UDK 620.169.2

THE USE OF NON-DESTRUCTIVE METHODS OF CONTROL IN THE EXAMINATION OF EXISTING FERRO-CONCRETE BUILDINGS AND FACILITIES

TAISIA KAZYANINA, ALEXANDER KOLTUNOV
Polotsk State University, Belarus

Currently thanks to the reconstruction it is possible to modernize most of the technically and morally obsolete buildings. However, it is worth noting that in the reconstruction of existing buildings and structures, an important stage is the determination of the parameters of the reinforcement and concrete (the thickness of the protective layer, the location of the reinforcement, the diameter, etc.). In order to perform verification calculations and subsequently determine where and how to strengthen it is necessary to conduct whether they are needed. This is especially important, as in the reconstruction of buildings and structures (associated with the construction of new floors), and when the object is replaced by a functional purpose.

The most important task in surveying structures is to determine the urgent class of reinforcement and, consequently, its strength parameters. To date, there are many different methods and approaches.

In most of the normative and technical documents for the inspection of buildings and structures, recommendations for determining the parameters of the reinforcement are provided. However, not all of the methods make it possible to determine the required parameters reliably and accurately. Some of the methods are obsolete, some are not practical because of the difficulties accompanying their use. A promising non-destructive method is considered, which makes it possible to determine the class of reinforcement by measuring the hardness of steel. Studies of the relationship between the strength and hardness of steels to date, many works have been devoted. The fundamental dependence for steels is reflected in GOST 2276-77 "Metals and alloys. Method for measuring Brinell hardness by portable hardness testers of static action" [1, 2].

The most common methods for determining concrete strength in structures are non-destructive testing methods. Among them, the most common methods nowadays are the methods of the third group: the ultrasonic method in accordance with GOST 17624-2012 [3], the methods of shock pulse and elastic rebound in accordance with GOST 22690-88 [4]. It should be noted that ultrasonic devices can be used not only to control the strength of concrete, but also for flaw detection, quality control of concreting, determining the depth of cracks, etc. It should also be noted that the strength of concrete is not the only factor affecting the durability and strength of the entire structure as a whole. Concrete should be considered as a material with fluctuating characteristics by a random principle. To achieve the same class of concrete, many different variations in the composition of the concrete mix can be used. Thus, structures having the same class of concrete can differ in their structure. This is due to the use of various technological and material science approaches. The main factors influencing the structure of concrete stone include the use of different grades of cement, different content of mineral additives in cement, variations in concrete mixes according to workability, water-cement ratio, the changes of which are associated with the use of cement of various activities, as well as with the use of various modifying additives. Thus, within the same strength, mixtures with different structures can be obtained, increasing the water-cement ratio leads to an increase in porosity, and hence permeability. While the use of modifying additives makes it possible to obtain concrete mixtures of a given ductility with a reduction in the amount of water used, which leads to a denser structure of concrete stone. With regard to the technological aspect, an important role is played by the methods of compacting the concrete mixture and the conditions of hardening.

The purpose of the study of this article is to analyze the correct use in practice of the method of checking the strength of reinforcement by the results of hardness measurements. Determination of the dependence of the transition from hardness to the class of reinforcing steel used in prestressed structures, and also the determination of the influence of errors in the methods of nondestructive testing of the strength of reinforcement and concrete on the determination of the load-carrying capacity of bent structures.

The strength of concrete was determined using the methods of nondestructive testing (the method of plastic deformations - using the Kashkarov hammer). The location and diameter of the reinforcement in the reinforced concrete structures were determined by the electromagnetic method using the IZS-10H instrument in accordance with GOST 22904-93 [5].

The diameter of the reinforcement was refined by mechanically opening the protective layer of the reinforcement. At the same time, the condition of the reinforcement was determined, the nature and degree of its corrosion, which was estimated by the depth and area of damage. The mechanical characteristics of the reinforcement were determined by the type of profile established at the dissection, and also by means of the portable hardness tester Constant K5U, on previously prepared surfaces, followed by the derivation of the "strength-hardness".

To determine the effect of errors in instruments used in the testing of reinforced concrete structures by the methods of nondestructive testing the worst bending moment in the calculation was taken from the values obtained having the greatest deviation from the mean value. The obtained bending moments were compared with the theoretical value of the bending moment adopted for the test series of plates.

