FIBRES FOR BUILDINGS

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1. CARBON FIBRES

Carbon fibres (or graphite fibres) are composed mostly of carbon atoms. They are a material consisting of extremely thin fibres about 0.005-0.010 mm in diameter. The atoms of carbon are bonded together in microscopic crystals that are more or less aligned parallel to the long axis of the fibre. The crystal alignment makes the fibre incredibly strong for its size. Carbon fibre can be combined with a plastic resin and wound or moulded to form composite materials such as carbon fibre reinforced plastic. The density of carbon fibre is also considerably lower than the density of steel. The properties of carbon fibre such as: high tensile strength, low weight, and low thermal expansion make it very popular in aerospace, military, and constructions. The unique appearance of carbon fibre also makes it popular for stylistic purposes.

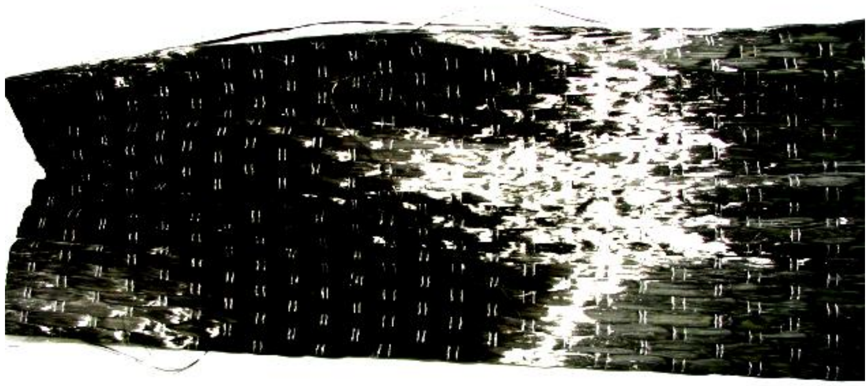

Fig. 1. Carbon fibre

Carbon fibre is most notably used to reinforce composite materials, particularly the class of materials known as Carbon fibre or graphite reinforced polymers. Another utilization of carbon fibre is its added aesthetic value to various consumer products. The fibre also finds use in filtration of high-temperature gases. Carbon fibre is also used in compressed gas tanks, including compressed air tanks.

8.2. FIBREGLASS

Fibreglass (**glass fibre**) is a material made from extremely fine fibres of glass. It is used as a reinforcing agent for many polymer products; the resulting material, properly known as *fibre-reinforced polymer* (FRP) or *glass-reinforced plastic* (GRP), is called "fibreglass" in popular usage. Glass fibre is formed when thin strands of silica-based or other formulation glass is extruded into many fibres with small diameters suitable for textile processing. The technique of heating and drawing glass into fine fibres has been known for millennia; however, the use of these fibres for textile applications is more recent. Glass fibres are useful because of their high ratio of surface area to weight. However, the increased surface area makes them much more susceptible to chemical attack.

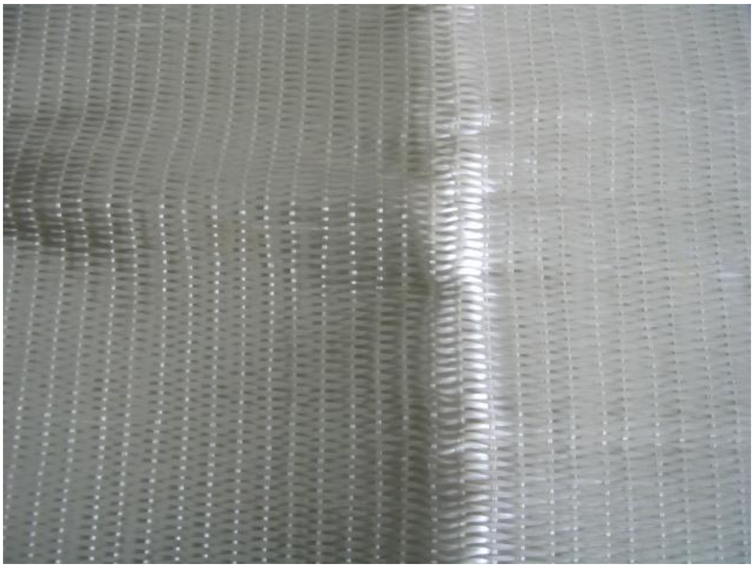

Fig. 2. Glass fibres

Glass strengths are usually tested and reported for "virgin" fibres: those which have just been manufactured. The freshest, thinnest fibres are the strongest because the thinner fibres are more ductile. The properties of the glass are the same along the fibre and across the fibre, because it has an amorphous structure. Compared to carbon fibres, glass fibres can undergo more elongation before they break. The applications of glass fibres are:

- reinforcement;
- insulation;
- sound absorption;
- corrosion resistant, etc.

