FRP SYSTEM®

Technology for structural reinforcement plating and wrapping of carbon fibre composite systems

OVERVIEW

The term composite system in carbon fibre refers to materials composed of high-resistance, continuous fibre fabrics immersed in a polymer matrix and pultruded laminates. Since a lot of years these materials have been used on a large scale in aeronautical and mechanical engineering because of their very high level of mechanical performance. In the last twenty years , they have been used in other industrial sectors, and especially in the field of structural reinforcement in buildings, infrastructure, cultural heritage.
The principle characteristics of the composite system are high resistance to tensile stress, high corrosion resistance , high flexibility and very limited weight.

DESCRIPTION

The FRP SYSTEM consist of high-density carbon-fibre strips and pultruded laminates attached to the supports with special resinous binders with superior mechanical characteristics. With both the plating and the wrapping methods of application, the system increase capacity of the structures where it is necessary to improve and repair static conditions, by increasing their resistance, load-bearing qualities and ductility on seismic areas, without overloading the structure.

USES

The main applications of the FRP SYSTEM are in the following areas of concrete and masonry:
- Reinforcement of deflected structures
Reduction of loaded deflection, increase of load-bearing capacity, and the regeneration of transmission of tension interrupted by cracking, in slabs, beams, interlocked elements, etc.
- Reinforcement of compressed structures
Increase of compressive strength and ductility, for example in pillars, columns, chimney stacks, etc. This type of intervention is particularly suitable for the improvement of structures in seismic zones without increasing weight.
- Reinforcement of weakened structures
Important applications are the repairing of concrete structures like bridges, building, industrial areas, the restoration of vaults and arches in masonry, cupolas, walls, etc.
In general, the FRP SYSTEM technique can be applied on structural reinforcement of concrete such as viaducts, car-parks, civil and industrial buildings, in historic buildings and monuments, in wooden structures.

ADVANTAGES

High level of mechanical characteristics and performance
High chemical resistance to corrosion
Increase stress resistance and ductility
Reliability and long-life of the system
Excellent applicability in humid environments (water absorption < 0.1%)
Excellent level of wettability of fabric
High tear resistance also on irregular, uneven substrates
Very low weight and impact technology
The FRP SYSTEM fabric can be easily draped over structures and adapted to complex forms and uneven surfaces. The laminate are very suitable for concrete beams and slabs with high load requirements
The system can be easily applied without complicated on-site management
During the rehabilitation work industrial activity can be kept open and on service
Limited reduction of permeability in frescoed vaults.
Very limited time prior to re-use.
Reduced time and costs for application

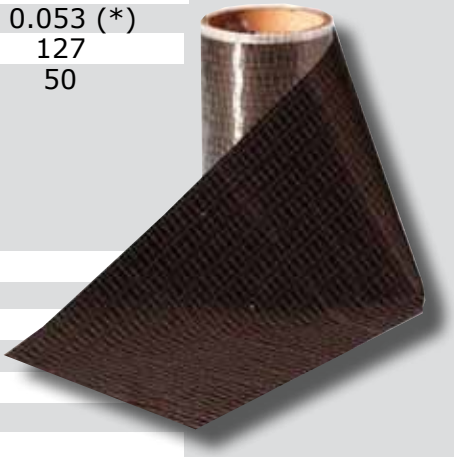
TECHNICAL DATA

The FRP SYSTEM system consists of carbon fibre reinforcement fabric unidirectional, bidirectional and quadriaxial, pultruded laminate, special anchoring connectors, special adhesives for smoothing, adhesion and protection. Additional metal plate anchoring system are available upon request

A) TYPE OF CARBON FABRIC FRP SYSTEM to be used with adhesives RESIN 75 - RESIN 90

Type (sp.gr.1.8 g/cm³)	Uni-directional C-SHEET 240	Bi-directional CTB 240	Quadriaxial C-Sheet 240 Q
Weight of the fabric g/m²	200 300 400 600	220 320	380
Thickness mm	0.11 0.167 0.22 0.334	0.061 0.09 (*)	0.053 (*)
Standard width cm	10-20-30-50	10-20-50	127
Standard length of rolls m	50	50	50

