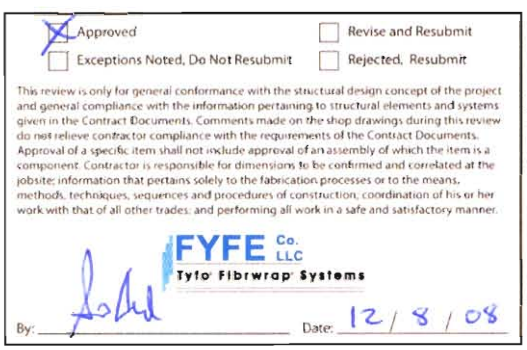
FYFE EUROPE S.A.
The FIBRWRAP® COMPANY

TECHNICAL REPORT

SLABS STRENGTHENING

ENKA, FC SHAKHTAR STADIUM, UKRAINE



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Date: 8 December 2008

Project:	ENKA, FC Shakhtar Stadium, Ukraine
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1. INTRODUCTION

Additional top reinforcement is required at the slabs of Level 2 at the SB section of the new FC Shakhtar Stadium (Donbass Arena) in Donetsk, Ukraine. The stadium is currently under construction by the construction company ENKA on behalf of the Stadium Shakhtar Ltd. Application of Tyfo® Composite Systems is proposed to fulfill the requirement.

The current technical report is conducted after site visit and includes design and proposal of Tyfo® Composite Systems according to the design assumptions and requirements. Detailed drawings and bill of quantities are provided as well.

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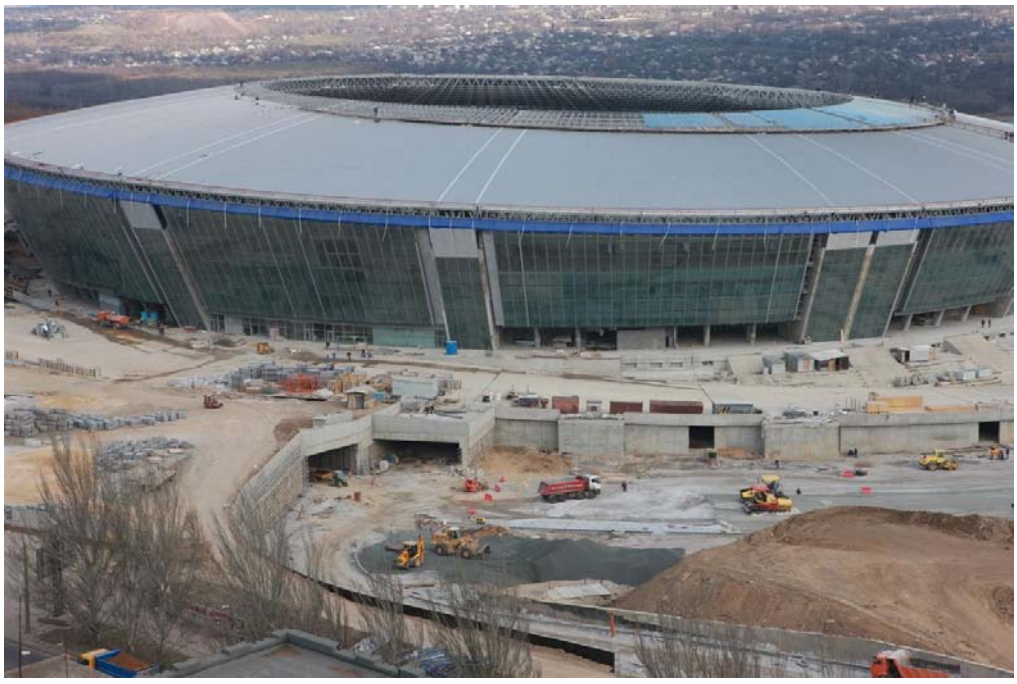
2. PROJECT STATUS

- The stadium is currently under construction. The slabs requiring additional top reinforcement are already constructed and are structural members of Level 2 at the SB section of the structure.

- The area around the slabs is closed. No finishing or flooring is applied above the slabs at the moment.

- The project status is verified after site visiting (2-3 December 2008).



