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REINFORCEMENT OF REINFORCED CONCRETE AND BRICK STRUCTURES WITH COMPOSITE MATERIALS

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Abstract:
The article provides information about the properties of composite reinforcement, its main advantages and disadvantages compared to traditional steel reinforcement. The areas of application of composite reinforcement are considered, examples are given in which it is advisable to use this type of reinforcement.

Keywords: reinforcement, fiberglass, fiberglass, composite reinforcement, steel reinforcement, concrete, reinforcement properties, corrosion.

Introduction

The issues of repair and reinforcement of reinforced concrete and brick structures are highlighted. Examples of the implementation of technical solutions for the strengthening of reinforced concrete structures of residential buildings by the method of external reinforcement with cold-curing composite materials are given.

The entire period of operation of buildings is associated with the need for periodic repairs of structures due to design errors, the impact of off-design loads and accidents, the influence of aggressive environments, the aging of structural materials, and, more recently, due to changes in design schemes as a result of re-planning of premises.

In many developed countries, the amount of material resources spent on maintaining the operational properties of buildings is comparable to the cost of building new ones.

For reinforced concrete structures, many technical solutions have been developed to strengthen them: increasing sections, changing the design scheme of structures in order to redistribute loads, installing clips, etc., many recommendations, design solutions and methods for designing repairs and strengthening building elements have been published. Experience shows that repairs carried out by traditional methods are not always effective and usually require an increase in the volume of the original elements, which entails a decrease in the volume of the

room. In addition, repair work in the conditions of an operated residential building often requires the resettlement of residents for a significant period of time.

Recently, modern technologies for the repair and strengthening of structures, which are widely used abroad, have become available. First of all, these are polymer-cement compositions with high adhesion to "old" concrete, migrating corrosion inhibitors of reinforcement, composite materials for reinforcement based on carbon or glass fibers. New technologies have made it possible to dramatically increase the overhaul period, carry out repairs and strengthen structures in the shortest possible time without increasing permanent loads and changing the volume of interior spaces.

The method of reinforcing reinforced concrete structures by external reinforcement with cold-hardening composite materials makes it possible to significantly (in some cases, multiple) increase their load-bearing capacity, crack resistance and rigidity. It should be noted that due to the high physical and mechanical characteristics of external reinforcement, the reinforcing elements practically do not increase the weight of the structures (usually the thickness of the reinforcing elements does not exceed 2-3 mm), and construction and installation work is not associated with large labor costs and terms of work. The essence of the method is to increase (or restore) the strength of the structure by sticking strips of high-strength materials onto its surface using a special adhesive, usually epoxy-based. The use of this technology makes it possible to strengthen beam and slab structures against the action of a bending moment, inclined sections of rod elements against the action of a transverse force, centrally or eccentrically compressed columns, ceilings in the area of holes or openings, limit the opening of existing cracks, and restore the solidity of brickwork.[1]

Consider the options for applying the technology of reinforcement with composite materials using some examples.

Reinforcement of floors after a fire

As a result of the fire in the floor slab, the protective layer was “shot off”, and the reinforcement of the slabs received residual deformations from overheating.

The most common amplification solutions are:

• summing up metal unloading beams from below;
• increasing the cross-section of the slabs from above or from below with the filling of voids;
• installation of trussed puffs;
• installation of prestressed sheet metal elements;
• installation of additional working fittings, etc.

Most often, the presence of such damage contributes to the decision-making on the part of designers and experts to replace the damaged floor. But this requires very complex work on cutting down the old and subsequent concreting of the new floor, and, as a result, the resettlement of residents from the floor above. As an alternative, a technical solution was proposed and implemented to restore the protective layer of concrete with polymer-cement materials with high adhesion to "old" concrete and to compensate for the lost properties of bar reinforcement by external reinforcement of the repaired surface with carbon fiber tapes (Figure1).

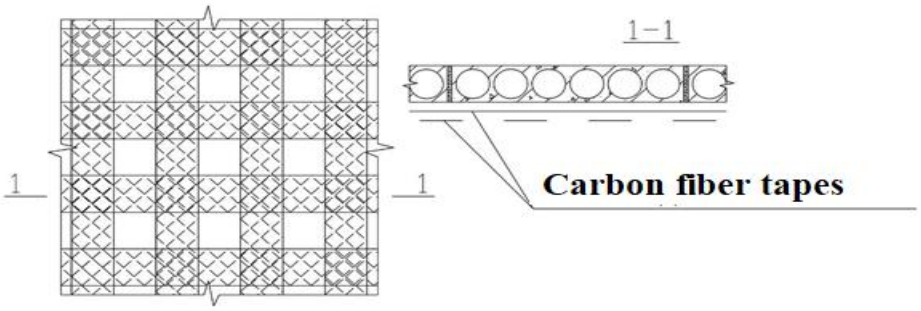


Figure 1. Scheme of strengthening the floor after a fire

This made it possible to completely "turn off" thermally damaged reinfocement from the calculation, as well as to ensure the required bearing capacity of the floor, its crack resistance and rigidity due to external reinforcement.

