LOAD-BEARING CAPACITY OF DAMAGED STONE STRUCTURES

Summary. The main factors affecting the load-bearing capacity of new and damaged stone structures are given. One of the most common types of damage to stone buildings is their cracking. According to statistics, the most frequent reasons for the formation of cracks in stone structures are: uneven settlement of foundations, load on structures, temperature deformations, moisture deformations. The load-bearing capacity of walls depends on the compressive strength of bricks and mortar, but it is difficult to make correct assumptions about these values. The main goal of the work is the analysis of the current state of affairs in the study of the technical condition of cultural heritage objects, the main types of damage and their causes. In order to improve the methodology of the non-destructive research method, laboratory tests were conducted in the OSACEA laboratory. Based on the obtained experimental data, it was proposed to model stone pillars with damage similar to the actual experiment in the SP ANSYS software complex.

Keywords: bearing capacity, damaged structures, mortar, finite element method, modeling.
The problem of assessing the overall problem. The problem of assessing the residual load-bearing capacity and reliability of elements of stone structures has also recently been intensively growing due to the fact that the age of a significant part of buildings and structures in the historical part of European cities and in Ukraine, which were built 50 or more years ago, is approaching regulatory term of service.

Highlighting previously unsolved parts of the overall problem. The problem of assessing the residual load-bearing capacity and reliability of elements of stone structures has also recently been intensively growing due to the fact that the age of a significant part of buildings and structures in the historical part of European cities and in Ukraine, which were built 50 or more years ago, is approaching regulatory term of service.

Presenting main material. According to GOST 31937-2011 "Buildings and structures. Rules for the inspection and monitoring of the technical condition" and SP 13-102-2003 "Rules for the inspection of load-bearing building structures of buildings and structures":

Inspection of stone structures:
1. During the examining the masonry, the design and material of the walls are established, as well as the presence and nature of deformations (cracks, deviations from the vertical, delaminations, etc.). To determine the design and characteristics of the wall materials, selective control probing of the masonry is carried out. Probing is performed taking into account the materials of previous surveys and carried out superstructures and extensions. During probing, samples of materials are taken from various layers of the structure to determine the moisture content and bulk density. The walls in the study areas are cleaned of cladding and plaster on an area sufficient to establish the type of masonry, size and quality of bricks, etc.
2. The strength of bricks and mortar in piers and solid sections of walls in the most loaded dry places can be evaluated using non-destructive testing methods. Places with lamellar destruction of bricks are unsuitable for testing.
3. During a comprehensive survey of the technical condition of a building or structure, if the strength of the walls is decisive in determining the possibility of additional load, the strength of the stone and mortar masonry materials is determined by laboratory tests in accordance with GOST 8462 and GOST 5802. The number of samples for laboratory testing when determining the strength of building walls is taken: for brick: at least 10, for mortar: at least 20. In the walls of layered masonry with internal concrete filling of large blocks, samples for laboratory testing are taken in the form of cores.
4. The establishment of voids in the masonry, the presence and condition of metal structures and reinforcement to determine the strength of the walls is carried out using standard methods and instruments or according to the results of the opening.
5. When examining buildings with deformed walls, the cause of the deformations is preliminarily established.

One of the most common types of damage to stone buildings is their cracking. According to statistics, the most common causes of cracks in stone structures are [1]:
- uneven settlement of foundations (65-75%);
- overload of structures (10-15%);
- temperature deformations (10-15%);
- moisture deformations (5-8%);
- special loads and impacts (2-5%).

The most characteristic defects of stone structures allowed during their construction include the foliowing:
- heterogeneity of mortar bed;
- the use of the type and grades of bricks and mortar that do not correspond to the design ones;
- poor-quality ligation of stones in the masonry;
- lack of ligation of longitudinal walls with transverse ones;
- omission or underestimation of the sections of the connections of walls with columns and ceilings;
- thickening of horizontal joints of masonry against the norms provided;
- poor filling of vertical masonry joints with mortar;
- violation of the verticality of walls and pillars;
- laying girders and beams on walls and pillars without base plates; insufficient length of support of jumpers on the walls;
- omission or reduction in the amount of reinforcement in reinforced masonry structures;
- poor-quality execution of metal coatings of parapets, cornices and corbels, as well as roof junctions with walls;
- incorrect execution of temperature, sedimentary and anti-seismic seams;
- masonry defects due to violation of the rules for the production of work in winter conditions.

Structural dampness in stone walls has a devastating effect not only on the usability of the rooms in the building, i.e.:
- microclimate;
- conditions conducive to the development of mold fungi;
- deterioration of thermal insulation properties, but also for the bearing capacity of masonry materials.

Brick walls began to protect against moisture as early as the 1920s [1], but today the solutions used in many cases have ceased to be effective. Sources of moisture are inside and outside buildings, as well as in the ground. Although there are many methods for checking the degree of moisture, they do not always give accurate information about the conditions found throughout the wall [1]. It is especially difficult to control the moisture content of historical stone walls of considerable thickness, especially in situations where conservation restrictions prevent destructive testing.
The bearing capacity of the walls depends on the compressive strength of the brick and mortar, but the correct assumption about these values is difficult. Buildings under conservation restrictions cannot be used to collect a large number of destructive testing samples, and non-destructive testing does not always provide sufficient information (often data is limited to surface parameters). For brick and mortar, the literature is dominated by low compressive strength data, although several available experimental studies provide information on higher values. The results obtained from the modeling described in the article show that for bricks of class 5 MPa and below, laid on lime mortar, the load-bearing capacity of the window post will be exceeded even for walls in an air-dry state [3].

In the Figure 1 shows the maximum stresses obtained for each of the options in the ANSYS program. In the Figure 1 shows the destructive forces and displacements for characteristic points, i.e. those points for which experimental values are known, discrepancies in experimental and calculated data are also shown here. The software complex obtained the maximum stresses (MPa) and converted them to the maximum destructive load (kN).

**Conclusion.** In general, the analysis of modern studies shows that many scientists have worked on the study of the causes of damage, methods of strengthening, calculation methods. At the moment, the operation of eccentrically compressed elements is not sufficiently studied. The article deals with the modeling of the work of damaged structures by the finite element method. Modeling and calculation of experimentally studied samples can be performed in various en-

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Figure 1. Modeling results in SP ANSYS

Figure 1 shows that the experimental data and the calculation results in the SP ANSYS are in good agreement with each other, the maximum discrepancy for stresses is 16.2%, and for displacements 12.3%.

gineering programs. It is advisable to use SP ANSYS based on what is known from the literature and the experience of modeling brickwork, it is advisable to choose 8 nodal elements as the main finite elements in both programs. The analysis of
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