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Non-metallic reinforcements for static load-bearing applications

Technical Information

06/2025

DIBt Zulassung
Allgemeine bauaufsichtliche Zulassung (abZ) vom Deutschen Institut für Bautechnik

ift ROSENHEIM EPD
EPD-SGR-65.0
www.ift-epd.de

Important notes on the use of this technical information

This Technical Information applies exclusively to Germany. Country-specific standards, directives etc. are taken into account for all products described. If the products are used in other countries, the respective country-specific Technical Information must be applied.

The non-metallic construction products listed in this information, which have a certificate of verification and applicability in the sense of a National technical approval (abZ) and General construction technique permit (aBG) with the notification number Z-1.6-308 (solidian abZ/aBG Z-1.6-308, 2024), may be used in components that have been designed in accordance with Part 1 of the DAfStb guideline "Concrete components with non-metallic reinforcement" (DAfStb Guideline, 2024). For other non-metallic construction products shown, a design based on Part 1 (DAfStb Guideline, 2024) of the is also possible, but this may require project-related approval in individual cases (ZiE). Missing product characteristics that are required for use in accordance with (DAfStb Guideline, 2024) must be determined by additional tests.

The current Technical Information, which is available in the download area of our website www.solidian-kelteks.com, must always be used..

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„Rusty buildings should be my future? No, thank you!"

We see it the same way! That's why we are happy to advise you on structural and design issues relating to fiber composite reinforcements. We develop proposals for dimensioning and support you with our commitment, our reliability and our expertise. Please do not hesitate to send us your planning documents (e.g. floor plans, sections, structural data).

Sales Germany
(Zip code area 0-4, 58-59)

Ole Wolfframm
M +49 151 44681013
info@solidian.com

Sales Germany
(Zip code area 50-57, 6-9), Austria, Switzerland

Johann Pfaff
M +49 170 7631543
info@solidian.com

Technical Support

Sebastian Sauter
M +49 160 8454219
info@solidian.com

Technical information, product data sheets, approval documents, etc.

www.solidian-kelteks.com

Tender texts

www.ausschreiben.de

Content

Carbon concrete

In the almost 150-year history of reinforced concrete construction, reinforced concrete has established itself as a material. Concrete in combination with steel is used worldwide for the construction of buildings. However, despite the strengths of this material combination in terms of load-bearing behavior, its weaknesses in terms of durability are obvious. Although not every structure rusts visibly, reinforcement corrosion, caused by concrete carbonation and the penetration of chlorides into the concrete, is the most common cause of damage in reinforced concrete structures. Corrosion often begins during construction due to improper planning and execution. Over the course of a structure's service life, wear and tear leads to further deterioration. Without regular maintenance measures, the service life of a structure is considerably shortened.

Figure 2: Consequences of reinforcement corrosion

But how can this be changed?

Professional and proper planning and execution are essential for the longevity of a building. Equally important is sustainable care and maintenance to keep life cycle costs low. But what if we could eliminate the weak points of reinforced concrete before this combination of materials is even used?

Carbon reinforced concrete is not the only solution for reducing damage to buildings, but it does offer a decisive opportunity: the elimination of the corrosion problem (surface and chloride corrosion). Because where no steel is used, no corrosion can occur.

If you are aware of this main argument for carbon concrete, further advantages of fiber-reinforced plastics as a reinforcement solution become clear:

Sustainability in construction: Promote sustainable building with a material that reduces the environmental footprint of your projects and supports forward-thinking construction methods.

Durability and reliability: Invest in a corrosion-free material that will remain durable for decades. This reduces maintenance and repair costs and ensures that your property retains its value in the long term.

Reduced construction costs: The low dead weight and elimination of the concrete cover significantly reduce manufacturing and transportation costs, enabling more economical construction and increasing the profitability of your projects.

Increased profit: Slimmer components create additional usable space that you can rent or sell profitably, increasing the economic value of your property.

Maximum design freedom: Fiber composites offer exceptional design flexibility, so even the most ambitious architectural visions can be realized without compromising on component thickness.

Figure 1: Comparison between the construction types (same span, same load-bearing capacity)

We would be happy to present the advantages of our reinforcement solutions to you in a personal meeting and develop the ideal solution for your project together.

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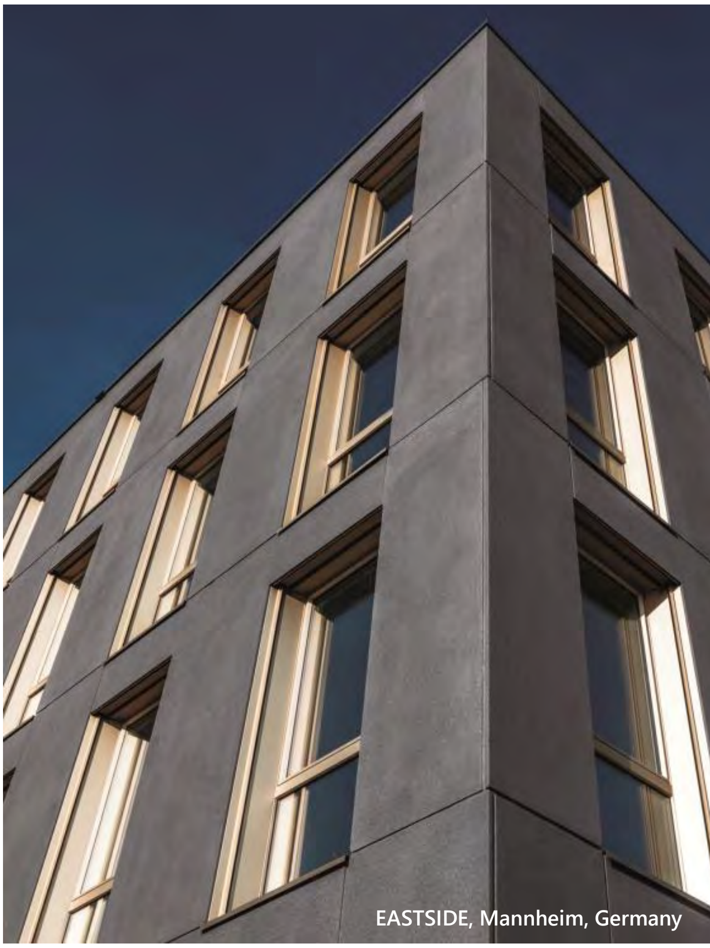
Non-metallic reinforcement

The non-metallic reinforcements from solidian consist of media-resistant fiber-reinforced plastics (FRP). Instead of short fibers, which are often mixed into the concrete as an additive, continuous fibers are used, which are embedded as bundled filaments (rovings) in a specified plastic matrix to ensure specific properties for use as reinforcement. In contrast to short fibers, which are distributed non-directionally in the fiber concrete matrix, solidian's fiber-reinforced plastics have clearly direction-dependent strength and stiffness properties. solidian processes carbon and glass fibers into load-bearing, non-metallic reinforcements.

Carbon fiber composite plastic (CFRP) in particular is characterized by its outstanding performance properties and is known as a high-performance material. It is widely used in vehicle construction, aerospace, wind turbines and now specifically in the construction industry.

The advantages of fiber-reinforced plastics as reinforcement for structural components compared to conventional reinforcing steel are obvious - see for yourself!


EASTSIDE, Mannheim, Germany

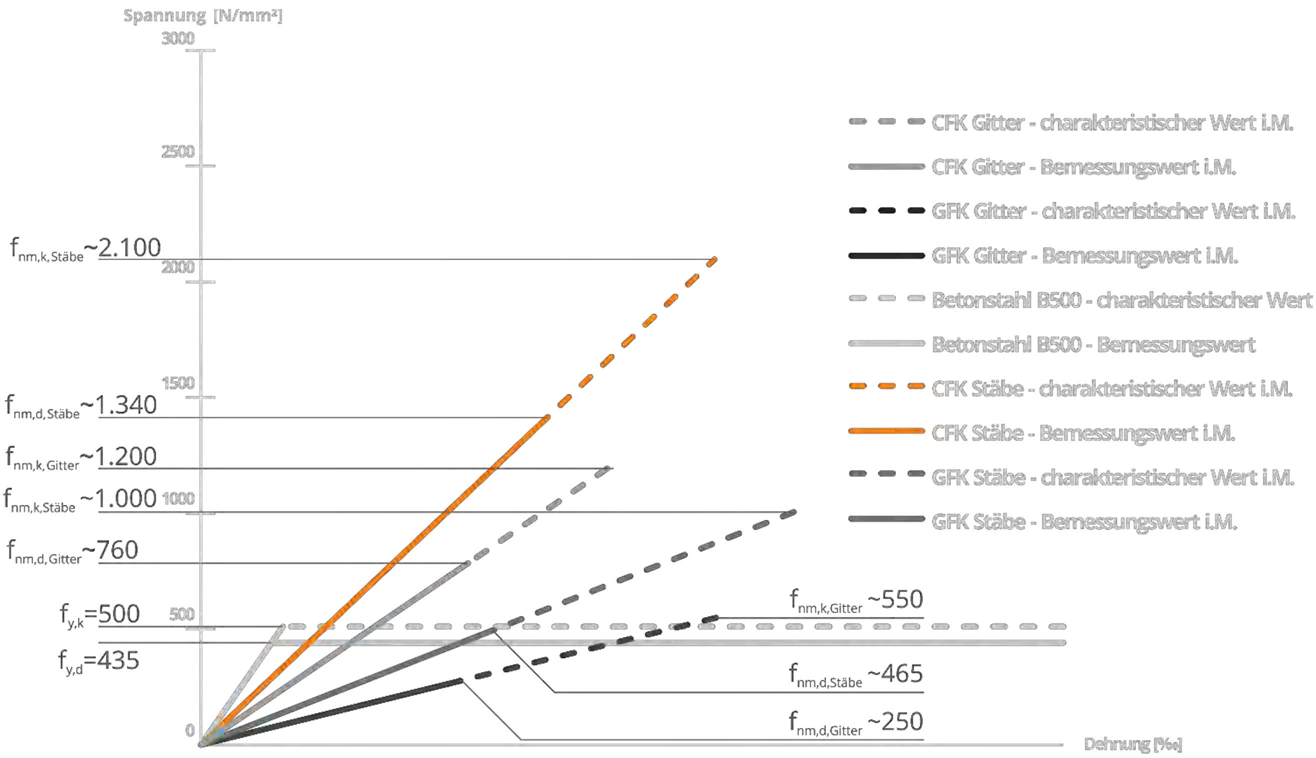


Figure 3: Stress-strain relationships in comparison

Guideline, approval, environmental product declaration

Guideline

In March 2024, the German Committee for Reinforced Concrete (DAfStb) published the guideline "Concrete components with non-metallic reinforcement" (DAfStb Guideline, 2024), which enables the planning, design and execution of concrete components with non-metallic reinforcement in Germany. The guideline is divided into 5 parts:

- Part 1: Dimensioning and construction
- Part 2: Reinforcement products
- Part 3: Notes on construction work
- Part 4: Recommendations for test procedures
- Part 5: Information on required verifications for the usability of the construction products (non-metallic reinforcement) and the applicability of the construction type

The content of Part 1 is based on (DIN EN 1992-1-1:2011-01) that of the National Annex (DIN EN 1992-1-1:2013-04) and deals with the design, calculation and dimensioning of buildings and civil engineering structures made of concrete that are reinforced with reinforcement elements (bars, grids and bar mats) made of fiber-reinforced plastics.

A fundamental precondition for the design of components in accordance with Part 1 of this guideline is the availability of the necessary verifications for the usability of the construction products used and the applicability of the type of construction (verifications of use and applicability). If such product approvals are available, a large number of carbon concrete applications can now be implemented independently by planners without approval in individual cases.

Approval

Not all reinforcement products listed in this Technical Information have a National technical approval (abZ) / General construction technique permit (aBG) and are therefore not readily suitable for use in accordance with the (DAfStb Guideline, 2024) (e.g. formed reinforcements). The guideline can still be applied, but an individual decision must be made for each construction project as to whether approval is required in individual cases (ZiE) if reinforcement made of fiber-reinforced plastics is used as static load-bearing reinforcement. The application for a ZiE must be submitted by the building owner to the responsible authority.

Most solidian GRID carbon grid reinforcements have a certificate of usability and applicability of the type of construction from the German Institute for Building Technology (DIBt) and are marked with the number Z-1.6-308 (solidian abZ/aBG Z-1.6-308, 2024).

Environmental Product Declaration (EPD)

In the construction industry, Environmental Product Declarations (EPDs) are a crucial basis for the holistic planning and evaluation of buildings. We have had the environmentally relevant properties of our solidian carbon grid reinforcement and solidian glass fiber reinforcement bars determined using neutral and objective data. This information is available to you in the download area on our website www.solidian-kelteks.com.

Please note:

The solidian reinforcement grids of the same type and material combination (e.g. solidian Q85-C-EP and solidian Q85-CCE) shown below are **identical** products. A different designation merely indicates the existence of a verification and proof of applicability for the respective product. The naming was carried out in accordance with the (DAfStb Guideline, 2024).