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3. DESIGN

3.1 Guidelines - Codes

- *fib* Bulletin No 14: Externally bonded FRP reinforcement for RC structures
- Fyfe Company Design Manual for the Tyfo® Fibrwrap® Systems (Rev.8)

3.2 Design Assumptions

3.2.1 General

- It is assumed that longitudinal direction is the direction following the circumference of the stadium and transverse direction is the direction following the radius of the stadium.
- It is assumed required top reinforcement equal to the existing bottom reinforcement according to Drawing No ENK-SHK-D-C-153-5.
- It is assumed steel quality of the required top steel reinforcement A500C.

  f_y = 450.00MPa (characteristic yield strength)

- It is assumed existing top steel reinforcement according to Drawing No ENK-SHK-D-C-154-5 as presented in paragraph 3.3.2. The existing top reinforcement is applied only close to the supports. The calculations will be performed as if existing reinforcement is applied at the entire span length. However, the location of the existing reinforcement is taken into account in the final proposal.

3.2.2 Required Top Steel Reinforcement in Longitudinal Direction

A. *Slabs R03-R04*

Ø12 / 150mm	(required top steel reinforcement)
7500mm	(application length in transverse direction)
51 Ø12	(required bars at the entire span)

B. *Slabs R04-R05*

Ø12 / 150mm	(required top steel reinforcement)
9300mm	(application length in transverse direction)
63 Ø12	(required bars at the entire span)

C. *Slabs R05-R07*

Ø12 / 150mm	(required top steel reinforcement)
9300mm	(application length in transverse direction)
63 Ø12	(required bars at the entire span)

D. *Slabs R07-R09*

Ø12 / 150mm	(required top steel reinforcement)
7200mm	(application length in transverse direction)
49 Ø12	(required bars at the entire span)

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3.2.3 Required Top Steel Reinforcement in Transverse Direction

A. *Slabs R03-R04*

Ø12 / 150mm (required top steel reinforcement)
5000mm (application length in longitudinal direction)
34 Ø12 (required bars at the entire span)

B. *Slabs R04-R05*

Ø12 / 150mm (required top steel reinforcement)
5400mm (application length in longitudinal direction)
37 Ø12 (required bars at the entire span)

C. *Slabs R05-R07*

Ø12 / 150mm (required top steel reinforcement)
5900mm (application length longitudinal direction)
41 Ø12 (required bars at the entire span)

D. *Slabs R07-R09*

Ø12 / 150mm (required top steel reinforcement)
6500mm (application length longitudinal direction)
45 Ø12 (required bars at the entire span)

3.2.4 Summary Table for Required Top Steel Reinforcement

Required Top Steel Reinforcement (Ø12)				
A500C	R03-R04	R04-R05	R05-R07	R07-R09
Longitudinal	51	63	63	49
Transverse	34	37	41	45

3.3 Existing Properties

3.3.1 Cross Section Properties

A. *Slabs R03-R04*

$L_{L,A}$ = 5850mm (span length of slab in longitudinal direction)

$L_{T,A}$ = 8000mm (span length of slab in transverse direction)

B. *Slabs R04-R05*

$L_{L,B}$ = 6500mm (span length of slab in longitudinal direction)

$L_{T,B}$ = 10500mm (span length of slab in transverse direction)

C. *Slabs R05-R07*

$L_{L,C}$ = 7350mm (span length of slab in longitudinal direction)

$L_{T,C}$ = 10500mm (span length of slab in transverse direction)

D. *Slabs R07-R09*

$L_{L,D}$ = 8000mm (span length of slab in longitudinal direction)

$L_{T,D}$ = 8000mm (span length of slab in transverse direction)

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3.3.2 Existing Steel Reinforcement

A. *Slabs R03-R04*

9 + 8 = 17 Ø10 (longitudinal existing top steel reinforcement)
8 + 8 = 16 Ø10 (transverse existing top steel reinforcement)

B. *Slabs R04-R05*

11 + 10 = 21 Ø10 (longitudinal existing top steel reinforcement)
8 + 8 = 16 Ø10 (transverse existing top steel reinforcement)

C. *Slabs R05-R07*

10 + 8 = 18 Ø10 (longitudinal existing top steel reinforcement)
8 + 8 = 16 Ø10 (transverse existing top steel reinforcement)

D. *Slabs R07-R09*

8 + 9 = 17 Ø10 (longitudinal existing top steel reinforcement)
8 + 8 = 16 Ø10 (transverse existing top steel reinforcement)

