

Estimation Of Seismic Stability Of Architectural Monuments Of Khorezm

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Abstract: This article touches upon the issue of seismic stability of historical-architectural monuments. Full-scale monitoring and researches of architectural monuments of Khorezm have shown that the ancient masters-architects were acquainted with quite various destructive effects of earthquakes. Of course, the broad sections of architects, engineer - builders and restorers are interested in their original methods and designs of seismic protection. To identify the technical state of constructions of the madrassahs and minarets, located in Ichan-Kala of Khiva, engineering survey was carried out on its load-bearing structures. Rather, based on the achievements of modern construction science, the constructive decision of above mentioned object is entrusted to engineering analysis. From the point of view of seismic stability of buildings, an attempt was made to extract something common from such difficult situations of ancient times and building regulations that have been emerged in the present.

Index Terms: Estimation, seismic, seismologic, stability, architectural monuments, Khorezm.

INTRODUCTION

Khiva is an open-air museum city. It came into existence in the 10th century, almost a millennium ago. Khiva developed quickly, as it was located on the important trading routes. However, the formation of its modern image began just in the 17th century. By that time, Khiva had already become the capital of Khorezm. The most famous palaces and mosques were constructed in the 18th-19th centuries. [3] The majority of them are located in Ichan-Qala. (Inner city). Planning of Ichan-Qala forms a harmonious ensemble. The four city Gates welcome travelers from the four winds. Unfinished minaret of Kalta-minor, it might have become the highest tower in Central Asia. Its diameter is 15 meters! The technical condition of monuments in Khorezm are worsened, their durability is reduced. Owing to a rising of a level of ground waters and the increases of salinity in soils, historical monuments come in an emergency condition. The complex researches of architectural monuments of «Ichan-Kala» will be carried out, the scientific bases of their estimation and reconstruction are developed

2.1 The practical significance of the research

Architectural monuments of Khorezm under the space-planning and constructive decisions and used building materials differ from civil and industrial buildings. The technique of their calculation is developed for an estimation of seismic stability of civil and industrial buildings and constructions in sufficient volume on seismic influences. As to architectural monuments, this question till now is less studied. [2] Activators of fluctuations can serve as artificial sources (explosion, vibratory machine, stay, swing, impact on a construction), and natural sources (earthquake, microseism) at full-scale study of constructions.

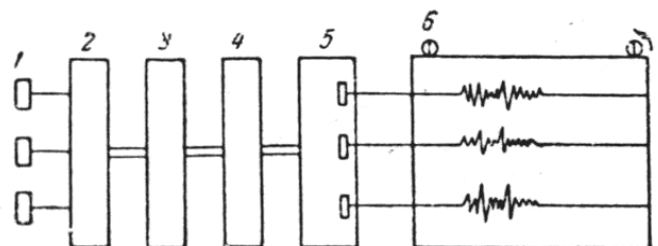
Microtremors caused by microseisms are considered as the most simple. Use of techniques of estimation of the seismic stability developed for civil and industrial buildings and constructions, does not reflect fully features of constructive decisions of architectural monuments. Development of the settlement device for an estimation of seismic stability of architectural monuments demands carrying out of special experimental researches by definition of their dynamic characteristics (period, forms and decrement of fluctuations).

2.1 Final Stage

Measurement of amplitudes and the periods of fluctuations of architectural monuments of Khiva were made by means of electrodynamic gauges of VECHIK (ВЭЧИК) type with oscillography Н-700, with galvanometers ГБ-Ш (frequency of 5 hertz). On fig. 1 the general scheme of typical vibration-survey channel consisting of gauges (seismometers) 1, switching points 2, signal easing regulator (box) 3, the amplifier 4, the target device, a galvanometer of an oscillography 5 and in regular intervals rotating cartridge with photographic paper or a film 6 is resulted. Data of inspections and on location studies of buildings and the constructions damaged as a result of earthquakes specify increase in damages 'as a result of earthquakes by intensity of 4-6 points that leads to downturn of their rigidity and as consequence, to increase in the period of free fluctuations.

