COMPLEX ENGINEERING TECHNICAL EXAMINATION OF THE ASCENT CHURCH AT THE STATE OUTDOOR MUSEUM KOLOMENSKOYE

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ABSTRACT:

Monuments of culture and history preservation constitute a responsible and complicated problem, the decision of which can be accomplished only on the basis of thorough study of their state. One of the main components of this process is carrying out complex engineering surveys. Complex engineering studies of architectural monuments, buildings and structures of Cultural Heritage, which KREAL Specialized Company carries out, include the following kinds of work:

- Geodesic-engineering
- Electronic measuring
- Geological-engineering
- Foundations and base examination
- Geophysical survey
- Examination of surface load bearing constructions, and underground parts of buildings and structures
- Ecological-engineering
- Development of engineering solutions for correction of revealed defects
- Drafts and proposals on implementation of developed engineering solutions
- Quality control of the developments

As a result step the detailed calculation of architectural monuments as a single "building - base - foundation" system with due account of the existing damages are carrying out. The above mentioned approach based on the initial examination and structure calculation would provide optimal solutions to the restoration of the Cultural Heritage. All of this principals are demonstrated on the examples of complex engineering surveys of Church of ascension in the Kolomenskoye State museum - reserve.

1. INTRODUCTION

Timely and professional restoration and renovation works performed at the World Heritage monuments are contingent upon an accurate and complex approach pursued in the course of the technical examination of such monuments. A fundamental basis used in order to forecast the way the monument will behave in the future is a diagnosis of the condition of such monument that includes determination of the extent of aggression of the operational environment, physic-mechanical and physic-chemical parameters of constructions, degree of corrosion of materials, and an extent to which mutual mechanical links between specific elements of such constructions were weakened, including changes in the condition of the background soil, etc.. Any further processing of meanings of diagnostic parameters and performance of required calculations in order to determine the residual resistance of monuments and constructions is intended for the assessment of a possibility and feasibility of restoration and renovation works, and if they are to be conducted, the above mentioned approach fully determines the means, methods and scope of such works. Besides, an acute need to objectively assess a technical and physical condition of specific elements of buildings and constructions (foundation, basement, walls, ceilings, roof) is linked to the task of capital costs minimization for restoration and renovation of architectural monuments in particular.

2. COMPLEX ENGINEERING SURVEYS

Specialized company KREAL conducts complex engineering surveys of various buildings, project drafting and construction, including the following works:

- Engineering and geodesic works;
- Electronic measurements;
- Engineering and geological works;
- Examination of the foundation and basement;
- Examination of supporting constructions of on-the-ground and underground parts of buildings;
- Engineering-environmental works;
- Development of technical solutions aimed at elimination of disclosed defects;
- Blueprints and project proposals aimed at implementation of developed technical solutions.

Engineering-geodesic works and measuring of monuments are intended for obtaining of a topographic shooting of the locale, floor plans, cross-sections, and facades, including photographic surveys. Engineering-geodesic works include a control over deformations of the monument, geodesic support of restoration works. Measurement results allow to determine the exact size and volume of the monument, create a spatial model, perform calculations on the basis of such spatial model.

Engineering-geological works include:

- Drilling holes with mechanical units for up to 50 meters down under the gorund
- Conducting statistic boring of the ground
- Conducting electro-dynamic boring of the ground
- Lab tests and field tests of the soil

- Working prospecting shafts, including the ones with a discharge
- Geophysical examination methods

The following works are conducted as a result of engineering-geological examinations:

- Determination of a geologic-lithological construction and engineering-geological conditions
- Determination of hydro-geological conditions
- Determination of physic-mechanical properties of the soil
- Assessment of a potential development of unfavorable engineering-geologic processes
- Determination of the construction and resistance characteristics of the foundations
- Assessment of the carrying capability of basements and foundation soils
- Issuance of recommendations related to re-enforcement of basements and foundation soils

Examination of foundations and basements include the following works:

1. Examination of foundations.

Such examination comprises the working of prospecting shafts (including the ones with a discharge even when a very insignificant inflow of water is present) in order to determine types, constructions, geometric parameters, materials and depth of foundations; disclosure and description of defects and determination of the condition of foundations; determination of resistance characteristics of foundation materials applying methods of non-interfering control.

2. Examination of the foundation ground.

In the course of such examination the following works are performed: selection of soil probes of broken and non-broken structure directly out of the foundation base; drilling of holes with a 10-meter depth out of prospective shafts selecting samples of soils and water; field tests of the foundation ground in prospecting shafts, including shifting, stamp test and conducting electro-dynamic boring.

3. Issuance of a report on the condition and supporting capacity of basements and foundation grounds.

In order to prepare a final report the following works are to be completed: calculation of the degree of strain under the foundation base that resulted from the existing load; assessment of the carrying capacity of basements; assessment of the carrying capacity of the foundation ground.

