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Analysis of Experimental Studies on the Reinforcement of Reinforced Concrete Columns with Polymer Composite Materials

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Annotation. The problem of collecting, analyzing and systematizing experimental information on the testing of reinforced concrete structures reinforced with polymer composite materials is considered. It is noted that these data are scattered over a large number of publications, which makes their use difficult. Therefore, the creation of databases based on the results of experimental studies of reinforced structures is an important task. Only 3 books have been written on this problem in Russian, and two of them are based on the results of foreign studies.

It is noted that the vast majority of other publications present general ideas about the reinforcement of reinforced concrete structures with the help of polymer composite materials, the technology of gluing composites, a number of works describe methods for calculating reinforced concrete structures reinforced with composite materials using the limit state method without justification. Next, the results of domestic experiments on the behavior of reinforced concrete structures reinforced with polymer composite materials under static loading are considered.

It is concluded that many domestic publications do not always provide complete and systematized information on the deformation of reinforced concrete structures reinforced with polymer composite materials, on test conditions, but only data on the magnitude of breaking loads for some reinforcement schemes. Then the results of a number of correct experiments on the behavior of reinforced concrete structures are presented, with an analysis that differs from that done by the authors of the experimental studies.

Key words: reinforced concrete columns; gain; fiber reinforced plastic; carbon fiber; composite; static loading; experimental studies.

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Introduction.

When solving the problem of reinforcing elements of reinforced concrete structures damaged during operation, using polymer composite materials, one has to deal with two types of resources.

The resources of the first type include materials, energy, time. These resources tend to decrease as they are used up.

The resources of the second type include knowledge and information. These resources do not decrease over time, and can even increase in the process of their use.

It is clear that the more reasonable and efficient the work is organized, the less resources of the first type are used in its execution and the more resources of the second type are used.

At the same time, by effectively using the resources of the second type, it is possible to achieve significant savings in the resources of the first type. But for this, it is necessary to properly organize, systematize, and make resources of the second type suitable for use.

Information about polymer composite materials and their application, both for creating new structures and their elements, and for strengthening existing structures damaged during operation, is scattered across a large number of sources, including books, dissertations, scientific journals, collections of papers and conference reports, articles, reports reference books, organization standards, guidelines and so on.

Moreover, the volume of this information grows extremely rapidly every year, so the procedure for searching and subsequent analysis of theoretical and especially experimental data describing the behavior of structures and their elements, both in the process and after reinforcement with polymer composite materials, is very laborious and lengthy. The situation is all the more complicated because data on the same issue have to be collected in publications that are different in nature, volume, completeness of description and timing of publication.

The immensity of the field of search has long led to the use of computer information technologies for storing and retrieving information. Information systems have been developed and are being used, which have become extensive knowledge bases that help researchers in solving their problems.

It is clear, however, that the creation of a large system for storing and retrieving information necessary for a researcher is a task of enormous complexity, especially since the ability to customize it for any user, taking into account his interests, seems difficult to implement. Moreover, such a system will never be complete, because it must be regularly updated with newly mined information.

Therefore, it seems more reasonable to use the experience, knowledge and intuition of the researcher to develop the structure and create databases containing information about the field of information of interest to the researcher and providing quick access to the necessary sections.

Databases in this case are, as it were, some information models that describe the data set of interest to the researcher and reflect his personal experience, knowledge, interests and passions. This is true, because when building a model, they usually tend to leave the main, essential features, discarding secondary ones (in relation to the problem under consideration).

Our experience in conducting research in the field of application of polymer composite materials for strengthening reinforced concrete and other structures [1-8] showed that in this relatively narrow area, a certain amount of experimental and theoretical information has been accumulated, the systematization and analysis of which will allow us to assess the achieved level of

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solving the problem, moreover, there are not so many Russian-language books containing sufficiently complete information on the issue under consideration [9-11], and practically no one stimulates their writing.

Books [9, 10] contain similar material and they "set out the basics of designing and technology for reinforcing reinforced concrete structures with modern composite materials based on carbon, aramid and glass fibers. The basic provisions for the design of reinforcement of bent reinforced concrete structures for the first and second groups of limit states are given. The technology of reinforcing reinforced concrete structures with composite materials of a new generation is presented. The requirements for mandatory monitoring of the reinforced structure have been considered.

The book [11], as the authors note, "contains the scientific basis for strengthening building structures with carbon fiber composites. The principles of strengthening various structures are given. A large place is given to examples of the real strengthening of construction projects. The features of the mechanical behavior and mechanisms of destruction of composites are considered.