The calculation of the bending moments was carried out in the program complex Beta 4.2.

The analysis of the obtained results showed that the strength properties of the reinforcement exert a significant influence on the load-carrying capacity of the structure, while the parameters of the concrete do not give significant changes. Thus, when using non-destructive testing methods, taking into account instrument errors, it is possible to determine the load-bearing capacity of the structure. However, deviations from the reference values range from 4.1% to 27.7%, depending on the instruments used. It should be taken into account that in the calculation the maximum and minimum values obtained on the instruments were taken, in practice, while performing tests by methods of nondestructive testing, a series of tests should be carried out with subsequent averaging of the results, which minimizes the effect of the drop-out values and more accurately determines the parameter.

Tests to determine the hardness of reinforcing steel samples were carried out using a portable hardness tester Constant K5U. All the tests with the static hardness tester were carried out using the same method which implies:

1. Determination of the position of reinforcing bars.
2. Opening the protective layer of concrete and determining the parameters of reinforcement by indirect characteristics in places where the reinforcing bar does not reach the maximum bending moments and the anchorage is not broken (at a distance ¼ of the span length).
3. Cleaning of the surface of the reinforcing bar with a cutting device of the required depth of 100 mm on each reinforcing bar.
4. The surface of the samples at the test site is processed to the required roughness by an angle grinder (USM) using a small grain size nozzle. The roughness parameter should be no more than Ra = 0.32 mkm [6].
5. Running 15 tests for each reinforcing bar.
6. Derivation of the mean and determination of the temporary resistance of the reinforcing bar according to the deduced "hardness-strength".

On each rod was carried out for 15 tests. To determine the dependence of hardness on the cut value on samples of class S800, thin sections of various depths. The thickness of the cut layer was assigned – 1 mm, 2 mm, 3 mm, 4 mm. To determine the optimum depth of cut, during the work, additional studies were conducted on reinforcing bars of class S540 and S600.

Since during the testing of the reinforcing bar in the body of the reinforced concrete structure and clamped in the vice, the fixation conditions can affect the results of the measurements, then comparative tests were carried out on the rods extracted from the existing structure and located in its body. In both cases, the readings of the hardness meter did not differ significantly. Thus, it can be concluded that the tests carried out.

Since the distribution of the results can be considered normal, therefore, one can deduce the relationship between the hardness indices and the temporary resistance of the materials of the tested samples. Using the ratio of the values of the temporary resistance of the samples and their hardness values in the Excel program, a linear dependence:

$$\sigma_B = (15HR+570) \mp 5, \text{ at } p = 0.7973$$

Taking into account the variability of the time resistance for the studied classes, it is possible to identify the zones of identification of the class of reinforcement. For comparison, we give a visual reflection of the zoning of reinforcement classes on the boundary values of the time resistance and hardness of steel for samples with a diameter of 12 mm, classes S540 and S800 at a cut of 1, 2, 3 mm (Figure 1).

From the graphs, it can be concluded that the optimal depth of cut for determining the time resistance is a 2 mm thin section. Since Figure 1 (3) shows that only at the 2 mm cutoff, the values of the time resistance for classes S540, S600 and S800 are not superimposed on each other. However, an additional study is needed for reinforcing bars of large diameters, since with larger diameters the required depth of cut may be greater, depending on the method of manufacturing the reinforcement.