(*) thickness for direction



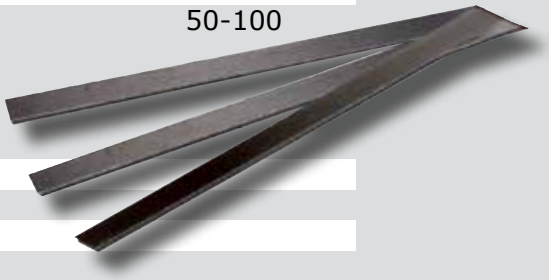
TECHNICAL CHARACTERISTICS OF FABRIC FRP SYSTEM C-SHEET, CTB, Q

FILAMENT	
Tensile strength	4,700 MPa
E-modulus	240 GPa
Elongation	2%
FABRIC (according with european norm EN 2561)	
Tensile strength	3,800 MPa
E-modulus	240 GPa
Elongation	1.8 %

The Company can produce on demand different types of weigth and width of fabric.

B)TYPE OF CARBON PULTRUDED LAMINATE LAMELLE CFK (fiber content > 68%) to be used with adhesive RESIN 90.

Type	width mm	thickness mm	Standard roll m
150/2000/0512	50	1.2	50-100
150/2000/0514	50	1.4	50-100
150/2000/1012	100	1.2	50-100
150/2000/1014	100	1.4	50-100



TECHNICAL CHARACTERISTICS OF LAMELLE CFK

(according with european norm EN 2561)	
Tensile strength	>2,500 MPa
E-modulus	>160 GPa
Elongation	> 1,5%

The Company can produce on demand different types and dimensions of LAMELLE CFK.

C)FIBER CONNECTOR FOR ANCHORING AFIX

The anchoring connector for FRP SYSTEM to be used with adhesive RESIN 75.

FILAMENT	
Tensile strength	2,900 MPa
E-modulus	120 GPa
Elongation	2.5 %
AFIX 10 Connector (according with european norm EN 2561)	
Diameter	10 mm
Tensile strength	1,600 MPa
E-modulus	110 GPa
Elongation	1.5%
Packaging	10 m carbon box

D)TYPES OF ADHESIVES FOR FRP SYSTEM (according with European norm EN 1504-4)
The application system varies in accordance with the type of substrate and the conditions of the same. In general, the application cycle requires for FRP SYSTEM fabric primer RESIN PRIMER , smoothing coat if substrate is rough RESIN 90 , adhesive coat and final saturation RESIN 75.
For Lamelle CFK the normal application is made by primer RESIN PRIMER and adhesive RESIN 90.
Connector AFIX 10 is used with RESIN 75.
Normally the final protection can be made by a protective coating like RESINCOLOR.

ADHESIVES
RESIN PRIMER

Structure type	porous
Specific gravity	0.98 g/cm²
Workability	>60 min
Touch dry at 20°C	5 h
Min application temperature	10 °C
Packaging A+B	5+5 l

RESIN 90 - SMOOTHING COAT AND ADHESIVE
Smoothing with special RESIN 90 epoxy binder as required when the surface is irregular , rough or when the substrate needs adequate reinforcing for the transmission of stress. RESIN 90 is used as adhesive for LAMELLE CFK.

Specific gravity	1.95 g/cm²
Workability at 20°C	60 min
Touch dry at 20°C	6-8 h
Min application temperature	8° C
E-modulus	>3,000 MPa (*)
Compressive strength	54 MPa
Concrete adhesion	>2.5 N/mm²
Flexural strength	32 MPa
Packaging A+B	5+5 kg

(*) Available a special binder RESIN 95 with higher modulus 12,000 N/mm²

RESIN 75 – ADHESIVE AND IMPREGNATION
The adhesive system features high performance epoxy adhesives RESIN 75

Specific gravity	1.20 g/cm²
Workability at 20°C	30 min
Touch dry at 20°C	4 h
Min application temperature	10° C
Adhesion to concrete	>2.5 MPa
Adhesion to steel	>14 MPa
Flexural strength	45 MPa
E-modulus	>4,600 MPa
Compressive strength	82 MPa
Packaging A+B	3+1 kg

E)RESINCOLOR FOR PROTECTION
In cases where a final protection is required for the FRP SYSTEM fibre reinforcement, it is advisable to use the RESINCOLOR special finishing product, which offers the high protection against U.V. rays and anticarbonation.
RESINCOLOR is available in colour RAL 7035 light gray.