Existing Top Steel Reinforcement (Ø10)				
A500C	R03-R04	R04-R05	R05-R07	R07-R09
Longitudinal	17	21	18	17
Transverse	16	16	16	16

3.3.3 Material Properties

f_y = 450.00MPa (characteristic yield strength of steel reinforcement)

3.4 Tyfo® Systems Properties

3.4.1 Tyfo® SCH-41 Carbon Composite System

f_{fu} = 834.00 MPa (ultimate tensile strength of composite)
ε_{fu} = 0.0085 (ultimate rupture strain of composite)
E_f = 82.00 GPa (tensile modulus of elasticity of composite)
t_f = 1.00 mm (thickness per layer of composite)

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3.5 Tyfo® Design Requirements

- The required top steel reinforcement area A'_s at the entire span is determined as:

$$A'_s = n'_s A'_{\emptyset}$$

Where:

$A'_{\emptyset}$ = Area of a single steel re-bar of the required top steel reinforcement

Calculating for each case of slabs:

Required Top Steel Reinforcement Area, A'_s (mm²)				
	R03-R04	R04-R05	R05-R07	R07-R09
Longitudinal	5763	7119	7119	5537
Transverse	3842	4181	4633	5085

- The existing top steel reinforcement area A_s at the entire span is determined as:

$$A_s = n_s A_{\emptyset}$$

Where:

$A_{\emptyset}$ = Area of a single steel re-bar of the existing top steel reinforcement

Calculating for each case of slabs:

Existing Top Steel Reinforcement Area, A_s (mm²)				
	R03-R04	R04-R05	R05-R07	R07-R09
Longitudinal	1334,5	1648,5	1413	1334,5
Transverse	1256	1256	1256	1256

- Steel quality of the required top steel reinforcement is the same with the steel quality of the existing top steel reinforcement. Therefore, the additional required top steel reinforcement $A_{s,add}$ for the entire span can be directly derived as:

$$A_{s,add} = A'_s - A_s \qquad (2)$$

Where:

A'_s = Area of required top steel reinforcement

A_s = Area of existing top steel reinforcement

Calculating for each case of slabs:

Additional Top Steel Reinforcement Area, $A_{s,add}$ (mm²)				
	R03-R04	R04-R05	R05-R07	R07-R09
Longitudinal	4428,5	5470,5	5706	4202,5
Transverse	2586	2925	3377	3829

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- The maximum loading carrying capacity of the additional required top steel reinforcement $F_{s,add}$ is equal to:

$$F_{s,add} = A_{s,add} f_y$$

Calculating for each case of slabs:

Additional Top Steel Reinforcement Capacity, $F_{s,add}$ (kN)				
	R03-R04	R04-R05	R05-R07	R07-R09
Longitudinal	1992,825	2461,725	2567,7	1891,125
Transverse	1163,7	1316,25	1519,65	1723,05

3.6 Tyfo® Design

- Application of Tyfo® SCH-41 Carbon Composite System by 1 layer strips of 600mm width each at the entire length of the spans in both longitudinal and transverse direction. Anchoring provided by Tyfo® Fibrwrap® Carbon Anchors.

- The effective stress in the composite system f_{fe} is determined as:

$$f_{fe} = E_f \varepsilon_{fe} \qquad (1)$$

Where:

ε_{fe} = Effective strain level in the composite (suggested values between 0.004 and 0.006). The enhanced debonding capacity of the composite using Tyfo® Fibrwrap® Carbon Anchors allows safe adoption of the value of **0.006**

Calculating:

$$f_{fe} = 82.00GPa \cdot 0.006 = \mathbf{492MPa}$$

- The area of the composite system A_f required as equivalent to the maximum loading carrying capacity of the additional required top steel reinforcement $F_{s,add}$ is determined as:

$$A_f = \frac{F_{s,add}}{f_{fe}}$$

Calculating for each case:

Required Composite System Area, A_f (mm²)				
	R03-R04	R04-R05	R05-R07	R07-R09
Longitudinal	4050,45732	5003,5061	5218,90244	3843,75
Transverse	2365,2439	2675,30488	3088,71951	3502,13415

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- For applying strips of 600mm width, the number of layers n_f required in total for each slab is determined as:

$$n_f = \frac{A_f}{600mm \cdot t_f}$$

Calculating for each case:

Required Number of Layers, n_f (pcs)				
	R03-R04	R04-R05	R05-R07	R07-R09
Longitudinal	6,7507622	8,33917683	8,69817073	6,40625
Transverse	3,94207317	4,45884146	5,14786585	5,83689024

Or:

Required Number of Layers, n_f (pcs)				
	R03-R04	R04-R05	R05-R07	R07-R09
Longitudinal	7	9	9	7
Transverse	4	5	6	6

3.7 Conclusions

- Strengthening of the slabs according to the design assumptions can be performed by application in both longitudinal and transverse direction of **strips 60cm width consisting Layers of Tyfo® SCH-41 Carbon Composite System, properly anchored by Tyfo® Fibrwrap® Carbon Anchors**

- The number of Layers required in total for each case are summarized in the following table:

Required Number of Layers, n_f (pcs)				
	R03-R04	**R04-R05**	**R05-R07**	**R07-R09**
Longitudinal	**7**	**9**	**9**	**7**
Transverse	**4**	**5**	**6**	**6**

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4. PROPOSAL

4.1 Description

- Strengthening of the slabs in order to compensate missing top reinforcement can be performed by application of Tyfo® SCH-41 Carbon Composite System properly anchored against debonding by use of Tyfo® Fibrwrap® Carbon Anchors.

- The exact application model is presented in the relevant drawing.

- Application will be performed in both longitudinal and transverse direction by strips of 60cm width, with constant 100cm distance on center. In each case, the strips will be aligned around the central axis of each slab in both directions. Standard strip lengths will be used as following:
  - *Type A: 6m*
  - *Type B: 7m*
  - *Type C: 8m*
  - *Type D: 9m*
  - *Type E: 11m*

- More than one layer is applied at certain cases to form a strip. This design is introduced in order to apply the additional top reinforcement mostly at the center of each slab where existing reinforcement is totally absent.

- Tyfo® Fibrwrap® Carbon Anchors must be applied in pairs at the entire strips length. For each of the standard strip Types there is specific distribution of Tyfo® Fibrwrap® Carbon Anchors as shown in the relevant details of the drawing.

- Application pattern of the strips alters in some cases from typical because of the existence of future holes or because of the stair case compartment. In this case elimination of strips is required. The eliminated layers are added in nearby strips.

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4.2 Specifications

- Attention is required at performing concrete surface preparation based on the specification of the Tyfo® SCH-41 Carbon Composite System. Concrete grinding is required until the top of the aggregates is exposed.

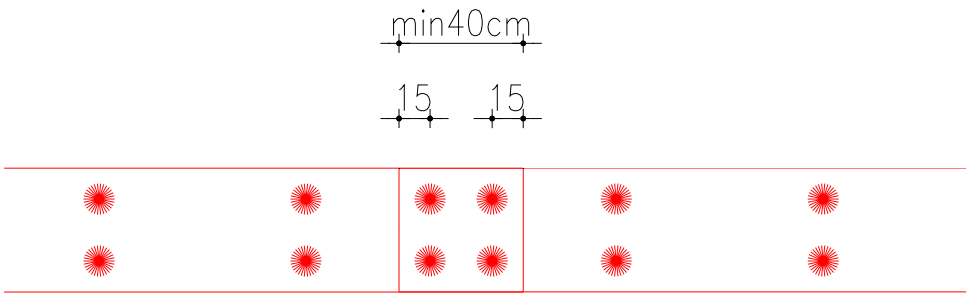
- Lap splice length of minimum 40cm must be applied. Anchoring of the composite system at lap splices must be performed by application of 4 Tyfo® Fibrwrap® Carbon Anchors as shown in relevant drawing.

- Tyfo® Fibrwrap® Carbon Anchors of proper diameter and length according to Fyfe Company Design Manual for the Tyfo® Fibrwrap® Systems (Rev.8) are taken into account for the design.

- Attention is required at keeping site temperature above 5° C during application and for a minimum curing period of 1 day.

- Material Data Sheets are attached.

