Organizational and technological approaches to the construction and technical expertise of cultural heritage sites

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Abstract. Construction and technical expertise plays an important role in the preservation of cultural heritage sites. Based on the data obtained in the course of construction and technical studies the technical condition of cultural heritage objects or their parts is determined as well as the possibility and methods of carrying out repair and restoration work. Construction and technical expertise of cultural heritage sites allows for control ensuring the prevention of damage, destruction, reshape or complete destruction of historical and cultural monuments. The special feature existence of such objects determines a special order and approaches to conducting construction and technical research attached to them.

1. Introduction
Construction and technical expertise as one of engineering and technical expertise is carried out on the basis of knowledge in the field of capital construction, technologies and features of building design, building materials production etc. [1]. It plays an important role in investigating events that have caused accidents, deformations or the external signs of hidden defects appearance in structures and units of capital construction objects.

The list of objects to research by a construction expert is very wide and differs in functional purpose, natural and technical characteristics as well as in procedural position [2, 3].

Work with historical and cultural monuments is one of the most difficult expertise types. The fate of such objects directly depends on the expert's conclusion and his assessment. Construction and technical expertise makes it possible to prove the facts that give rise to include capital construction objects in the cultural heritage register as well as withdrawal from the state register, to identify the projects compliance of protected zones of historical and cultural monuments with provisions on the protection of cultural heritage and town planning regulations, to determine on the basis of historical and cultural significance and other signs, to which monuments category should one or another object be attributed [4]. According to the examination results, repair and restoration work can be assigned, and the composition of measures for the object preservation can be determined.

2. Materials and methods
Work with monuments of history and culture in Russia implies the availability of both traditional certificates of admission for construction and design, issued by self-regulatory organizations, and additional approvals and permits from the Ministry of Culture and other organizations responsible for the state of the historical and cultural heritage of the Russian Federation. Relations arising in the process of preservation and use of cultural heritage objects in Russia are regulated by Federal Law No.
73 of June 25, 2002 "On cultural heritage objects (historical and cultural monuments) of the peoples of the Russian Federation".

Cultural heritage objects are divided into the following categories of historical and cultural significance:

- cultural heritage site федерального значения;
- objects of cultural heritage of regional significance;
- objects of cultural heritage of local (municipal) significance.

The status of an object does not determine property rights, and monuments of federal significance can be owned by regions, as well as vice versa.

Cultural heritage objects stand out among other real estate objects with their historical value as well as architectural, planning and constructive solutions, which determine the presence of some peculiarities in the construction and technical examination of such objects [5].

When carrying out construction and technical expertise of historical and cultural monuments, the objects of research can be:

- capital construction objects, building structures and building materials;
- unfinished repair and restoration work;
- construction production technologies;
- results of previous construction examinations;
- accident reports;
- design and estimate documentation;
- contracts.

Work with these sites requires deep knowledge in many related areas so specialists must have a high level of qualifications and professional training, this is a distinctive feature of the construction and technical expertise of cultural heritage sites.[6]. When carrying out construction and technical expertise directly on historical and architectural monuments as well as various sculptural compositions not only technical but also creative methods are used.

3. Results and Discussion

The result of the expert's work can determine the further object fate - reconstruction, restoration or other work. Expert work with objects of cultural heritage is designed to solve a wide variety including highly specialized tasks, which include [7, 8]:

- determination of the object age;
- setting the terms of restoration work;
- fixation of changes in the hydrogeological regime;
- identification of deformations and defects of supporting structures;
- determination of the supporting structures reliability;
- monitoring of the technical condition of the building;
- determination of the redevelopment or reconstruction possibility;
- recommendations formation for increasing the elements bearing capacity;
- determination of restoration methods for the most complete and effective object restoration;
- implementation of adaptation projects of historical and cultural monuments for operation in accordance with modern requirements;
- impact assessment of various technogenic factors on the cultural heritage site;
- verification of the performed repair and restoration works compliance with the requirements of regulatory and contractual documentation;
- verification of the design estimates validity;
- quality control of finishing, repair, restoration work, etc.

The content of the engineering and technical expertise is determined by the customer's assignment. Construction expertise is appointed in controversial issues, it can be pre-trial or carried out in court. Basically, the following types of construction expertise are distinguished at cultural heritage sites:
• examination of the building technical condition, its destruction degree, normal operation time without restoration or reconstruction work;
• cause examination of accidents, destruction, defects;
• examination of design and estimate documentation
• examination of the quality, volume and cost of repair and restoration work;
• estimation of the work cost in progress during the conservation of capital construction objects;
• damage determination of building or structure.

