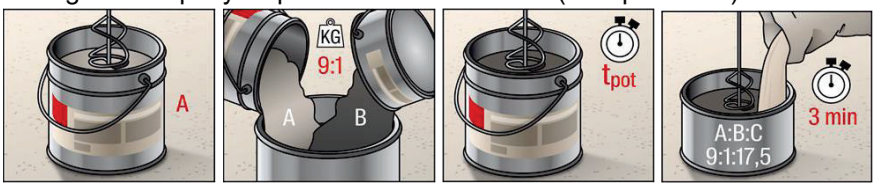
Graphic depictions of the strengthening method – Near surface mounted CFRP strips (Part II)

Depiction of the stages of concrete repair and strengthening of concrete structures with the fischer C-Fiber Force Strengthening System with near surface mounted CFRP strips

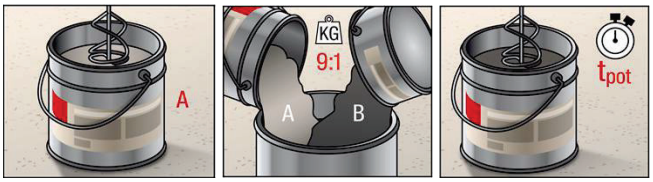
The hereby presented installation steps do not compensate for an installation instruction and are not exhaustive. For detailed application and processing information consult the corresponding Manufacturer Product Installation Instructions (MPII).

Concrete Repair using the Epoxy Repair Mortar FRS-PC 11 with the Bonding Agent FRS-BA

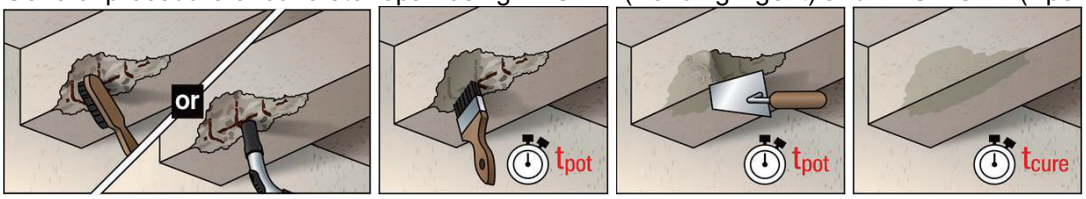
Mixing of the Epoxy Repair Mortar FRS-PC 11 (Component C):



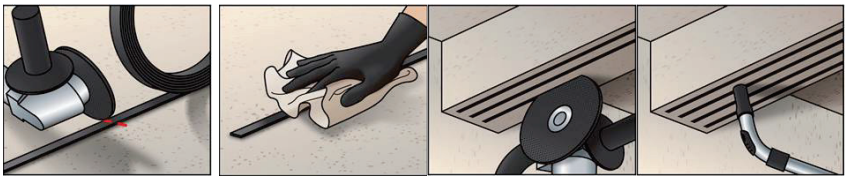
Mixing if the Bonding Agent FRS-BA (Component D):

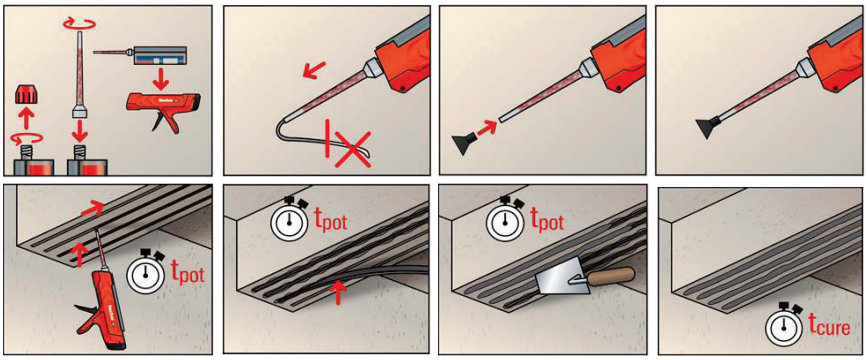


General procedure of concrete repair using FRS-BA (Bonding Agent) and FRS-PC 11 (Epoxy Repair Mortar):



Installation of FRS-L-S NSM CFRP strips using the Epoxy Mortar FRS-CS /FRS-CS 585 S cartridge system





fischer C-Fiber Force Strengthening System	
Overview of the stages of the repair and strengthening of concrete structures with near surface mounted CFRP strips	**Annex B6**

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Characteristics of the structural bonding agent FRS-CS	
Appearance - Component A - Component B - Mixture of A and B (4:1)	 Highly viscous paste of beige colour with visible aggregates Highly viscous paste of black colour with visible aggregates Smooth, highly viscous paste of grey colour with visible aggregates
Density - Component A - Component B - Mixture of A and B (4:1)	 1,92 g/cm³ ± 0,05 g/cm³ 1,63 g/cm³ ± 0,05 g/cm³ 1,86 g/cm³ ± 0,05 g/cm³
Mixing ratio by weight	4 : 1
Elastic modulus in compression** and tension:***	≥ 7500 MPa
Tensile strength:***	≥ 35 MPa
Minimum workability time - at minimum installation temperature (10°C) and maximum container size (10 kg)* - at standard conditions (21 °C) and maximum container size (10 kg)* - at maximum installation temperature (40 °C) and maximum container size (10 kg)*	 120 min. 80 min. 25 min.
Minimum curing time - at minimum installation temperature (10 °C) - at standard conditions (21 °C) - at maximum installation temperature (40 °C)	 4 days 2 days 1 day
*Acc. to EN ISO 9514. **Acc. to EN 13412. ***Acc. to EN ISO 527-1, after 7 days at standard conditions.	

fischer C-Fiber Force Strengthening System	**Annex C1**
Product description Technical parameters and details of the structural bonding agent FRS-CS	

Glass transition temperature of the structural bonding agent FRS-CS		
Curing conditions and curing times		**Glass transition temperature [°C]**
- after 7 days curing at 21 °C ± 2 °C, 50% Rh.	T_{Ggi}	54 – 59 *; 55 – 59 *
Determination of the glass transition temperature was performed using the first heating cycle. * Due to the post-curing of the epoxy resin, which is superimposed on the measurement of the glass transition temperature, only one temperature range can be specified for the glass transition temperatures.		

Characteristics of the repair mortar FRS-PC 11	
Appearance - Component A - Component B - Component C - Mixture of A, B and C (3,6 : 0,4 : 7)	 Highly viscous paste of white colour Low viscosity, fluent liquid of black colour Free flowing coarse aggregates of beige colour Firm thixotropic mortar of light grey colour
Density - Component A - Component B - Component C - Mixture of A and B (3,6 : 0,4 : 7)	 2,12 g/cm³ ± 0,05 g/cm³ 0,99 g/cm³ ± 0,05 g/cm³ 2,20 g/cm³ ± 0,05 g/cm³ 2,12 g/cm³ ± 0,05 g/cm³
Mixing ratio by weight	3,6 : 0,4 : 7
Elastic modulus in compression**	≥ 20.000 MPa
Minimum workability time - at minimum installation temperature (10 °C) and maximum container size (11 kg)* - at standard conditions (21 °C) and maximum container size (11 kg)* - at maximum installation temperature (40 °C) and maximum container size (11 kg)*	 180 min. 80 min. 25 min.
Minimum curing time - at minimum installation temperature (10 °C) - at standard conditions (21 °C) - at maximum installation temperature (40 °C)	 4 days 2 days 1 day

*Acc. to EN ISO 9514.
**Acc. to EN 13412.

fischer C-Fiber Force Strengthening System

Product description
Technical parameters and details of the repair mortar FRS-PC 11

Annex C3

Glass transition temperature of the repair mortar FRS-PC 11		
Curing conditions and curing time		**Glass transition temperature [°C]**
- after 7 days curing at 21 °C ± 2 °C, 50% Rh.	T_{Ggi}	59 – 63 * 59 – 63 *
Determination of the glass transition temperature was performed using the first heating cycle. * Due to the post-curing of the epoxy resin, which is superimposed on the measurement of the glass transition temperature, only one temperature range can be specified for the glass transition temperatures.		

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Flexural strength of the structural bonding agent FRS-CS		
Curing conditions and curing times		**Flexural strength [MPa]**
- after 1 day curing at 10 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Gflij} $\boldsymbol{f_{Gflmj}}$ $\boldsymbol{f_{Gflkj}}$	26,0; 25,7; 25,6; **25,8** **25,1**
- after 7 days curing at 10 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Gflij} $\boldsymbol{f_{Gflmj}}$ $\boldsymbol{f_{Gflkj}}$	34,2; 34,0; 32,4; **33,5** **30,2**
- after 14 days curing at 10 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Gflij} $\boldsymbol{f_{Gflmj}}$ $\boldsymbol{f_{Gflkj}}$	34,6; 31,7; 33,2; **33,2** **28,3**
- after 7 days curing at 21 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Gfli} $\boldsymbol{f_{Gtflm}}$ $\boldsymbol{f_{Gflk}}$	34,0; 31,3; 29,5; **31,6** **24,0**

fischer C-Fiber Force Strengthening System	**Annex C5**
Performance Flexural strength of the structural bonding agent FRS-CS cured at standard environmental or minimum temperature of installation	

Compressive strength of the structural bonding agent FRS-CS		
Curing conditions and curing time		**Compressive strength [MPa]**
- after 1 day curing at 10 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Gcij} $\boldsymbol{f_{Gcmj}}$ $\boldsymbol{f_{Gckj}}$	51,2; 50,1; 51,4; 48,7; 52,9; 47,5; **50,3** **46,0**
- after 7 days curing at 10 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Gcij} $\boldsymbol{f_{Gcmj}}$ $\boldsymbol{f_{Gckj}}$	87,8; 85,9; 87,5; 84,3; 86,6; 82,6; **85,8** **81,4**
- after 14 days curing at 10 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Gcij} $\boldsymbol{f_{Gcmj}}$ $\boldsymbol{f_{Gckj}}$	91,6; 91,3; 91,7; 90,1; 90,2; 89,1; **90,7** **88,4**
- after 7 days curing at 21 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Gci} $\boldsymbol{f_{Gcm}}$ $\boldsymbol{f_{Gck}}$	89,9; 87,6; 89,8; 89,4; 88,8; 90,7; **89,4** **87,0**

fischer C-Fiber Force Strengthening System	**Annex C6**
Performance Compressive strength of the structural bonding agent FRS-CS cured at standard environmental or at minimum temperature of installation	

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Flexural strength of the repair mortar FRS-PC 11		
Curing conditions and curing time		**Flexural strength [MPa]**
- after 1 day curing at 10 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Mflij} $\boldsymbol{f_{Mflmj}}$ $\boldsymbol{f_{Mflkj}}$	26,3; 25,7; 25,6; **25,9** **24,6**
- after 7 days curing at 10 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Mflij} $\boldsymbol{f_{Mflmj}}$ $\boldsymbol{f_{Mflkj}}$	37,5; 36,9; 38,7; **37,7** **34,6**
- after 14 days curing at 10 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Mflij} $\boldsymbol{f_{Mflmj}}$ $\boldsymbol{f_{Mflkj}}$	40,5; 43,0; 42,4; **42,0** **37,6**
- after 7 days curing at 21 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Mfli} $\boldsymbol{f_{Mtflm}}$ $\boldsymbol{f_{Mflk}}$	42,4; 42,3; 41,6; **42,1** **41,4**

fischer C-Fiber Force Strengthening System	**Annex C7**
Performance Flexural strength of the repair mortar FRS-PC 11 cured at standard environmental or at minimum temperature of installation	