As the solidian products shown in the Environmental Product Declaration (EPD) with the declaration number EPD-SGR-65.0 of ift Rosenheim differ only in the designation to the reinforcement meshes with a verification of suitability and applicability, the environmental effects specified there apply equally to the reinforcement products approved by the building authorities.

Reinforcement material and designations

Reinforcement material

Continuous fibers (rovings) made of carbon and glass are used as the material for non-metallic reinforcements from solidian. The carbon fibers used for concrete construction are black and have a tensile strength of more than 4,000 N/mm² and a modulus of elasticity of over 240,000 N/mm². The glass fibers used by solidian are white to slightly yellowish, have an approx. 50 % lower tensile strength compared to carbon fibers and a modulus of elasticity of over. 70,000 N/mm². We use media-resistant ECR fibers for glass fiber reinforcements. In the manufacturing process, these carbon or glass rovings are bundled into fiber strands.

A usable reinforcement is only created by impregnating the fiber strands. The fibers or filaments of the yarns are firmly bonded together by the impregnation material to form fiber strands, which also ensures the internal bond (bond between the individual fibers). solidian mainly uses epoxy resin as an impregnating agent, but acrylate dispersions also offer an alternative option for impregnation. Depending on the construction application, the specific advantages of both resin systems can be used as impregnating agents.

Designations

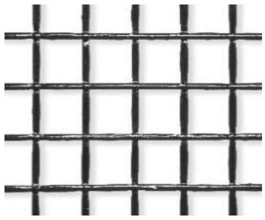
As in the reinforced concrete construction method, the respective types of reinforcement mesh must also be precisely recorded in the reinforcement and installation plan when using non-metallic reinforcement and installed in accordance with the specifications listed there.

The system of R and Q reinforcement meshes made of reinforcing steel has been adopted in (DAfStb Guideline, 2024) in the same way. Minor deviations from the usual definitions are explained in the following sections.

solidian GRID / **solidian** ANTICRACK Reinforcement grids

For reinforcement grids made of fiber-reinforced plastics, the usual definition deviates slightly from the reinforcing steel conventions. According to (DAfStb Guideline, 2024), Part II, Section 4.1.1. applies to Q and R grids:

- Type Q: Grids are designated as "Q" if the same fiber type and fiber cross-sectional areas per meter are present in the longitudinal and transverse directions (0° and 90° direction) and the same base material is used. This ensures a comparable nominal load-bearing capacity. However, it is possible that the final transmittable force per direction is almost the same, but the material and production conditions result in slightly different cross-sections and therefore different tensile strengths. For our approved solidian GRID type Q, we have deliberately defined the same nominal cross-sections in the warp and weft directions in order to keep the tensile strengths the same in both directions. There is no requirement for equal spacing of the fiber strands in the longitudinal and transverse directions.



- Type R: Grids are designated with "R" if different fiber types or fiber cross-sectional areas per meter are installed in the longitudinal and transverse directions (0° and 90° direction), resulting in different properties. Here too, there are no specifications for the strand spacing in the longitudinal and transverse directions. An "R" reinforcement grid therefore does not necessarily have to have rectangular opening areas, as is usual with steel mesh . The 20% of the longitudinal reinforcement for the transverse or distribution reinforcement required by current reinforced concrete construction standards is also not necessary here.

Reinforcement material and designations

Reinforcement meshes can look very similar, although they have completely different properties. It is therefore advisable to leave the exact designation on the label until the reinforcement mesh is installed. Reinforcing bars are printed with the corresponding product name.

The designation system of our solidian reinforcements, in particular according to the (DAfStb Guideline, 2024), is also explained on the corresponding product description pages.

solidian REBAR Reinforcing bars:

Reinforcing bars made of fiber-reinforced plastic follow the applicable agreements on the designation of reinforcing bars in the reinforced concrete construction standards.


CUBE House, Dresden | Image: TU Dresden / Stefan Gröschel

Material behavior and properties in comparison

You can choose between carbon and glass fibers. Both materials have different properties as reinforcement elements, which develop their specific advantages depending on the application.

	solidian Glass fiber reinforcements	solidian Carbob fiber reinforcement	Stainless reinforcing steel	Reinforcing steel	Areas of application
Unrestricted corrosion resistance	++	++	+ [1]	--	(thin) façade panels, parking garages, underground garages, bridge caps and decks, general hydraulic engineering, components with high exposure classes
High resistance to alkalis	o	++	+ [1]	--	Applications in concretes with binders that are not designed to passivate the reinforcing steel
High resistance to chlorides	+	++	+ [1]	--	Repair of concrete components, in particular those from parking garages, underground garages, bridge caps and decks
High resistance to chemicals	+	++	+ [1]	-	Agricultural buildings and facilities, sewage treatment plants, industrial floors and containers, storage and transshipment sites
Low thermal conductivity	++	o	-	--	Sandwich and element walls, façade anchors
Not electrically conductive	++	o [2]	+/- [1]	--	Slab track in the area of switches and signal systems, foundations of devices with high field strengths
Not magnetic	++	o	+/- [1]	--	Foundation and floor slabs under sensitive measuring equipment (MRI, nanotechnology, etc.), metal-free concrete components
Easy to process	++	++	--	--	all applications
Easy to machine	++	o	--	--	Shaft walls in tunnel construction (Soft Eye), formwork anchors, scheduled dismantling, temporary use
Low dead weight	+	++	--	--	general lightweight construction, modular and prefabricated construction, concrete repair measures, including reinforcement of concrete components

[1] depending on the material number

[2] Carbon fibers alone conduct currents. However, the epoxy resin coating usually acts as an insulator.

Legend: (++) applies in particular | (+) applies | (o) neutral | (-) tends not to apply | (--) does not apply

Prestressed bridge superstructure made of five prefabricated parts as part of PAMB (pilot application of modular bridge construction using the example of a carbon concrete bridge girder)) | Image: Hentschke Bau GmbH

Product description

solidian GRID

Reinforcement grids made of fiber-reinforced plastics (glass and carbon fiber)

solidian GRID is a bidirectional reinforcement grid made of media-resistant carbon or glass fiber composite plastic. It is preferably used in load-bearing, flat concrete components to absorb tensile forces. solidian GRID is characterized by its corrosion resistance, which reduces maintenance and replacement costs in the long term. It also offers maximum design freedom, so that even the most demanding architectural visions can be realized without compromising on material strength or durability.

With a service life of over 100 years, solidian GRID is a sustainable and environmentally friendly alternative to conventional steel reinforcement, significantly reducing the ecological footprint of your construction projects.

Approval	Type designation Carbon fiber grids	Type designation Glass fiber grids	Delivery forms (L x W)
DIBt Zulassung Z-1.6-308 solidian GRID (Allgemeine bauaufsichtliche Zulassung (abZ) vom Deutschen Institut für Bautechnik)	**solidian** GRID ▪ Q47-C-EP-s38-F145 [1] ▪ Q71-C-EP-s51-F207 [1] ▪ Q85-C-EP-s21-F262 [1] ▪ Q95-C-EP-s38-F278 [1] ▪ R24/95-C-CP-s76/38-F72/278 ▪ R95/24-C-CP-s38/76-F278/72	-	**Single grid:** 6.0 x 2.30 m (up to 3.0 m on request) **Roll:** Wooden frame: ≤250.0 x 3.0 m in CS[2]: ≤130.0 x 3.0 m in CS-U[3]: ≤130.0 x 2.30 m in CS-C[3]: ≤130.0 x 2.30 m Please specify the desired length of the grid on a roll when ordering. Cuts and other grid dimensions are possible up to a width of 3.0 m. Delivery times on request.
-	**solidian** GRID ▪ Q27-CCE-68 [1] ▪ Q43-CCE-21 [1] ▪ Q47-CCE-38 [1] ▪ Q71-CCE-51 [1] ▪ Q85-CCE-21 [1] ▪ Q95-CCE-38 [1] ▪ Q122-CCE-59 ▪ R24/95-CCE-76/38 ▪ R95/24-CCE-38/76	**solidian** GRID ▪ Q121-RRE-38	

[1] EPD available
[2] in CS = role in the solidian CARGO System CS (see page 29)
[3] in the CS-U or CS-C = roll in the solidian CARGO System CS-U with unwinding device and optional cutting device CS-C (see page 29)

Designation example

solidian GRID Q85-C -EP -s21-F262

DIBt Zulassung Z-1.6-308 solidian GRID

- F262: Characteristic tensile force transmission of the reinforcement [kN/m]
- s21: Grid width (center distance) in longitudinal and transverse direction [mm]
- EP: Impregnating agent (EP = epoxy resin)
- C: Fiber material in longitudinal and transverse direction (C = carbon fiber / ECR = ECR glass fiber)
- 85: Fiber cross-sectional area in longitudinal and transverse direction [mm²/m]
- Q: Arrangement of the fiber type and cross-sectional area (type Q / type R)

solidian GRID Q85-CCE -21

- 21: Grid width (center distance) in longitudinal and transverse direction [mm]
- E: Impregnating agent (E = epoxy resin / Y = acrylate dispersion)
- CC: Fiber material in longitudinal and transverse direction (C = carbon fiber / R = ECR glass fiber)
- 85: Fiber cross-sectional area in longitudinal and transverse direction [mm²/m]
- Q: Arrangement of the fiber type and cross-sectional area (type Q / type R)

Standard program

Grid designation[1]	Dimensions[2] Length / Width	Grid structure in longitudinal dir. / transversal dir.: Grid width (clear distance)	Nominal diameter per fiber strand	Nominal cross-sectional area per fiber strand	Nominal cross-sectional area lengthwise / transverse	Char. tensile force transmission lengthwise / transverse	Weight
	[m]	[mm]	[mm]	[mm^2]	[mm^2/m]	[kN/m]	[kg/m^2]
solidian GRID							
Carbon reinforcement grid with epoxy resin impregnation							
Q27-CCE-68	6,00 2,30	68 (64) 68 (63)	2,37 2,37	4,4 4,4	65 65	74 74	0,183
Q43-CCE-21		21 (18) 21 (19)	1,67 1,67	2,2 2,2	105 105	136 136	0,280
Q47-C-EP-s38-F145		38 (34) 38 (35)	2,37 2,37	4,4 4,4	116 116	145 145	0,309
Q71-C-EP-s51-F207		51 (45) 51 (46)	3,35 3,35	8,8 8,8	173 173	207 207	0,454
Q85-C-EP-s21-F262		21 (17) 21 (18)	2,37 2,37	4,4 4,4	210 210	262 262	0,512
Q95-C-EP-s38-F278		38 (33) 38 (34)	3,35 3,35	8,8 8,8	232 232	278 278	0,559
Q122-CCE-59		59 (51) 59 (50)	4,73 4,73	17,6 17,6	298 298	313 313	0,709
R24/95-CC-EP-s76/38-F72/278		76 (74) 38 (32)	2,37 3,35	4,4 8,8	58 232	72 278	0,381
R95/24-CC-EP-s38/76-F278/72		38 (32) 76 (73)	3,35 2,37	8,8 4,4	232 58	278 72	0,350
Glass reinforcement grid with epoxy resin impregnation							
Q121-RRE-38	6,00 2,30	38 (31) 38 (33)	3,57 3,57	10,0 10,0	263 263	145 145	0,901

1) according to DAfStb guideline “Concrete components with non-metallic reinforcement” or solidian nomenclature

2) as single grid up to 8,00 / 3,00, in rolls up to 250,00 / 3,00 in wooden frame

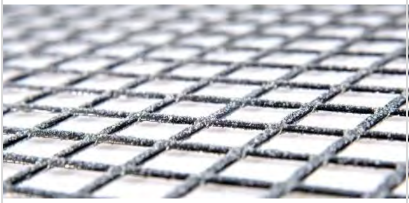
2) in rolls up to 130,00 / 3,00 in CARGO Sys.; up to 130,00 / 2,30 in the CARGO system with devices

(grey shading) Carbon reinforcement grid with abZ/aBG No. Z-1.6-308 for the reinforcement of concrete components

Please refer to our technical product data sheets for solidian GRID grid reinforcement. These are always available on our website at www.solidian-kelteks.com.

Product description

solidian ANTICRACK



Crack-limiting reinforcement grids with high load-bearing capacity and optimum bond to the concrete

solidian ANTICRACK are symmetrical, bidirectional reinforcement grids made of media-resistant carbon or glass fiber composite plastic. They are based on the solidian GRID reinforcement grids and are additionally sanded. These load-transferring and crack-width-limiting reinforcement grids are preferably used in load-bearing, flat concrete components where there are high requirements for limiting crack widths (e.g. for repairs, waterproofing components, SFH systems). With a service life of over 100 years, solidian ANTICRACK is a sustainable and environmentally friendly alternative to conventional steel reinforcement that significantly reduces the ecological footprint of your construction projects.

The reinforcement grid can be installed close to the surface and effectively reduces crack widths, which provides greater protection against surface spalling, among other things. The sanded surface ensures greater efficiency in the limitation and distribution of cracks as well as a reduction in overlap and anchorage lengths compared to the solidian GRID. Further information can be found in the section "Cracking and bonding behavior" on page 40.

