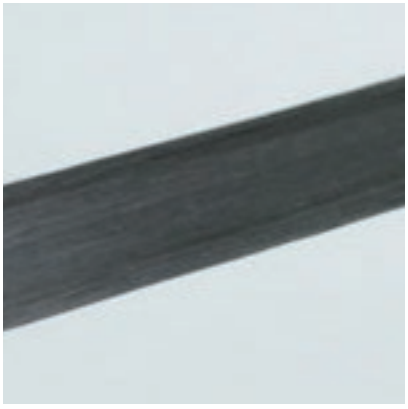
2. Textile concrete at a glance

Textile concrete is a composite material made of special fine concrete matrices and reinforcements of latticed textile layer. The base layer consists of carbon fibers or other suitable high-performance fibers such as alkali-resistant glass fibers. The maximum grain size of the mineral matrix is generally between 1 to 4 mm.

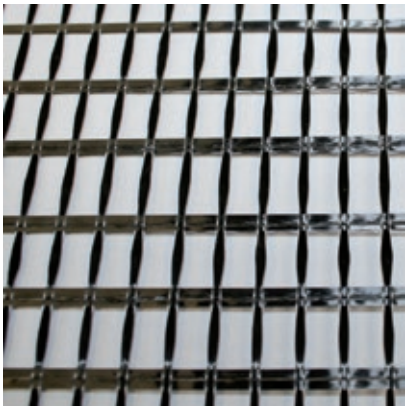
The textile carbon reinforcements do not corrode. Hence, for textile concrete with carbon reinforcement, in contrast to reinforced concrete, thick concrete covers are not required. The minimum concrete covers in the textile concrete must only ensure the bond of textile reinforcement and the concrete matrix and must be the reinforcement diameters in the millimeter range.

Textile concrete components for the strengthening reinforced concrete with TUDALIT® in accordance with abZ [General building inspectorate approval]

Fig.2.1 Carbon filaments



Carbon roving



Mesh scrim (textile reinforcement)
Photos: Frank Schladitz

Fig.2.2 Fine concrete (Dry mortar)

Contents:

- ❑ Cement CEM III B 32,5
- ❑ Hard-coal fly ash
- ❑ Micro silika suspension
- ❑ Sand 0/1
- ❑ Superplasticizer

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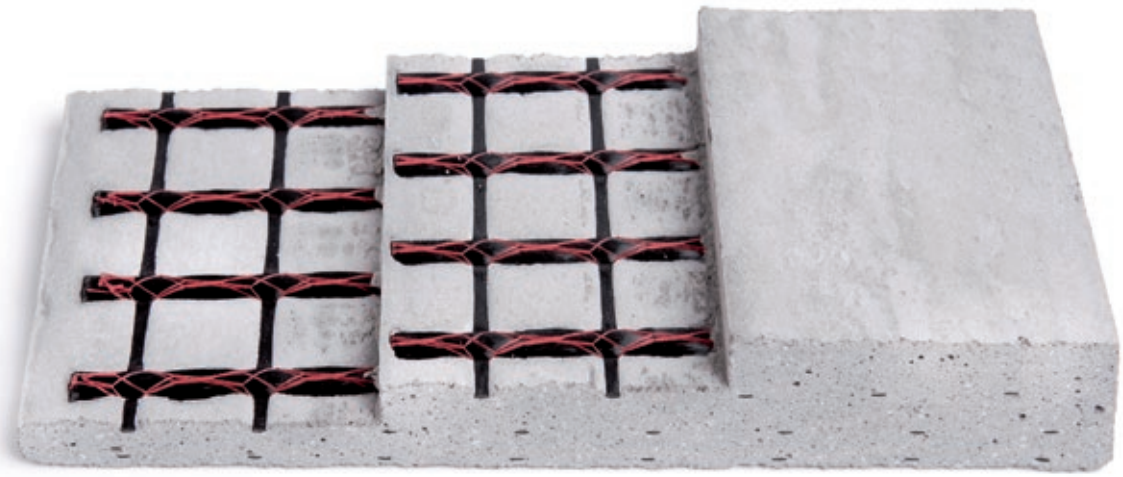