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Compressive strength of the repair mortar FRS-PC 11		
Curing conditions and curing time		**Compressive strength [MPa]**
- after 1 day curing at 10 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Mcij} $\boldsymbol{f_{Mcmj}}$ $\boldsymbol{f_{Mckj}}$	91,4; 88,1; 87,8; 87,1; 86,9; 87,3; **88,1** **84,4**
- after 7 days curing at 10 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Mci} $\boldsymbol{f_{Mcm}}$ $\boldsymbol{f_{Mck}}$	137,6; 137,1; 133,5; 135,6; 139,2; 134,3; **136,2** **131,5**
- after 14 days curing at 10 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Mci} $\boldsymbol{f_{Mcm}}$ $\boldsymbol{f_{Mck}}$	146,1; 146,6; 144,3; 143,4; 144,6; 143,8; **144,8** **142,0**
- after 7 days curing at 21 °C ± 2 °C, 50% Rh. **Mean value** **Characteristic value**	f_{Mci} $\boldsymbol{f_{Mcm}}$ $\boldsymbol{f_{Mck}}$	147,0; 150,2; 147,4; 148,4; 146,3; 152,6; **148,7** **143,5**

fischer C-Fiber Force Strengthening System	**Annex C8**
Performance Compressive strength of the repair mortar FRS-PC 11 cured at standard environmental or at minimum temperature of installation	

Characteristics of the FRS-L-H CFRP strips			
Type of application	Externally bonded (EB) Reinforcement		
Minimum coil diameter	≥ 800 mm		
Fiber volume content	≥ 67 % by volume*		
Glass transition temperature	≥ 100 °C**		
Geometry	Width b_l [mm]	Thickness t_l [mm]	Cross section area [mm²]
FRS-L-H 50 x 1,2 mm	50	1,2	60
FRS-L-H 50 x 1,4 mm	50	1,4	70
FRS-L-H 75 x 1,2 mm	75	1,2	90
FRS-L-H 75 x 1,4 mm	75	1,4	105
FRS-L-H 100 x 1,2 mm	100	1,2	120
FRS-L-H 100 x 1,4 mm	100	1,4	140

Characteristics of the FRS-L-S CFRP strips			
Type of application	Externally bonded (EB) Reinforcement		
Minimum coil diameter	≥ 800 mm		
Fiber volume content	≥ 67 % by volume*		
Glass transition temperature	≥ 100 °C**		
Geometry	Width b_l [mm]	Thickness t_l [mm]	Cross section area [mm²]
FRS-L-S 50 x 1,2 mm	50	1,2	60
FRS-L-S 50 x 1,4 mm	50	1,4	70
FRS-L-S 75 x 1,2 mm	75	1,2	90
FRS-L-S 75 x 1,4 mm	75	1,4	105
FRS-L-S 100 x 1,2 mm	100	1,2	120
FRS-L-S 100 x 1,4 mm	100	1,4	140

Characteristics of the FRS-L-S NSM CFRP strips			
Type of application	Near surface mounted (NSM) Reinforcement		
Minimum coil diameter	≥ 800 mm		
Fiber volume content	≥ 67 % by volume*		
Glass transition temperature	≥ 100 °C**		
Geometry	Width b_l [mm]	Thickness t_l [mm]	Cross section area [mm²]
FRS-L-S NSM 10 x 1,7 mm	10	1,7	17
FRS-L-S NSM 15 x 1,4 mm	15	1,4	21
FRS-L-S NSM 20 x 1,2 mm	20	1,2	24

Types of CFRP strips FRS-L-H and FRS-L-S / FRS-L-S NSM only differ in the type of fibers used but are identical in their matrix material and fiber volume content as well as production process.

*Acc. to EN 2564
**Acc. to EN 12614

fischer C-Fiber Force Strengthening System

Product Description
Types and Geometries of CFRP strips

Annex C9

Modulus of elasticity, tensile strength and ultimate strain of CFRP strips FRS-L-H		
Essential characteristic		**Performance**
Modulus of elasticity [GPa]	E_{Li}	206; 206; 191; 199; 205; 194; 202; 195; 191; 191; 206; 201; 200; 199; 199; 209; 206; 208; 203; 205
Mean value [GPa]	$\boldsymbol{E_{Lm}}$	**201**
Tensile strength [MPa]	f_{Li}	3499; 3513; 3084; 3226; 3385; 3524; 3230; 3289; 3317; 3196; 3607; 3031; 3679; 3302; 3554; 3609; 3601; 3774; 3369; 3429
Mean value [MPa]	$\boldsymbol{f_{Lm}}$	**3411**
Characteristic value of the tensile strength [MPa]	$\boldsymbol{f_{Lk}}$	**3056**
Ultimate strain [%]	ε_{Lui}	1,80; 1,65; 1,67; 1,63; 1,64; 1,76; 1,60; 1,64; 1,86; 1,63; 1,71; 1,42; 1,76; 1,59; 1,71; 1,68; 1,70; 1,73; 1,59; 1,77
Mean value [%]	$\boldsymbol{\varepsilon_{Lum}}$	**1,68**

Please note that the values of tensile properties in **Annex C10** were determined on five separate tensile measurements from all characteristic cross sections of the type FRS-L-H.

fischer C-Fiber Force Strengthening System	**Annex C10**
Performance Modulus of elasticity, tensile strength and ultimate strain of FRS-L-H CFRP strips	

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Modulus of elasticity, tensile strength and ultimate strain of CFRP strips FRS-L-S und FRS-L-S NSM		
Essential characteristic		**Performance**
Modulus of elasticity [GPa]	E_{Li}	173; 169; 178; 170; 177; 177; 175; 167; 170; 178; 176; 178; 181; 177; 177; 175; 173; 178; 174; 170; 167; 169; 170; 170; 173; 176; 167; 163; 175; 166; 173; 173; 176; 173; 172; 171; 170; 174; 171; 169; 181; 178; 176; 177; 175; 177; 178; 174; 170; 174; 176; 178; 173; 181; 173; 173; 172; 170; 172; 174; 171; 170; 167; 176; 169; 171; 172; 170; 172; 171
Mean value [GPa]	E_{Lm}	**173**
Tensile strength [MPa]	f_{Li}	2959; 3057; 2929; 3047; 2989; 3213; 3203; 3193; 3318; 3282; 3060; 3160; 3183; 2911; 3164; 3287; 3094; 2954; 3132; 2966; 2866; 2878; 2913; 2803; 3086; 3040; 2994; 2894; 3136; 2871; 3135; 3278; 3239; 3230; 3155; 3137; 3218; 3171; 3192; 3247; 2241; 2848; 3297; 3111; 2533; 3104; 3238; 3115; 3268; 3230; 2825; 2874; 2839; 2887; 2987; 2935; 3155; 2969; 2994; 3039; 2809; 2807; 2824; 2847; 2779; 3316; 3245; 3220; 3419; 3438;
Mean value [MPa]	f_{Lm}	**3054**
Characteristic value of the tensile strength [MPa]	f_{Lk}	**2701**
Ultimate strain [%]	ε_{Lui}	1,69; 1,80; 1,66; 1,76; 1,67; 1,76; 1,70; 1,86; 1,89; 1,84; 1,72; 1,77; 1,89; 1,68; 1,73; 1,82; 1,88; 1,69; 1,75; 1,73; 1,64; 1,77; 1,94; 1,67; 1,78; 1,63; 1,70; 1,73; 1,69; 1,70; 1,75; 1,96; 1,90; 1,78; 1,72; 1,76; 1,82; 1,81; 1,69; 1,86; 1,52; 1,53; 1,81; 1,68; 1,69; 1,67; 1,75; 1,76; 1,79; 1,77; 1,65; 1,57; 1,61; 1,63; 1,85; 1,67; 1,78; 1,69; 1,68; 1,78; 1,77; 1,65; 1,68; 1,55; 1,68; 1,82; 1,88; 1,69; 1,75; 1,73; 1,77; 1,65; 1,68; 1,55; 1,68; 1,87; 1,79; 1,84; 1,92; 1,99;
Mean value [%]	ε_{Lum}	**1,74**

Please note that the values of tensile properties in **Annex C11** were determined on five separate tensile measurements from all characteristic cross sections of the type FRS-L-S and FRS-L-S NSM.

fischer C-Fiber Force Strengthening System	**Annex C11**
Performance Modulus of elasticity, tensile strength and ultimate strain of FRS-L-S & FRS-L-S NSM CFRP strips	

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Resistance of CFRP strips FRS-L-H to storage in alkaline environment (pH > 11,0) at maximum temperature for the intended use		
Essential characteristic		**Performance**
Modulus of elasticity [GPa] **Mean value [GPa]**	E_{Lai} $\boldsymbol{E_{Lam}}$	192; 196; 198; 196; 200 **196**
Ratio of modulus of elasticity after / before exposure **(R_{LEa}=E_{Lam} / E_{Lm})**	$\boldsymbol{R_{LEa}}$	**0,98**
Tensile strength [MPa] **Mean value [MPa]**	f_{Lai} $\boldsymbol{f_{Lam}}$	3135; 3016; 3021; 3243; 3200 **3123**
Ratio of tensile strength after / before exposure **(R_{Lfa}=f_{Lam} / f_{Lm})**	$\boldsymbol{R_{Lfa}}$	**0,92**
Ultimate strain [%] **Mean value [%]**	ε_{Luai} $\boldsymbol{\varepsilon_{Luam}}$	1,90; 1,48; 1,69; 1,72; 1,72 **1,70**
Ratio of ultimate strain after / before exposure **($R_{L\varepsilon ua} = \varepsilon_{Luam}/\varepsilon_{Lum}$)**	$\boldsymbol{R_{L\varepsilon ua}}$	**1,01**

Please note that the values of tensile properties in **Annex C12** were determined from five measurements of FRS-L-H CFRP strips with 1,2 mm thickness after 1800 h exposure to alkaline solution (pH > 11,0) at maximum temperature of use (40 °C).

fischer C-Fiber Force Strengthening System	**Annex C12**
Performance Resistance of FRS-L-H CFRP strips to storage in alkaline environment (pH > 11,0) at maximum temperature according to the intended use (40 °C)	

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Resistance of CFRP strips FRS-L-H to storage in alkaline environment (pH > 13,7) at maximum temperature for the intended use		
Essential characteristic		**Performance**
Modulus of elasticity [GPa] **Mean value [GPa]**	E_{Lai} $\boldsymbol{E_{Lam}}$	194; 196; 184; 192; 194; **192**
Ratio of modulus of elasticity after / before exposure **(R_{LEa}=E_{Lam} / E_{Lm})**	$\boldsymbol{R_{LEa}}$	**0,96**
Tensile strength [MPa] **Mean value [MPa]**	f_{Lai} $\boldsymbol{f_{Lam}}$	3054; 3407; 3153; 2932; 3356; **3180**
Ratio of tensile strength after / before exposure **(R_{Lfa}=f_{Lam} / f_{Lm})**	$\boldsymbol{R_{Lfa}}$	**0,93**
Ultimate strain [%] **Mean value [%]**	ε_{Luai} $\boldsymbol{\varepsilon_{Luam}}$	1,66; 1,68; 1,65; 1,53; 1,68; **1,64**
Ratio of ultimate strain after / before exposure **($R_{L\varepsilon ua} = \varepsilon_{Luam}/\varepsilon_{Lum}$)**	$\boldsymbol{R_{L\varepsilon ua}}$	**0,98**

Please note that the following values of tensile properties in **Annex C13** were determined from measurements of strips with 1,2 mm thickness after 1800 h exposure to alkaline solution (pH > 13,7) at maximum temperature of use (40 °C).

fischer C-Fiber Force Strengthening System	**Annex C13**
Performance Resistance of FRS-L-H CFRP strips to storage in alkaline environment (pH > 13,7) at maximum temperature according to the intended use (40 °C)	

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Resistance of CFRP strips FRS-L-S & FRS-L-S NSM to storage in alkaline environment (pH > 11,0) at maximum temperature for the intended use		
Essential characteristic		**Performance**
Modulus of elasticity [GPa] **Mean value [GPa]**	E_{Lai} $\boldsymbol{E_{Lam}}$	171; 168; 173; 172; 170; **171**
Ratio of modulus of elasticity after / before exposure **(R_{LEa}=E_{Lam} / E_{Lm})**	$\boldsymbol{R_{LEa}}$	**0,99**
Tensile strength [MPa] **Mean value [MPa]**	f_{Lai}, $\boldsymbol{f_{Lam}}$	3167; 3175; 3122; 3086; 3039; **3118**
Ratio of tensile strength after / before exposure **(R_{Lfa}=f_{Lam} / f_{Lm})**	$\boldsymbol{R_{Lfa}}$	**1,02**
Ultimate strain [%] **Mean value [%]**	ε_{Luai}, $\boldsymbol{\varepsilon_{Luam}}$	1,81; 1,83; 1,79; 1,73; 1,77; **1,79**
Ratio of ultimate strain after / before exposure **($R_{L\varepsilon ua} = \varepsilon_{Luam}/\varepsilon_{Lum}$)**	$\boldsymbol{R_{L\varepsilon ua}}$	**1,02**