Approval	Type designation Carbon fiber grids	Delivery forms (L x W)
-	**solidian** ANTICRACK ▪ Q43-CCE-21 [1)] ▪ Q47-CCE-38 [1)] ▪ Q85-CCE-21 [1)] ▪ Q95-CCE-38 [1)]	**Single grid:** 6.0 x 2.30 m (up to 3.0 m on request) **Roll:** Wooden frame: ≤250.0 x 3.0 m in CS[2)]: ≤130.0 x 3.0 m in CS-U[3)]: ≤130.0 x 2.30 m in CS-C[3)]: ≤130.0 x 2.30 m Please specify the desired length of the grid on a roll when ordering. Cuts and other grid dimensions are possible up to a width of 3.0 m. Delivery times on request.

[1)] EPD available

[2)] in CS = role in the solidian CARGO System CS (see page 29)

[3)] in the CS-U or CS-C = roll in the solidian CARGO System CS-U with unwinding device and optional cutting device CS-C (see page 29)

Designation example

solidian ANTICRACK Q47 -CCE -38

- Grid width (center distance) in longitudinal and transverse direction [mm]
- Impregnating agent (E = epoxy resin)
- Fiber material in longitudinal and transverse direction (C = carbon fiber)
- Fiber cross-sectional area in longitudinal and transverse direction [mm²/m]
- Arrangement of the fiber type and cross-sectional area (type Q)

Standard program

Grid designation[1]	Dimensions[2] Length / Width	Grid structure in longitudinal dir. / transversal dir.: Grid width (clear distance)	Nominal diameter per fiber strand	Nominal cross-sectional area per fiber strand	Nominal cross-sectional area lengthwise / transverse	Char. tensile force transmission lengthwise / transverse	Weight
	[m]	[mm]	[mm]	[mm²]	[mm²/m]	[kN/m]	[kg/m²]
solidian ANTICRACK							
Carbon reinforcement grid with epoxy resin impregnation							
Q43-CCE-21	6,00 2,30	21 (18) 21 (19)	1,67 1,67	2,2 2,2	105 105	136 136	0,717
Q47-CCE-38	6,00 2,30	38 (34) 38 (35)	2,37 2,37	4,4 4,4	116 116	145 145	0,722
Q85-CCE-21	6,00 2,30	21 (17) 21 (18)	2,37 2,37	4,4 4,4	210 210	262 262	0,929
Q95-CCE-38	6,00 2,30	38 (33) 38 (34)	3,35 3,35	8,8 8,8	232 232	278 278	0,929

1) according to solidian nomenclature

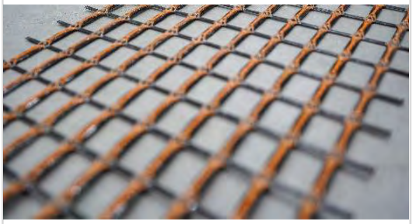
2) as single grid up to 8,00 / 3,00, in rolls up to 250,00 / 3,00 in wooden frame

2) in rolls up to 130,00 / 3,00 in CARGO Sys.; up to 130,00 / 2,30 in the CARGO system with devices

Please refer to our technical product data sheets for solidian ANTICRACK grid reinforcement. These are always available on our website at www.solidian-kelteks.com.

Product description

solidian GRID
CARBOrefit®



Carbon grid reinforcement for structural reinforcement with carbon concrete

CARBOrefit® is a process for strengthening the load-bearing structure of reinforced concrete components with carbon concrete. It consists of a special fine concrete and a carbon grid reinforcement, such as solidian GRID. According to the national technical approval, the area of use and application includes uniaxial bending reinforcements on prepared surfaces in the tensile zone of reinforced concrete components under static load. With a service life of over 100 years, solidian GRID offers a durable, economically superior reinforcement method that protects the existing structure and is superior to the reinforcement measures commonly used today. In addition, reinforcement with grid reinforcement offers an economical alternative to reinforcement with lamellas. Advantages at high temperatures, which result from the existing concrete cover, can also be utilized.

Approval	Type designation Carbon fiber grids	Delivery forms (L x W)
	solidian GRID **CARBOrefit**® Typ 3 Regular version ▪ solidian GRID R142/28-CCY-13/16 **solidian** GRID **CARBOrefit**® Typ 3 Special version ▪ solidian GRID Q85-CCY-21	**Single grid:** 6.0 x 2.30 m (up to 3.0 m on request) **Roll:** Wooden frame: ≤250.0 x 3.0 m in CS[1]: ≤130.0 x 3.0 m in CS-U[2]: ≤130.0 x 2.30 m in CS-C[2]: ≤130.0 x 2.30 m Please specify the desired length of the grid on a roll when ordering. Cuts and other grid dimensions are possible up to a width of 3.0 m. Delivery times on request.

[1] in CS = role in the solidian CARGO System CS (see page 29)

[2] in the CS-U or CS-C = roll in the solidian CARGO System CS-U with unwinding device and optional cutting device CS-C (see page 29)

Designation example

solidian GRID R142/28 -CCY -13/16

- 13/16: Grid width (center distance) in longitudinal and transverse direction [mm]
- Y: Impregnating agent (Y = acrylate)
- CC: Fiber material in longitudinal and transverse direction (C = carbon fiber)
- 142/28: Fiber cross-sectional area in longitudinal and transverse direction [mm²/m]
- R: Arrangement of the fiber type and cross-sectional area (type Q / type R)

Up-to-date and comprehensive information, including a planner folder, on the CARBOrefit® reinforcement solution can be found on the website www.carborefit.de.

Standard program

Grid designation[1]	Dimensions[2]	Grid structure in longitudinal / transversal direction		Fiber cross-section area	Char. short-term tensile strength	Char. bond strength fiber strand	Weight
	Length Width	Grid width (clear distance)	Fiber cross-sectional area per fiber strand	lengthwise transverse	lengthw. transverse	lengthwise transverse	
	[m]	[mm]	[mm²]	[mm²/m]	[N/mm²]	[N/mm²]	[kg/m²]
solidian GRID CARBOrefit®							
Carbon reinforcement mesh with acrylate impregnation							
R142/28-CCY-13/16	6,00 3,00	12,7 16	1,81 0,45	142,0 28,0	2.430 -	14,5 -	0,447
Q85-CCY-21		21 21	1,81 1,81	85,0 85,0	2.670 - [3]	14,1 - [3]	0,421

[1] according to solidian nomenclature

[2] as single grid up to $\frac{8,00}{3,00}$, in rolls up to $\frac{250,00}{3,00}$ in wooden frame

[2] in rolls up to $\frac{130,00}{3,00}$ in CARGO Sys.; up to $\frac{130,00}{2,30}$ in the CARGO system with devices

[3] The exact value will be determined if required. Please contact us in advance.

(grey) Carbon reinforcement grid with abZ/aBG No. Z-31.10-182 for the reinforcement of reinforced concrete with carbon concrete

Bitte beachten Sie unsere technischen Produktdatenblätter zu den solidian GRID CARBOrefit® Gitterbewehrungen. Diese halten wir stets aktuell auf unserer Website unter www.solidian-kelteks.com bereit.

Product description

solidian GRID Form

Formed reinforcement grids made of fiber composite plastics (glass and carbon fiber)

solidian GRID Form / solidian GRID CARBOrefit® Form are formed, bidirectional reinforcement grids made of media-resistant carbon or glass fiber reinforced plastic (glass fiber only for solidian GRID Form).

These durable reinforcement grids can **currently only be used for structural concrete constructions** and, in the future, for statically relevant concrete constructions, in particular for absorbing tensile and transverse forces. They are manufactured exclusively at the factory and delivered to the construction site ready-formed.

Approval	Type designation formed carbon fiber grids	Type designation Formed fiberglass grids
-	On the basis of all available **solidian** GRID: ▪ Q47-CCY-38 ▪ Q71-CCY-51 ▪ Q85-CCY-21 ▪ Q95-CCY-38 ▪ R24/95-CCY-s76/38-F72/278 ▪ R95/24-CCY-s38/76-F278/72 **solidian** GRID CARBOrefit® (Standard program on the following page)	-

Delivery forms
Formed single grids available as a standard L or U profile up to a length of 3.0 m. Delivery times on request. **Other shapes and dimensions are available on request – please contact us.**

Designation example

Bending roller D related to all deflection points [mm] (30 / on request)
Geometry description according to standard program (external dimensions)
Form L: a x b – α – length or form U: a x b x c – length

solidian GRID Form Q85 -CCY -21 -L -30 -300x300 -90 -2500

Shaping (L = angle / U = connector / O = bracket / X = free geometry)
Grid width (center distance) in longitudinal and transverse direction [mm]
Impregnating agent (Y = acrylate dispersion for standard / E = epoxy resin for special)
Fiber material in longitudinal and transverse direction (C = carbon / R = ECR glass)
Fiber cross-sectional area in longitudinal and transverse direction [mm²/m]
Arrangement of the fiber type and cross-sectional area (type Q / type R)

Standard program

Grid designation[1)]	Form	Bending roll diameter	Dimensions					Grid width (clear distance)	Nominal cross-sectional area	Weight
			Leg length a	Leg length b	Leg length c	Angle α	Total length	lengthwise transverse	lengthwise transverse	
		[mm]	[mm]	[mm]	[mm]	[°]	[mm]	[mm]	[mm²/m]	[kg/m²]
solidian GRID Form										
Carbon reinforcement grid with acrylate impregnation										
No standards currently defined										
[1)] according to solidian nomenclature										

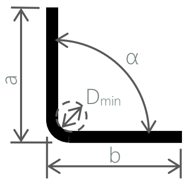
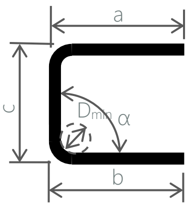
solidian offers formed reinforcement grids, which are divided into two main categories: standard shapes and special shapes.

Standard shapes

All standard shapes are created by one or more straight-line deformations of flat grids on a forming machine. The maximum component width is 3.0 m. Depending on the bending angle and basic shape, there are different geometric limitations for leg and web lengths. Currently, L and U shapes can only be produced by machine within specified limits (see table below) upon consultation.

We use a bending roll diameter of 30 mm as standard. Other bending roll diameters are available on request. Shapes outside the limit dimensions are produced using epoxy resin impregnation (xxE).

All geometries must be agreed with solidian in advance - please contact us.

Form		Bending roller diameter D_{min}	Current limit dimensions				
			Leg length a	Leg length b	Leg length c	Angle α	Total length
		[mm]	[mm]	[mm]	[mm]	[°]	[mm]
	L	30 (others on on request)	≤ 1000	≤ 6000	-	≥ 90	≤ 3000
	U	30 (others on on request)	≤ 900	≤ 6000	≥ 170 + D_{min}	≥ 90	≤ 3000

Special shapes and spherically curved shapes

For specific geometries, please contact us and together we will find the technically and economically optimal solution for your project.

Product description

solidian REBAR

Reinforcing bars made of fiber composite plastics (glass and carbon fiber)

solidian REBAR is made of media-resistant carbon or glass fiber composite plastic and is used as bar reinforcement in statically relevant, beam-like or flat concrete components. This ecological alternative to conventional steel reinforcement impresses with a service life of over 100 years under predominantly static loads. With solidian REBAR, you are investing in a material that remains corrosion-free and durable for decades, reducing maintenance and replacement costs in the long term. By using this material, you promote sustainable construction and reduce the ecological footprint of your projects.

Approval	Type designation Carbon fiber bars	Type designation Glass fiber bars	Delivery forms
-	**solidian** REBAR ▪ D4-CCE ▪ D6 CCE ▪ D8-CCE ▪ D10-CCE ▪ D12-CCE	**solidian** REBAR ▪ D4-RRE [1)] ▪ D6 RRE [1)] ▪ D8- RRE [1)] ▪ D10- RRE [1)] ▪ D12- RRE [1)] ▪ D14- RRE [1)] ▪ D16- RRE [1)] ▪ D20- RRE [1)] ▪ D25- RRE [1)] ▪ D28- RRE [1)]	**Bars** in the lengths L = 6.0 m Cut to size possible. Delivery times on request.

[1)] EPD available

Designation example

solidian REBAR D12 - RRE

- Impregnating agent (E = epoxy resin)
- Fiber material of the core and rib (C = carbon fiber / R = ECR glass fiber)
- Nominal diameter [mm]

Standard program

Bar designation[1)]	Dimensions Length	Nominal diameter	Nominal cross-sectional area	Char. Tensile force transmission	Weight
	[m]	[mm]	[mm²]	[kN]	[kg/m]
solidian REBAR					
Carbon fiber bar reinforcement with epoxy resin impregnation					
D4-CCE	6,00	4,0	12,6	27	0,022
D6-CCE		6,0	28,3	56	0,049
D8-CCE		8,0	50,3	105	0,090
D10-CCE		10,0	78,5	157	0,134
D12-CCE		12,0	113,1	226	0,190
Glass fiber bar reinforcement with epoxy resin impregnation					
D4-RRE	6,00	4,0	12,6	14	0,032
D6-RRE		6,0	28,3	31	0,066
D8-RRE		8,0	50,3	55	0,119
D10-RRE		10,0	78,5	82	0,177
D12-RRE		12,0	113,1	119	0,257
D14-RRE		14,0	153,9	161	0,362
D16-RRE		16,0	201,1	201	0,476
D20-RRE		20,0	314,1	298	0,725
D25-RRE		25,0	490,9	442	1,115
D28-RRE		28,0	615,7	554	1,399

[1)] according to solidian nomenclature

Please refer to our technical product data sheets for solidian REBAR reinforcing bars. These are always kept up to date on our website at www.solidian-kelteks.com.

