Complex monitoring of natural-technogenic sphere in preserving of cultural heritage

A N Nesterova
National research Moscow State University of Civil Engineering, 26 Yaroslavskoye highway, Moscow, 129337, Russia

E-mail: Lisa.858@yandex.ru

Abstract. Complex monitoring includes a range of essential factors that allow to fulfil effective activity on preserving cultural heritage and to track technical condition of objects. Performance of monitoring of objects of historical-cultural heritage and adjacent territory promotes the piling of necessary bulk of data about technical condition of memorials, the causes of appearance of ruins and making meliorative and governing decisions.

Complex monitoring – is the system of observing and control, covering most or all of the components natural-technogenic sphere such as dangerous geological processes and phenomena, monitoring of the changes of ecological condition of environment, monitoring of sources of technogenic impact ant etc. [1].

In order to get more accurate data, it is important to examine all constituents of complex monitoring separately. The structure of complex monitoring includes: geotechnical monitoring, monitoring of technical condition of the object of research, ecological monitoring.

Introduction

Figure 1 represents system, which in complex provides the monitoring of technical condition of investigated objects (architectural-memorial complexes) and monitoring of anthropogenic factors (fig.1).

![Complex monitoring diagram]

Figure 1. Complex monitoring on reconstruction of city building

Materials and methods of investigation
Geotechnical monitoring – includes the system of complex control, based on the study of behavior of construction of building or structure, its foundation, at the same time massive of priming, that surrounds the building and construction of surrounding buildings. On the base of MGSN 2.07-01 geotechnical monitoring need to be held both during the construction or reconstruction of the building and after it – during at least one year [1,2,3,5]. Geotechnical monitoring is one of the main constituents for secure exploitation of the given object, as preservation of historical-cultural heritage needs constant control on their technical condition and on ecological condition of the sphere in which these objects located.

| Geotechnical MONITORING | 1 Event on observation of upper-ground and underground constructions of building or reconstructed building, or building, existing building, that lays in the zone of its impact. |
|-------------------------|-----------------------------------------------------------------------------------------------------------------|
|                         | 2 Event on observation of massive of priming, adjoined to the underground part of the object including underground water |
|                         | 3 Event of the value of results and observation and comparison of them with projective data |
|                         | 4 Forecasting on the base of results of observation of change of condition, constructed or reconstructed building, existing objects in zone of impact |
|                         | 5 Forecasting on the base of results of observation of change of condition of massive priming, including underground water |
|                         | 6 Working out of events on liquidation of unacceptable error and negative results |
|                         | 7 Control of fulfilling of make decisions |

**Figure 2.** Structure of events of geotechnical monitoring [4]

The aim of the geotechnical monitoring is to provide the security of construction and the operating safety of objects of new construction or reconstruction or surrounding buildings due to the timely revealing of changes of controlled parameters of construction and priming foundation, that can lead to switch of objects into limited able to work or emergency condition [2,3].

In order to control the condition of the architectural heritage objects needs constant observation of technical condition and sphere in which the memorial located. Today the problem may be solved on the base of geotechnical monitoring.

Geotechnical monitoring consists of the following principles:
- geodesic;
- geophysic;
- strain gauge;
- visual-instrumental;
- vibrometric.

Structure of monitoring of historical-cultural heritage, in the given case of architectural-memorial complex, has to correspond the structure of object, the structure of systematic parameters and processes connected with it.

**Ecological monitoring** – includes a range of various factors of environment, that influence of the objects of historical-cultural heritage. Ecological monitoring consists of the following stages:
The following considered as the factors of ecological monitoring of impacts on objects:

1. External impact:
   - Natural (radiation, temperature, biological pest, storm, seismic waves, frost, moisture etc.)
   - Synthetic (noise, chemical substances, sound vibration, gases, radio waves, electromagnetic waves, priming pressure, stray currents, vibration etc.)

2. Inner impact:
   - Constant and time load,
   - Long and short-time load from its own weight, equipment and people;
   - Technological processes: stroke, vibration, abrasion, spillage;
   - Variation of temperature;
   - Variation of moisture of the sphere;
   - Biological pests.