Please note that the following values of tensile properties in **Annex C14** were determined from measurements of strips with 1,2 mm thickness after 1800 h exposure to alkaline solution (pH > 11,0) at maximum temperature of use (40 °C).

fischer C-Fiber Force Strengthening System	**Annex C14**
Performance Resistance of FRS-L-S & FRS-L-S NSM CFRP strips to storage in alkaline environment (pH > 11,0) at maximum temperature according to the intended use (40 °C)	

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Resistance of CFRP strips FRS-L-S & FRS-L-S NSM to storage in alkaline environment (pH > 13,7) at maximum temperature for the intended use		
Essential characteristic		**Performance**
Modulus of elasticity [GPa] **Mean value [GPa]**	E_{Lai} $\boldsymbol{E_{Lam}}$	170; 171; 166; 169; 172; **170**
Ratio of modulus of elasticity after / before exposure **(R_{LEa}=E_{Lam} / E_{Lm})**	$\boldsymbol{R_{LEa}}$	**0,98**
Tensile strength [MPa] **Mean value [MPa]**	f_{Lai} $\boldsymbol{f_{Lam}}$	2632; 2868; 2647; 2819; 2835; **2760**
Ratio of tensile strength after / before exposure **(R_{Lfa}=f_{Lam} / f_{Lm})**	$\boldsymbol{R_{Lfa}}$	**0,90**
Ultimate strain [%] **Mean value [%]**	ε_{Luai} $\boldsymbol{\varepsilon_{Luam}}$	1,64; 1,76; 1,67; 1,73; 1,64; **1,69**
Ratio of ultimate strain after / before exposure **($R_{L\varepsilon ua} = \varepsilon_{Luam}/\varepsilon_{Lum}$)**	$\boldsymbol{R_{L\varepsilon ua}}$	**0,97**

Please note that the following values of tensile properties in **Annex C15** were determined from measurements of strips with 1,2 mm thickness after 1800 h exposure to alkaline solution (pH > 13,7) at maximum temperature of use (40 °C).

fischer C-Fiber Force Strengthening System	**Annex C15**
Performance Resistance of FRS-L-S & FRS-L-S NSM CFRP strips to storage in alkaline environment (pH > 13,7) at maximum temperature according to the intended use (40 °C)	

Characteristics of the Bonding Agent FRS-BA	
Appearance - Component A - Component B - Mixture of A and B (9:1)	 Highly viscous paste of white colour Low viscosity, fluent liquid of black colour Medium viscosity liquid of light grey colour
Density - Component A - Component B - Mixture of A and B (9:1)	 2,12 g/cm³ ± 0,05 g/cm³ 0,99 g/cm³ ± 0,05 g/cm³ 2,01 g/cm³ ± 0,05 g/cm³
Mixing ratio by weight	9 : 1
Elastic modulus in tension*	≥ 7000 MPa
Mean value of the tensile strength**	≥ 35 MPa
Glass transition temperature***	≥ 50 °C
Minimum workability time - at minimum installation temperature (10 °C) and maximum container size (5 kg) - at standard conditions (21 °C) and maximum container size (5 kg) - at maximum installation temperature (40 °C) and maximum container size (5 kg)	 180 min. 50 min. 20 min.
Minimum curing time - at minimum installation temperature (10 °C) - at standard conditions (21 °C) - at maximum installation temperature (40 °C)	 4 days 2 days 1 day

*Acc. to EN ISO 9514.
**Acc. to EN ISO 527-1:2019, after 7 days of curing at standard conditions (21 °C, 50 % Rh).
***Acc. to EN 12614 after 7 days of curing at standard conditions (21 °C, 50 % Rh).

fischer C-Fiber Force Strengthening System

Product Description
Technical parameters and details of the bonding agent FRS-BA

Annex C16

Deutsches Institut für Bautechnik DIBt

Bond strength of specimens cured at standard environmental conditions				
Kit composition and layer structure			**Bond strength [MPa]**	**Failure mode**
Bonding agent FRS-BA, repair mortar FRS-PC 11, structural bonding agent FRS-CS, CFRP strip FRS-L-H	Single values	$f_{cti,surf}$	2,59 3,00 2,39 2,79 3,10	100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion*
	Mean value	$\boldsymbol{f_{ctm,surf}}$	**2,77**	-
	Characteristic value	$\boldsymbol{f_{ctk,surf}}$	**2,09**	-
Structural bonding agent FRS-CS, CFRP strip FRS-L-H	Single values	$f_{cti,surf}$	2,00 2,97 3,30 3,66 3,29	100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion*
	Mean value	$\boldsymbol{f_{ctm,surf}}$	**3,04**	-
	Characteristic value	$\boldsymbol{f_{ctk,surf}}$	**1,56**	-
Bonding agent FRS-BA, repair mortar FRS-PC 11, structural bonding agent FRS-CS, CFRP strip FRS-L-S	Single values	$f_{cti,surf}$	3,07 3,37 2,51 3,48 3,15	100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion*
	Mean value	$\boldsymbol{f_{ctm,surf}}$	**3,12**	-
	Characteristic value	$\boldsymbol{f_{ctk,surf}}$	**2,24**	-
Structural bonding agent FRS-CS, CFRP strip FRS-L-S	Single values	$f_{cti,surf}$	3,24 3,54 3,19 3,50 3,20	100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion*
	Mean value	$\boldsymbol{f_{ctm,surf}}$	**3,33**	-
	Characteristic value	$\boldsymbol{f_{ctk,surf}}$	**2,92**	-

Layer thicknesses:
Bonding agent for the repair mortar FRS-BA: 500-800 g/m²
Concrete repair mortar FRS-PC 11 $d_{M,max.}$: 30 mm
Structural bonding agent FRS-CS $d_{G,min.}$: 1 mm
CFRP strip FRS-L-S or FRS-L-H t_L: 1,4 mm

Curing time: 7 days — f_{cm}: 50,5 MPa ; f_{ck}: 49,0 MPa
Curing temperature: 21 °C ± 2 °C

*100 % Cohesive failure in the concrete substrate. Reference concrete strength class C50/60

fischer C-Fiber Force Strengthening System

Kit Performance
Bond strength of the C-Fiber Force Strengthening System to concrete cured at standard environmental conditions

Annex C17

Deutsches Institut für Bautechnik DIBt

Bond strength after low cycle fatigue action				
Kit composition and layer structure			**Bond strength [MPa]**	**Failure mode**
Bonding agent FRS-BA, repair mortar FRS-PC 11, structural bonding agent FRS-CS, CFRP strip FRS-L-H	Single values	$f_{\text{cti,surf,fat}}$	4,73 3,60 3,98 4,39 5,53	100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion*
	Mean value	$\boldsymbol{f_{\text{ctm,surf,fat}}}$	**4,45****	-
	Characteristic value	$\boldsymbol{f_{\text{ctk,surf,fat}}}$	**2,72**	-
($R_{\text{fat,m}} = f_{\text{ctm,surf,fat}} / f_{\text{ctm,surf}}$)	**Ratio**	$\boldsymbol{R_{\text{fat,m}}}$	**1,45**	-
Structural bonding agent FRS-CS, CFRP strip FRS-L-H	Single values	$f_{\text{cti,surf,fat}}$	5,14 4,33 5,31 4,31 4,10	100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion*
	Mean value	$\boldsymbol{f_{\text{ctm,surf,fat}}}$	**4,64****	-
	Characteristic value	$\boldsymbol{f_{\text{ctk,surf,fat}}}$	**3,37**	-
($R_{\text{fat,m}} = f_{\text{ctm,surf,fat}} / f_{\text{ctm,surf}}$)	**Ratio**	$\boldsymbol{R_{\text{fat,m}}}$	**1,51**	-

Layer thicknesses:
Bonding agent for the repair mortar FRS-BA: 500-800 g/m²
Concrete repair mortar FRS-PC 11 $d_{\text{M,max.}}$: 30 mm
Structural bonding agent FRS-CS $d_{G,\text{min.}}$: 1 mm
Curing time: 7 days f_{cm}: 50,5 MPa ; f_{ck}: 49,0 MPa
Curing temperature: 21 °C ± 2 °C
Exposure: 100,000 load cycles with an upper load of 3,32 kN (corresponds to 55 % of reference bond strength 3,07 N/mm²) and a lower load of 0,60 kN (corresponds to 10 % of reference bond strength 3,07 N/mm²)

*100 % Cohesive failure in the concrete substrate. Reference concrete according to EN 1542, class C50/60.
**Reference bond strength of the unexposed reference member: $f_{\text{ctm,surf}}$ = 3,07 MPa

fischer C-Fiber Force Strengthening System	**Annex C18**
Kit Performance Bond strength of the C-Fiber Force Strengthening System to concrete after low cycle fatigue action	

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Bond strength of specimens cured at minimum temperature of installation				
Kit composition and layer structure			**Bond strength [MPa]**	**Failure mode**
Bonding agent FRS-BA, repair mortar FRS-PC 11, structural bonding agent FRS-CS, CFRP strip FRS-L-H	Single values	$f_{\mathrm{cti,surf,T_{min}}}$	3,12 2,30 3,41 2,75 3,74	100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion*
	Mean value	$\boldsymbol{f_{\mathrm{ctm,surf,T_{min}}}}$	**3,06**	-
	Characteristic value	$\boldsymbol{f_{\mathrm{ctk,surf,T_{min}}}}$	**1,75**	-
$(R_{\mathrm{T_{min,m}}} = f_{\mathrm{ctm,surf,T_{min}}} / f_{\mathrm{ctm,surf}})$	**Ratio**	$\boldsymbol{R_{\mathrm{T_{min,m}}}}$	**1,01**	-
Structural bonding agent FRS-CS, CFRP strip FRS-L-H	Single values	$\boldsymbol{f_{\mathrm{cti,surf,T_{min}}}}$	3,55 3,04 3,55 3,95 3,66	100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion*
	Mean value	$\boldsymbol{f_{\mathrm{ctm,surf,,T_{min}}}}$	**3,55**	-
	Characteristic value	$\boldsymbol{f_{\mathrm{ctk,surf,T_{min}}}}$	**2,78**	-
$(R_{\mathrm{T_{min,m}}} = f_{\mathrm{ctm,surf,T_{min}}} / f_{\mathrm{ctm,surf}})$	**Ratio**	$\boldsymbol{R_{\mathrm{T_{min,m}}}}$	**1,07**	-
Bonding agent FRS-BA, repair mortar FRS-PC 11, structural bonding agent FRS-CS, CFRP strip FRS-L-S	Single values	$f_{\mathrm{cti,surf,T_{min}}}$	3,38 3,67 3,17 3,49 3,59	100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion*
	Mean value	$\boldsymbol{f_{\mathrm{ctm,surf,T_{min}}}}$	**3,46**	-
	Characteristic value	$\boldsymbol{f_{\mathrm{ctk,surf,T_{min}}}}$	**3,0**	-
$(R_{\mathrm{T_{min,m}}} = f_{\mathrm{ctm,surf,T_{min}}} / f_{\mathrm{ctm,surf}})$	**Ratio**	$\boldsymbol{R_{\mathrm{T_{min,m}}}}$	**1,25**	-
Structural bonding agent FRS-CS, CFRP strip FRS-L-S	Single values	$f_{\mathrm{cti,surf,T_{min}}}$	3,70 3,58 3,78 3,78 3,68	100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion* 100% Cohesion*
	Mean value	$\boldsymbol{f_{\mathrm{ctm,surf,T_{min}}}}$	**3,71**	-
	Characteristic value	$\boldsymbol{f_{\mathrm{ctk,surf,T_{min}}}}$	**3,51**	-
$(R_{\mathrm{T_{min,m}}} = f_{\mathrm{ctm,surf,T_{min}}} / f_{\mathrm{ctm,surf}})$	**Ratio**	$\boldsymbol{R_{\mathrm{T_{min,m}}}}$	**1,19**	-