Examination of carrying constructions of on-the-ground and underground parts of buildings comprises the following works:

Collection of initial information:

- Obtaining and analysis of historic and archive project materials, results of previously conducted examinations, materials of operating services;
- Disclosure of production and technological influence on the buildings.

Preparation of a constructive scheme of the building:

- Description of the scope-planning solution for the building;
- Preparation of a three-dimensional scheme of placement of major carrying constructions;
- Assessment of the general stability and firmness of the building.

Measurements of constructions and their elements:

- Determination of a constructive decision, composition and geometric dimensions of walls, ceilings and the covering;
- Determination of sections of construction elements.

Assessment of the condition of constructions:

- Description of general deformations of the monument;
- Disclosure of mechanical defects that occurred in the process of operation of such monument;
- Disclosure of cracks and increased deformations of constructions;
- Determination of the extent of corrosion of steel elements, splitting-off of concrete (if any) and stone constructions;
- Search for fungoid affection on constructions.

Assessment of the carrying capacity of the building:

- Determination of the load onto elements of the building with the account of completed openings;
- Determination of the strain in constructions utilizing a prepared calculation scheme;
- Controlling calculation of elements of the building with the account of the current condition of constructions and resistance-related characteristics of materials that were obtained through a series of tests.

Assessment of the overall condition of the building:

- Analysis of examination results, including an assessment of deformation, condition of constructions and calculation results;
- Determination of the category of the condition of the building (normal, satisfactory, unsatisfactory, emergency).

Preparation of recommendations in order to ensure the operational applicability of the monument:

- Preparation of a list of elements to be restored or re-enforced;
- Preparation of recommendations aimed at completion of hydro insulation, elimination of leaks, liquidation of corrosion and fungoid consequences.

Engineering-environmental examinations are conducted in order to assess contamination of soil, ground, surface and subsoil waters with chemicals or their combinations of various toxic categories, both of a non-organic and organic nature.

On the basis of a complex examination of natural and man-created conditions the following works are conducted:

- Evaluation of an environmental danger and risk;
- Evaluation of a current environmental condition of specific elements of the natural environment and ecosystem in general, their resistance against any influence of a man-created nature and their capacity to return to their normal functioning;
- Preparation of a forecast of potential changes of natural (natural-technical) systems in the course of construction, operation and liquidation of the site;
- Preparation of a feasibility study for environmental and compensation events aimed at the maintenance, restoration and recovery of the environment;
- Preparation of recommendations and (or) a program for organization and conducting of a local environmental monitoring.

The entire above-presented complex of examinations was utilized in the course of a complex engineering and technical examination of the Church of Ascent in the State Outdoor Museum Kolomenskoye in Moscow.

Over its almost five-century existence this church survived several wars, various natural disasters, fires and restorations.

It should be noted that before the beginning of the twentieth century even when full-scaled restoration works were conducted more or less significant examinations of construction, basements, foundations were never carried out.

On the basis of previously conducted examination works in relation to the Church of Ascent in Kolomenskoye a conclusion should be made that an acute need has arisen in the conducting

of complex scientific-research works with the account of requirements for the World Heritage monuments which the Church is a part of.

In the framework of "The Program for restoration works at architectural monuments of the State Outdoor Museum Kolomenskoye" for 2000-2004, Specialized company KREAL in 2001 commenced and still continues completion of complex engineering-technical examination of the Church building under an assignment of the General Contractor (CNRPM), utilizing modern methods and means involving mainly non-interfering technologies.

The works are conducted under a program agreed with a Division named "Architectural monuments" of the Federal Scientific-Methodological Council for the protection of the cultural heritage of the Ministry of Culture of the Russian Federation.

The program includes:

- Engineering-geodesic (measurement) works
- Examination of basements and foundations
- Examination of constructions.

In the result of engineering-geodesic works performed in an electronic form the following was completed: floor plans on various heights, facades, and cross-sections. A situational plan of the land plot was performed.

Obtained materials allowed constructing a three-dimensional model of the church and they will serve as grounds for the restoration and recovery project.

Received materials allowed us to construct a three-dimensional model of the church and will be used as the basis of the project for restoration and recovery works. Such three-dimensional model in addition to external and internal sizes includes all information available about the site (construction elements, defects, cracks, geological composition of the underlying subsoil). Such three-dimensional modeling has a number of major advantages:

firstly, it is a fullest and compact description of the examined site, secondly, it allows us to fix, or, if we may say so, clone the site. A solid model makes it possible to obtain any sections and cross-sections and perform any measurements. As a result, we have an electronic copy of the examined site, which encompasses the fullest information about the site at the time of its examination.

Analysis of already obtained examination results related to the examination of the basement and foundation allow to conclude that the relief of the plot has a significant slope in the direction of the Moskva River, to the east of the building the slope was artificially planned. The slope of the Moskva River around the Church of Ascent is characterized as stable from the point of view of landslides. Until 1980 there existed slight erosion due to the closeness of the river. In 1980 – 1983 the river bank was re-enforced.