Product description

solidian REBAR Form

Formed reinforcing bars made from fiber-reinforced plastics
(glass and carbon fiber)

solidian REBAR Form is a formed reinforcement bar made of media-resistant carbon or glass fiber reinforced plastic. These durable reinforcement bars can **currently be used exclusively for structural** and, in the future, for statically relevant concrete structures, in particular for absorbing tensile and transverse forces. They are manufactured exclusively at the factory and delivered to the construction site ready-formed..

Approval	Type designation formed carbon fiber bars	Type designation formed glass fiber rods
-	On the basis of all available **solidian** REBAR	On the basis of all available **solidian** REBAR up to diameter D20

Delivery forms
Formed bars available in L or U geometry. Delivery times on request. Other shapes and dimensions are available on request – please contact us.

Designation example

solidian REBAR Form D10 -CCE -L -48 -300x300 -90

- -300x300 -90: Geometry description according to standard program (external dimensions)
  Form L: a x b – α
  Form U: a x b x c
- -48: Bending roll D_{br} related to all deflection points [mm]
- -L: Shape (L = Angle / U = U-bar / X = free geometry)
- E: Impregnating agent (E = epoxy resin)
- CC: Fiber material of the core and rib
  (C = carbon fiber / R = ECR glass fiber)
- D10: Nominal diameter [mm]

Standard program

Bar designation[1)]	Form	Bending roll diameter	Dimensions					Grid width (clear distance)	Nominal cross-sectional area	Weight
			Leg length			Angle	Total length	lengthw. transverse	lengthw. transverse	
			a	b	c	α				
		[mm]	[mm]	[mm]	[mm]	[°]	[mm]	[mm]	[mm²/m]	[kg/m²]
solidian REBAR Form										
Carbon fiber bar reinforcement with epoxy resin impregnation										
No standards currently defined										
Glass fiber bar reinforcement with epoxy resin impregnation										
No standards currently defined										

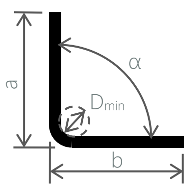
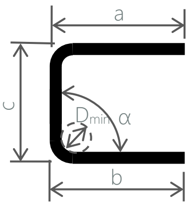
1) according to solidian nomenclature

Shaping

All shapes are created by forming one or more straight bars in a straight line on the forming line. Depending on the angle and basic shape, there are different geometric limits for the leg and web lengths. Currently, L and U shapes can only be produced by machine within specified limits (see table below) upon consultation.

As standard, we use a bending roller diameter of $\geq 6 \cdot D_{br}$ for the diameters, so that this classification guarantees the design requirement for a minimum value of the bending roller diameter for hooks, angle loops, loops and hangers. Alternative bending rollers are available on request.

All geometries must be agreed with solidian in advance – please contact us.

Form		Bending roller diameter D_{min}	Current limit dimensions			
			Leg length			Angle
			a	b	c	α
		[mm]	[mm]	[mm]	[mm]	[°]
	L	$\geq 6 \cdot D_{min}$	≤ 1130	≤ 1130	-	≥ 90°
	U	$\geq 6 \cdot D_{min}$	≤ 1130	≤ 1130	$\geq 90+2 \cdot D_{min}$	≥ 90°

Product description

Tokyo Rope CFCC

Stranded wires made of fiber composite plastic (carbon fiber) for prestressing with and without composite

The Carbon Fiber Composite Cable (CFCC) from Tokyo Rope International (TRI) is a specially developed strand for prestressed concrete components that can be prestressed with or without a bond. Made of stranded carbon fiber composite plastic, this cable makes optimum use of the excellent material properties of twisted carbon fibers. Compared to conventional steel strands, the CFCC impresses with its outstanding corrosion resistance, low weight, high tensile strength, flexibility, minimal linear expansion and high fatigue resistance. Thanks to the strand construction, CFCC can be easily wound onto reels, making it particularly suitable for applications requiring long lengths.

Approval	Type designation Carbon fiber tensioning cable	Delivery forms
-	**Tokyo Rope** CFCC (Carbon Fiber Composite Cable) ▪ CFCC 1x7 12,5D ▪ CFCC 1x7 15,2D ▪ CFCC 1x7 17,2D ▪ Other types on request	**Reel:** e.g. 1x7 12,5D: CFCC wound on wooden reel up to max. 3,600 m. Further lengths on request. Maximum winding length depends on type. Cutting to size and assembly possible. Delivery times on request.

Designation example

Tokyo Rope CFCC 1x7 12,5D

- Diameter D [mm]
- Number of strands per cable (1 cable with 7 strands)

Fastening methods

A distinction is made between the following types of fastening for attaching carbon prestressing strands to a stressing jack:

1. Prestressing with immediate bonding (stressing bed method)
   In this process, the carbon prestressing strands are attached to the steel strands mounted on the tensioning jack using special adapters.
2. Prestressing with subsequent bonding and without bonding
   Here, the carbon tensioning strands are bonded into steel sleeves at the factory and delivered to the construction site or factory in this form. If you decide on this type of prestressing, please contact us in advance. We will be happy to put you in touch with our partner.

Please refer to the manual "Tokyo Rope CFCC - Manual for the installation and maintenance of the fastening systems", which you will soon find in the download area of our website at www.solidian-kelteks.com.

solidian provides all necessary materials and tools (except tensioning jack) for the stressing process.

CFCC (Carbon Fiber Composite Cable) is a product of Tokyo Rope International, Japan

solidian.

build solid.

Standard program

Strand designtion[1)]	Dimen-sions Length	Diameter	Cross section area	Guaranteed tensile force transmission	Weight	Prestressing	
						with imme-diate bond-ing	with subse-quent bonding and without bonding
	[m]	[mm]	[mm²]	[kN]	[kg/m]		
Tokyo Rope CFCC							
Carbon fiber tensioning cable							
CFCC 1x7 12,5D		12,5	75,6	192,5	0,146	✓	✓
CFCC 1x7 15,2D		15,2	115,6	294,4	0,223	✓	✓
CFCC 1x7 17,2D		17,2	151,1	385,0	0,292	✓	✓

[1)] according to Tokyo Rope nomenclature

(grey box) = Article available from stock

All data according to the information provided by Tokyo Rope International.

Pre-tensioning with immediate bonding – CFCC carbon tensioning strands coupled to steel tensioning strands using special adapters | Image: Tokyo Rope

Accessories, production and transportation aids

Spacer

We offer specially developed plastic spacers, the **solidian** SPACER, which are primarily designed for the construction of exposed concrete façades in combination with the solidian GRID reinforcement grids in grid sizes 21 and 38 mm.

For spacers and supports up to a height of 70 mm, we refer to common plastic and fiber-reinforced concrete spacers (e.g. www.nevoga.com), which can be used with solidian reinforcements without any problems. For non-metallic supports with a height of over 70 mm, please send us an inquiry.

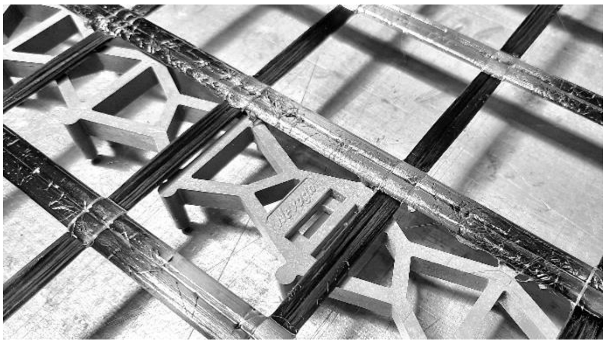


Figure 5: Picture above: solidian SPACER spacers for grid widths 21 mm and 38 mm
Center and bottom image: Alternative use of conventional plastic or fiber cement-based spacers (e.g. NEVOGA)

Fixing aid

The **solidian** GRIDFIX fixing aid is ideal for the production of slab-like components with solidian reinforcement grids. This accessory makes the production of fair-faced concrete components considerably easier by ensuring consistently technically and visually perfect results. By simply clamping the reinforcement, an absolutely stable position is achieved, making the use of spacers on the formwork base superfluous.

The solidian GRIDFIX fixing aid is available both for rent and for purchase.

Contact us - we will be happy to support you with your project.

Figure 4: solidian GRID for fixing reinforcement grids without additional spacers

Accessories, production and transportation aids

Stacking and transport rack

Our collapsible stacking and transport racks **solidian** CARGO System offer an efficient solution for the transportation and storage of solidian roll goods. Made from high quality steel, these racks are more durable and robust than traditional wooden pallets and can be reused multiple times, reducing both operating costs and environmental impact.

The racks are stackable and enable optimum use of space: up to three racks can be stored on top of each other, and up to 16 racks fit into one truck for transportation. After unloading, the racks can be folded together, allowing up to 64 racks to be stored in one truck, which minimizes return transport costs.

An additional advantage is the optional equipment with integrated unrolling and cutting devices, which prevent unintentional unrolling and make it easier and less time-consuming to cut the rolled material to size on site. In addition, the racks allow rolled grids to be laid over a large area, significantly reducing the impact and overlap areas compared to individual grids.

The solidian CARGO system is available for both rental and purchase, giving you the flexibility to choose the best option for your project or warehouse. Contact us for a personal consultation and a non-binding offer.

solidian CARGO System		
Short form	Description	Max. grid dimensions
CS	Foldable stacking and transport rack for solidian roll goods	L: ≤ 130.0 m B: ≤ 3.0 m
CS-U	Foldable stacking and transport rack for solidian roll goods, with unwinding device ("unwinding brake")	L: ≤ 130.0 m B: ≤ 2.30 m
CS-C	Foldable stacking and transport rack for solidian roll goods, with unwinding device ("unwinding brake"), with cutting device	L: ≤ 130.0 m B: ≤ 2.30 m

Figure 7: solidian CARGO System stacking and transport rack

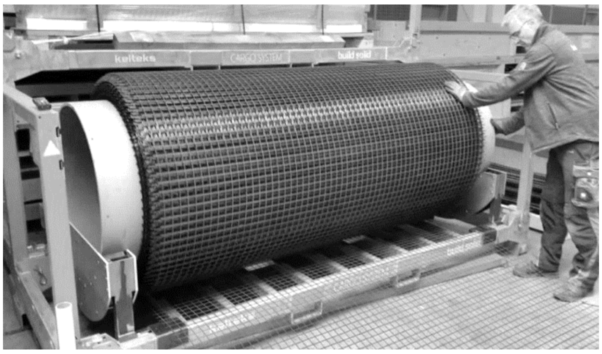


Figure 6: solidian CARGO System stacking and transport rack with unwinding device

Space eye Uecht, Bern (CH)

Transportation, storage, handling during installation

Transportation and storage

Non-metallic reinforcement from solidian must not be damaged during transportation, storage, processing or installation. They must be stored dry, protected from the weather and without touching the ground. Until concreting, they must be protected from UV radiation and moisture and be free from bond-reducing impurities (e.g. grease, soil, loose concrete residue).

Figure 9: Pallet transport for flat reinforcement grids

Non-metallic reinforcements from solidian may be exposed to temperatures above 80°C for short periods during transportation, storage, processing and installation.

Figure 10: Disposable wooden racks for transporting rolled reinforcement grids

Due to the sensitivity of the composite material to lateral pressure, mechanical damage, e.g. from direct walking, must be avoided at all costs. Damaged fiber bundles (chipped resin, brittle areas, etc.) must not be installed, as the specified load-bearing capacity can no longer be guaranteed.

In the case of slack or wavy reinforcement, measures must be taken to secure the position/fixing during concreting.

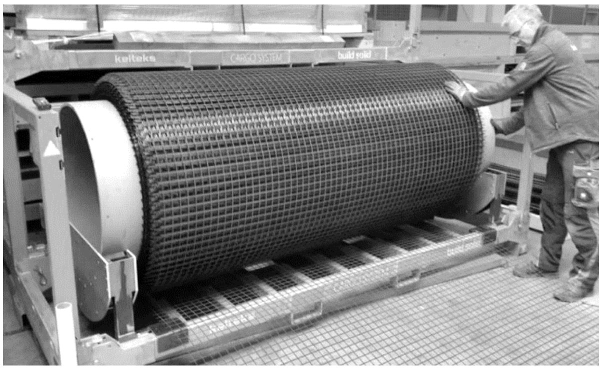


Figure 8: Stacking and transport racks with optional unrolling and cutting device for rolled grids

Reinforcement grids can be transported rolled together, whereby the following minimum roll diameters must be ensured:

solidian Product	Minimum roll diameter
solidian GRID	≥ 700 mm
solidian ANTICRACK	≥ 800 mm

Table 1: Min. roll diameter for transportation and storage

Please note that the rolled-up reinforcement is under internal stress. Precautionary measures must be taken, especially when opening the rolled goods, to prevent sudden, unintentional opening.