4.3 Drawings



Drawing 1

Created for Fyfe Europe by:	Checked for Fyfe Europe by:	Checked for Fyfe Co by:
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BILL OF QUANTITIES

- The required quantities of Tyfo® SCH-41 Carbon Composite System and Tyfo® Carbon Fibrwrap Anchors for each slab and in total are presented in the following table:

		R03-R04		R04-R05		R05-R07		R07-R09		Layer Strips (pcs)	SCH-41 Length (m)	SCH-41 Area (m^2)	Carbon Anchors (pcs)
		Lon.	Tr.	Lon.	Tr.	Lon.	Tr.	Lon.	Tr.				
Type A													
6m	1x	6		6						12	72	43,2	72
6	2x	4		4						16	96	57,6	48
anchors	4x					1				4	24	14,4	6
								Subtotal		32	192	115,2	126
Type B													
7m	1x	6				15		6		27	189	113,4	162
6	2x	4				6		4		28	196	117,6	84
anchors	4x					1				4	28	16,8	6
								Subtotal		59	354	212,4	252
Type C													
8m	1x			6				20		26	208	124,8	156
6	2x			4				5		18	144	86,4	54
anchors	4x									0	0	0	0
								Subtotal		44	264	158,4	210
Type D													
9m	1x	3	4	3	1			6		17	153	91,8	136
8	2x	2	2	2				4		20	180	108	80
anchors	4x									0	0	0	0
								Subtotal		37	296	177,6	216
Type E													
11m	1x		4		8		6	3		21	231	138,6	210
10	2x		4		8		6	2		40	440	264	200
anchors	4x					1				4	44	26,4	10
								Subtotal		65	650	390	420
								Total		237	1756	1053,6	1224

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TYFO® SCH-41 Composite
using TYFO® S EPOXY[1]

DESCRIPTION
The Tyfo® SCH–41[1] Composite is an ICC ESR-2103 listed, NSF-Certified material comprised of Tyfo® S Epoxy and Tyfo® SCH–41 reinforcing fabric.
Tyfo® SCH–41 is a custom unidirectional carbon fabric with glass cross fiber for added strength and fabric stability during installation. The carbon material is orientated in the 0° direction.
The Tyfo® S Epoxy is a two-component epoxy matrix material for bonding applications. Tyfo® S Epoxy may also be thickened and used as a putty or protective finish-coat depending on the project requirements.

USE
Tyfo® SCH–41 fabric is combined with Tyfo® S Epoxy material to add strength and ductility to bridges, buildings and other structures.

ADVANTAGES
- ICC-ES ESR-2103 listed material
- Component of UL listed, fire-rate assembly
- NSF/ANSI Standard 61 listed product for drinking water systems
- Good high and low temperature properties
- Long working time
- High elongation
- Ambient cure
- 100% solvent-free
- Rolls can be cut into desirable widths prior to shipping

COVERAGE
Approximately application of 13m² - 18m² of Tyfo® SCH–41 Fabric with 1 unit of Tyfo® S Epoxy.

PACKAGING
Order Tyfo® SCH–41 in 91.4m x 0.61m = 55.75m² rolls.
Typically ships in 30cm x 30cm x 160cm boxes.
Order Tyfo® S Epoxy in pre-measured units comprised of Component A (bucket weighing 12.23kg) and Component B (bucket weighing 4.22kg). Tyfo® UC-1.00mm

EPOXY MIX RATIO
100 Component A to 42 Component B *by volume*. 100 Component A to 34.5 Component B *by weight.*

SHELF LIFE
Epoxy: Two years in original, unopened and properly stored containers.
Fabric: Ten years in proper storage conditions.

TYPICAL DRY PROPERTIES	
Tensile Strength (GPa)	3.8GPa
Tensile Modulus (GPa)	230GPa
Ultimate Elongation	1.7%
Density (g/cm^3)	1.74g/cm^3
Weight per. sq. Meter (g/m^2)	644g/m^2
Fiber Thickness (mm)	0.37mm
Fabric Width (m)	0.61m

COMPOSITE LAMINATE PROPERTIES			
PROPERTY	**ASTM METHOD**	**TYPICAL TEST VALUE**	**DESIGN VALUE***
Ultimate tensile strength in primary fiber direction (MPa)	D-3039	986MPa	834MPa
Elongation at break	D-3039	1.0%	0.85%
Tensile Modulus (GPa)	D-3039	95.8GPa	82.0GPa
Nominal Laminate Thickness (mm)		1.00mm	1.00mm

* Design and specification values will vary based on individual project requirements and applicable safety factors. Please contact Fyfe Europe S.A. engineers to determine appropriate specification values.

