The use of composite glass-fiber reinforcement (CGFR) in construction

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Abstract. The article considers the use of composite glass-fiber reinforcement in construction. Its main advantages and disadvantages, installation technology, scope, comparison and some technical characteristics of the material are observed. The following conclusion is made: CGFR, in comparison with metal, wins in almost all points of comparative characteristics.

Introduction
Today, composite reinforcement is becoming stronger and stronger in the construction market. The concept of "composite reinforcement" (or as it is also called - "polymer reinforcement") is quite comprehensive, in fact, composite reinforcement can be of different types, depending on the main supporting fiber type. For example, there are “glass-fiber reinforcement”, “basalt reinforcement”, “carbon fiber reinforcement” - all of them are the subspecies of the same “composite reinforcement”. The article considers the history of this type of reinforcement, the advantages and disadvantages of composite reinforcement, the news of its current use.

Main part
Glass-fiber reinforcement is a building material created on the basis of fibers connected with a complex composition. It is made on the basis of basalt, glass and carbon fiber, and they can be combined. However, the most popular are basalt-plastic rebar and glass-fiber.

It consists of two parts. The first one is the trunk, due to which the high strength of the material is achieved. The fibers are bonded together by the polyester resin of the composite. The outer layer serves for reliable adhesion to concrete: it is a fibrous body that is wound around the trunk in a spiral. It is due to this composition that the plastic reinforcement received positive reviews as a reliable material for construction.

There are various variations of the reinforcement model, some of which are quite unusual. Glass-fiber is used for the production of these building reinforcement. Its peculiarity is that there are practically no analogues in the world, and its positive qualities significantly expand the scope of application.
In addition, this material is modern and effective, and therefore meets the requirements of the construction process in the best possible way. Any glass-fiber reinforcement is based on two components. The first is directly a reinforcing material, the second is a binder (a mixture based on epoxy resin). The ratio of these components is 75 to 25. In composite reinforcement, all mechanical loads fall on the reinforcing component, while the bonding materials are a kind of matrix that evenly distributes the load over the entire length of the bar and protects it from the external influences. The following most common recipe can be considered: glass roving or basalt fiber act as a reinforcing link, epoxy resin is used for bonding, in addition, a hardener and an accelerator will be included in the material. However, there is no universal composition, since each manufacturer creates its own technological process.

The essence of the technology for the plastic materials’ production lies in the following algorithm:
1. The fibers are unwound and formed into a bundle.
2. Then the bundles are saturated with a specific binder and a cross-section is formed.
3. A glass-fiber cord is wound on the surface of the bundle, forming a spiral and sent to the oven for polymerization.
4. Finally, rods of a certain length are cut or wound into bights.

**Installation of composite reinforcement**

Reinforcement technology with composite rebar is almost the same as with steel rods. It does not require much effort or knowledge, and it is quite possible to do. After all, working with this material is much easier and faster. It is possible to cut glass-fiber like steel with a grinder. In just a couple of seconds, several rods with a diameter of 12 mm are cut through. It is also possible to use a conventional metal saw. The plastic rods are knitted in several ways: with soft metal wire. This process is identical to knitting steel rods. It is carried out manually or using a special crochet hook. It can be tightened with plastic ties, which greatly reduces the time spent on the knitting process. Special fasteners that simply snap into place on the reinforcing bars.

Like any building material, glass-fiber reinforcement has its own advantages and disadvantages compared to similar metal ones, which can become a serious help or hindrance in its application in various fields of construction.

Advantages:
1. Low specific gravity. This advantage allows it to be used in lightweight structures, such as, for example, aerated concrete, etc. This property of glass-fiber reinforcement allows to reduce the weight of the entire structure.

   It is worth noting that the use of glass-fiber reinforcement in ordinary concrete will not significantly affect the mass of the structure, taking into consideration that the bulk of the weight will be given by concrete itself.
2. Low thermal conductivity. As it is known, glass-fiber conducts heat through itself much worse than metal. This advantage of glass-fiber reinforcement allows it to be used where it is necessary to reduce cold bridges, which are so remarkably created by steel reinforcement.

3. Packing in bights. For the private houses’ construction, this is a very significant advantage of glass-fiber reinforcement, because it is possible to reduce its delivery cost to the site. In addition, the use of glass-fiber reinforcement in bights reduces its consumption, since there will be practically no overlaps in the reinforcement cage, and this will also slightly reduce financial costs.

4. Durability. Manufacturers rely on the fact that glass-fiber, in comparison with metal, is much more durable (The dubious advantage of glass-fiber reinforcement, given that the metal inside the concrete is practically not subject to corrosion and inside the reinforced concrete structure will also last a very long time).

5. Dielectric. This property, most likely, in private construction does not give any advantages of glass-fiber reinforcement over metal, but it should be taken into account.

6. Resistance to chemical attack. This means that in acidic and other aggressive chemical environments, glass-fiber reinforcement is much more comfortable than steel.

   In low-rise private construction, this advantage of glass-fiber, like the previous one, practically does not play any role, except for construction in winter, when various salts are added to the solution or concrete, which adversely affect the metal.

7. Radio transparency. This means that the glass-fiber reinforcement does not generate any radio interference, unlike the metal circuits created by the steel reinforcement.

   Such an advantage of glass-fiber reinforcement as radio transparency will play a significant role only if there are a lot of reinforcement in the walls of the building. Then the use of glass-fiber reinforcement will reduce radio interference inside it.

Disadvantages:

1. Glass-fiber reinforcement is more expensive than conventional steel when comparing reinforcement of the same diameter.