Reinforcement of overlap after off-design loads

A similar approach was applied in a residential building, where, during the repair, the ceiling was overloaded with stored building materials, as a result of which cracks with an opening width of up to 1.5 mm appeared on the lower surface of the slabs. The use of traditional methods was not possible due to limited access to the top surface of the slabs in the apartment above.

As a result of calculating the bearing capacity of the floor, the required cross section of the reinforcing elements was determined. To prevent further opening of cracks and increase the rigidity of the floor, a mesh of external reinforcement was additionally created (Figure 2).

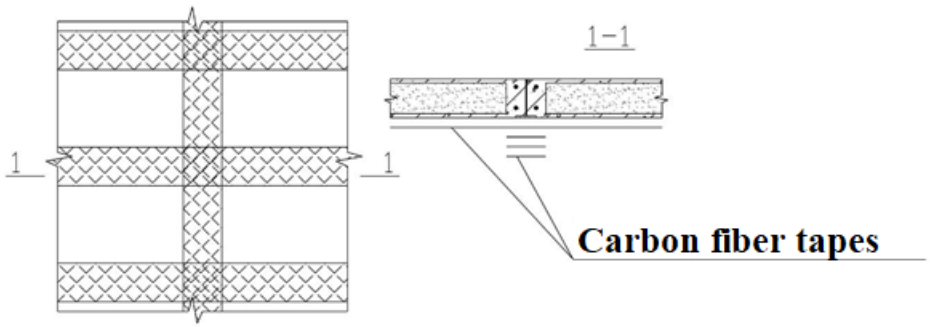


Figure 2. Scheme of reinforcing the floor after non-design loads.

Strengthening the overlap in the area of negative moments

If it is necessary to reinforce the floors of frame buildings in the zone of negative bending moment, carbon fiber tapes are glued on the upper surface of the ceiling with their planting beyond the point of zero bending moment for the length of the tape anchoring (usually 200-300 mm). In the zone of support of the overlap on the column or wall, the tapes are wound on them with the sizing of the transverse tape, which makes it possible to reduce the length of the anchoring of the tape and put them into operation directly at the support zone (Figure 3).

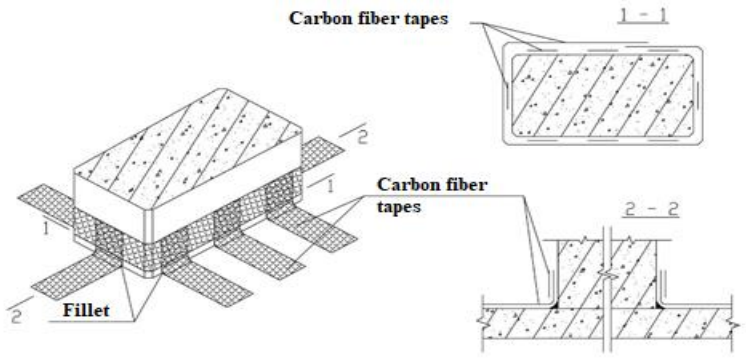


Figure 3. Principal solution of the support node with reinforcement of the overlap in the negative moment zone.

Strengthening when creating or increasing openings in floors and walls

Quite often there are problems of strengthening structures when arranging openings in ceilings and walls. Often, openings in the ceilings are arranged for the installation of stairs in two-level apartments, in the walls - when moving or increasing doorways.

As a rule, the traditional solution for reinforcing floors is the supply of metal beams, which is rather complicated due to the need to create support zones for beams in the walls, the heavy weight of structures, ensuring a reliable connection between the floor and beams, and due to a decrease in the building volume of internal premises.

An example of the effective application of the external reinforcement method is the strengthening of a 3.4 x 3.8 m opening in a two-level apartment in one of the residential buildings in Fergana, cut into the ceiling for the installation of a staircase. Computer modeling of the stress-strain state of the floor in the presence of an opening revealed a significant change in the nature of its work. According to the results of calculations in the zones of dangerous concentration of tensile stresses on the lower and upper surfaces of the plate, strips of carbon fabric were glued (Figure 4) [2].