EPOXY MATERIAL PROPERTIES		
Curing schedule: 72 hours post cure at 60°C		
PROPERTY	**ASTM METHOD**	**TYPICAL TEST VALUE**
Tg (24 hours post cure at 60°C)	ASTM D-4065	82°C
Tensile Strength[1] (MPa)	ASTM D-638 Type 1	72.4MPa
Tensile Modulus (GPa)	ASTM D-638 Type 1	3.18GPa
Elongation Percent	ASTM D-638 Type 1	5%
Flexural Strength (MPa)	ASTM D-790	123.4MPa
Flexural Modulus (GPa)	ASTM D-790	3.12GPa

[1] Testing temperature: 21°C. Crosshead speed: 13mm/min. Grips Instron 2716-0055-30kips

STORAGE CONDITIONS
Store at 4°C to 32°C. Avoid freezing. Store rolls flat, not on ends. Avoid moisture and water contamination.

CERTIFICATE OF COMPLIANCE
- Will be supplied upon request with copy of labels used is necessary.
- Material safety data sheets will be supplied upon request.
- Possesses 0% V.O.C. level.

HOW TO USE THE TYFO® FIBRWRAP® SYSTEM

DESIGN
The Tyfo® Fibrwrap System shall be designed to meet specific design criteria. The criteria for each project are dictated by the engineer of record and any relevant building codes and/or guidelines. The design should be firmly based on the allowable strain for each type of application and the design modulus of material.

INSTALLATION
Tyfo® Fibrwrap System shall be installed by Fyfe Europe S.A. trained and certified applicators. Installation shall be in strict compliance with the Fyfe Europe S.A. Quality Control Manual.

SURFACE PREPARATION
The required surface preparation is strongly dependent on the type of the element being strengthened. In general, the surface must be clean, dry and free of protrusions or cavities, which may

[1] ICC ESR-2103 listed material name

cause voids behind the Tyfo® Composite. Column surfaces that will receive continuous wraps typically require only a broom cleaning. Round off sharp and chamfered corners to a radius of 2.5 cm either by grinding or by using the system's thickened epoxy (Tyfo® WS Epoxy) or repair mortar approved by the engineer. Discontinuous wrapping surfaces such as walls, beams, slabs, etc, typically require a light sandblast, grinding or other approved methods in order to be prepared for bonding. Before application of the prime coat, clean thoroughly from dust by using a vacuum cleaner or a wet cloth and wait to dry. At the time of application the substrate shall not have any free moisture on it. If moisture cannot be avoided, use of the wet prime epoxy (Tyfo® WP Wet-Prime Epoxy) is recommended.
Tyfo® FibrAnchors™ are incorporated in some designs. The engineering staff will provide the proper specifications and details based on the project requirements.

MIXING
For pre-measured units of "PACKAGING", pour the contents of Component B (Hardener) into the pail of Component A (Epoxy). In general, mix 100 parts of Component A to 42 parts of Component B *by volume* or 100 parts of Component A to 34.5 parts of Component B *by weight*. Mix thoroughly for five minutes with a low-speed mixer at 400 - 600 RPM until uniformly blended. No air bubbles should be created during the mixing.

APPLICATION
Apply one prime coat of Tyfo® S Epoxy on the substrate by using a roller. Allow primer to become tacky to the touch. Saturate the fabric at both sides by using a roller. A Tyfo® Saturator machine can be used alternatively. Prior to the application of the saturated fabric, fill any uneven surface with Tyfo® WS Epoxy. Saturate and apply subsequent layers of the fabric according to the Specifications and the Design Requirements. The use of a roller or hand pressure, ensure proper orientation of fibers, release or roll out entrapped air and ensure that each individual layer is firmly bedded and adhered to the preceding layer or substrate. Apply a final coat of Tyfo® WS Epoxy and detail all fabric edges, including butt splice, termination points and jacket edges.

PROTECTIVE COATINGS
In case of plaster final coating, apply sand by hand for better bonding surface while the final coat of epoxy is still tacky.
In case of paint final coating, paint between 24 and 72 hours after final application of epoxy. If more than 72 hours after application, prepare the surface of the final coat of epoxy by light sandblast or hand sanding to slightly etch the surface.

LIMITATIONS
Minimum application temperature of the epoxy is 4°C. DO NOT THIN, solvents will prevent proper cure.