In fairness, it should be noted that the vast majority of publications present general ideas about the reinforcement of reinforced concrete structures using polymer composite materials, the technology for gluing composites is described with some nuances, a number of works describe the methodology for calculating reinforced concrete structures reinforced with composite materials using the limit states method, moreover, this is done practically without any justification for the applicability of this technique, according to the principle - after all, reinforced concrete structures were calculated using this technique earlier, and why should it work poorly when calculating reinforced concrete structures reinforced with polymer composite materials.

There are very few studies on the durability of reinforced concrete structures reinforced with polymer composite materials, that is, the same mistakes are repeated that were made in the era of intensive use of reinforced concrete, when it was believed that it was eternal, material and therefore repair and replacement of reinforced concrete structures will not be required at all or will not be required soon.

When presenting the main material, we will try to adhere to the following division of experimental studies into groups:

- experiments under static loading;
- experimental studies of the influence of temperature;
- experimental studies of the influence of aggressive environments, physical fields;
- long-term experimental studies (endurance, creep, long-term strength);
- experimental studies under modal or dynamic loading.

The paper [25] presents the results of testing reinforced concrete columns when they are reinforced with scrims based on carbon fibers FibARM Tape 530/300 and FibARM Lamel 14/100 lamellas. The height of the columns is 2500 mm, the section is square with a side of 250 mm. Concrete class for strength not less than B20, frost resistance F300 and water resistance W6. The column reinforcement scheme is shown in Figure 1.

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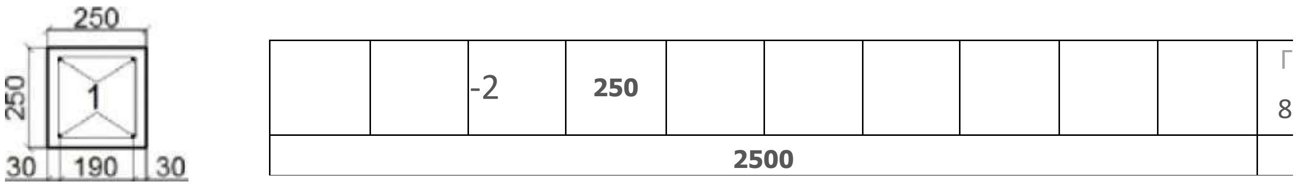

Figure. 1. Design and scheme of reinforcement of reinforced concrete columns: 1-rod reinforcement with a diameter of 10 mm class A400,
2 - transverse reinforcement with a diameter of 6.5 mm class A240 (source [5])

Three groups of columns were tested: A - non-reinforced columns, B - columns reinforced with FibARM Tape 530/300 clamps in one layer (Fig. 2), C - reinforced with FibARM Lamel 14/100 lamellas 100 mm wide, while sample 5 lamellas (Fig. 3), and a sample of 6 lamellas and additional clamps (Fig. 4).

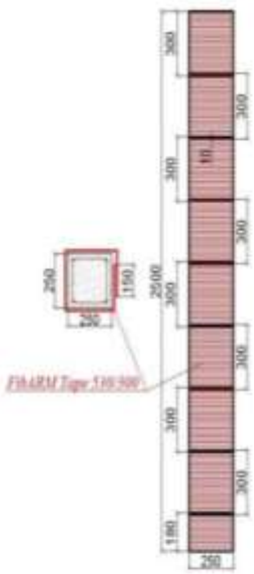

Figure 2. Scheme of strengthening columns of group B (source [5])

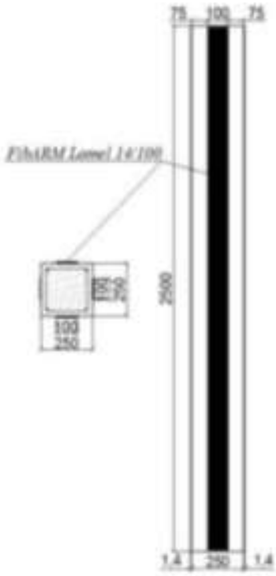

Figure 3. Reinforcement of a column of group B only with lamellas (source [5])

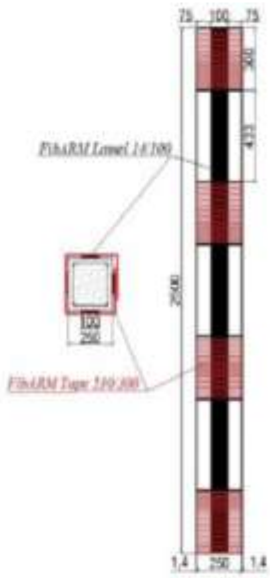

Figure 4. Reinforcement of a column of group B with lamellas and collars (source [5])

The tests were carried out at a temperature of + (15 - 22) ° C on a testing machine TsD 20/400 PU according to the axial compression scheme, while absolute deformations were recorded on a base of 500 mm in the middle of the length of the columns. The load was applied to the column in steps of 5000 kg at a speed of 500 kg/min.