When lifting non-metallic reinforcement with a crane, suitable lifting gear must be used.

Transportation, storage, handling during installation

Protective equipment

The currently valid legal regulations on occupational health and safety must be observed during all transport activities. Appropriate protective measures must be taken when working with cutting equipment, such as wearing long work clothing, leather or puncture-resistant gloves, safety goggles and, if necessary, a respirator mask.

The handling of fiber composites should be based on the Technical Rules for Hazardous Substances (TRGS) of the Federal Institute for Occupational Safety and Health (baua). We also refer to the DGUV information "Processing CFRP materials - Guidance for protective measures" (FB-HM 074, issue 10/2014).

Cutting

One advantage of solidian reinforcement is the ease of processing, which differs from the processing of reinforcing steel.

The non-metallic reinforcements from solidian must not be angled or subjected to sharp transverse pressures. If necessary, they may be cut to size on site using a suitable tool.

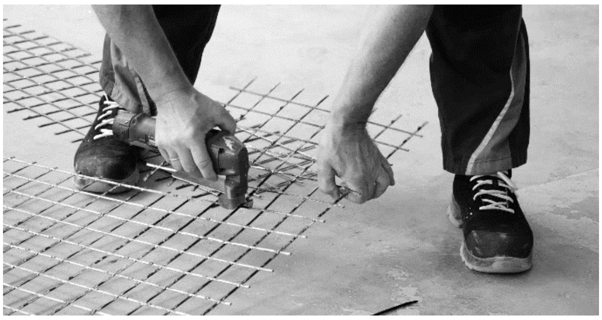


Figure 11: Simple cutting with plate shears

In general, all fiber-reinforced plastics should be cut without generating cutting dust. For reinforcing grids and bars (up to a diameter of 6 mm), regardless of glass or carbon fiber, plate shears in electric or compressed air mode are ideal. We recommend the use of hacksaws or cut-off grinders with diamond or carbide blades for rebars with a diameter of 8 mm or more.

Note: Due to the electrically insulating resin, solidian reinforcements made of carbon fiber material are generally not initially electrically conductive, but can become electrostatically charged depending on the processing. The dust produced during processing can then be electrically conductive. We therefore advise against using electrical devices for processing our solidian carbon reinforcements that generate dust (e.g. cut-off grinders), as there is a risk of a short circuit. Alternatively, we recommend protecting or shielding electrical devices.

If necessary, interfaces can simply be deburred with sandpaper, a file or rasp.

Bending

Due to their material properties, non-metallic reinforcements from solidian can be bent elastically up to a limit value (see "Minimum permissible radius of curvature" tables below) without impairing their mechanical properties. This means that they can be bent within the elastic range. However, bending beyond the elastic range leads to plastic deformation of the reinforcement (up to brittle fracture), which is not possible with fiber-reinforced plastics without impairing the mechanical properties. If you require special bending forms for your project, these can be produced in our factory (see next sect solidian reinforcements

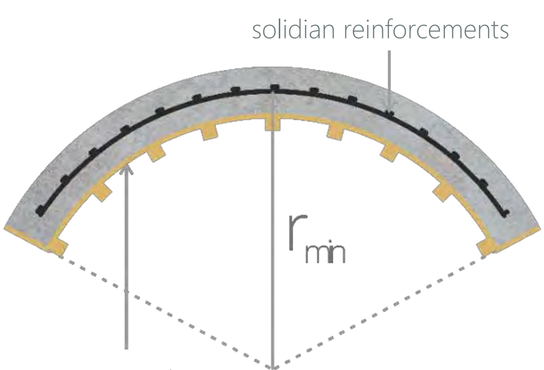


Figure 12: Installation only in compliance with the minimum permissible radius of curvature

Transportation, storage, handling during installation

The minimum permissible radius of curvature must not be exceeded when handling the non-metallic reinforcement. Information on the minimum permissible radius of curvature can be found in the technical product data sheets or in the following table.

solidian Produkt	Min. permissible radius of curvature r_{min}
solidian GRID carbon fiber	≥ 350 mm
solidian GRID glass fiber	≥ 300 mm
solidian ANTICRACK	≥ 400 mm
solidian REBAR D4 up to D6	≥ 635 mm
solidian REBAR D8 up to D10	≥ 850 mm
solidian REBAR D12	≥ 1.000 mm
solidian REBAR D14	≥ 1.300 mm
solidian REBAR D16	≥ 1.500 mm
solidian REBAR D20	≥ 2.000 mm
solidian REBAR D25	≥ 2.300 mm
solidian REBAR D28	≥ 2.650 mm

Table 2: Minimum permissible radius of curvature r_{min}

Bent solidian reinforcement returns to its original shape (straight) as soon as the force to bend it is removed. Therefore, elastically bent reinforcing bars and grids must be held in their planned shape by suitable fasteners or connectors until the concrete has hardened.

If solidian reinforcement is to be installed in the component in a bent state, it must be checked whether this is covered by the existing approvals for the reinforcement. In principle, it is essential to add the stress introduced by the bending of the reinforcement and the stress introduced by the planned load. The resulting total stress in the mesh must not exceed the permissible design value of the reinforcement.

Non-metallic reinforcements from solidian must not have any buckling, defects or other damage.

Forming

All solidian formed reinforcement products are manufactured exclusively in the factory and then delivered to the construction site or precast plant. Several methods are available for the forming process, including the forming of reinforcement grids into solidian GRID Form shaped reinforcement grids (e.g. stirrup mesh) on a specially developed, automated forming system.

Figure 13: Formed reinforcement grids

Spacer

For our solidian GRID reinforcement grids, you can use either the solidian SPACER for grid widths of 21 and 38 mm. The solidian SPACER 21 and 38 are screwed into the grid opening and ensure a defined distance from the center axis of the reinforcement grid to the formwork of between 5 and 25 mm for fair-faced concrete quality.

Alternatively, you can also use commercially available plastic or fiber-reinforced concrete/plastic-based spacers, such as NEVOGA DRUSPITZ (www.nevoga.de).

Transportation, storage, handling during installation

Figure 16: solidian SPACER spacer

Steel spacers that come into direct contact with the concrete surface are only permitted in a dry environment, i.e. for exposure classes X0 and XC1 according to (DIN EN 206-1:2001-07) in conjunction with (DIN 1045-2:2008-08).. Cement and concrete spacers should provide at least the same strength and corrosion protection as the concrete of the structure.

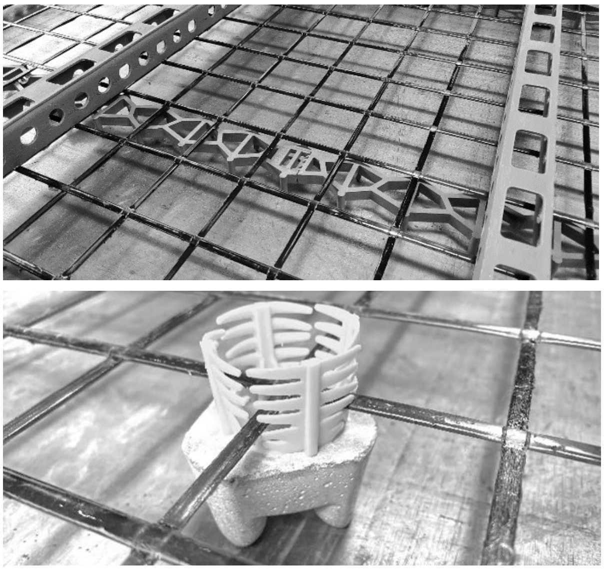


Figure 15: Reinforcement grid with plastic spacers and base made of fiber-reinforced concrete

To ensure the structural effective height of the component, the solidian GRID reinforcement grids must be laid as level as possible. For this purpose, the spacing between the spacers must be selected in such a way that the reinforcement does not sag during installation and concreting.

Direct contact between carbon reinforcement and metal spacers should be avoided due to the risk of contact corrosion. Further information can be found in the section "Contact corrosion" on page 36.

Supports

Various products are available to support the upper reinforcement or to secure the distance between reinforcement layers. The selection of products depends on the intended use, the design details of the reinforcement layout, the load during the construction process, the environmental conditions (corrosion protection) and the required support heights.

For supports, we recommend plastic supports/spacers. NEVOGA products are particularly suitable for this, e.g. DLV20 or the DLO series from 25 to 70 mm. For support heights over 70 mm with multi-layer reinforcement, we recommend the use of plastic filter tubes.

Figure 14: Plastic filter tubes as supports for a metal-free component

When using metal supports, we distinguish between two cases:

<u>solidian reinforcements with glass fibers</u>

Metal supports (support cages, snakes) can be used when using solidian glass fiber composite plastic, provided that the requirements for the component permit this (e.g. free from magnetism, free from electrical conductivity, concrete cover in accordance with the exposure classes).

<u>solidian reinforcements with carbon fibers</u>

When using solidian carbon fiber composites, the use of metallic supports is not recommended due to the risk of contact corrosion, especially if the reinforcement lies directly on the supports. Further information can be found in the section "Contact corrosion" on page 36.

Transportation, storage, handling during installation

Connection technology

The connection must not cause any mechanical damage to the non-metallic reinforcement, e.g. through transverse pressure.

When using metallic connections (binding wire, e.g. normal, galvanized, stainless steel, insulated copper wire), the exposure class of the component must be taken into account. The admissibility of these connections must be specified in the planning documents.

Conventional binding wire is suitable for connecting solidian reinforcements made of glass fibers with other grids or bars made of glass fibers or conventional reinforcing steel, provided that the requirements for the component permit this.

Figure 17: Binding reinforcements with cable ties

Due to the properties of the glass fiber reinforcement, such as non-magnetizable and electrically non-conductive, a completely steel-free construction may be required. In such cases, cable ties from the electrical installation can be used. This connection method is also necessary to connect glass reinforcement to carbon reinforcement or carbon reinforcement to each other.

When connecting grids, care must be taken to arrange the fiber strands of the individual layers as precisely as possible on top of each other to ensure an optimum connection.

Welding

Welding and soldering of non-metallic solidian reinforcements is not possible.

On-site installation of attachments by welding or soldering in the area around solidian products should only be carried out after prior consultation with the specialist engineer or with solidian in order to avoid excessive heat exposure to the component, which could have a negative effect on the load-bearing capacity of the reinforcement.

Floating of the reinforcement

When compacting the concrete, the reinforcement grids may “float up”. However, this phenomenon can be avoided by adapting the concrete mix design, using a suitable spacer system or ensuring the position is secured/fixed during concreting (e.g. with the solidian GRIDFIX fixing aid). solidian can provide appropriate recommendations for this - please contact us.

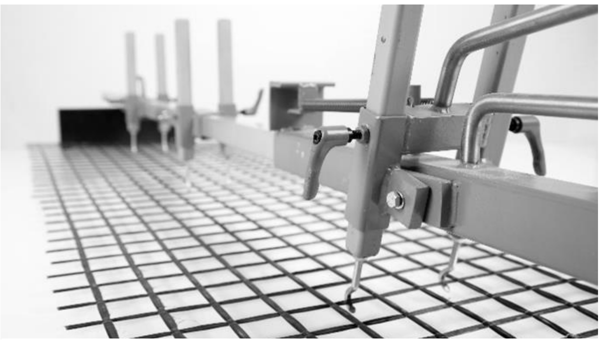


Figure 18: Fixing aid solidian GRIDFIX

Transportation, storage, handling during installation

Limitation of the maximum grain size

The maximum grain size of the aggregate used in the concrete must be determined in such a way that professional concreting is ensured, taking into account the concrete cover and the clear distance between the bars and grids.

In contrast to reinforcing steel mats, which usually have bar spacings of 100 to 150 mm, the maximum grain size should be limited during the production of the concrete, depending on the solidian product used, in order to prevent a sieving effect. The following table provides information on the recommended or limited maximum grain size according to (DAfStb Guideline, 2024) depending on the solidian reinforcement grids.

According to (DAfStb Guideline, 2024), the clear spacing of the fiber strands in grids in the grid plane must not be less than three times the maximum grain size ($3 \cdot d_g$).

When using solidian reinforcement grids, the following table must therefore be observed to ensure sufficient bonding.

solidian reinforcement grid	Max. grain size
solidian GRID Q27-CCE-68	16 mm
solidian GRID Q43-CCE-21 solidian ANTICRACK Q43-CCE-21	5 mm
solidian GRID Q47-C-EP-s38-F145 solidian GRID Q47-CCE-38 solidian ANTICRACK Q47-CCE-38	8 mm
solidian GRID Q71-C-EP-s51-F207 solidian GRID Q71-CCE-51	8 mm (16 mm)
solidian GRID Q85-C-EP-s21-F262 solidian GRID Q85-CCE-21 solidian ANTICRACK Q85-CCE-21	5 mm
solidian GRID Q95-C-EP-s38-F278 solidian GRID Q95-CCE-38 solidian ANTICRACK Q95-CCE-38	8 mm
solidian GRID Q122-CCE-59	16 mm
solidian GRID R24/95-CC-EP-s76/38-F72/278 solidian GRID R24/95-CCE-76/38	8 mm
solidian GRID R95/24-CC-EP-s38/76-F278/72 solidian GRID R95/24-CCE-38/76	8 mm
solidian GRID Q121-RRE-38	8 mm

Table 3: Maximum grain size for solidian reinforcement mesh according to (DAfStb Guideline, 2024) and recommended maximum grain size for products without national technical approval

The screening effect can be prevented by the lamination process (multi-layer application).