QUALITY CONTROL

PREPARATION
Visit site to ensure that all patch work is completed and cured. Review project specifications in details.
Verify ambient and concrete temperatures. No work shall proceed if the temperature of the concrete surface being repaired is less than 7,5°C or greater than 40°C.
In case of discontinuous wrapping surfaces such as walls, beams, slabs, etc, the bonding strength to substrate (concrete or repair mortar) should be greater than 1.5MPa (this shall be verified by pull-off strength tests according to ASTM D-4541-95).

FIELD QUALITY CONTROL
Record batch numbers for fabric and epoxy used each day and note locations of installations. Measure square meters of fabric and volume of epoxy used each day.

SAMPLE PREPARATION
From a standard epoxy mix saturate fabric according to specified fiber-resin ratio. On a smooth, flat, level surface covered with polyethylene sheeting, prime with epoxy resin. Prepare sample by placing two layers of saturated fabric with primary fibers oriented in the same direction. Apply additional topping of epoxy. Cover with plastic film and squeeze out all bubbles. Samples shall be stored in a sample box and not be moved for a minimum of 48 hours after casting. A minimum of two samples shall be made daily. The two sample batches will be taken at appropriate times during the day so as to ensure the maximum material deviance in the components of the composite.

LABORATORY TESTING
The samples shall be given to pre-approved testing laboratory. Samples are to be cured for 48 hours at 60° C before testing. Testing shall be in accordance with ASTM D-3039 and Fyfe Europe S.A. sample preparation and testing procedures.

CAUTION

COMPONENT A – Irritant:
Prolonged contact to the skin may cause irritation. Avoid eye contact.

COMPONENT B – Irritant:
Contact with skin may cause severe burns. Avoid eye contact. Product is a strong sensitizer. Use of safety goggles and chemical resistant gloves is recommended. Remove contaminated clothing. Avoid breathing vapors. Use adequate ventilation. Use of an organic vapor respirator is recommended.

SAFETY PRECAUTIONS
Use of an approved particle mask is recommended for possible airborne particles. Gloves are recommended when handling fabrics so that skin irritation will be avoided. Safety glasses are recommended to prevent eye irritation.

FIRST AID
In case of skin contact, wash thoroughly with soap and water. In case of eye contact, wash immediately. For respiratory problems, move to fresh air. Wash clothing before reuse.

CLEAN UP
Collect with absorbent material, wash with water. Dispose of in accordance with local disposal regulations. Uncured material can be removed with approved solvent. Cured materials can only be removed mechanically.

- **KEEP CONTAINER TIGHTLY CLOSED.**
- **NOT FOR INTERNAL CONSUMPTION.**
- **CONSULT MATERIAL SAFETY DATA SHEET (MSDS) FOR MORE INFORMATION.**
- **KEEP OUT OF REACH OF CHILDREN.**
- **FOR INDUSTRIAL USE ONLY**.

Fyfe Europe S.A.
''The Fibrwrap® Company''
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TYFO® CARBON ANCHOR USING TYFO® S EPOXY

DESCRIPTION
The Tyfo® Carbon Anchor is comprised of Tyfo® S Epoxy and Tyfo® SCH carbon fiber reinforced roving. Tyfo® SCH is a custom, uni-directional carbon roving for improved end details and force transfer. The Tyfo® S Epoxy is a two-component epoxy matrix material for saturation and bonding applications.

USE
Tyfo® Carbon Anchors are combined with Tyfo® S Epoxy material to improve end details and anchorage of various Fibrwrap® designs.

ADVANTAGES
- Durability
- Good high and low temperature properties
- High tensile modulus and strength
- Ambient cure
- 100% solvent-free

PACKAGING
Packaged in lots of 50 anchors. Weight will vary based on anchor design requirements.

EPOXY MIX RATIO
100 Component A to 42 Component B *by volume*. 100 Component A to 34.5 Component B *by weight*.

SHELF LIFE
Epoxy: Two years in original, unopened and properly stored containers.
Fabric: Ten years in proper storage conditions.

STORAGE CONDITIONS
Store at 4°C to 32°C. Avoid freezing. Store rolls flat, not on ends. Avoid moisture and water contamination.

CERTIFICATE OF COMPLIANCE
- Will be supplied upon request with copy of labels used.
- Material safety data sheets will be supplied upon request.
- Possesses 0% V.O.C. level.