Fibre glass is also used by the modern automobile industry.

3. ARAMID

Aramid fibres are a class of heat-resistant and strong synthetic fibres. They are used in aerospace and military applications and as an asbestos substitute.

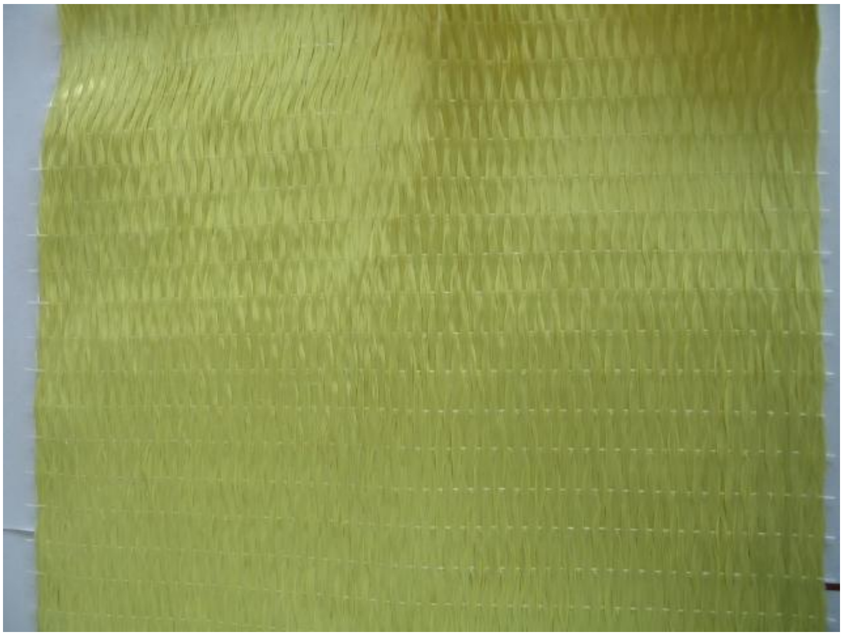

Fig. 3. Aramid fibre

General properties of aramid fibres: nonconductive, low flammability, good resistance to organic solvents and to abrasion. Aramid fibres are sensitive to acids, salts and ultraviolet radiation.

4. CORROSION MANAGEMENT IN REINFORCED CONCRETE STRUCTURES

The successful repair and protection of concrete structures which have been damaged or which have deteriorated requires professional assessment, then design, supervision and execution of technically correct principles – according to the forth - coming European Standard being developed by EN 1504.

The key stages in the process are:

1.) With most damaged or deteriorated structures the owner has a number of options which will effectively decide the appropriate repair and protection strategy to meet the future requirements of the structure. The options include:

- do nothing;
- downgrade the structure or its capacity;
- prevent or reduce further damage without repair;
- improve, refurbish or strengthen all or part of the structure;
- demolition.

2.) It is necessary to clarify the owner's requirements and instructions in relation to:

- the required durability, requirements and performance;
- intended design life;
- how loads will be carried before, during and after the repair;
- the possibility for future repair works including access and maintenance;
- costs of the alternative solutions;
- the consequences and likelihood of structural failure;
- the consequences and likelihood of partial failure (falling concrete, water ingress, etc);
- the need for protection from sun, rain, frost, wind, salt and/or other pollutants during the works;

- the environmental impact or restrictions on the works in progress, particularly the noise and the time taken to carry out the work.

3.) What is the mode and result of the selected materials deterioration, i.e. chalking, embitterment, discoloration, delaminating?
What surface preparation and access systems will eventually be required and when?
Who is responsible and how will it be financed?

4.1. Principles of Concrete Repair and Protection

Select the appropriate Sika System:

1. Hydrophobic Impregnations Anti-Carbonation Coatings SikaTop – Armatec 110 EpoCem:
- Protects reinforcement in a highly alkaline cementitious environment. Can be applied on damp surfaces. Increases barrier to chlorides and carbonation. Steel reinforcement primer and bonding bridge. Fully complies with load transfer requirements.

2. SikaTop Repair Mortars
Two-component prebatched polymer modified repair mortars. Lower modulus for increased durability.

- SikaTop Levelling Mortars coarse/fine used to fill surface defects, to ensure continuous protective coating. Produces the desired surface texture. Provides uniform substrate.

- Sika MonoTop Mortars that are one-component polymer-modified repair mortars. They are suitable for hand and wet spray machine application.