Unless otherwise specified, the technical product data sheets must be observed.

Contact corrosion

Due to the different material properties of carbon fibers and reinforcing steel, contact corrosion cannot be ruled out if they come into direct contact with each other. Therefore, direct contact of carbon reinforcement with metallic installation parts and metallic reinforcements must be avoided.

To avoid any risk, we recommend laying a non-conductive layer (e.g. plastic, glass fiber or basalt rods or grid cuttings) between the carbon fiber material and other metallic objects. However, this layer should only be used selectively so as not to impair the bond between the reinforcement and the concrete.

Walkability

It is not possible to walk directly on solidian GRID reinforcement grids according to (solidian abZ/aBG Z-1.6-308, 2024).

However, aids such as climbing boards or similar devices can be used to create an accessible surface. The aids must be supported in the grid openings so that stress on the grid is avoided.

For solidian REBAR reinforcing bars, accessibility of the bars is possible from diameter D8 or D10, depending on the number and position of the bars. For example, rebars with a diameter of 8 mm can be walked on, provided there are at least 3 bars next to each other over a width of 10 cm and the man load is evenly distributed over these 3 bars.

Transportation, storage, handling during installation

Figure 19: Access aids to prevent direct access to reinforcement made of fiber-reinforced composites

The following principles apply to all other solidian reinforcements:

- Entering by trained personnel: Entering is only to be carried out by instructed personnel. solidian offers comprehensive support through personnel instruction and advice on site.
- Permitted walking on the material: It is possible to walk on the reinforcement products, including the reinforcement grids, if the weight of the person is bearing directly by a spacer element. solidian reinforcement grids can be supported over their entire surface and thus walked on, especially during repair work. In order to achieve full-surface support, a solidian FLEX GRID, for example, can be used as a spacer under the actual grid reinforcement.
- Avoid stepping on directly: Do not walk directly between the spacers/supports in order to avoid damage and breakage due to large deformations of the fiber material.
- Prohibited driving: Any kind of driving over with vehicles or equipment is prohibited, as the high load transmission transverse to the fiber direction can damage the fiber material.

Figure 20: Plane support of reinforcement grids using grids as spacers

Damaged fiber bundles (chipped resin, brittle areas, etc.) must not be installed, as the specified load-bearing capacity can no longer be guaranteed.

Repair of circulation sewer at lock Anderten, Hannover | Image: BAW / ibac, RWTH Aachen

Background information

Behavior under tensile stress

In contrast to steel, solidian glass and carbon fiber reinforcements behave linearly elastic until fracture, whereby plastic deformation components do not occur or only occur in the already damaged area.

Despite the brittle material failure in the tensile test, components reinforced with solidian GRID show a quasi-ductile load-bearing behavior with early signs of failure due to large crack widths and deflections.

The characteristic tensile strengths of carbon reinforcements offer more than twice the design potential compared to glass fiber reinforcements. In order to exploit this economically, the concrete grades should also be selected accordingly high. Carbon reinforcements require a larger surface area in order to effectively transfer high tensile forces into the concrete. This is optimally achieved with solidian GRID and solidian ANTICRACK, which is why the grid reinforcements made of carbon fibers are also economically advantageous and form the focus of the solidian portfolio. Since reinforcing bars offer a smaller bond area in relation to the core cross-section compared to reinforcing grids, the less load-bearing solidian REBAR made of glass fibers can be used more economically than reinforcing bars made of carbon fibers.

Due to their significantly higher modulus of elasticity, non-metallic carbon fiber reinforcements are more suitable for preventing large component deflections and crack widths than glass fiber reinforcements. Despite the significantly higher tensile strength, carbon reinforcements have smaller characteristic elongations at break compared to glass fiber reinforcements, but are still perfectly adequate in this respect.

The solidian product portfolio offers a wide range of solutions for different areas of application in terms of tensile load-bearing behavior. However, non-metallic reinforcements are fundamentally subject to various ageing and temperature influences that must be taken into account. Therefore, the characteristic short-term tensile strengths cannot be used for static design without reduction. For this purpose, values for the tensile strengths must be obtained through long-term or temperature tests and then derived mathematically from the short-term strengths using a reduction factor.

The DAfStb guideline "Concrete components with non-metallic reinforcement" (DAfStb Guideline, 2024) specifies the reduction factor α_{nmt}, which covers the ageing effects over a period of up to 100 years (see section "Durability" on page 43).

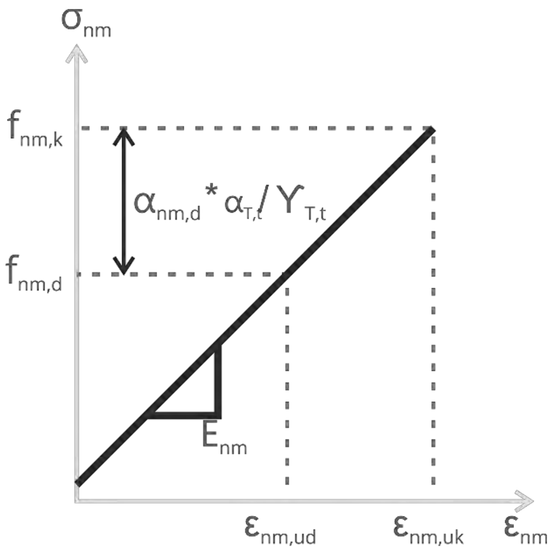


Figure 21: Calculated stress-strain curve of the non-metallic reinforcement for the design for tension

In addition to the reduction factor, which takes into account the aging effects over the entire service life, the behaviour of fiber-reinforced plastics with regard to short-term exposure to service temperatures must also be taken into account. The impregnating agents commonly used (e.g. epoxy resins, vinyl ester resins or acrylates) exhibit temperature-dependent behavior. After reaching a certain temperature range, known as the glass transition range, the reinforcement begins to soften, resulting in a decrease in strength and stiffness.

To ensure that the mechanical short-term properties of the reinforcement remain constant, it is crucial to maintain a sufficient distance from the glass transition temperature when the concrete components are in use. This is particularly important in direct sunlight to ensure the temperature stability of the impregnating agent, the integrity of the interfaces between fiber and impregnating agent and between impregnating agent and concrete.

Background information

For the practical design of non-metallic reinforcements, a corresponding reduction factor α_{Tt} for the tensile properties can be determined as a function of the expected acting temperatures in the reinforcement plane. This is done by testing the tensile strengths at the respective minimum and maximum service temperature and comparing them with the respective properties at 20°C.

It has proven useful to determine such reduction factors directly for limit temperatures of e.g. -20°C and 80°C in the verification and applicability certificates. This temperature range is generally recognized as the minimum and maximum temperature effects to be expected in typical application scenarios. This standardization means that time-consuming individual tests for specific temperature effects can be avoided. For the approved reinforcement products from solidian, the reduction factor α_{Tt} for a temperature of 80°C can be found in the current data sheets. It should be noted that the approved solidian GRID reinforcements fully retain their mechanical properties up to a temperature of 70°C in the reinforcement plane. Above this temperature range, there may be a reduction in mechanical performance, which is why the corresponding reduction factor must be taken into account.

Behavior under shear loads

The (DAfStb Guideline, 2024) follows an additive design model. For components without inclined chords, the shear force resistance of a component is made up of the concrete bearing component of the shear force resistance $V_{Rd,c}$ and the reinforcement bearing component of the shear force resistance $V_{Rd,nm}$.

$$V_{Rd} = V_{Rd,c} + V_{Rd,nm}$$

The concrete load-bearing component $V_{Rd,c}$ stands for the shear force resistance of a component without shear force reinforcement. The familiar equation from the Eurocode with various modifications is used to calculate $V_{Rd,c}$. It is possible to use reinforcement grids and reinforcement bars for components without shear force reinforcement required in the calculation.

For components without shear force reinforcement required by calculation, the shear force verification can be carried out in the usual form and in accordance with the regulation (DAfStb Guideline, 2024) using the $V_{Rd,c}$ approach and the corresponding geometric and mechanical input variables solidian GRID carbon reinforcement grids (solidian abZ/aBG Z-1.6-308, 2024).

In several realized projects, shear force reinforcement made of solidian carbon reinforcement grids was used and the shear force bearing capacity was investigated experimentally. Based on research findings, it can be deduced that, in principle, grids are also suitable as shear reinforcement. The corresponding approaches are currently being validated and could not yet be included at the time of printing of the current edition of the (DAfStb Guideline, 2024). Components with shear force reinforcement required by calculation therefore require bar-shaped reinforcement elements and must have component thicknesses of at least 200 mm.

Despite the wide range of material properties of various non-metallic reinforcement elements, the design model was kept pragmatic, is therefore understandably conservative compared to the approach in the (DIN EN 1992-1-1:2011-01) with (DIN EN 1992-1-1:2013-04) and takes into account the significant influence of shear slenderness. In contrast to (DIN EN 1992-1-1:2011-01) the (DAfStb Guideline, 2024) does not define a minimum value v_{min}. The value of $V_{Rd,c}$ calculated according to (DAfStb Guideline, 2024) is partially below the shear force resistance $V_{Rd,c}$ calculated with v_{min} according to (DIN EN 1992-1-1:2011-01).

Cracking and bonding behavior

The geometry of the surface profiling and the materials used for fiber-reinforced plastics differ considerably from those of conventional steel bar reinforcement. In the case of reinforcement grids, such as the solidian GRID, there is also the fact that they are much more filigree in design and have significantly smaller opening widths, which leads to a significantly larger surface or composite area.

Background information

Both the cross-sections of the carbon fiber strands and their axial spacing are significantly smaller, which leads to fundamentally different composite properties that must be determined individually as part of the verification and applicability checks. In contrast to ribbed reinforcement bars, solidian GRID reinforcement grids do not have typical ribs. Instead, the constrictions created by the sewing thread in the textile manufacturing process ensure sufficient positive locking and therefore direct anchoring in the concrete.

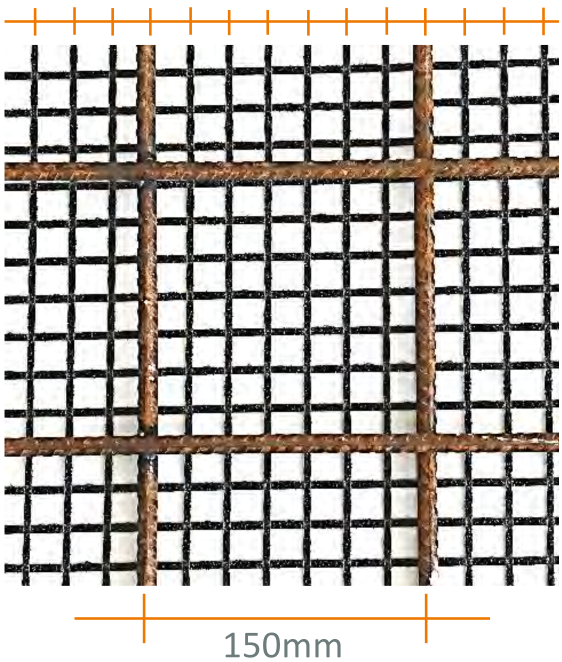


Figure 23: Exemplary comparison of the grid geometry and opening widths between solidian GRID Q85-CCE-21 (solidian GRID Q85-C-EP-s21-F262) and a commercially available reinforcing steel mesh

Despite the seemingly smoother surface of the reinforcement grids compared to ribbed bars and the lower material hardness of epoxy resins compared to steel, the larger available surface area enables a comparable transfer of tensile forces into the concrete. With sanded reinforcements such as solidian ANTICRACK, this force transmission can be increased even further compared to reinforcing steel (see figure 23).

The main advantage of the cracking behavior of carbon grid reinforcements lies in their complete freedom from corrosion, which enables the reinforcement layer to be arranged close to the surface and can therefore further increase the static effective height.

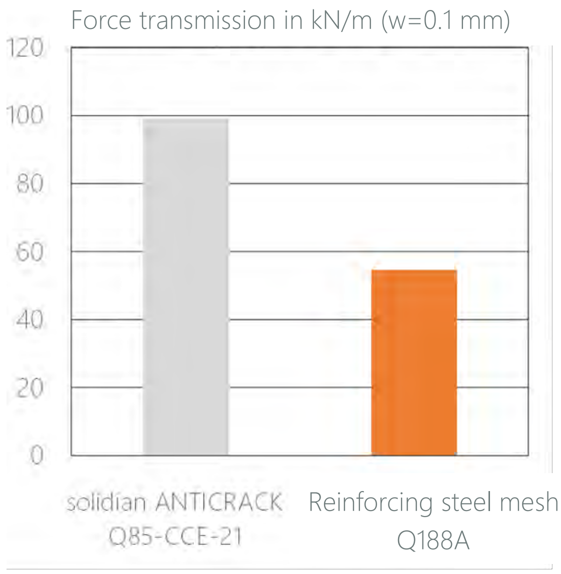


Figure 22: Exemplary comparison of the force transmission of solidian ANTICRACK and a reinforcing steel mesh in a rising crack with a crack opening of 0.1 mm

The geometry of the reinforcement grids is also advantageous with regard to the final anchoring, as the extremely high-strength reinforcing fibers are present in a small cross-section and the tensile forces can therefore be transferred very evenly into the concrete.