Figure 13 shows the test process for an unreinforced column (left) and a scrim-reinforced one (right). Figure 14 shows the process of testing reinforced concrete columns reinforced with lamellas (left) and lamellas and collars (right). The dependences of the magnitude of the shortening

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of reinforced concrete columns on the applied load for various groups of columns obtained as a result of tests are shown in Figure 5.

Table 3 shows the values of breaking loads for different groups of columns, obtained as a result of tests.

An analysis of the test results shows that strengthening reinforced concrete columns working in compression by wrapping them with carbon sheets led to an increase in the bearing capacity for compression by 54%, while strengthening them with lamellas led to an increase in the bearing capacity of the columns by only 8%, and only the addition of a partial winding with canvas to the lamellas led to an increase in the bearing capacity for compression by 35%. It is obvious that the "cage effect" works here, although for a more correct analysis it would be necessary to compare the cross-sectional areas of the cage of their carbon canvas and the lamellas used for reinforcement. In addition, the experiment does not mention the magnitude of the tension force that was created when the column was wrapped with canvases.

Figure 5. The process of testing an unreinforced (left) and canvas-reinforced (right) reinforced concrete column (source [5])

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Figure 6. The process of testing a reinforced concrete column reinforced with lamellas (left) and lamellas and clamps (right) (source [5])

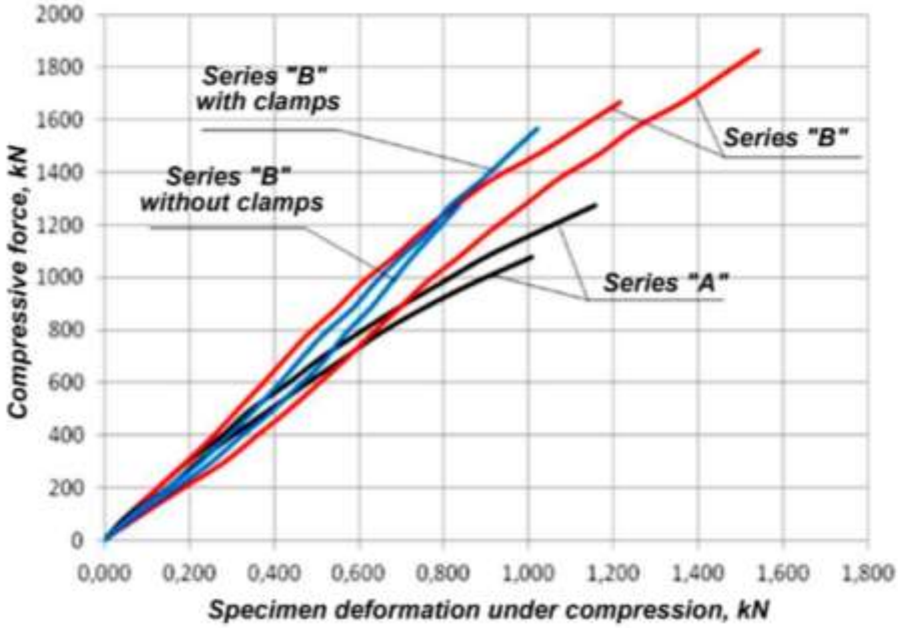

Figure 7. Experimental deformation curves of various groups of reinforced concrete columns: unreinforced (A) and reinforced (B and C) (source [5])

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Table 3
Test results of reinforced concrete columns with various reinforcement schemes (source [5])

Group	Column number	Breaking load, kN	Compressive strength, MPa	Average compressive strength, MPa	Increase in the bearing capacity of the column for compression, %
A	1	1274	20	18,5	0
	2	1078	17		
B	3	1666	27	28,5	54
	4	1862	30		
C	5	1274	20	20	8
	6	1568	25	25	35

Conclusion.

The analysis shows that in our country, to date, there is an insufficient number of studies on the experimental study of the behavior of reinforced concrete structures reinforced with polymer composite materials, and the description of a significant part of those experiments that are carried out is not complete and systematized, which makes it difficult to use them to build and identification of models of deformation of structures reinforced with polymer composite materials.

We did not set ourselves the task of analyzing foreign publications on the problem under consideration, however, we note the works, which provide a description and analysis of fairly well-posed experiments.

It should be noted that there are a fairly large number of publications in which a computational analysis of the behavior of reinforced concrete structures reinforced with polymer composite materials is carried out, however, all of them are mainly focused on the use of the limit state calculation method, the applicability of which in the cases under consideration has not been proven.but simply postulated, or the use of the finite element method, and in this case the models of deformation and reinforced concrete and reinforcing material are used primitive, without taking into account such effects as the nonlinearity of deformation and the uneven work of reinforced concrete in tension and compression, and therefore the correctness of the results obtained is doubtful.

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