Layer thicknesses:

Bonding agent for the repair mortar FRS-BA:	500-800 g/m²
Concrete repair mortar FRS-PC 11 $d_{\mathrm{M,max.}}$:	30 mm
Structural bonding agent FRS-CS $d_{G,\mathrm{min.}}$:	1 mm
CFRP strip FRS-L-S or FRS-L-H t_{L}:	1,4 mm

Curing time: 7 days — f_{cm}: 50,5 MPa ; f_{ck}: 49,0 MPa

Curing temperature: 10 °C ± 2 °C

*100 % Cohesive failure in the concrete substrate. Reference concrete according to EN 1542, class C50/60

fischer C-Fiber Force Strengthening System

Annex C19

Kit Performance
Bond strength of the C-Fiber Force Strengthening System to concrete cured at minimum installation temperature depending on the curing time

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Shear resistance of the anchorage of CFRP strips externally bonded to concrete (without repair mortar)

Type of the strip	Conc. comp. strength [MPa]	Conc. surf. tensile strength [MPa]	Ultimate anchorage load [kN]			Failure mode
FRS-L-H	C12/15 f_{cm}: 18,6 f_{ck}: 14,1	$f_{ctim,surf}$: 1,47 $f_{ctik,surf}$: 0,64	Single values	F_{bLi}	84,17 87,82	100% Cohesion* 100% Cohesion*
		$f_{ctim,surf}$: 1,59 $f_{ctik,surf}$: 1,30			80,23 104,62	100% Cohesion* 100% Cohesion*
		-	**Mean value**	$\boldsymbol{F_{bLm}}$	**89,21**	-
		-	**Characteristic value**	$\boldsymbol{F_{bLk}}$	**61,00**	-
FRS-L-H	C30/37 f_{cm}: 33,2 f_{ck}: 29,7	$f_{ctim,surf}$: 2,25 $f_{ctik,surf}$: 0,85	Single values	F_{bLi}	116,75 127,06	100% Cohesion* 100% Cohesion*
		$f_{ctim,surf}$: 1,81 $f_{ctik,surf}$: -**			93,95 104,57	100% Cohesion* 100% Cohesion*
		-	**Mean value**	$\boldsymbol{F_{bLm}}$	**110,58**	-
		-	**Characteristic value**	$\boldsymbol{F_{bLk}}$	**72,71**	-
FRS-L-H	C50/60 f_{cm}: 47.6 f_{ck}: 42,3	$f_{ctim,surf}$: 4,04 $f_{ctik,surf}$: 3,45	Single values	F_{bLi}	121,19 144,15	100% Cohesion* 100% Cohesion*
		$f_{ctim,surf}$: 2,10 $f_{ctik,surf}$: 1,47			119,59 118,37	100% Cohesion* 100% Cohesion*
		-	**Mean value**	$\boldsymbol{F_{bLm}}$	**125,83**	-
		-	**Characteristic value**	$\boldsymbol{F_{bLk}}$	**93,56**	-
FRS-L-S	C12/15 f_{cm}: 18,6 f_{ck}: 14,1	$f_{ctim,surf}$: 2,26 $f_{ctik,surf}$: 1,12	Single values	F_{bLi}	83,11 92,37	100% Cohesion* 100% Cohesion*
		$f_{ctim,surf}$: 1,10 $f_{ctik,surf}$: -**			85,95 92,35	100% Cohesion* 100% Cohesion*
		-	**Mean value**	$\boldsymbol{F_{bLm}}$	**88,45**	-
		-	**Characteristic value**	$\boldsymbol{F_{bLk}}$	**76,17**	-
FRS-L-S	C30/37 f_{cm}: 33,2 f_{ck}: 29,7	$f_{ctim,surf}$: 2,45 $f_{ctik,surf}$: 0,85	Single values	F_{bLi}	109,49 134,98	100% Cohesion* 100% Cohesion*
		$f_{ctim,surf}$: 2,10 $f_{ctik,surf}$: 1,10			102,60 111,04	100% Cohesion* 100% Cohesion*
		-	**Mean value**	$\boldsymbol{F_{bLm}}$	**114,53**	-
		-	**Characteristic value**	$\boldsymbol{F_{bLk}}$	**77,39**	-
FRS-L-S	C50/60 f_{cm}: 47.6 f_{ck}: 42,3	$f_{ctim,surf}$: 3,80 $f_{ctik,surf}$: 2,69	Single values	F_{bLi}	112,53 119,29	100% Cohesion* 100% Cohesion*
		$f_{ctim.surf}$: 2,57 $f_{ctik,surf}$: 1,31			105,01 106,34	100% Cohesion* 100% Cohesion*
		-	**Mean value**	$\boldsymbol{F_{bLm}}$	**110,79**	-
		-	**Characteristic value**	$\boldsymbol{F_{bLk}}$	**93,58**	-

Bond length l_v of CFRP strip:	1000 mm
Layer thickness of the structural bonding agent FRS-CS $d_{G,min.}$:	1 mm
Thickness of CFRP strips FRS-L-S or FRS-L-H t_L:	1,4 mm
Width of the CFRP strip b_L:	100 mm

fischer C-Fiber Force Strengthening System

Kit Performance
Shear resistance of the anchorage of FRS-L-H and FRS-L-S CFRP strips externally bonded to concrete (without repair mortar)

Annex C20

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Shear resistance of the anchorage of CFRP strips externally bonded to concrete (without repair mortar)

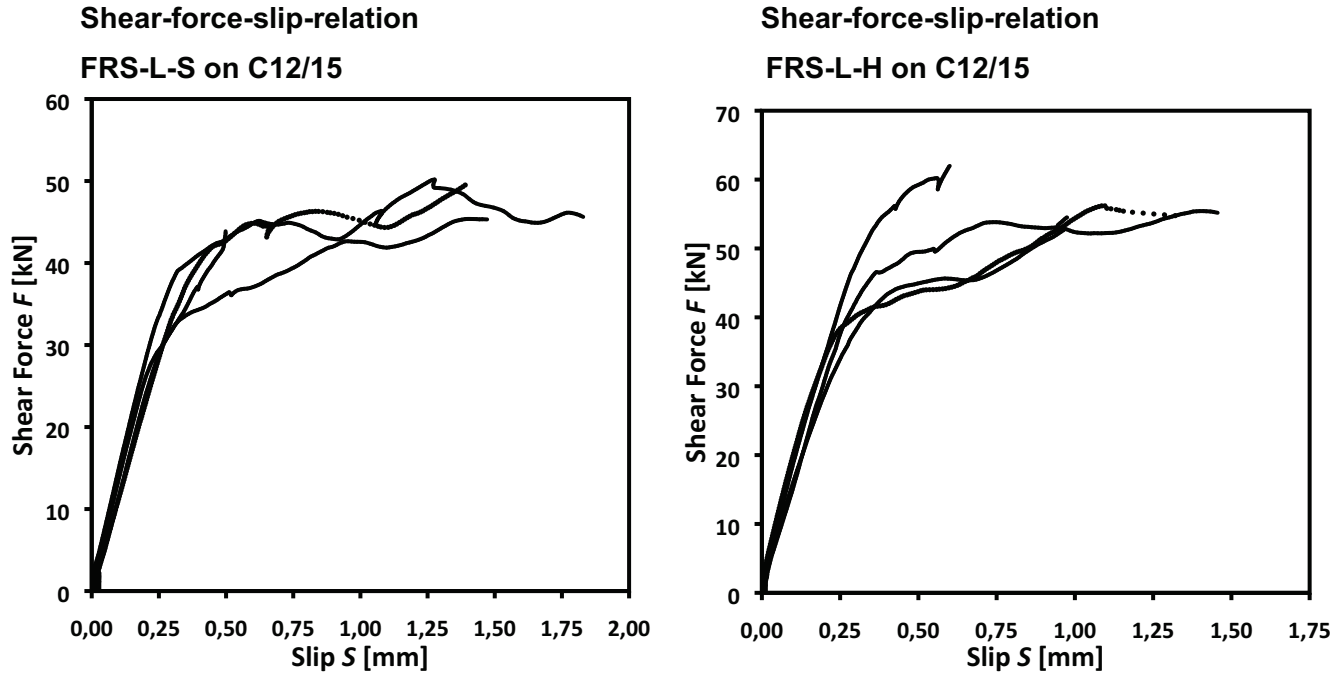


Figure C21.1: Shear force-slip curves of shear resistance measurements of the anchorage of FRS-L-S and FRS-L-H CFRP strips externally bonded to concrete of class C12/15.

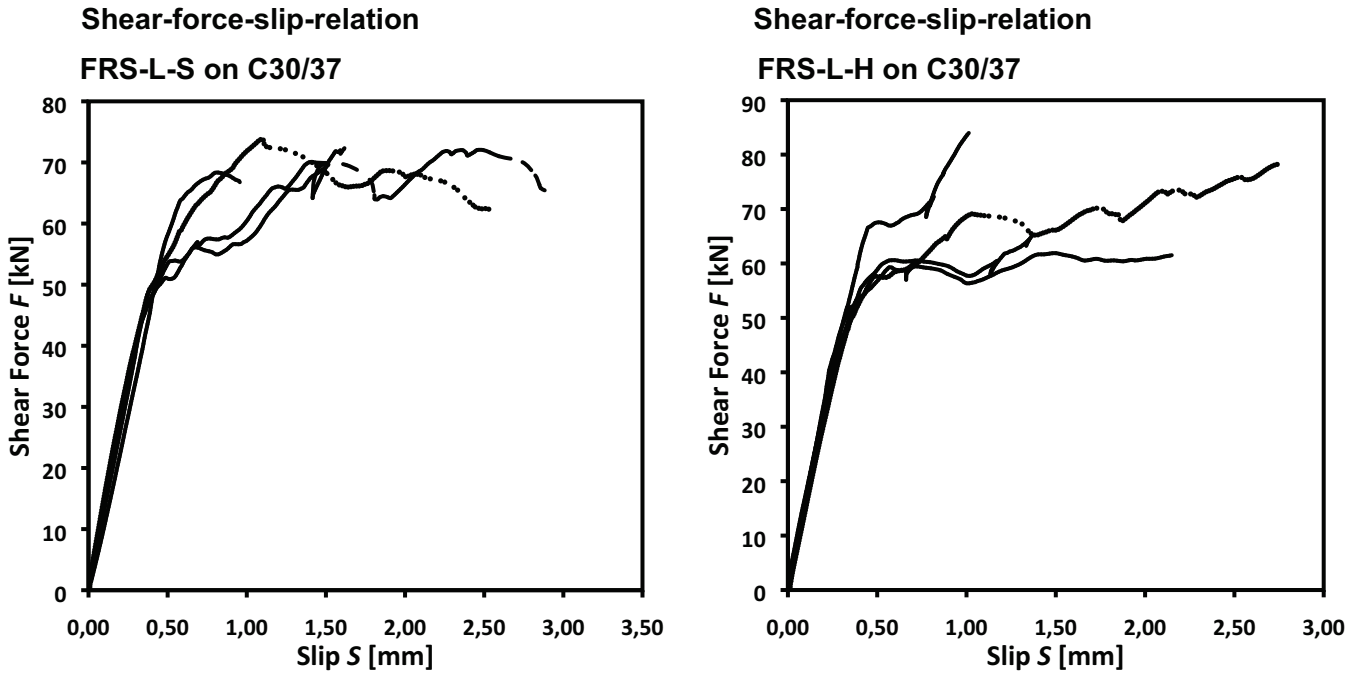


Figure C21.2: Shear-force-slip curves of shear resistance measurements of the anchorage of FRS-L-S and FRS-L-H CFRP strips externally bonded to concrete of class C30/37.