Compared to reinforcement grids, bar reinforcements such as solidian REBAR exhibit less significant differences in bond behavior compared to steel bars.

The size ratios of the bar core and ribbing are similar, but the material hardness of the epoxy resin and the stiffness of the reinforcing fibers differ considerably.

solidian offers glass fiber bars with large core diameters of up to 28 mm, which can compensate for the reduced stiffness of the glass fibers compared to steel. Carbon rods, on the other hand, are only offered up to a diameter of 12 mm due to their high total tensile strength.

Background information

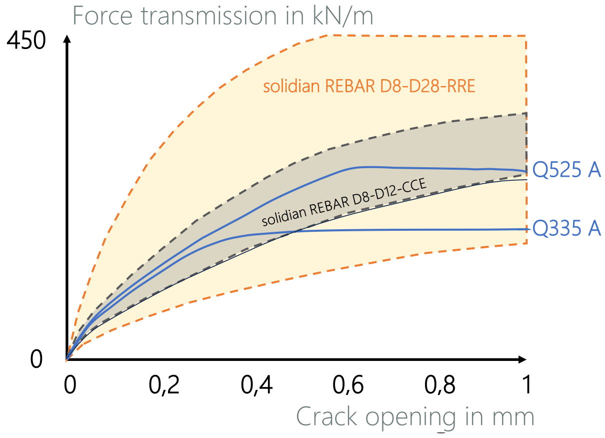


Figure 24: Force transmission of the reinforcement in the opening crack - comparison of typical reinforcing steel meshes with glass and carbon bars

In figure 24, the resistances of the glass fiber bars in the opening crack are shown in yellow and those of the carbon bars in grey. Both fiber materials can be used as equivalent substitutes for typical reinforcing steel meshes such as Q335A and Q525A.

solidian ANTICRACK: For special requirements for the smallest crack widths

A further development of solidian GRID for special requirements in crack width limitation is solidian ANTICRACK. These reinforcements are additionally provided with sanding on the grid surface, which leads to a considerable increase in the bond quality. solidian ANTICRACK reinforcement grids are therefore particularly suitable for applications where water impermeability is required, even for cracked concrete surfaces. The sanding creates a strong profiling of the surface and thus considerably improves the form fit to concrete.

Figure 25 compares the products solidian GRID Q85-CCE-21 without and with sanding (solidian ANTICRACK Q85-CCE-21). With sanded solidian grid reinforcement, approx. 65% smaller crack widths can be achieved at a tensile force of 150 kN/m than with unsanded reinforcement.

In addition, the longitudinal cracking in the reinforcement level frequently observed with non-metallic grid reinforcements is reduced with solidian ANTICRACK reinforcements. Although the sanding introduces a concentrated tensile force into the concrete, the crack spacing is shortened to such an extent that the transverse tensile strength of the concrete is barely exceeded.

Our solidian ANTICRACK reinforcements are therefore preferably used in the repair of highly stressed parking areas, where the reduction in crack widths also increases the durability of the applied surface protection systems. SFH facilities (storage, filling and handling facilities substances hazardous to water) are also potential areas of application, both in new construction and in repair work.

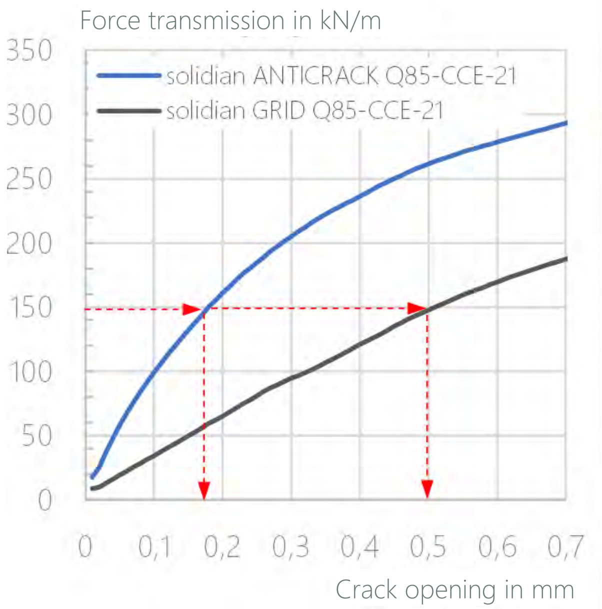


Figure 25: Comparison of the force transmission in the opening crack of unsanded and sanded reinforcement

A special area of application is the distribution of coarse existing cracks over several fine surface cracks. Here, a thin layer of concrete reinforced with solidian ANTICRACK is applied to the existing cracked concrete, whereby the bond around the existing crack is dissolved with a debonding material. This creates a free length in the carbon concrete cover layer that allows multiple cracks to form, dividing a coarse crack into several fine cracks (see figure 26).

Background information

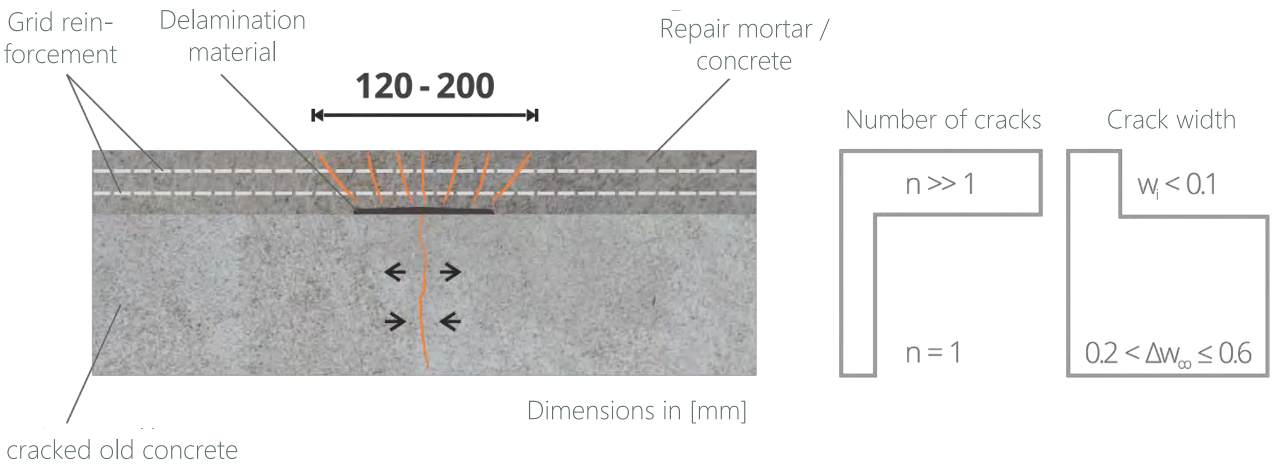


Figure 26: Application principle of crack distribution by solidian ANTICRACK

Anchoring and overlapping

Sufficient anchoring of the reinforcement in concrete must be ensured so that the reinforcement can transfer its full tensile force into the concrete without premature pull-out failure occurring. The bonding mechanisms of non-metallic reinforcements vary greatly depending on the geometric design and execution and are not standardized as is the case with reinforcing steel. The special features of the respective products are therefore described in the verification and applicability certificates.

solidian REBAR reinforcing bars have a similar surface area to steel bars. Depending on the design of the ribs (pitch angle, rib height and rib spacing), tensile forces can be introduced into the concrete at a comparable rate. However, with high tensile forces, such as with carbon bars, the transverse tensile strength of the concrete can become a limiting factor, especially with smaller concrete coverings. This is taken into account in the product approvals.

The tendency for longitudinal cracking or splitting of the concrete cover is even more pronounced with reinforcement grids than with bars because, on the one hand, tensile forces can be transferred to the concrete even faster via the large number of parallel fiber strands and, on the other hand, often only very small concrete covers are realized anyway. In most cases, delamination failure then occurs in the level of the reinforcement. This is also fully taken into account for the approved solidian GRID reinforcements and can therefore lead to slightly longer anchorage or lap lengths compared to the reinforcing steel.

Durability

The durability of our solidian GRID carbon grid reinforcement has been proven for a service life of over 100 years in concrete - supported by the tests in the approval process for national technical approval (solidian abZ/aBG Z-1.6-308, 2024) in Germany. For all other solidian reinforcements, results from internal tests were compared with the data from the approval tests.

During the durability tests in the approval process, expansion bodies reinforced with solidian GRID were loaded in water at 60°C under a permanent load of 83% of the average short-term tensile strength for different periods of up to more than 7,000 h in accordance with the specifications of (DAfStb Guideline, 2024). As none of the test specimens failed, the residual strengths of the strain test specimens were then tested. The residual strengths determined were 100% within the scatter range (±5%) of the average short-term tensile strengths, which proves that no ageing of the reinforcement could be detected in the tests carried out. According to (DAfStb Guideline, 2024), the reduction factor α_{nmt} was set at 0.83 for a period of up to 100 years.

Background information

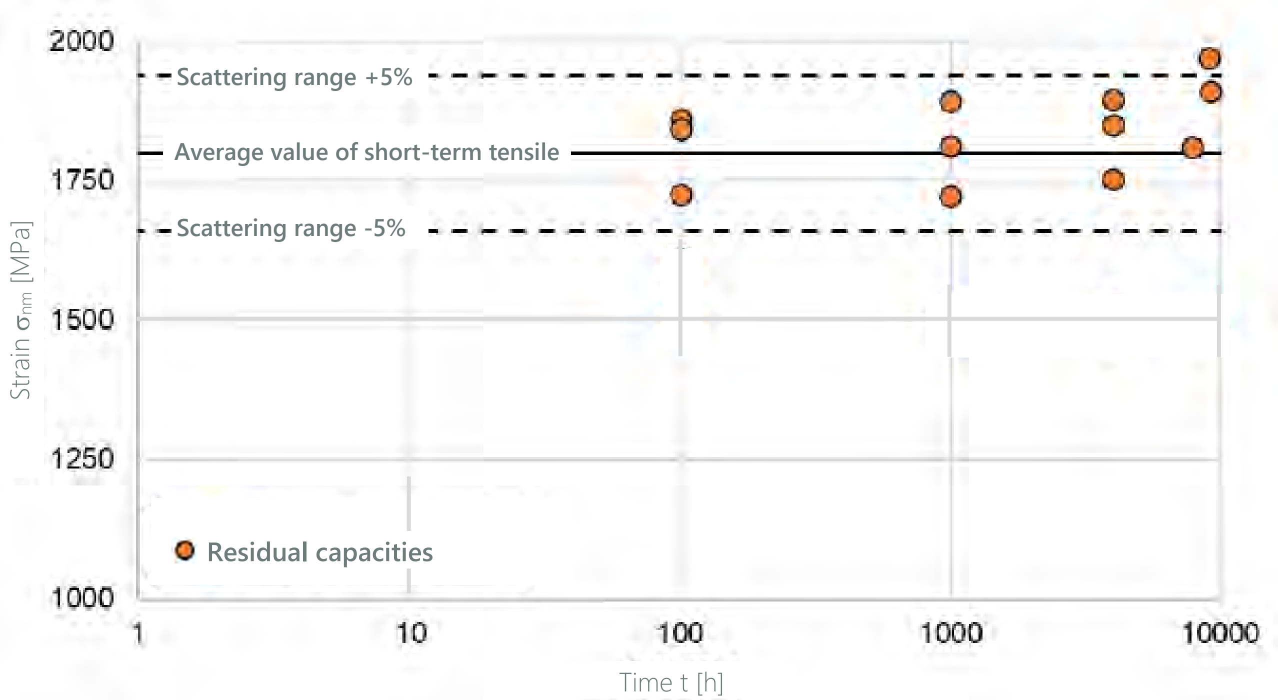


Figure 27: Results of the durability tests on the residual load-bearing capacities of strain specimens test reinforced with solidian GRID carbon grid reinforcement

This reduction factor is applied to the characteristic short-term tensile strength $f_{nm,k}$ in order to determine the characteristic value of the long-term tensile strength $f_{nm,k,100a}$ of the non-metallic reinforcement for a reference period of 100 years ($f_{nm,k,100a} = \alpha_{nmt} \cdot f_{nm,k}$). Either the characteristic long-term tensile strength $f_{nm,k,100a}$ or the coefficient α_{nmt} can be specified in the verifications and proofs of applicability. solidian indicates the corresponding coefficients in the approval (solidian abZ/aBG Z-1.6-308, 2024) and Technical Product Data Sheets for solidian GRID.

The results of the durability tests also show that the service life of solidian GRID carbon reinforcements is significantly longer than 100 years. However, according to the current version of the method, it may not be used to verify service lives longer than 100 years. Therefore, no proven reduction factors can be defined for longer periods of use accord. to (DAfStb Guideline, 2024).