The basement of the main tall part of the building and carousel columns complete a unified platform faced with masonry utilizing a limestone solution (dimensions 24,5×27,2 meters). The foundation under the walls of the western part of the overlapping foundation and foundations of the porches are strip footing.

The upper part of the foundation platform is made of limestone that was roughly cut using a limestone solution, and its lower part is made of broken limestone using a limestone solution filled with crashed stone and crashed brick.

It must be noted that for the first time in the history of studying a monument a constructive solution of the foundation was disclosed. The foundation platform has a close to a wedge-shaped form, the capacity of the platform increases in the western direction, and it is placed in the depth of 4 to 7 meters.

We may suppose that such construction of the platform was used in order to prevent from the slide of the foundation down the slope in the direction of the Moskva River.

Under the foundation platform IGIT LLC disclosed a pile field of wooden piles made in the form of logs, semi-logs and squared beams with a diameter of about 18 cm and 0,80 – 1,15 meters long placed within a distance of 0,3 – 0,4 meters. The piles have a different degree of rot. Some of them are almost completely rotten and there are empty spaces on the place where they were installed that are called "glasses".

Subsoil "foundation" waters were encountered during the working two prospective shafts 4,07 – 7,00 meters under the ground from the upper surface of the blind areas. Reservoir material for them is the rubble laying of the foundation platform of the building through which rain waters are filtered. The waterproof barriers for them are loams of moraine of the Dnepr ice-formation. The chemical composition of encountered waters includes hydro-carbonate-calcium type saturated with ions of free carbonic acid, which proves that there is a filtration of water through the laying of the foundation platform.

A minimal meaning of the calculated resistance of the soil was observed the zone of the strip footing foundation of the western porch, and maximum meanings – in the zone of the deepest part of the foundation platform.

Visual examination of the on-the-ground part of the church disclosed the following:

Split-off of the masonry of the overlapping foundation resulting in internal vertical cracks of up to 10 mm; tear-off of internal pilasters of the western overlapping foundation walls and broken tie-up bricks and occasional insignificant vertical shift of split-off masonry lines; sloping cracks in side walls of the western overlapping foundation, proving the uneven setting of the foundation platform of the central part and the strip footing foundation of the western wing of the church; vertical through cracks dividing the church building in the medium-tall zone into four practically unrelated parts; a vertical crack (scale-off) of the external wall of chamber of the inter-wall stairs; broken metallic links under the galleries and along the perimeter of the church walls at level of the lower part of kokoshniks, and their complete loss in the western overlapping foundation; layer-type corrosion of interlinks in the central part of the overlapping foundation wherein a layer is 15 mm thick; cracks on the lower surface of the gallery arches and in the zones of stripping of formwork of the ceiling arch of the western overlapping foundation; split-off of the masonry, especially in the locks, arches of the western and central overlapping foundation that is 50 mm deep, and in specific parts – up to 150 mm; defects of the plaster layer and weathering of the masonry of the external walls.

Geophysical examinations allowed to see a significantly uneven masonry (the speed of lengthwise waves in the course of X-raying reduces two to five times).

Resistance-related characteristics of the brickwork based on the test results vary from 40 to 60 kilos/см2.

The Chemical analysis of the links made of steel showed that the links are made of practically pure steel.

The mechanical boring of the wall masonry in the zones with abnormally low speed of distribution of lengthwise waves as determined in accordance with the results of geophysical examinations showed that the visually observed in the window-frames split-off of the wall masonry goes through practically all the wall masonry of the western overlapping foundation, and such split-off exists both from the internal and external part of the wall at a depth of up to 450 mm; at the places of split-off in vertical seams of the masonry the solution has lost its structure, the connection of the solution with the brick is broken; at a depth of over 450 mm from the external and internal surfaces of

the walls the masonry is wet, the split-off cannot be observed; in the walls of the overlapping foundation of the central part a similar split-off can be observed mainly on the external surface of the walls.

When boring the ceilings (11 bores) the following was disclosed: ceiling arches of the western and central part of the overlapping foundation are 450 mm thick in the lock area; in the area of church-porches, porches, and stairwells – 300 mm; under the white-stoned floor of the north gallery there are two layers of brickwork on the side arranged in the «goose feet» manner, under them there are a number of brickwork layers arranged “flatways”, and they are wet; under the same floor of the west gallery there is a backfill of broken brick made with the limestone solution, significantly wet; under the floor of the southern porch area there is a sand cushion which is 800 mm thick, and underneath one may see horizontal brickwork layers.

Utilization of new methods of diagnosis and forecasts of structural changes in the brickwork materials applying a scanning microscope and other equipment allowed to determine a mineralogical composition of the brickwork and the type of defects related to the biochemical corrosion.

Engineering examination of the on-the-ground part of the church with the account of the above-presented results allows us to make a complex assessment of the condition of the building, and prepare recommendations for any further examination of the building.

Upon completion of the full volume of planned complex engineering technical examinations it will be possible to prepare recommendations aimed at the protection of the World Heritage monument, which is The Church of Ascent in Kolomenskoye.