fischer C-Fiber Force Strengthening System	**Annex C21**
Kit Performance Shear resistance of the anchorage of FRS-L-H and FRS-L-S CFRP strips externally bonded to concrete (without repair mortar)	

Shear resistance of the anchorage of CFRP strips externally bonded to concrete (without repair mortar)

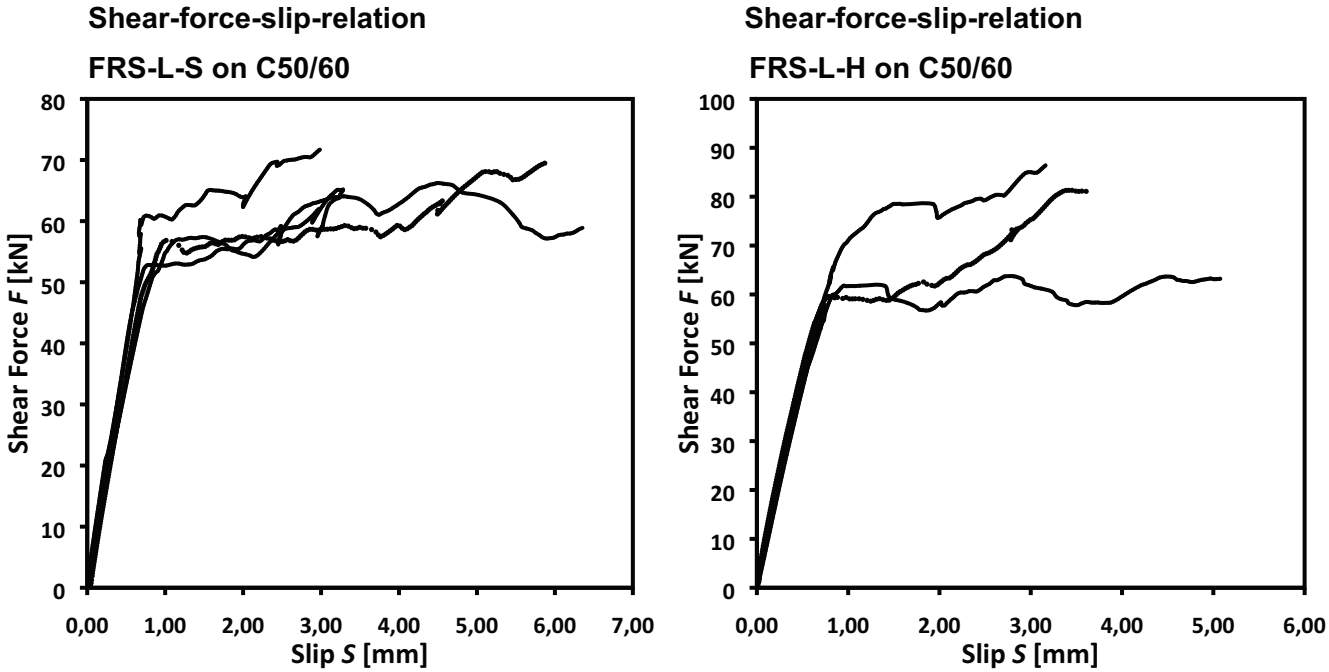


Figure C22: Shear-force-slip curves of shear resistance measurements of the anchorage of FRS-L-S and FRS-L-H CFRP strips externally bonded to concrete of class C50/60.

fischer C-Fiber Force Strengthening System	**Annex C22**
Kit Performance Shear resistance of the anchorage of FRS-L-H and FRS-L-S CFRP strips externally bonded to concrete (without repair mortar)	

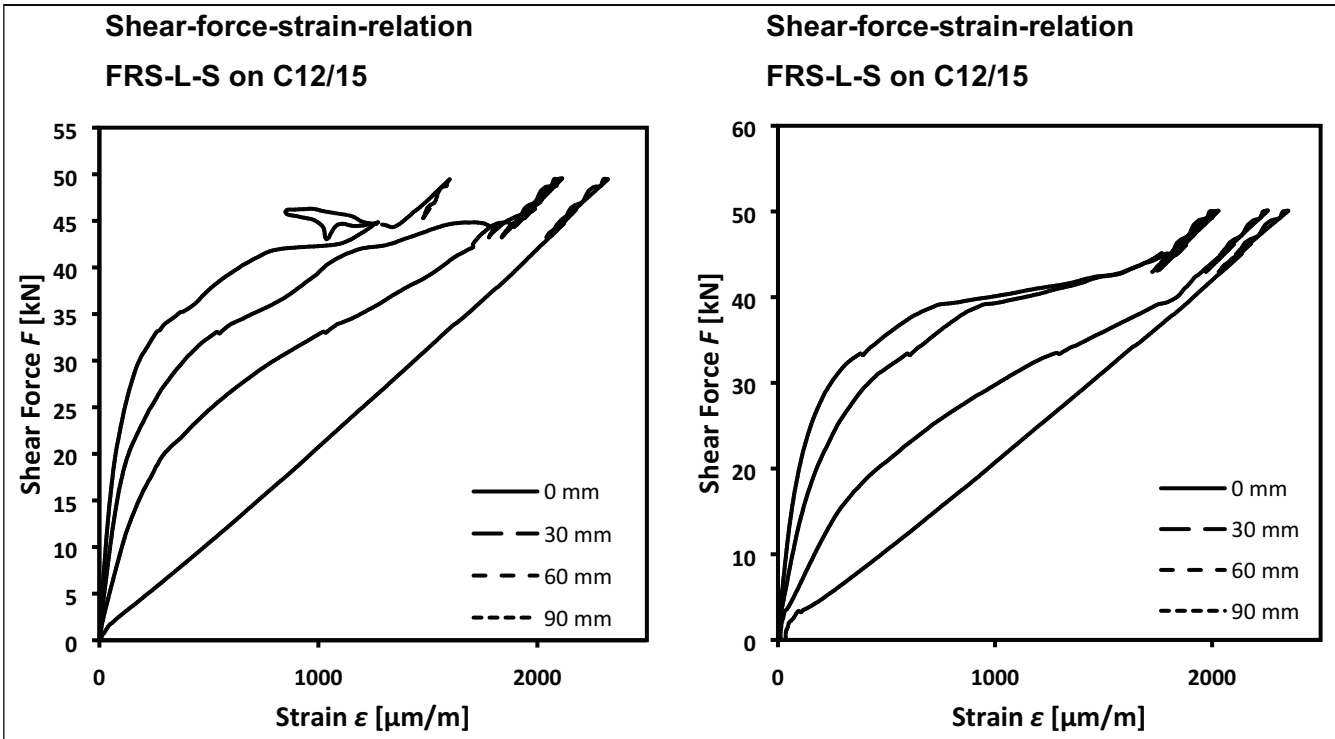


Figure C23.1: Shear-force-strain curves of shear resistance measurements of the anchorage of FRS-L-S CFRP strips externally bonded to concrete of class C12/15 along the bond length. Strain measurement at 0, 30, 60, 90 mm distances from the beginning of the bonded area.

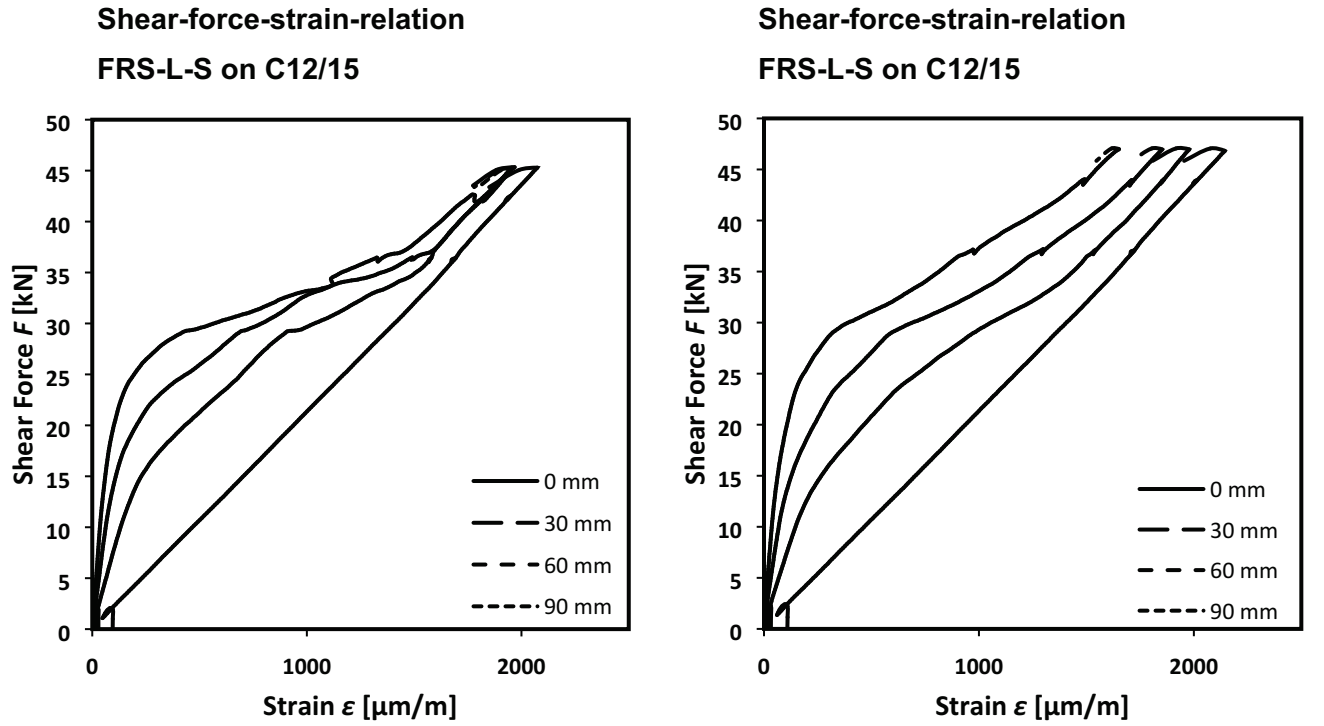
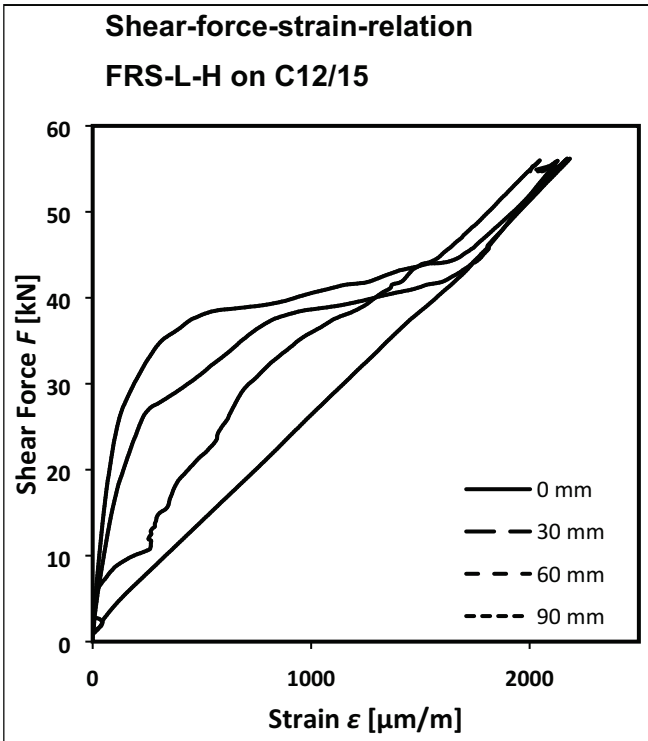


Figure C23.2: Shear-force-Strain curves of shear resistance measurements of the anchorage of FRS-L-S CFRP strips externally bonded to concrete of class C12/15 along the bond length. Strain measurement at 0, 30, 60, 90 mm distances from the load application point.

fischer C-Fiber Force Strengthening System	**Annex C23**
Kit Performance Shear resistance of the anchorage of FRS-L-S CFRP strips externally bonded to concrete (without repair mortar). Evaluation of the strains along the load application zone.	