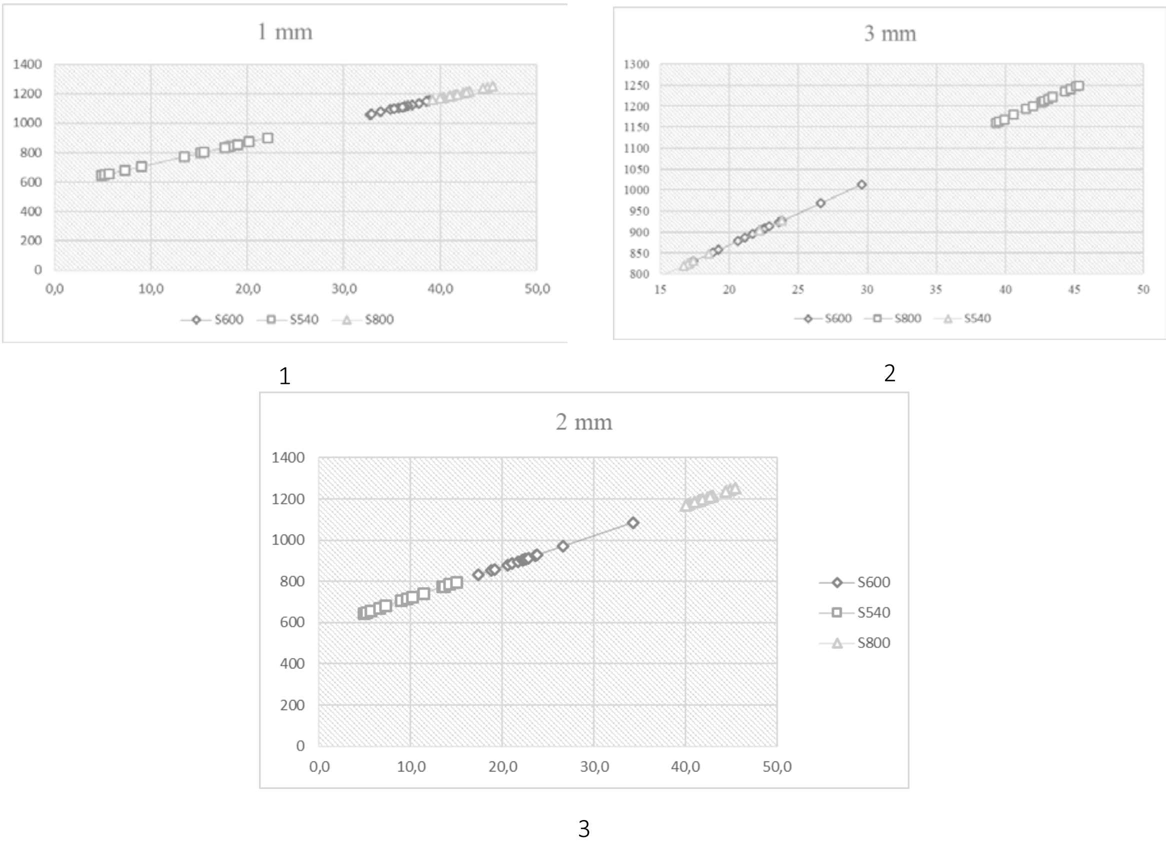

Fig. 1. Zoning classes of reinforcement by the boundary values of the temporary resistance and hardness of steel

Based on the foregoing, it is possible to draw the conclusions indicated below:

- The "strength-hardness" dependence was deduced on samples of class S800, which, when tested on samples of classes S540 and S600, showed sufficient convergence. The result of the measurement, taking into account the expanded uncertainty, can be represented in the form:

$$\sigma_B=(15HR+570) \mp 5, \text{ at } p=0.7973$$

- the optimum depth of cut for determining the time resistance for diameters of 10, 12, 14 mm is a 2 mm section. However, an additional study is needed for reinforcing bars of large diameters;

- when inspecting bent elements, special attention should be given to the strength characteristics of the reinforcement, since they have the most significant effect on the bearing capacity. The permissible load on a structure obtained using non-destructive testing devices gives comparable results when compared with those recommended in the series.

REFERENCES

1. Улыбин, А.В. Методы контроля параметров армирования железобетонных конструкций / А.В. Улыбин // Инженерно-строительный журнал. – 2011. – №1 (27).
2. Пособие по обследованию строительных конструкций зданий. – М. : АО "ЦНИИПРОМЗДАНИЙ", 1997. – 179 с.
3. Бетоны. Ультразвуковой метод определения прочности : ГОСТ 17624-2012.
4. Бетоны. Определение прочности механическими методами неразрушающего контроля : ГОСТ 22690-88.
5. Конструкции железобетонные. Магнитный метод определения толщины защитного слоя бетона и расположения арматуры : ГОСТ 22904-93.
6. Металлы и сплавы. Метод измерения твердости по Бринеллю переносными твердомерами статического действия : ГОСТ 22761-77.