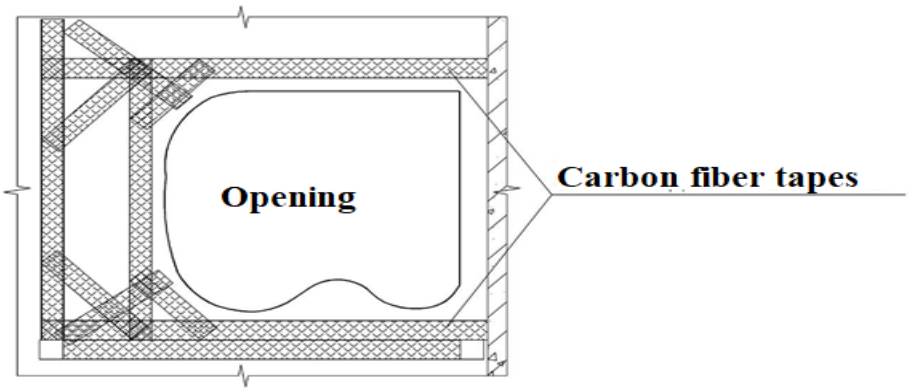


Figure 4. Strengthening the floor slab with an opening

An alternative solution was to bring metal I-beams under the ceiling, which created great difficulties for the builders in delivering and installing the beams in the finished room and at

the same time reduced the construction volume of the lower room (due to the installation of a suspended ceiling 35 cm below the ceiling surface).

In a similar way, the reinforcement of the load-bearing walls and ceilings was carried out in the process of redevelopment of another residential area. The arrangement of openings in the bearing transverse walls led to a change in the scheme of operation of these walls and ceilings in the area of the openings. In order to prevent the possibility of unacceptable deformations, carbon-fiber linings were made along the contour of the openings and adjacent areas of overlap (Figure 5)