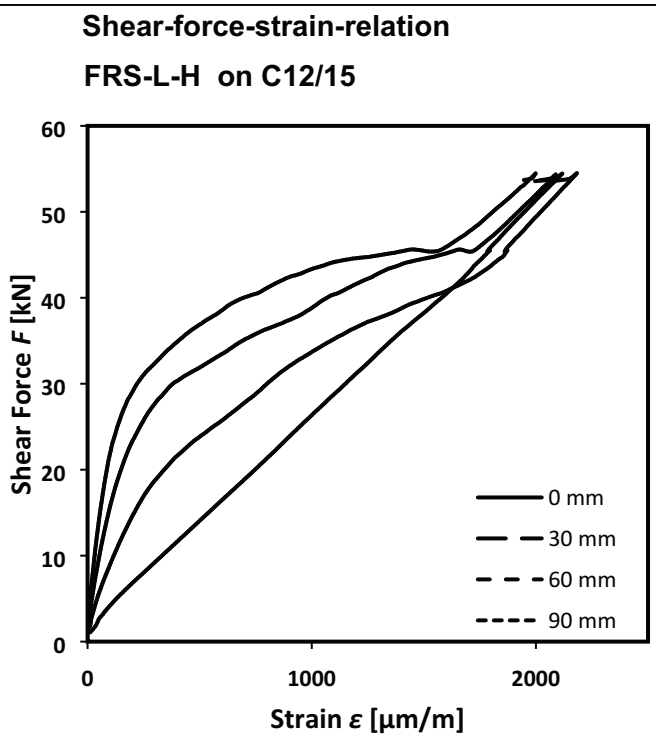
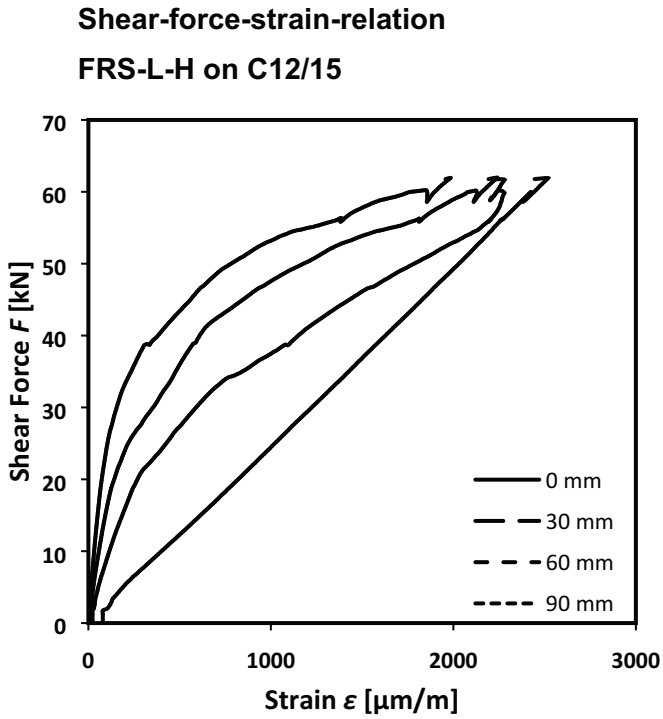


Figure C24.1: Shear-force-strain curves of shear resistance measurements of the anchorage of FRS-L-H CFRP strips externally bonded to concrete of class C12/15 along the bond length. Strain measurement at 0, 30, 60, 90 mm distances from the load application point.



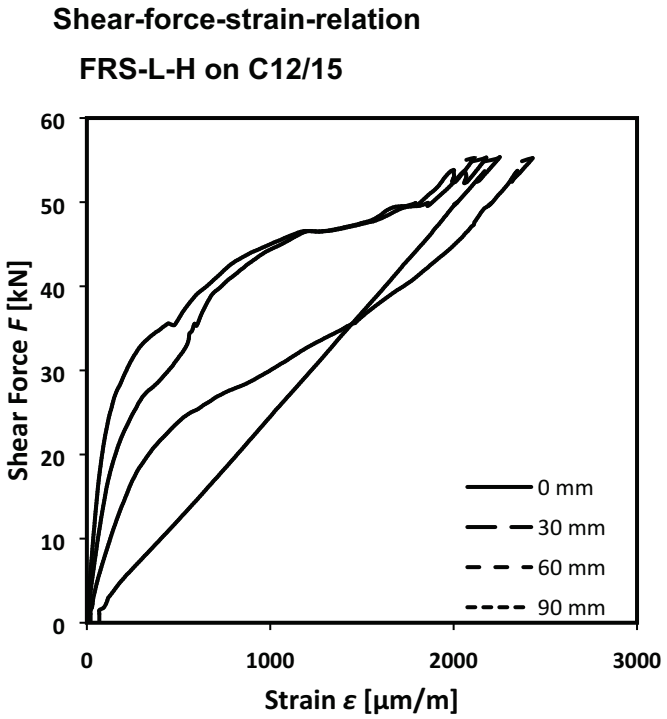


Figure C24.2: Shear-force-strain curves of shear resistance measurements of the anchorage of FRS-L-H CFRP strips externally bonded to concrete of class C12/15 along the bond length. Strain measurement at 0, 30, 60, 90 mm distances from the load application point.

fischer C-Fiber Force Strengthening System	**Annex C24**
Kit Performance Shear resistance of the anchorage of FRS-L-H CFRP strips externally bonded to concrete (without repair mortar). Evaluation of the strains along the load application zone.	

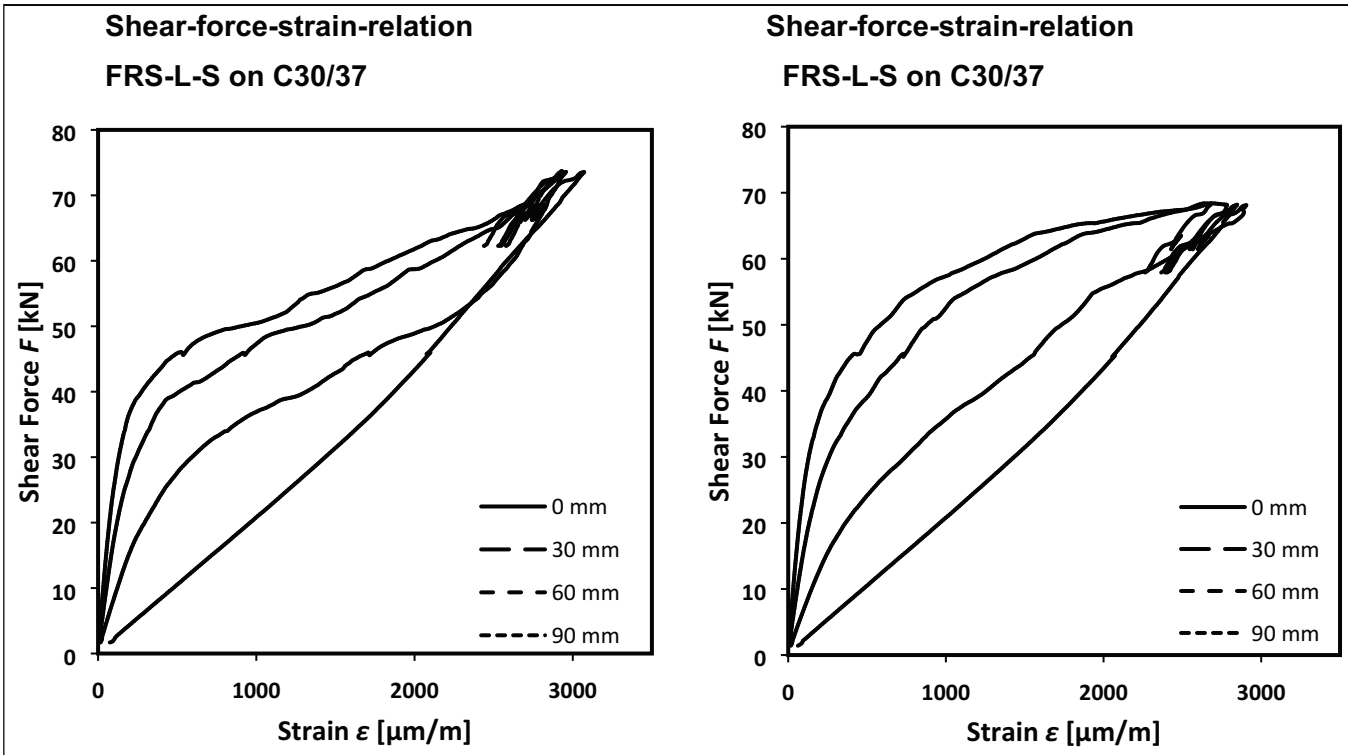


Figure C25.1: Shear-force-strain curves of shear resistance measurements of the anchorage of FRS-L-S CFRP strips externally bonded to concrete of class C30/37 along the bond length. Strain measurement at 0, 30, 60, 90 mm distances from the load application point.

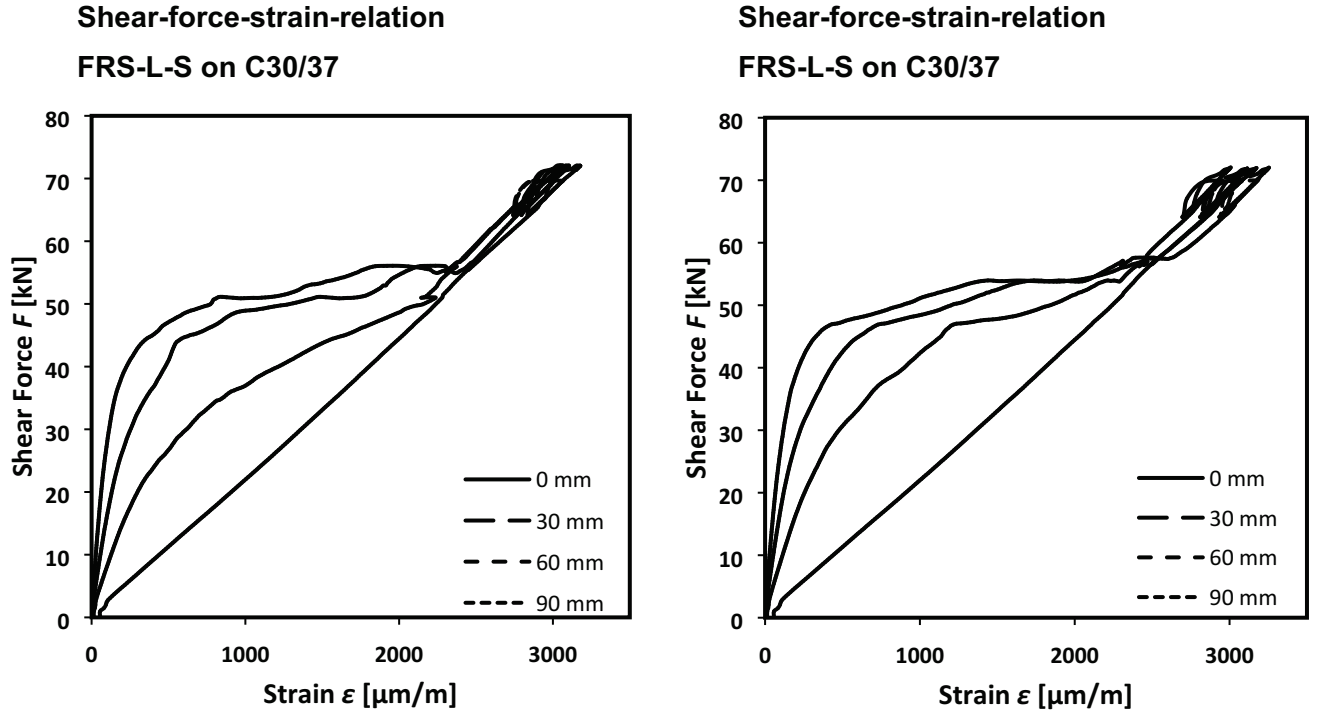


Figure C25.2: Shear-force-strain of shear resistance measurements of the anchorage of FRS-L-S CFRP strips externally bonded to concrete of class C30/37 along the bond length. Strain measurement at 0, 30, 60, 90 mm distances from the load application point.