Cultural monuments, as a rule, do not have standard design documentation. In this case during the construction and technical expertise, archives are studied and materials are examined for a specific historical period or for similar objects, therefore, the study of design documentation for cultural heritage sites is a rather complicated and time-consuming process. When performing construction and technical expertise of cultural heritage objects, it is necessary to apply special measures:

• study of materials from various archives related to the object under study (search for archival information, analysis of materials on similar buildings and structures built at the same time as the object under study);
• visual and instrumental examination, as well as diagnostics using modern technology;
• geological surveys to determine the foundation durability and possible geological and hydrogeological risks;
• determination of the material strength used in construction by means of load simulation;
• object measurements to determine the exact geometry of buildings, including three-dimensional scanning and volume modeling;
• examination of all structures, defect identification (the strength of the supporting structures is determined as well as possible ways to strengthen them);
• performing calculations required for strength checks taking into account detected defects, damages and changes in material characteristics;
• drawing up a report based on the results of the examination containing if necessary comprehensive recommendations for strengthening and restoring the object.

The status of historical and cultural monuments stipulates a more detailed study. Significant part of buildings and structures related to cultural heritage sites are under state protection. Their technical condition is examined in order to preserve such objects.

Construction and technical expertise production in relation to cultural monuments often involves the use of methods and devices for non-destructive testing.

Non-destructive methods imply the determination of the structure strength characteristics of the building under study without their direct destruction while the results obtained are quite reliable [9]. This control method makes it possible to inspect critical structures of buildings, for which the selection of individual samples is not possible.

Despite the presence of quite significant drawbacks, the non-destructive testing method is actively used in the activities of construction experts. Any weakening of the surveyed objects, which is inherent in destructive methods, leads to a decrease in the bearing capacity not only of individual structures but also of the building as a whole. Also subsequent repair of damaged areas requires additional costs. Method use of non-destructive testing makes it possible to avoid such negative consequences thereby reducing not only the time, but also the cost of the technical inspection of buildings and structures [10].

Modern devices for non-destructive testing allow to check various construction objects, analyze the internal state of building structures, elements and assembly units without violating their integrity. The current selection of devices with different operating principles is applicable to a wide range of materials, including metal, concrete and brick. Also during the examination ordinary measuring instruments are used to check the geometry of structures and to measure damage: rulers, tape measures and levels. Non-destructive testing devices allow to determine the characteristics and data of building structures, which are necessary in the examination process. Such possibility not only reduces the
examination time but also increases the accuracy and precision of the research carried out. The use of any devices during construction and technical inspection implies the need to check them because if the examination is carried out using measuring instruments and instruments that have not been verified but are subject to verification its results will be inadequate evidence.

Inspections of the technical condition of cultural heritage sites in Russia are regulated by GOST R 55567-2013 “Procedure for organizing and conducting engineering research at cultural heritage sites. Monuments of history and culture”. The document contains provisions on the scope of work in terms of the engineering and technical conditions of cultural heritage objects necessary to establish the state of cultural heritage objects, to carry out conservation, restoration, adaptation of such objects for operation in modern ones, as well as to recommend their preservation.

Engineering and technical research of a complex nature is provided by research, design and production work, including additional examinations in the process of repair and restoration and other works, the study of archival, historical, expert and other information.

When carrying out work on the survey of historical and cultural monuments the status of the objects should be taken into account. In some cases the protected part of a building or structure (facade, walls, any fragments of columns, etc.), however the safety of a separate part depends on the integrity of the entire object. During a full-scale instrumental examination, especially valuable fragments of monuments of cultural history are examined and evaluated most carefully. Increased requirements are imposed on the determination of the strength and elements durability [11].

Inspection of the technical condition of the cultural heritage object is carried out before the start of design work as well as the period of work on the preservation of cultural heritage after the structures opening that are inaccessible during the main survey.

The completeness and accuracy of the full-scale examination of the object is of great importance for further research and drawing up a conclusion [12]. When performing the survey the features of the object and the specifics of its environment should be taken into account, while the expert must use personal protective equipment that meets the conditions of the inspection, comply with the requirements of labor protection and safety.

All data obtained as a result of inspection of a cultural heritage site must be recorded in detail, including through the use of modern photo and video equipment. The use of special technical means and devices in the process of examination allows obtaining more accurate information about the object of research [13].

Further to the object inspection all available materials should be studied and if necessary, supplemented with comments. After completing the full-scale inspection, the expert needs to check the equipment and aids for completeness.

When performing construction and technical studies experts should have access to an appropriate laboratory and material and technical base or the ability to involve specialized laboratories in carrying out certain work types.

The use of information technologies in the process of construction and technical expertise allows more efficient work in this area. Optimization of information support for construction and technical expertise through the use of the latest generation software allows to solve a large number of repetitive processes at high speed, which in turn makes it possible to increase the efficiency of construction experts[14].

Based on the data obtained as a result of the construction and technical research the technical condition of the building or its individual parts is determined, as well as the possibility and methods of restoring the cultural heritage object.

4. Summary
As a result of the examination the customer receives an expert opinion, which indicates all the main characteristics of the cultural heritage object, determined as a result of the examination. Based on the data obtained, the expert can determine the technical condition, the destruction degree and the time of possible operation of the facility without repair and restoration work. Also the conclusion may contain
the professional opinion of an expert on what methods can be used during the planned repair and restoration work to increase their efficiency, recommendations for restoring the original building appearance, the methods description and materials that are closest to those used in its construction.

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