In addition, no improved reduction factors can be specified for carbon reinforcements with shorter planned service lives, as is possible with durability tests for reinforcements made of glass fibers that have demonstrated defined aging. In the case of carbon reinforcements that show no ageing, the maximum reduction factor that was determined in the tests as a percentage of the short-term tensile strength must always be used, even if the potential is higher. However, this higher potential could not be verified in the tests.

Exposure classes

The environmental conditions according to (DAfStb Guideline, 2024) are defined analogously to (DIN EN 1992-1-1:2011-01) with (DIN EN 1992-1-1:2013-04) by chemical and physical influences to which a supporting structure, individual components, the reinforcement and the concrete itself are exposed. These conditions are not directly taken into account in the verifications of the ultimate and serviceability limit states. The environmental conditions for reinforced concrete components are classified into exposure classes based on Table 4.1 of (DIN EN 206-1:2001-07).

The exposure classes X0 and XC1 to XC4 refer to the exposure of concrete and are not affected by the use of non-metallic reinforcement.

Background information

With regard to the reinforcement-relevant environmental influences

- XD1 to XD3 (reinforcement corrosion caused by chlorides other than seawater) and
- XS1 to XS3 (reinforcement corrosion caused by chlorides from seawater) and
- XA1 to XA3 (concrete attack caused by chemical attack from the environment)

proofs of resistance to the effects of the exposure classes for all classifications in the concrete strength classes C30/37 to C70/85 were provided for the solidian GRID carbon reinforcement grids, which are subject to the (solidian abZ/aBG Z-1.6-308, 2024). These verifications are also available for the solidian REBAR glass and carbon reinforcement bars.

According to the (DAfStb Guideline, 2024) there are no specific requirements for concrete composition and properties to protect the non-metallic reinforcement against corrosion for the exposure classes XC1 to XC4, XD1 to XD4 and XS1 and XS3.

For exposure class XF4 (frost attack with thawing agent), internal investigations have so far not revealed any indications of an influence on the tensile load-bearing behavior due to freeze-thaw cycles.

The assessment of concrete corrosion due to alkali-silica reaction for the exposure classes WO, WF and WA is not influenced by the type of reinforcement. Classification WS, which additionally includes dynamic loading of the component, requires a separate verification with regard to dynamic loading with solidian reinforcement products (see also the section “Fatigue” on page 46).

The technical product data sheets for our reinforcement products provide information on which exposure classes have been tested for the respective product. Exposure classes that are not listed do not rule out use, but merely indicate that the corresponding proof has not yet been provided in these cases.

Concrete cover

The concrete cover for reinforced concrete components plays a decisive role in durability, as it protects the steel from corrosion and ensures the longevity of the structure. In Germany, the thickness of the concrete cover is calculated according to the (DIN EN 1992-1-1:2011-01) with (DIN EN 1992-1-1:2013-04), taking into account the exposure class, concrete quality and service life.

The concrete cover required for carbon reinforcement is significantly lower due to the corrosion resistance of the material. The calculation of the concrete cover for carbon reinforcements is regulated by the (DAfStb Guideline, 2024). However, the minimum concrete cover can be taken from the bond requirements in the reinforcement manufacturer's approvals.

In addition, the (solidian abZ/aBG Z-1.6-308, 2024) of the solidian carbon grid reinforcement regulates specific requirements for concrete cover, especially with regard to thin components.

Comparison of the concrete cover with different reinforcement materials for the practical example “Parking garage slab“

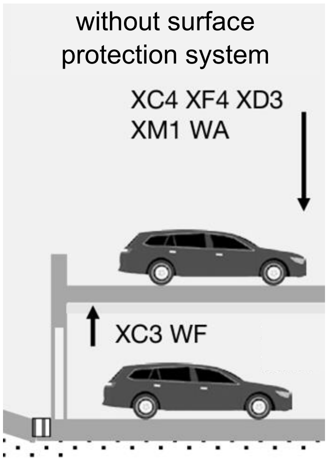


Figure 28: Exemplary exposure class (excerpt of figure 1 from Cement Code of Practice Concrete Technology B9 7.2021 "Exposure classes for concrete components within the scope of EC2"

In the planning and execution of reinforced concrete components, the concrete cover plays a key role in the durability of the structure. For the design of a parking garage slab with a component thickness of 20 cm, a concrete quality of C35/45, a maximum grain diameter of 8 mm and the exposure classes XC4, XF4, XD3, XM1 and WA without further surface protection system, different requirements for the concrete cover arise depending on the reinforcement used.

Background information

Overview of the calculation results:

Product	Regulations	c_{nom} [mm]
B500A/B - 1.0438/1.0439	DIN 488-1:2009-08 DIN EN 10080:2005-08	55
FV Betonstahl	Z-1.4-165	55
B500B NR - 1.4003 "Top12"	Z-1.4-266	45
B500A NR - 1.4362	Z-1.4-228	25
B500B NR - 1.4362	Z-1.4-255	25
B700B NR - 1.4482 "Inoxripp 4486"	Z-1.4-261	25
B500B NR - 1.4571	Z-1.4-50	25
B500B NR - 1.4571	Z-1.4-153	25
solidian GRID	Z-1.6-308	19

Table 4: Overview of the calculation results for the concrete cover with different approved reinforcements

Results of the comparison calculation:

The direct comparison of the calculated c_{nom} values shows that hot-dip galvanized reinforcing steel in exposure classes XD and XS does not allow a reduction in the concrete cover, as the additional protective effect of the hot-dip galvanizing cannot be sufficiently quantified. The stainless reinforcing steel "Top12" only allows a reduction of the concrete cover by 10 mm to 45 mm. In contrast, significant reductions to 25 mm can be achieved with the other stainless reinforcing steels.

The carbon grid reinforcement solidian GRID takes the top spot in this comparison. With a required concrete cover of only 19 mm, which results from the (DAfStb Guideline, 2024) and the approval, considerable material savings can be realized.

If the laying dimension c_v were set at 20 mm, the concrete cover would be reduced by 35 mm. For an area of 300 m², this means a saving of around 10.5 m³ of concrete, which at an average list price of approx. 190 Euro/m³ for a C35/45 concrete leads to a cost reduction of just about 2,000 Euro.

Even taking into account the higher initial costs of carbon mesh reinforcement, the long-term savings due to the elimination of concrete repair measures due to corrosion are considerable and should be offset, as these are not incurred with carbon reinforcement.

This detailed illustration shows the significant advantages of the solidian GRID carbon mesh reinforcement in terms of reducing the concrete cover and the associated economic savings.

Fatigue

The area of application of (DAfStb Guideline, 2024) is currently limited to predominantly static actions. For this reason, only the robustness proof according to (DAfStb Guideline, 2024) was provided for the solidian GRID carbon reinforcement grids (solidian abZ/aBG Z-1.6-308, 2024). This verification was carried out with a number of ≥200,000 cycles and an amplitude of at least ±10% of the mean load. The top load corresponded to (DAfStb Guideline, 2024) ≥50% of the long-term tensile strength of the reinforcement.

As soon as the extended version of the (DAfStb Guideline, 2024) also includes dynamic actions and defines the corresponding tests, solidian will have the proof provided accordingly for the reinforcements approved in Germany.

Deformation behavior

The modulus of elasticity of non-metallic reinforcement is lower than that of structural steel, which results in a lower tensile strength. In addition, the reinforcement cross-section of components with non-metallic reinforcement is generally smaller than that of reinforced concrete cross-sections. This lower stiffness leads to increased deformations in the cracked cross-section. Therefore, verifications in service condition are often decisive criteria when determining the component dimensions and reinforcement cross-sections.

Background information

Components with non-metallic reinforcement have a high deformation capacity. The safety criterion of sufficient failure indication is therefore usually sufficiently fulfilled despite the brittle material behavior of non-metallic reinforcement.

Figure 29: Two-point bending test on a slab strip with non-metallic reinforcement

Due to the fully linear-elastic behavior of the non-metallic reinforcement, no gaping cracks occur in the component even after exceeding the yield strain of structural steel ε_{yd} (2.174 ‰). Even if the non-metallic reinforcement is loaded up to the limit strain in the ULS (see also figure 3: Comparison of stress-strain relationships), the component surface retains an appropriate visual appearance after the component is unloaded.

Fire behavior

The evaluation and classification of the fire behavior of building materials, both as individual materials and in combination with other materials, is carried out according to (DIN 4102-1:1998-05) in different building material classes. Building material class A, subdivided into A1 and A2, comprises non-combustible building materials. Building material class B comprises flammable building materials and is further subdivided into B1 (flame-retardant), B2 (normally flammable) and B3 (easily flammable).

For all solidian GRID carbon reinforcement grids based on epoxy resin, proof of building material class A2 in combination with concrete was provided by using a centrally reinforced concrete slab with a thickness of 30 mm. This classification also remains valid for thicker components, provided that a concrete cover of at least 15 mm is maintained. Due to the selected boundary conditions in the classification test, the A2 classification is limited to concrete strength classes up to C50/60. In addition, for non-metallic reinforcements in general, the standard concretes used must meet the requirements in accordance with (DIN EN 1992-1-1:2011-01), section 4.5.1 in conjunction with (DIN EN 1992-1-1:2013-04) to prevent concrete spalling in the event of fire. solidian GRID carbon reinforcements are classified in building material class 2 if the aforementioned boundary conditions for the concrete are not met. This means that solidian GRID carbon grid reinforcements may be used in areas in which the building regulations stipulate that the building materials used must be "non-combustible", "flame-retardant" or "normally flammable" - see (solidian abZ/aBG Z-1.6-308, 2024), section 3.3.

Alternatively, the fire behavior of construction products and building materials is classified according to the European standard (DIN EN 13501-1:2019-05), which will gradually replace the German standard system. Classification is based on classes F, E, D, C, B, A1 and A2, with the classes differing in terms of flame exposure times and the type and number of additional test criteria. In Germany, class E (normal flammability) is generally the minimum requirement for the use of a building material.

This proof was provided for the grids included in the approval and most other solidian GRID grids made of carbon and glass. The specific classification of the respective grids is listed in the technical data sheets. If no classification is given, the required tests have not yet been carried out.

Fire resistance

Components are divided into different fire resistance classes based on their fire resistance duration. In Germany, this is regulated by the (DIN 4102-2:1977-09) and the (DIN EN 13501-2:2023-12). Proof must be provided either in accordance with (DIN 4102-2:1977-09) or (DIN EN 1363-1:2020-05) .

Background information

The (DIN 4102-2:1977-09) generally classifies the fire resistance classes as F30 (fire-retardant), F60 (highly fire-retardant), F90 (fire-resistant), F120 (highly fire-resistant) and F180 (highly fire-resistant). The number after the letter F indicates the minimum fire resistance duration in minutes, which must be verified during the fire exposure according to the defined standard temperature-time curve. Additional code letters are used for special components, which are described in more detail in the individual parts of DIN 4102.

The (DIN EN 13501-2:2023-12) uses several criteria for the fire resistance classification, including R (load-bearing capacity), E (room closure) and I (thermal insulation). Here too, the corresponding letter is followed by the minimum duration of the resistance time to be demonstrated for the respective criterion. The time increments include 15, 20, 30, 45, 60, 90, 120, 180, 240 and 360 minutes

For load-bearing components without a room closure, building authority requirements apply with regard to the fire resistance class, which are defined as "fire-retardant" (F30 or R30), "highly fire-retardant" (F60 or R60) and "fire-resistant" (F90 or R90).

The basic principles of the fire behavior of non-metallic reinforcements are similar to those of reinforced concrete or steel reinforcements. The load-bearing capacity of the respective materials decreases depending on the course of the fire and the applied temperature and duration. To ensure that certain temperature limits are not exceeded during the intended fire resistance class, the concrete cover or additional structural fire protection measures must achieve an "insulating" effect. These measures are intended to prevent critical temperatures or exposure times from being exceeded.

The procedures for achieving the desired fire resistance class for non-metallic reinforcements do not differ in principle from those for steel reinforcements. However, to date there are no generally applicable specifications for the necessary measures, such as the required concrete cover to achieve a certain fire resistance class. In addition, there are no completed test programs for components with solidian reinforcement that we are allowed to publish.

Neither the die (DIN EN 1992-1-1:2011-01) nor the (DAfStb Guideline, 2024) currently address the topic of hot design for components with non-metallic reinforcement. This topic is currently being developed for an extended version of the (DAfStb Guideline, 2024). Until the publication of this extended version, solidian aims to carry out appropriate tests and expert opinions in order to classify the fire resistance of components with non-metallic solidian reinforcement. Currently, sufficient fire resistance can either be ensured by an appropriate concrete cover or, if this is not sufficient, by additional design measures such as fire protection boards or coatings and the use of technical systems as part of the fire protection concept.

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Notes

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Croatia

Dr. Slavka Rozgaja 3
47000 Karlovac Croatia - EU
+385 47 693 314
sales@solidian-kelteks.com

Germany

Sigmaringer Straße 150
72458 Albstadt, Germany - EU
+ 49 7431 103135
sales@solidian-kelteks.com

Türkiye

Cinarli Mah. Ozan Abay Cad. Ege Perla
No:10/222 35170 Konak, İzmir, Turkiye
+ 49 7431 103135
sales-turkiye@solidian-kelteks.com