fischer C-Fiber Force Strengthening System	**Annex C25**
Kit Performance Shear resistance of the anchorage of FRS-L-S CFRP strips externally bonded to concrete (without repair mortar). Evaluation of the strains along the load application zone	

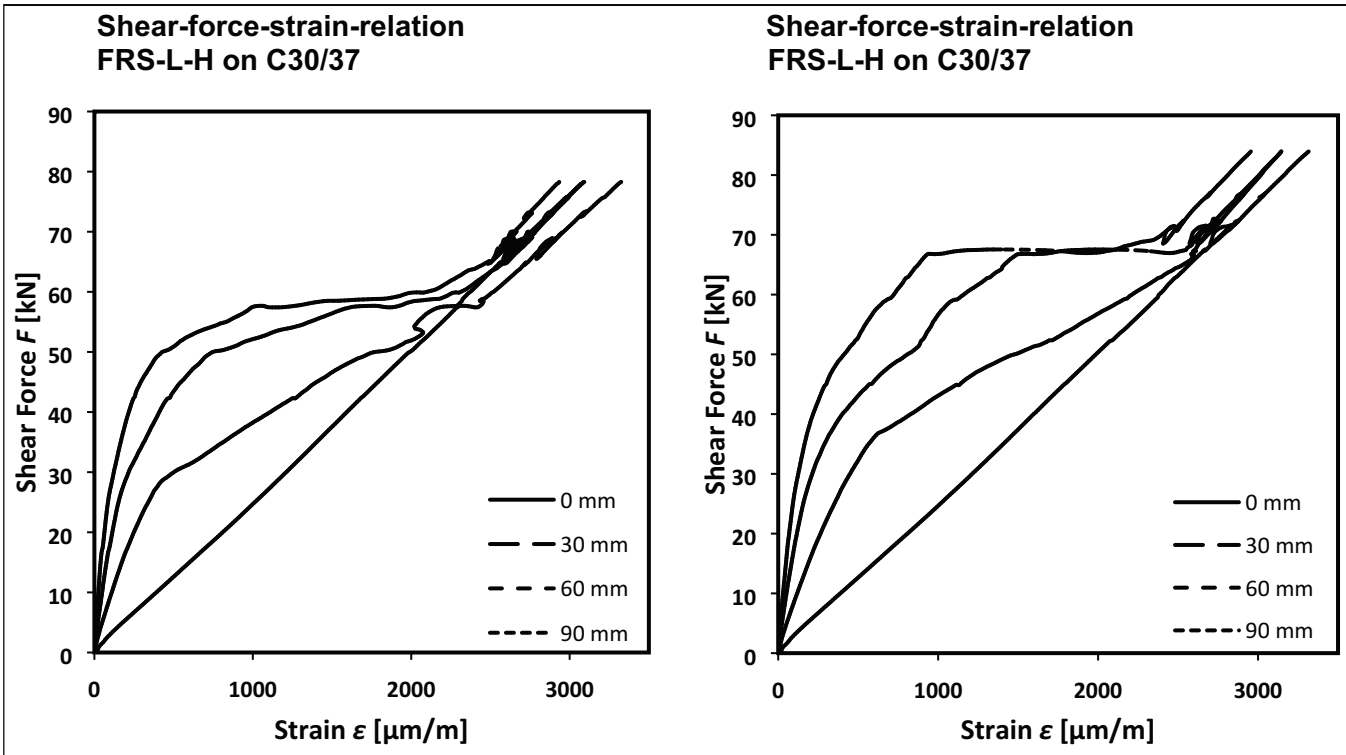


Figure C26.1: Shear-force-strain curves of shear resistance measurements of the anchorage of FRS-L-H CFRP strips externally bonded to concrete of class C30/37 along the bond length. Strain measurement at 0, 30, 60, 90 mm distances from the load application point.

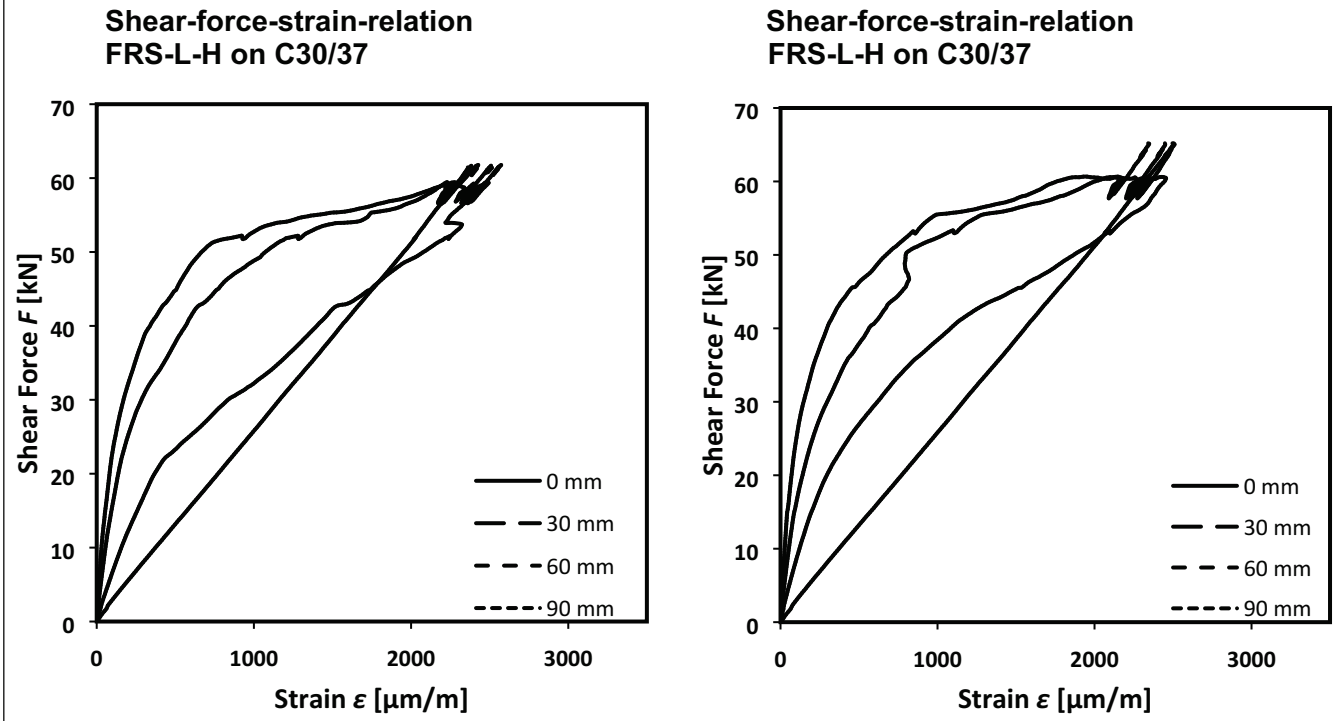


Figure C26.2: Shear-force-strain curves of shear resistance measurements of the anchorage of FRS-L-H CFRP strips externally bonded to concrete of class C30/37 along the bond length. Strain measurement at 0, 30, 60, 90 mm distances from the load application point.

fischer C-Fiber Force Strengthening System	**Annex C26**
Kit Performance Shear resistance of the anchorage of FRS-L-H CFRP strips externally bonded to concrete (without repair mortar). Evaluation of the strains along the load application zone	

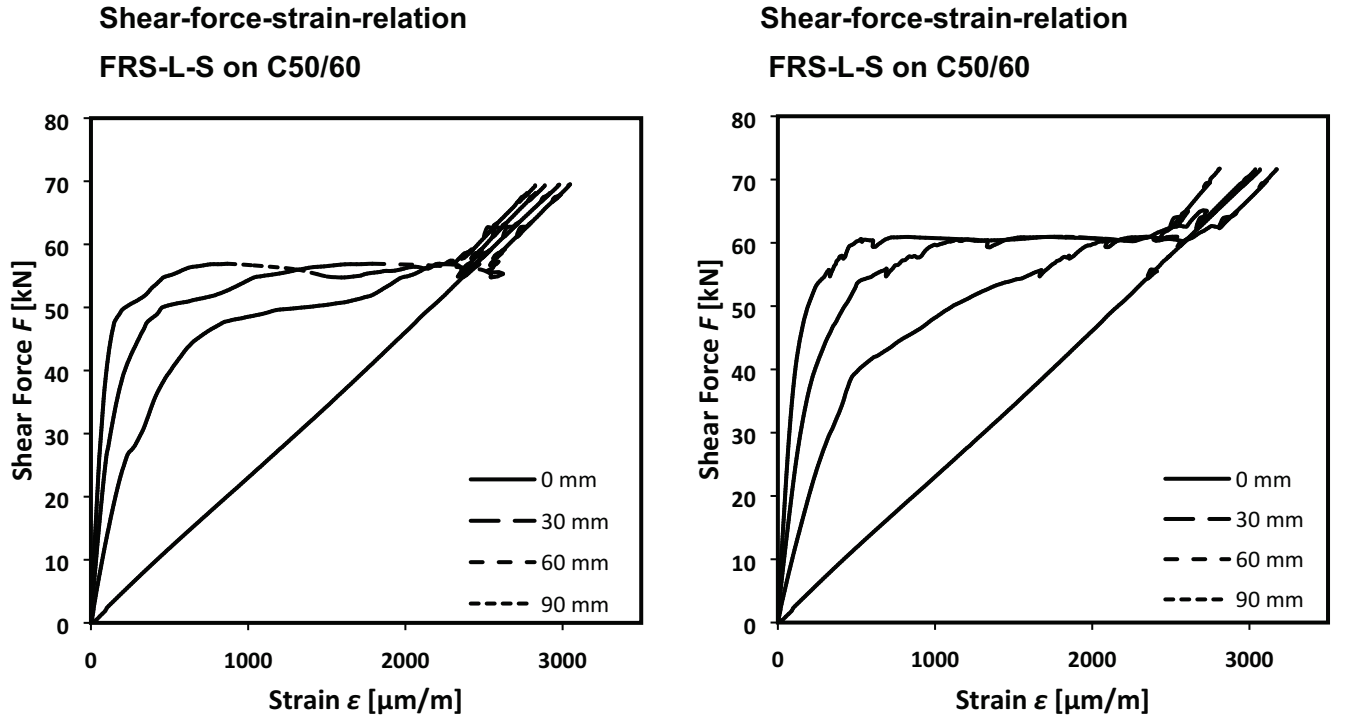


Figure C27.1: Shear-force-strain curves of shear resistance measurements of the anchorage of FRS-L-S CFRP strips externally bonded to concrete of class C50/60 along the bond length. Strain measurement at 0, 30, 60, 90 mm distances from the load application point.

