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THE PROBLEM OF SEISMIC STABILITY OF UNIQUE HISTORICAL MONUMENTS – THE PRIMARY PROBLEM BEFORE US

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ABSTRACT
The article discusses some features in the nature of the damage during seismic impact on the minarets of Central Asia and analyzes their directional state.
KEYWORDS: *minaret, seismic impact, conservation.*

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Аннотация
В статье рассматриваются некоторые особенности в характере разрушений при сейсмическом воздействии на минареты Средней Азии и производится анализ их направленного состояния.
Ключевые слова: минарет, сейсмическое воздействие, сохранение.

DISCUSSION

The architectural monuments located in Central Asia reflect the history of the development of science, art and culture of the epochs of their construction. The study of historical monuments, their careful preservation and restoration is our duty to our descendants. Recently, intensive destruction of these structures has been observed, the cause of which is a long service life, atmospheric, seismic, industrial impacts, etc.

As prof. GP Gorshkov [3.54] "The intensity of modern tectonic processes within Central Asia is higher than in any other place on the Asian continent (with the possible exception of some parts of the Himalayas). With seismic vibrations of the soil in buildings and structures occurs along with translational and torsional vibrations. They can appear not only in the presence of eccentricity between the center of gravity and the center of rigidity of the structure, but also in its absence. One of the reasons for the occurrence of torsional vibrations of buildings may be the fact that the direction of displacements and accelerations of the seismic wave can coincide with the direction of wave motion, and be perpendicular to it.

Some authors note in sufficient detail the rather diverse nature of damage to architectural monuments caused by earthquakes and simplistically

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explain these differences by the different nature of soil vibrations, rotational motion, the influence of the “plastic” properties of gypsum mortars and other factors. Some features in the nature of the destruction can be explained by these reasons. However, the essence of the phenomena is that in the minarets there is a complex stress state caused by shear and torsion strains.

The behavior of various buildings and structures during earthquakes suggests that it can not always be described with the necessary accuracy by one-dimensional design schemes. Seismic impact is a multicomponent movement of the soil, propagating at a finite speed. The last factor determines the angular displacement of the structures of the monuments relative to the vertical axes. The presence of this factor requires a transition to calculations using complex calculation models, which take into account the real properties of structures and seismic effects. The seismic reactions of high-rise structures in an inhomogeneous field of influence are still not well understood and, for this reason, the existing regulatory documents do not contain sufficient guidance to ensure their seismic resistance. The solution to this problem requires the study of new types of seismic reactions, which are not always considered significant. Therefore, the study of issues such as the influence of the finite velocity of seismic waves in the soil on the magnitude of seismic effects and the nature of the stress state are very relevant.

The greatest danger to the vast majority of structures during earthquakes is represented by the horizontally component movements of the base, and the task of ensuring their earthquake resistance from this type of impact is the main one.

Studies show that, based on averaged calculation results, which exclude random factors, physical methods, they give a more objective forecast of seismic effects and lead to more reliable results than standard ones.

The mathematical problem of calculating systems for the impact of accelerograms is reduced to solving differential equations, which are usually performed by one of the known methods of numerical analysis, or to calculating reactions, as a process at the output of a mechanical system, to the input of which an accelerogram is presented in the form of a graph or a digitized record of earthquakes

$$\overline{Y}(t) = \int \bar{h}(t-\tau)\overline{w}_0(\tau)d\tau \qquad (1.)$$

For this, weight (pulse-transition) fictions of the corresponding reactions are preliminarily constructed.

The spectra of most accelerograms have a pronounced oscillatory character, as a result of which the contribution of each individual form to the overall movement of the system will strongly depend on the composition of the spectra of natural frequencies and exposure. A significant reason, which also determines the randomness of the result, is the approximation of determining the natural frequencies during design, in addition, the probability of accurately setting the structure to these settings during an earthquake is practically zero. In this regard, the exclusion of the accident factors described below is made by double averaging over the spectrum of models and the set of accelerograms. The results of these calculations are the maximum values of the system reactions during the earthquake, which is assumed to be equal to the length of the processed portion of the accelerogram. In calculations limited to three to five first frequencies and modes of vibration, which leads to the replacement of the design scheme by a system with one input and no. outputs. Using this idealization, seismic effects on minarets of Central Asia are determined and their directional state is analyzed. The magnitudes of the calculated seismic efforts are compared with the normative, distinguishing features are noted between them in the minarets, depending on their design scheme.

The study of the stress state of minarets is necessary to determine their earthquake resistance. In fig. 2. for the Kalon minaret, the values of the stress ratios obtained using physical and regulatory calculation methods are shown. The scale of the curves for clarity is selected so that the stress values at the base of the structure are equal. It also allows you to determine how many times the voltage at various points along the height of the structure is greater than the voltage at the base of the structure. An analysis of the results allows us to draw the following conclusions.

The greatest tangential and normal stresses approximately occur in cross sections 1/3 of the height from the top of the minaret crowning structures, and the greater the ratio of stresses in the upper levels to the stresses at the base of the structure corresponds to the normal stress “σ”.

Each monument is unique and represents a valuable cultural heritage. As you know, the choice of methods of restoration and strengthening depends on the degree of damage to the structures of the monument.

Considering the foreign experience and the results of our own research, mortars for masonry, sealing joints and cracks should be prepared on previously used types of binders (lime, ganch, gypsum, clay), by creating complex composite solutions. This is the main factor when choosing building materials for the restoration of architectural monuments.

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Fundamentally, the issues of using modern building materials — cement, concrete, metal, polymers, synthetic varnishes and paints, and especially burnt bricks using traditional technology — should be reviewed. In this case, attention should be paid not only to obtaining durable bricks, but also to the density (pore nature) of this material, which is the main component in the construction of the bearing part of buildings and the construction of the architectural heritage.

Fig. 1. Minaret Kalon.

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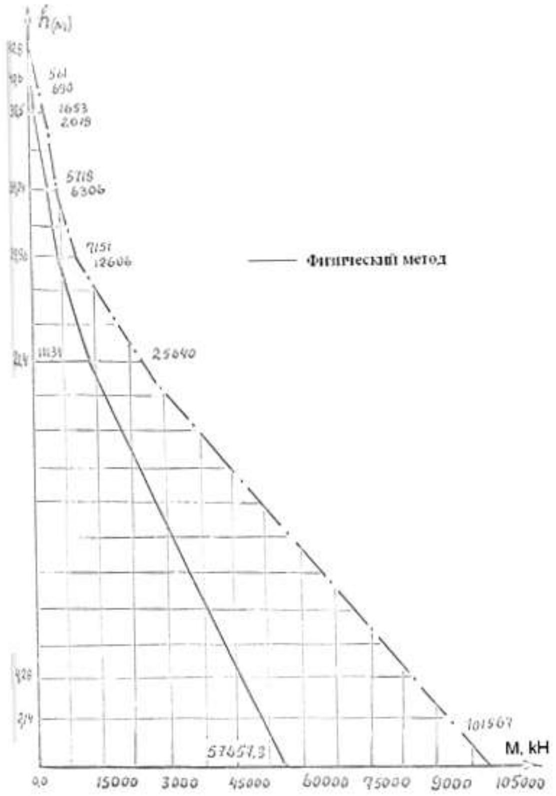

Fig. 2. Distribution of bending moments along the height of the Kalon minaret.

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