   Above mentioned factors lead to quick violation, characterizing physical-chemical and mechanical character, that leads to contraction of the bearing capacity of construction and whole complex. Contraction of technical condition of complexes, consequently, fulfilled in the process of changing physical-chemical property of material, as well as change of their size and form.

**Monitoring technical condition of the object**

Monitoring of technical condition of objects of cultural heritage means the system of observing the buildings, with structure and their elements, of processing received data, of making forecasts and recommendations, essential for making decisions on extension of vital circle of objects of cultural heritage and of supporting normal functioning, by the means of conservation, repair, adaptation and reconstruction of its separate elements [6].

Monitoring of technical condition of the objects includes the following problems:

- Preventing from damage, the process of destruction and abolition, as well as the change of the shape of object of historical-cultural heritage;
- Fixing of the cases of violation of set order of usage and prevention of analogous action, that harms cultural heritage;
- Defining the factors of unfavorable influences of environment;
- Defining the events on the providing preservation of objects of historical-cultural heritage.

The program of monitoring should contain:

- Description of the object;
- Described landscape – climate conditions of territory;
- Description of engineering – geological conditions;
- Key capacities of the object (the level of responsibility, construction diagram, historical peculiarities, peculiarities of erection and technical exploitation);
- Consideration about earlier fulfilled work, as well as about the results of observation;
- Consideration about the instruments, installed for fixing of various parameters;
- State of surrounding natural sphere, as a controlled parameter of considered object;
- Basis of chosen system of monitoring, including the methods of change of controlled parameters, stages, periodicity and time of realization of observation;
- Requirement of order of making record documents.

Monitoring of technical condition of memorial complex can be constant and urgent.

Table 1. Classification of the category of technical condition of objects of historical–cultural heritage

| Category of condition | Characteristic of condition of AMK                                                                 |
|-----------------------|----------------------------------------------------------------------------------------------------|
| I – normal            | Follows the condition of exploitation of requirements of normative, projective documentation. Exists necessity of repair work. |
| II – satisfied        | For I group – with the account of actual property of materials satisfied requirements of norms of maximum condition. For II group – requirement of norms maximum condition – violation, normal conditions of exploitation followed. Required current repair. |
| III – unsatisfied     | Requirements of norms broken, but danger of collapse and security threat of people do not exists. Required to work out a range of events on reinforcement of construction and restoration of their bearing capacity. |
| IV – pre-emergency or emergency | Character of damage causes disqualification of the construction for its usage, defined the danger of destruction of object, and danger for people |

Results and their analyses

Results of complex monitoring of objects of historical-cultural meaning must contain:
- Results of analysis and generalized results of preceding examination of technical condition;
- Results of monitoring and their analyses, including data about the control of construction quality;
- Systematized information, results of collection and analysis of instructions, which supervisory and controlling organs are responsible for;
- Forecasted condition of OKN, located in the impact zone of construction;
- Forecasting of changes of internal climate, ecological as well as geological factors;
- Variants of solution of complex of constructive and technological problems, which occurred during monitoring [1].

Results of complex monitoring allow forecasting the development of dangerous geological and ecological processes. As well as they promote making administrative decisions of organs of local self-government for preservation of valuable objects for human being.

Summary

For providing of preservation of immovable memorials of historical-cultural heritage before beginning of repair work, it is essential to organize monitoring of their technical condition and monitoring of natural-technogenic sphere (NTS). Complex monitoring must reveal tendencies and intensity of development of unfavorable processes of impact of natural-technogenic system on memorial. Monitoring is required to carry out according to the requirements of GOST P 53778 and other active documents. As well as essential to study separately the city as technogenic system (further – NTS).
Monitoring of natural-technogenic system – is complex system of observation of condition of natural technogenic sphere, supposing systematic collection of information about parameters of environment for defining of tendencies of their changes.

Due to complex monitoring may be worked out a range of events on decrease of negative impact of factors of natural-technogenic sphere on technical condition of objects of historical-cultural heritage.

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