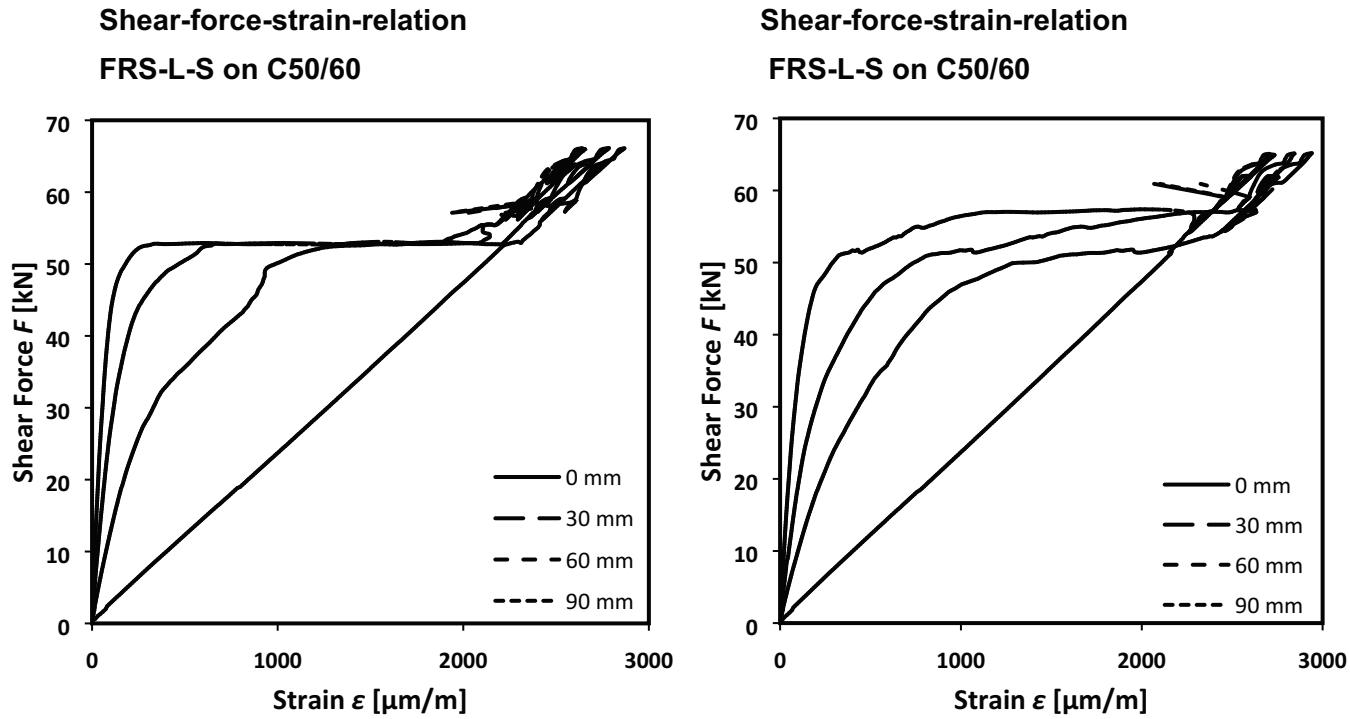


Figure C27.2: Shear-force-strain curves of shear resistance measurements of the anchorage of FRS-L-S CFRP strips externally bonded to concrete of class C50/60 along the bond length. Strain measurement at 0, 30, 60, 90 mm distances from the load application point.

fischer C-Fiber Force Strengthening System	**Annex C27**
Kit Performance Shear resistance of the anchorage of FRS-L-S CFRP strips externally bonded to concrete (without repair mortar). Evaluation of the strains along the load application zone	

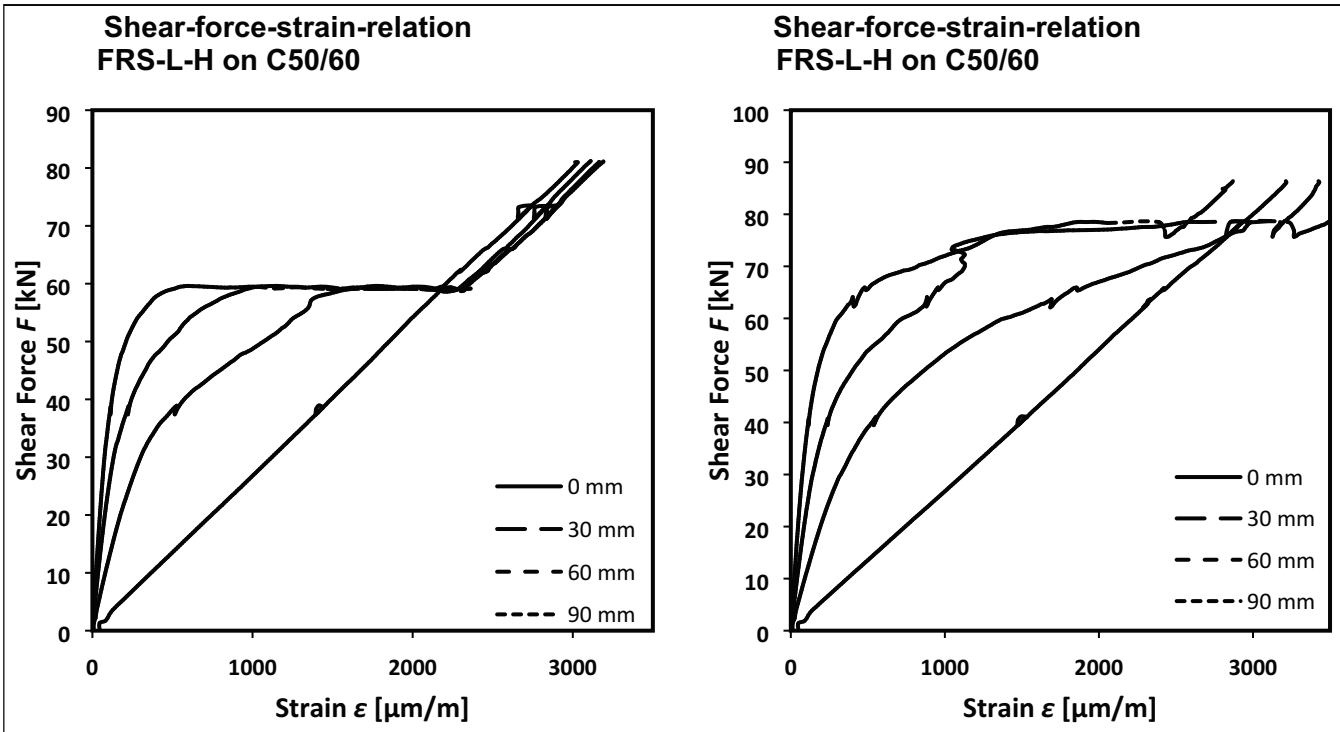


Figure C28.1: Shear-force-strain curves of shear resistance measurements of the anchorage of FRS-L-H CFRP strips externally bonded to concrete of class C50/60 along the bond length. Strain measurement at 0, 30, 60, 90 mm distances from the load application point.

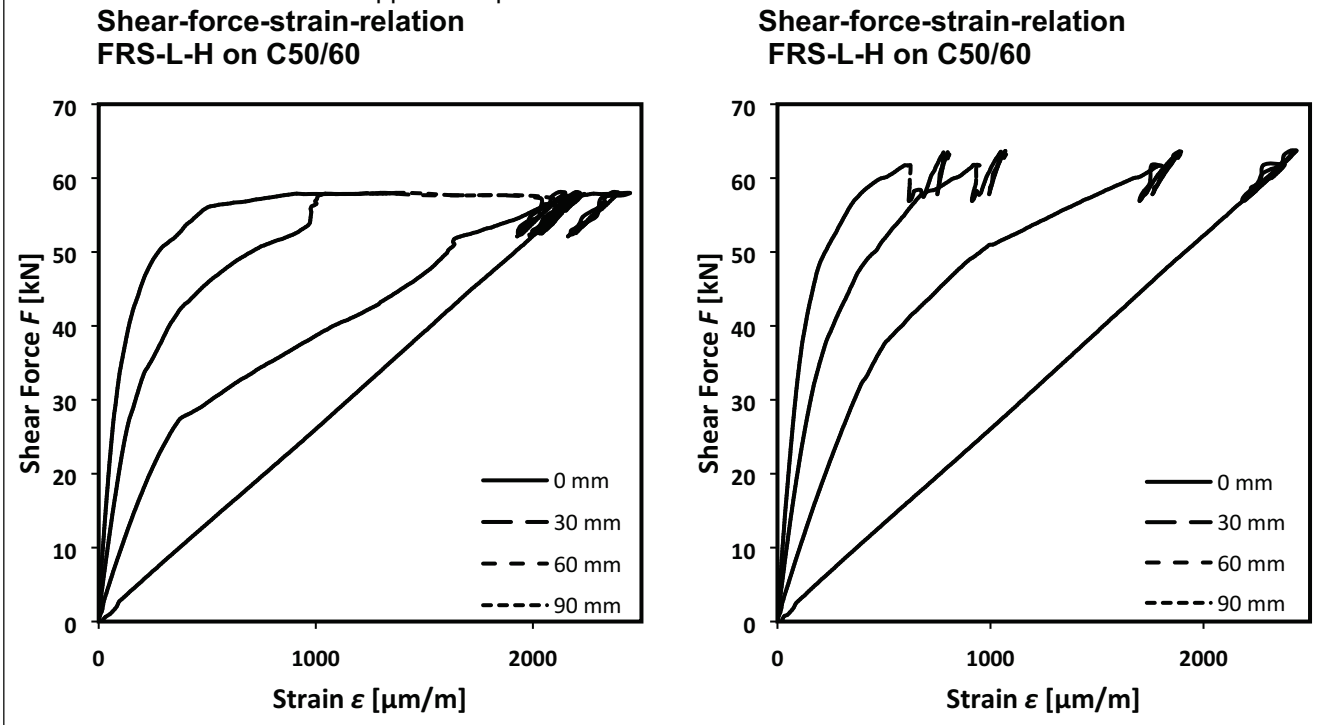


Figure C28.2: Shear-force-strain curves of shear resistance measurements of the anchorage of FRS-L-H CFRP strips externally bonded to concrete of class C50/60 along the bond length. Strain measurement at 0, 30, 60, 90 mm distances from the load application point.

fischer C-Fiber Force Strengthening System	**Annex C28**
Kit Performance Shear resistance of the anchorage of FRS-L-S CFRP strips externally bonded to concrete (without repair mortar). Evaluation of the strains along the load application zone	

Deutsches Institut für Bautechnik DIBt

Ultimate anchorage load of near surface mounted CFRP strips

Concrete grade	Bond length l_{bl} [mm]	Edge distance a_r [mm]	Ultimate load [kN]					Type of Fracture
C12/15	300	30	Single values	Test No.	4.1**	F_{bLi}	19,28	A*
					4.2		18,05	B, A*
					4.3		20,16	B, A*
			Mean value			F_{bLm}	**19,16**	
			Characteristic value			F_{bLk}	**15,60**	
C12/15	300	150	Single values	Test No.	5.1	F_{bLi}	29,43	B*
					5.2**		30,51	B*
					5.3		24,17	B*
			Mean value			F_{bLm}	**28,04**	-
			Characteristic value			F_{bLk}	**16,61**	-
C50/60	100	150	Single values	Test No.	2.1	F_{bLi}	24,69	B*
					2.2		23,16	B*
					2.3**		28,59	B*
			Mean value			F_{bLm}	**25,48**	-
			Characteristic value			F_{bLk}	**16,04**	-
C50/60	300	30	Single values	Test No.	3.1	F_{bLi}	26,00	B, L*
					3.2		30,82	B, L*
					3.3		29,85	B, L*
			Mean value			F_{bLm}	**28,89**	-
			Characteristic value			F_{bLk}	**20,31**	-
C50/60	300	150	Single values	Test No.	1.1	F_{bLi}	25,34	B*
					1.2**		28,81	B*
					1.3**		35,00	B*
			Mean value			F_{bLm}	**29,72**	-
			Characteristic value			F_{bLk}	**13,23**	-

Concrete strength:
f_{cm}: 20,3 MPa; f_{ck}: 19,0 MPa (C12/15)
f_{cm}: 48,1 MPa; f_{ck}: 46,8 MPa (C50/60)

Installation parameters:
Width of the slot b_s: 3.7 - 4,2 mm
Depth of the slots t_s: 13 mm
21 °C, 50 Rh, cured for 7 days

Type and geometry of the CFRP strips:
FRS-L-S NSM 10 x 1,7 mm

Characteristics of the CFRP strips and structural bonding agent:
FRS-L-S NSM: E_{Lm}: 173 GPa ; f_{Lm}: 3054 MPa; W_{fi}: 77,4 %
FRS-CS: f_{Gflm}: 31,6 MPa ; f_{Gflk}: 24,0 MPa
f_{Gcm}: 89,4 MPa ; f_{Gck}: 87,0 MPa
*Type of failure: A ≙ Cohesive failure in the concrete substrate;
B ≙ Cohesive failure in the adhesive;
L ≙ Tensile failure of the CFRP strip

** Recalculation of the slip from the fiber optic strain measurement not possible

fischer C-Fiber Force Strengthening System

Performance
Ultimate anchorage load of near surface mounted FRS-L-S NSM CFRP strips

Annex C29