3. Sikagard Coatings: effectively halts carbonation and allows each way water vapors diffusion. Prevents water and chloride ingress. Outstanding color retention.

4. Sikagard- 720 EpoCem: has an unique epoxy cement technology and integral curing ability. Also can be used as a protective coating. Is ideal for leveling and reprofiling after application of Sika Ferrogard - 903.

5. Sika FerroGard- 903: penetrates via liquid and vapors diffusion. It is also a film forming inhibitor. It is mixed inhibitor acting on anodic and cathode sites. Blended inhibitor combining special amino-alcohol and inorganic inhibitors.

6. SikaCem Gunite Mortars

It is ideal for use with Aliva dry-sprayed concrete equipment. This mortar was tested for application to structures subject to vibration under load and tested for use with most cathode protection systems.

4.2. Strengthening Fibres, Fabrics and Resins

Strengthening Fibre Types:

Three different main types of fibres are suitable for the use in civil engineering: carbon, glass and aramid fibres. Depending on the structural requirement, job site and environmental conditions, the best suited material can be selected. The main differences are the fibre stiffness and the damage tolerance.

Carbon Fibres

Carbon fibres are available in different stiffness grades. They all have a perfect linear-elastic behaviour and high strength. Typical examples:

- High strength (HS), “standard” elastic modulus 230 GPa;
- High modulus (HM), elastic modulus 440 to 640 GPa.

Main use: Active strengthening (constantly loaded).
Carbon fibres exhibit alkali, acid and UV resistance, high fatigue strength and a low thermal expansion coefficient. They do not suffer stress corrosion.

Glass Fibres

Glass fibres are most commonly used for general purpose structural applications. They are available in different types, the most common one is E-glass. Elastic modulus is 76 GPa.
Main use: Passive strengthening (e.g. seismic)
E-Glass fibres have the disadvantage of low alkali resistance. To overcome this weak point a considerable amount of zirconium is added to produce alkali resistance AR-glass. Glass fibre fabrics often lead to the cost optimized system. The disadvantage of low stiffness can be compensated by combining several fabric layers.

Aramid Fibres

Highly specialized fibre with high fracture energy. Elastic modulus is 100 GPa. Aramid fabrics can protect bridge columns from collapsing due to the impact of vehicles. Another important application field is blast mitigation.

Mechanical Properties of Fibres used for SikaWrap Fabrics

A wide range of reinforcing fibres from the cost-efficient glass fibre to the tough aramid and from the strong carbon fibre to the very stiff high modulus carbon fibre is available.
The perfect fibre type for every strengthening requirement can be found in the **SikaWrap** fabric range. When considering various fibre-reinforced polymer (FRP) systems for a particular application, the FRP systems should be compared on the basis of equivalent stiffness only.
SikaWrap Fabric Types are available in many types of weights, production types and fibre alignments. They are selected by the type of strengthening and the loading requirements:

- **Woven Fabrics** - These have the best handling properties and are easy to impregnate with the thyxotropic mid-viscous resin **Sikadur- 330** (weights up to 300 g/m^2) or with **Sikadur - 300** (300 g/m^2 or more).

- **Non-woven Carbon Fibre Fabrics** - These have the best fibre alignment (no deviations) which is of great importance for stiffening applications. This non-crimp arrangement allows utilization of the full stiffness capacity of the fibre.

Beside the regular range of **SikaWrap** fabrics, other weights and combinations of fibres as well as woven and nonwoven fabrics can be produced on request.
Examples: Bi-directional fibre fabric can be the ideal arrangement for a combined flexural / shear strengthening of a concrete beam. Thanks to the arrangement of fibres in two directions an efficient application with one fabric layer can be achieved. Hybrid fabrics with different types and content of fibres in all the directions can be customized e.g. for seismic applications.

Impregnating Resins

Depending on the fabric type and weight, the optimized impregnation resin can be selected. **Sikadur** epoxy resins are especially formulated products to meet the needs of the contractor as well as the structure. Durability and easy application are important issues for the long-term success of a strengthening project.

Mid-viscous Resins

Creamy, pasty 2-component impregnation resins with a thixotropic behaviour (e.g. **Sikadur- 330**). To be used with the dry application method or as a sealer for the wet application. Best application properties on walls and for overhead applications.

Low-viscous Resins

Honey-like 2-component impregnation resins (e.g. **Sikadur - 300**) for use with the wet application of heavy-weight woven and for non-woven fabrics.

BIBLIOGRAPHY

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2.***Documentații SIKA – www.sika.ro, www. sika.com