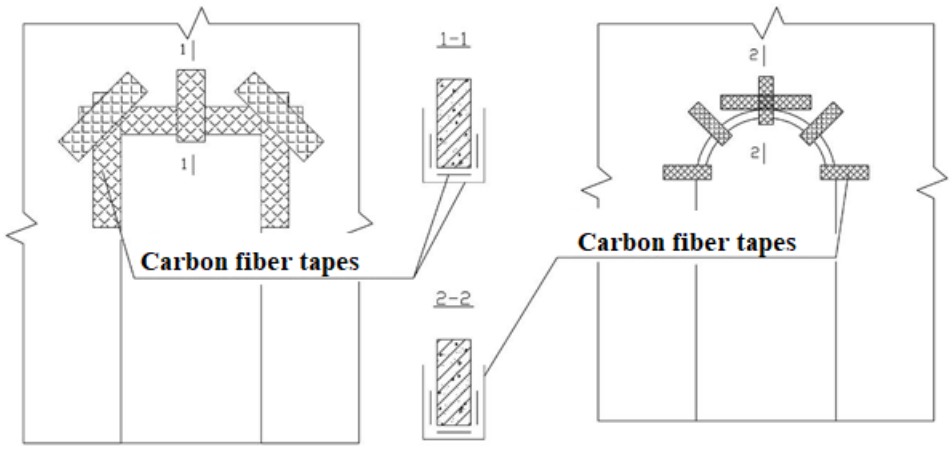


Figure 5. Reinforcement scheme: a) rectangular opening, b) arches

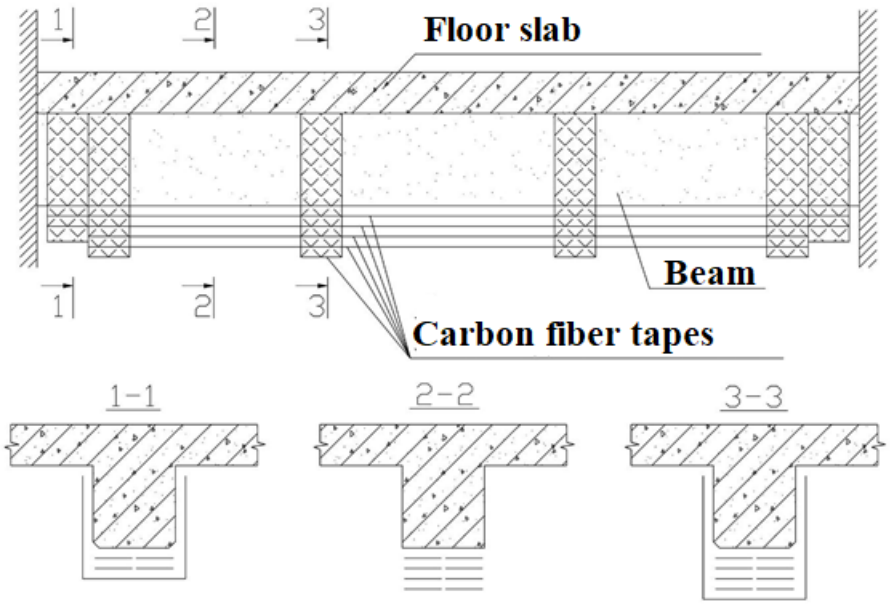
Beam reinforcement

To increase (or restore) the bearing capacity of beams, the following solutions are used:

- arrangement of reinforced concrete casing;
- arrangement of external sheet or profile fittings;
- installation of sprengels made of reinforcing steel;
- summing up metal beams;
- installation of portal frames and so on.

When installing a reinforced concrete cage, it is necessary to provide for measures to connect the old and new reinforcement cages. There are also difficulties in ensuring a tight abutment and adhesion of the new concrete to the ceiling surface of the beam, even when using non-shrink concretes. As a rule, a longitudinal crack remains at the junction of the layers. The method of reinforcing a beam with carbon fiber tapes is fundamentally close to gluing (or installing on an anchor) metal sheets in the tension zone.

Longitudinally glued tapes provide an increase in the bearing capacity, crack resistance and bending moment rigidity of the beam, and transverse U-shaped clamps play a dual role - firstly, they ensure reliable inclusion of the tapes into operation (play the role of anchors); secondly, they increase the bearing capacity of the beam along inclined sections, which is especially important in the support zones (Figure 7).



a) b) c)

Figure 7. Scheme of beam reinforcement: a near-support zone, b span, c periodic anchoring of longitudinal strips.

Strengthening the columns.

The traditional solution for strengthening columns is the installation of a variety of metal and reinforced concrete clips. As experience shows, reinforcement with metal clips is often performed without ensuring joint work with the concrete of the columns (without grouting), which sharply reduces the effectiveness of the reinforcement. The use of reinforced concrete cages is associated with an increase in their cross section, which does not always ensure the joint operation of columns with a cage due to the low adhesion of the "old" and "new" concretes.

External reinforcement of carbon tapes in the transverse direction of the columns allows you to create a holder of carbon fiber, limiting their transverse deformation. Thus, with longitudinal deformation and increasing loads, circular (for round sections) or transverse pressure (for rectangular sections) is created, the columns operate in a triaxial stress state, which increases their bearing capacity.

Reinforcing masonry

Along with traditional brickwork reinforcement solutions:

• arrangement of tension belts from the outer and inner sides of the building;
• device of metal slips;
• arrangement of reinforced concrete belts;
• installation of a reinforced concrete cage, etc.,

the reinforcement method using composite materials is simpler and, in many cases, more efficient. The basis of the technology is the injection of existing cracks with special solutions, leveling the surface in the zone of sticking tapes made of carbon and glass fibers, creating bandages from composite materials from the outer and, if necessary, from the inner surface (in

the presence of through cracks). The bandages created in this way include a large area of brickwork (Figure 8).

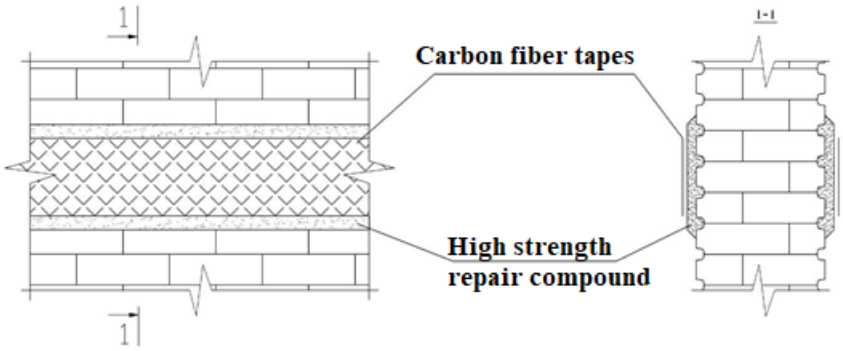


Figure 8. Strengthening a brick wall.

Conclusions

1. It should be noted the high efficiency of strengthening building structures with composite materials and for preventing destruction under the influence of emergency situations (explosions, terrorist attacks, etc.).
2. Tests of structures reinforced with composite materials have shown that such structures, despite the presence of damage, prevent the building from collapsing, giving the necessary time for people to evacuate [3].

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