Specific gravity	1.3 g/cm²
Workability at 20°C	40 min
Touch dry at 20°C	5 h
Min application temperature	5° C
Packaging	Prime 18 l
	Resin 20 kg

Different packaging are available upon request.

YELD

Consumption of the materials is closely linked to project requirements and basic condition of support (concrete, masonry). Check the right consumption in the job site.
A) Fabric FRP SYSTEM C-SHEET, CTB, Q the average consumption of adhesives per 1 m² of fabric are the followings:
RESIN PRIMER 0.25-0.3 kg/m²
Surface smoothing , upon request, by RESIN 90 2-3 kg/m²
Impregnation of fabric by RESIN 75 0.8-1.2 kg/m², depending also of weight of fabric
B) Laminate LAMELLA CFK the average consumption of adhesives per 1 m. of Lamella CFK , excluding surface preparation and smoothing, is the following:

LAMELLA CFK 50 mm width	Resin Primer	0.015 kg/m	Resin 90 0.3 kg/m
LAMELLA CFK 100 mm width	Resin Primer	0.03 kg/m	Resin 90 0.6 kg/m

C) Connector AFIX 10 the consumption of adhesive Resin 75 per 1 m of connector is approx. 0.2 kg/m for fixing and impregnation.
D) Protection RESINCOLOR RAL 7035 the consumption is approx. 0.3-0.4 kg/m². Primer can be requested for porous surface.
RESIN CLEANER for Lamelle CFK the consumption is approx. 1 l. per 30-40 m laminates.

INSTRUCTIONS FOR USE

Surface preparation

Application of FRP SYSTEM carbon structural reinforcement requires careful and precise preparation of the surface to be treated. For work on concrete the substrate must be prepared checking the state of deterioration of the surface to be treated. Care must be taken to avoid sharp, protruding or jagged points, which may impede the normal performance of the reinforcement. If there are any such structural areas, smoothing coats should be applied or the protruding points should be reduced or eliminated by flexible or other means. Corner has to be rounded up to 2 cm radius. If the surface is deteriorated, remove the weakened layer by scraping, sandblastering, hydro-demolition or using other methods, and then repair the reinforcement rods and concrete with a repairing cycle, using CONCRETE ROCK V-V2 fibro-reinforced mortars on moist surface and FERROSAN anti-corrosion system to protect reinforced metal. In the case of levelling/smoothing of concrete, use the CONCRETE ROCK V2 –RASEDIL mortars for thickness up to 5 mm, and RESIN PRIMER + RESIN 90 epoxy levelling skim coats for thickness less 5 mm. If necessary to improve adhesion between old and new concrete and mortar a previous hand of adhesive RESIN 78 water base can be applied on the substrate before mortar levelling.
For intervention and operation on masonry and vaults, it is important to remove any loose or crumbling parts first. The surface must then be brushed and all dust removed. Remove all traces of grease or oil. Any cracks and voids must be saturated with LIMECRETE or with lime-base slurries. In the case of levelling/smoothing of surface, use the CONCRETE ROCK S or LIMECRETE mortars or RESIN PRIMER + RESIN 90 epoxy levelling skim coats according with the thickness required as above reported. If necessary a previous hand of adhesive RESIN 78 water base can be applied before mortar levelling.
Before application of the carbon reinforcement system in any case remove all traces of oil, grease and dust. Moreover the humidity content of substrate has to be less than 4%. Apply at the temperature range 10-35°C.