Fig. 2.3:
2-layer textile reinforcement made of carbon filament yarns according to abZ (12 K yarn in side load direction, 50 K yarn in main load direction
Photo: Jörg Singer

Fig. 2.4:
Example of a cylindrically curved shell with a spacer made of carbon fibers (Manufacturer V. FRAAS Solutions in Textile GmbH)
Photo: Ulrich van Stipriaan

Composite material textile concrete

Advantages of the composite material textile concrete

- Textile concrete constructions are narrow, light, high-performance and material-saving.
  Typical thickness range of structural component lies between10 mm to 50 mm.
  According to the present general building inspectorate and approval, based on the number of reinforcement layers (up to a maximum of 4), a layer thickness of approx. 6 mm to 30 mm is required while reinforcing steel concrete components.

- The low space requirement of the textile reinforcements makes the material ideal for the restoration and reinforcement of monument-protected structure and for geometrically restricted conditions in existing buildings.

- Another advantage of building and restoring the stand with textile concrete is the significantly lower additional loads (dead load of the reinforcing layer).

- The plasticity of the textile reinforcement meshes allows creative freedom for architects and designers as well as individual restoration solutions that are suitable for the monument.

- Textile concrete has a uniform cracking pattern with a very small crack width. Hence, it is denser than normal steel concrete.

- Textile concrete is distinguished by its optical and haptic appearance.

- Textile concrete is material-efficient, resource-conserving and sustainable.

Textile concrete as reinforcement material

Textile concrete has proved its suitability for the reinforcement reinforced concrete in an extensive series of tests:

- Reinforcement of the bending tension zone for boards and beams (increase of bending load bearing capacities),

- Reinforcement of shell-shaped load-bearing structures

- Reinforcement of the shear reinforcement on the web of beams and T-beams (increase of the shear force resistance),

- Wrapping of supports (increase of the normal load bearing capacity),

- Reinforcement of round and square components (increase of the torsion resistance)

The present general building inspectorate approval regulates the reinforcement of the bending tension zone for boards and beams of steel concrete under defined framework conditions.

Further application scenarios, approvals are currently required in individual cases. We support you with our many years of experience and extensive knowledge of the material behavior.

Textile concrete as restoration material

In addition to the reinforcement, textile concrete is ideal for the restoration of cracks and damaged concrete surfaces. Textile concrete is characterized by low water penetration depth. As a result, the penetration of harmful substances to the protective building structure can be prevented.

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Table 2.1: Technical comparison of the reinforcement procedures – based on application of abZ [General building inspectorate approval] [1)]

Criterion (5 stage assessment from ++ best assessment to -- worst assessment)	Shotcrete	Bonded reinforcement				Textile concrete according to AbZ [General building inspectorate approval] conditions
		Steel	FRP[fibre-reinforced plastic]			
			Affixed lamella	Slot-applied laminate	Sheet	
Technical properties						
German institute for standardization(++) / General building inspectorate approval (+) / Approval in each individual case (O))	++	+	+	+	+	+
Load bearing capacity	++	+	+	+	+	+
Reinforcement level	++	O	O	+	O	+
Anchoring of old concrete	++	-	-	+	+	++
Additional dead weight or layer thickness	-	+	++	++	++	+
Building climate control	++	+	+	++	--	++
Building material class	++	--	--	--	--	++
Corrosion protection of the strengthening of reinforcing	+	--	++	++	++	++
Corrosion protection of provided reinforcemen	++	--	--	--	-	++
Aspects of production (from ++ high to – low)						
Preparation effort	O	+	+	+	+	O
Application effort	-	++	++	++	++	-
Fire resistance	++	--	--	-	--	(++) Currently applied. Proof required.
Adaptability	++	--	--	--	+	++

Explanations

Technische Eigenschaften:

- Standards are available for shotcrete, for bonded reinforcement, the DAfStB directive “Reinforcing concrete components with glued reinforcement” is used in conjunction with an abZ [General building inspectorate approval], for textile concrete the present abZ [General building inspectorate approval] or a ZiE [Approval in each individual case] is applicable for special applications on the basis of abZ [General building inspectorate approval]