TYPICAL DRY FIBER PROPERTIES	
Tensile Strength (GPa)	3.79GPa
Tensile Modulus (GPa)	230GPa
Ultimate Elongation	1.7%

COMPOSITE GROSS LAMINATE PROPERTIES			
PROPERTY	**ASTM METHOD**	**TYPICAL TEST VALUE**	**DESIGN VALUE***
Ultimate tensile strength in primary fiber direction (MPa)	D-3039	876MPa	745MPa
Elongation at break	D-3039	1.2%	1.2%
Tensile Modulus (GPa)	D-3039	72.4GPa	61.5GPa

*** Design and specification values will vary based on individual project requirements and required area of composite anchor. Contact Fyfe Europe S.A. engineers to determine required design.**

EPOXY MATERIAL PROPERTIES		
Curing schedule: 72 hours post cure at 60°C		
PROPERTY	**ASTM METHOD**	**TYPICAL TEST VALUE**
Tg (24 hours post cure at 60°C)	ASTM D-4065	82°C
Tensile Strength[1] (MPa)	ASTM D-638 Type 1	72.4MPa
Tensile Modulus (GPa)	ASTM D-638 Type 1	3.18GPa
Elongation Percent	ASTM D-638 Type 1	5.0%
Flexural Strength (MPa)	ASTM D-790	123.4MPa
Flexural Modulus (GPa)	ASTM D-790	3.12GPa
[1] Testing temperature: 21°C. Crosshead speed: 13mm/min. Grips Instron 2716-0055-30kips		

HOW TO USE THE TYFO® FIBRWRAP® SYSTEM

DESIGN
The Tyfo® System shall be designed to meet specific design criteria. The criteria for each project are dictated by the engineer of record and any relevant building codes and/or guidelines. The design should be based on the allowable strain for each type of application and the design modulus of material. The Fyfe Europe S.A. engineering staff will provide preliminary design at no obligation.

INSTALLATION
Tyfo® System to be installed by Fyfe Europe S.A. trained and certified applicators. Installation shall be in strict compliance with the Fyfe Europe S.A. Quality Control Manual.

SURFACE PREPARATION
The required surface preparation is strongly dependent on the type of element being strengthened. In general, the surface must be clean, dry and free of protrusions or cavities, which may cause voids behind the Tyfo® Composite. Discontinuous wrapping surfaces (walls, beams, slabs, etc.) typically require a light sandblast, grinding or other approved methods to prepare for bonding. The Fyfe Europe S.A. engineering staff will provide the proper specifications and details based on the project requirements.

MIXING
For pre-measured units of "PACKAGING", pour the contents of Component B (Hardener) into the pail of Component A (Epoxy). In general, mix 100 parts of Component A to 42 parts of Component B *by volume* or 100 parts of Component A to 34.5 parts of Component B *by weight*. Mix thoroughly
for five minutes with a low-speed mixer at 400 - 600 RPM until uniformly blended. No air bubbles should be created during the mixing.

APPLICATION
Apply the Tyfo® Epoxy to the Tyfo® Carbon Anchors by hand. The fully saturated anchor is then applied as detailed on the project drawings.

LIMITATIONS
Minimum application temperature of the epoxy is 4° C. DO NOT THIN, solvents will prevent proper cure.

CAUTION

COMPONENT A – Irritant:
Prolonged contact to the skin may cause irritation. Avoid eye contact.

COMPONENT B – Irritant:
Contact with skin may cause severe burns. Avoid eye contact. Product is a strong sensitizer. Use of safety goggles and chemical resistant gloves recommended. Remove contaminated clothing. Avoid breathing vapors. Use adequate ventilation. Use of an organic vapor respirator recommended.

SAFETY PRECAUTIONS
Use of an approved particle mask is recommended for possible airborne particles. Gloves are recommended when handling fabrics to avoid skin irritation. Safety glasses are recommended to prevent eye irritation.

FIRST AID
In case of skin contact, wash thoroughly with soap and water. For eye contact, flush immediately. For respiratory problems, remove to fresh air. Wash clothing before reuse.

CLEAN UP
Collect with absorbent material, flush with water. Dispose of in accordance with local disposal regulations. Uncured material can be removed with approved solvent. Cured materials can only be removed mechanically.

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