2. Not thermally stable. Glass-fiber reinforcement does not withstand high temperatures.

3. Does not bend. Thus, if it is necessary, for example, to bend the reinforcement at an angle of 90 degrees, this will not be possible. Although on the other hand, we can make all the bends from ordinary steel and build them up with glass-fiber.

4. Low modulus of elasticity for fracture. This means that glass-fiber reinforcement cannot withstand the same fracture loads as metal reinforcement.

5. Difficulty in the construction of a rigid reinforcement cage. In other words, the frame made of glass-fiber reinforcement is not as rigid as that of metal, and, accordingly, is less resistant to vibration and loads that will be present when pouring concrete from a car mixer.

**Comparison of glass-fiber reinforcement with steel**

The main competitor of glass-fiber composite reinforcement (CGFR) is steel reinforcement. Their characteristics are largely similar, but in some respects, glass-fiber is clearly superior to the usual type of metal equipment.

Let us compare glass-fiber with steel according to some parameters:

1. Deformability. Steel reinforcement - elastic-plastic, CGFR - perfectly elastic.

2. Ultimate strength: steel - 390 MPa, glass-fiber - 1300 MPa.

3. Coefficient of thermal conductivity. In the first case, it is equal to 46 W / m°C, in the second - 0.35.

4. Density. Steel reinforcement has a value of 7850 kg / m³, CGFR - 1900 kg / m³.

5. Thermal conductivity. Glass-fiber is not thermally conductive, unlike steel.

6. Corrosion resistance. CGFR is a stainless metal, steel corrodes relatively quickly.

7. Ability to conduct electricity. Dielectric is glass-fiber reinforcement. The disadvantages of steel rods are that they are 100% current conductors.
Almost all the main advantages and disadvantages of glass-fiber reinforcement are listed. Judging by them, it is impossible to say with great certainty that it is much better or worse than metal reinforcement, therefore, in which building structures and frames the use of glass-fiber reinforcement will be justified and expedient.

The use of glass-fiber reinforcement is justified in some cases both in industrial construction and in private low-rise construction.

**Scope of glass-fiber reinforcement in private low-rise construction**

1. Glass-fiber reinforcement is used in some types of foundations, such as strip - buried below the freezing depth, slab foundation.

   ![Figure 3. An example of the glass-fiber reinforcement use](image)

   It should be noted that this applies only for the low-rise private buildings, on good soil. On floating soils, there will be increased fracture loads, which glass-fiber reinforcement may not withstand.

2. It is advisable to use glass-fiber reinforcement in the reinforcement of brick walls, walls from blocks, very often it is possible to find the reinforcement of walls from gas silicate blocks with glass-fiber reinforcement.

   The use of glass-fiber reinforcement in wall reinforcement is very popular among the developers. Moreover, such reinforcement is used as a reinforcement element of the walls themselves, and as a bundle of the facing wall with the load-bearing one.

3. In multi-layer panels as links. Since there is usually a dense insulation inside the panels, glass-fiber reinforcement is used to bond the concrete parts together.

4. Justified the use of glass-fiber reinforcement in the bearing parts of elements subject to increased corrosion, swimming pools, for example.
Metal reinforcement will corrode when concrete is in water, and glass-fiber reinforcement is devoid of such a disadvantage, based on one of its advantages.

5. Also, glass-fiber reinforcement is widely used in the reinforcement of glued wooden beams, increasing their rigidity.

6. Reinforcement of asphalt, in places of increased loads, though can be rarely seen.

As it is seen, the scope of glass-fiber reinforcement application in construction is quite wide, although there are some limitations.

**Examples of the composite glass-fiber reinforcement use in the construction of public buildings**

CGFR is slowly gaining market share as government agencies begin to incorporate it into building codes and design guides, and as the test methods are developed. As a result, an increasing number of such agencies as the Manitoba Floodway Authority have chosen CGFR as the most efficient and durable product for public projects. An example is the Floodway Bridge over the Red River in Winnipeg, Manitoba, Canada, which was completed in 2006. The bridge contains 16 spans between supports, each approximately 50 to 143 feet (15.3 to 43.5 meters). All concrete elements above the main beams are reinforced with Aslan 100 CGFR rods manufactured by Hughes Brothers Inc. (Seward, Nebraska). Consuming 310,000 lb / 140.614 kg of CGFR rebar, the project is the largest concrete bridge in the world that is not reinforced with metal.

![Figure 4. Floodway Bridge](image)

Glass-fiber composite rebar was selected for the Miami-Dade MetroRail project, a 2.5-mile (4 km) overhead “heavy” rail moving walkway that will carry passengers (and luggage) from Miami International Airport (Miami, Florida) to downtown. The reinforcement shown in the first photo is wired and ready for a team of construction workers to pour concrete on the guide track. In the second photo, the glass-fiber composite rebar in the Miami-Dade MetroRail track, after pouring the concrete, forms a stable platform for the steel rails. The use of a corrosion-resistant composite reinforcement guarantees the guide track durability and thus will increase the useful life cycle of the rail system and reduce maintenance and repair costs.
Summary

Many professionals and ordinary consumers in the construction equipment choice choose such a material as composite glass-fiber reinforcement. Reviews about it in most cases are positive. Ease of operation and ease of use are noted. Glass-fiber rods are practically waste-free, since one of the main advantages of glass-fiber is that the reinforcement is produced in bights, which means that it is possible to work with the required length. CGFR, in comparison with metal, wins in almost all positions.

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