- Increase of the load bearing capacity for each reinforcement procedure

- Reinforcement grade for shotcrete without limitation, for bonded reinforcements application-specific, normally factor 2, in the case of textile concrete, currently the factor greater than 3 is possible

- In case of bonded reinforcement, the composite joint is usually decisive for the introduction of forces

1) According to Jesse, F.; Curbach, M.; in Betonkalender 2010, S. 475 – 565, in consideration of granted abZ [General building inspectorate approval] and the experience gained

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into concrete, Textile concrete, on the other hand, dissipates forces over a large area into old concrete cross-sections (favorable)

- ❑ Dead weight in the case of bonded reinforcement too negligible, low in case of reinforcements with textile concrete and very high in the case of shotcrete
- ❑ Sprayed and textile concrete hardly affect building climate control and sheets act as a diffusion barrier
- ❑ Fire resistance in shotcrete corresponding to steel concrete, in the case of reinforcements with textile concrete, fire resistance times of 90 minutes were achieved in the first tests; requirement of ZiE [Approval in each individual case] is case-dependent, for adhesive bonding, the operating temperature range is limited to 40 ° C without fire-resistant cladding
- ❑ Corrosion protection for textile concrete and fiber-reinforced plastics (CFK-Lamella / Sheets) Sprayed concrete requires thick concrete cover
- ❑ Corrosion protection of the existing reinforcement is improved by means of injection and textile concrete, there is no influence on the stand situation for adhesive bonding

Aspects of the production/construction:

- ❑ Surface treatment with certain adhesive tensile strengths necessary, only slit production required for slotted lamella
- ❑ Fire protection measures for adhesive bonding are already very high in class F 30, no additional measures for shotcrete, textile concrete requires additional examinations and, if necessary, evidence dependent on the concrete application (if applicable, ZiE [Approval in each individual case])
- ❑ Customization of injection and textile concrete to existing structures very good, adhesive bonding can be glued only in a uniaxial manner, sheets can be processed according to the flux
- ❑ Qualification of the personnel makes high demands, whereby sprayed and textile concrete are similar to the steel concrete

Economic comparison of the reinforcement procedures

Specific example (with table):

Framework conditions:

- ❑ Reinforcement level $\eta \leq 2$❑ 500 m² reinforce ceiling surface
- ❑ Ceiling is monolithically connected with main- and substructures
- ❑ Max. span width of the ceiling panels is 1.80 m
- ❑ Crack formation in the supporting torque range is considered (Single-span beam)
- ❑ Slot-applied CFK- laminate is not possible due to insufficient concrete cove

Table 2.2: Cost of reinforcement procedures (Basis: shotcrete)[1)]

Cost block (share in %)	CFK	Shotcrete	Textile
Site equipment	8	11	≤ 16*
Surface preparation	≥ 17	19	19
Total expenditure on reinforcement	75	70	46
Sum	≥ 100	100	≤ 81

* Applicable with ZiE [Approval in each individual case]-effort, otherwise low

Results:

- **Shotcrete reinforcement** requires an additional reinforcement of 1.2 cm² / m (chosen Mat Q188 A, which is overlapped with steel bars every 25 cm and is anchored 8 cm deep into the mortar with reaction resin mortar); The additional dead weight can be removed over existing construction.

- With regard to the maximum limit distances, **affixed CFK- laminates** require 1,500 linear meters with the smallest commercial cross-section; at 200 m, major unevenness must be compensated; execution is monitored externally.

- **Textile concrete reinforcement** requires a layer of textile reinforcement according to abZ [General building inspectorate approval] as well as monitoring of the execution work by the PÜZ body [Testing, Surveillance and Certification body].

Textual description of the table:

- The site equipment includes the costs for the static calculations and the external monitoring.

- The pre-treatment of the subsurface is the same for textile and shotcrete, in the case of CFK-Lamella, in addition to the adhesive surfaces, damaged surfaces are also repaired or re-profiled.

- Thus the reinforcement effort for textile concrete is low, because only one layer of textile reinforcement must be carried out; a higher level of reinforcement leads to a reassessment of costs

Outlook

The development of the building materials systems (“construction kit”) for all types of reinforcement and requirement levels as required by the outdoor applications and non-static loads is carried out as intensively as in the process and production techniques for their reproducible and economical production.

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