FABRIC application C-SHEET, CTB, Q

The substrate must then be primed, using a brush or roller, and applying quantities of RESIN PRIMER suitable for the absorption capacity of the surface. After the touch-dry period has elapsed and in any case within the first 24 hours following application of the primer, the smoothing coat RESIN 90 is applied if required by means of a spatula or plasterer's float or trowel. Then apply first coat of the adhesive RESIN 75 with a brush or roller after the smoothing coat has become touch dry and in any case within 24 hours. Lay on fresh resin the carbon reinforcement C-SHEET, CTB, Q in accordance with the requirements of the design and exercise constant pressure with a roller or manually until the fibres are fully impregnated. After about one hour apply a second coat of adhesive RESIN 75 to full impregnation of fiber. Repeat the procedure if more than one reinforcement layer is needed. According with regulations let the fibre reinforcement fabric overlap by at least 20 cm in the longitudinal direction of the fibres and by 2 cm in the transverse direction.
Quartz sand may be applied 'fresh-on-fresh' over the final coat of adhesive if it is necessary to produce subsequent plaster coating layers or adherent coverings. When required, the final protection coating RESINCOLOR is applied when the adhesive is dry.

LAMELLE CFK application

After checking and repair the concrete substrate as above reported, it is necessary to control the concrete resistance by tests of pull off with minimum value of 1.2 MPa and the leveling of substrate 5 mm in 2 meter. Lamelle CFK have to cleaned before by using RESIN CLEANER. After primerization of the support , cut the laminate by mechanical device according with the length requested and apply by spatula Resin 90 both on the Lamella CFK and the support according with the rate suggested. Apply the Lamella CFK on the surface to be treated according with the requirements of the design and press the laminate by hard rubber roll to a complete adhesion. When required, the final protection coating RESINCOLOR is applied when the adhesive is dry. For pretressed laminates ask to the Company the instruction manual.

CONNECTOR AFIX for anchoring

When required on design the use of connector AFIX 10 is very important for anchoring as for shear resistance and connections between elements like wall-cross wall and vault-wall.
Before application of connector it is necessary to drill the hole 14 mm diameter in the support for a deep of at least 10 mm. Clean the hole from dust and loose material. Then insert RESIN 75 into the hole followed by the connector AFIX 10 cutted for the request length (normally length is hole deep+20 cm) and wet with the same resin. Wait 6-12 hours for resin hardening, then open the staple fiber and glue the strand of fiber to the fabric of the carbon reinforcement by using Resin 75. An additional carbon fabric over the staple fiber is recommended. For more informations ask to the Company.

GENERAL RULES FOR APPLICATION

The final resulting performance of the structural FRP SYSTEM reinforcement system strictly depends on the care by which the phases of the application cycle are carried out.
In particular, care must be taken with the following factors:

- Carefully observe application times and requirements of the structural design ;
- In case of reinforcement bridges and structures on service, reduce the vibration on the structure as much as possible (i.e. vehicular traffic) at least for 24 h after finishing the work;
- Prepare the substrates adequately;
- Handle carefully the carbon roll and the laminates during the application and the cutting.
- Visually check for perfect impregnation of the reinforcement system over the entire area treated, in which there should be no areas left out and not wetted by the resin and no air pockets;
- The fabric must be flattened, well-anchored and laid out properly so as to properly transmit stress;
- Do not allow the fabric to rise or become loosened in peripheral areas or around edges, which may initiate progressive peeling. If this happens, apply resin or specific covering;
- Round off or reduce any sharp points.

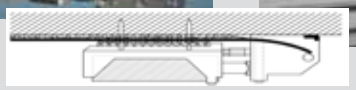
CAUTION

Use gloves during application, and do not allow the resin to come into contact with the skin or delicate parts of the body or eyes. In the event of contact, wash with abundant quantities of water and neutral soap. Use protective glasses or lenses when working with the materials. For additional informations consult the safety sheet SDS.

STORAGE

FRP SYSTEM fabrics, laminates and connectors can be stored for an unlimited period of time when fully protected. The adhesives and resins can be stored for at least 12 months when kept in their original sealed packaging in a warm environment. The resins must be protected against freezing.

FRP SYSTEM is certified technology complying the European Norms for structural reinforcement: EN 1504-3; EN 1504-4; EN 2561; EUROCODE 2; CNR DT 200/2004; BS 8110; DIN 1045-1
FRP SYSTEM has been tested in several national and international Universities and scientific papers have been presented to international congress like CICE, ANIDIS, IABMAS, RILEM, FRAMCOS, PIARC-WORLD ROAD ASSOCIATION.
Ask to the Company for specific references all over the world and for approvals of Technical Public Committee.



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