2.3 Figures

Fig. 1. Seism metric gauges



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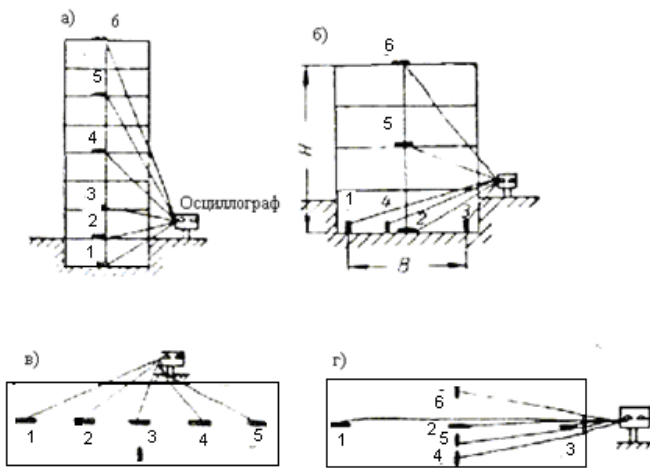
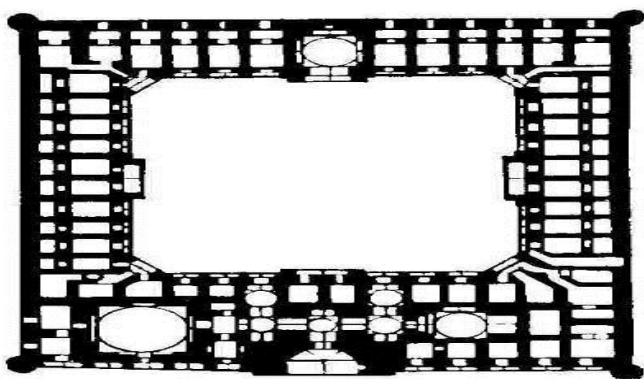


Fig. 2. Seism metric gauges

3. SECTIONS

In the present work the question of protection of buildings and constructions from harmful action earthquake also is mentioned, is truer on achievements of modern building sciences architectural monuments of Khiva are exposed to the engineering analysis. Attempt to take something common of complex situations of ancient times and building rules generated in the present is made. The study of architectural monuments of Khorezm has shown that masters-architects were familiar with rather various influences of earthquakes on architectural constructions. Constant threat of earthquakes, undoubtedly, was considered by the Khorezm architects already during very remote times. Their original receptions and designs, undoubtedly, will be of interest to the broad audiences of architects, civil engineers, as well as restorers. The analysis of on location studies and projects by way of monuments of Khiva, shows, that ancient architects in all cases chose by way of square (or the sides of buildings on size are close among themselves), (figure 3). By results of modern sciences this is most correct decision. The study of consequence of strong earthquakes show that the optimum form of the plan of a building is the square or close to them on a ratio of the sides of a rectangular.



principle of application of these elastic designs as the basic idea of antiseismic actions remains valid until now (figure 4).

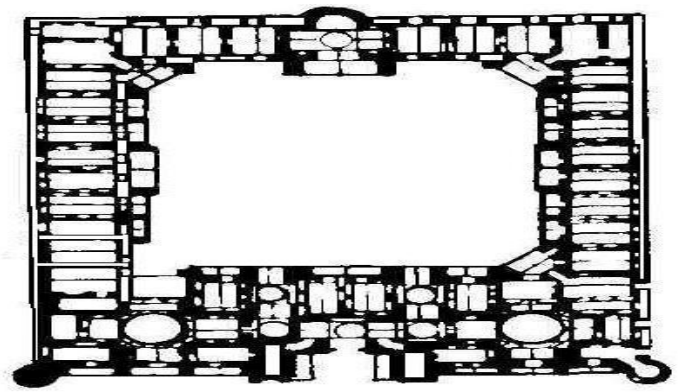


Fig. 3. A) plan of Muhammad Aminkhan madrasah

Fig. 3. B) plan of Sherghazikhan madrasah

Ancient -architects' special attention gave to seism isolation of buildings and constructions. After leveling of a building site in most cases (proceeding from geological and hydro- geological conditions) the bases were greased with alabaster layer or a clay solution after that atop filled a layer of sand. [1] By this way, firstly, a waterproofing of the base from the salted underground water shave been achieved, secondly, seism isolation - owing to relatively high plasticity of the clay pillow partially extinguishes the most dangerous to rigid buildings and constructions high-frequency seismic fluctuations of the ground at earthquakes. Application of burnt brick has given a push to introduction of such a new high-flowing, antiseismic solutions, as alabaster (ganch) and kyr. In an elevated part of a wall for seism isolation of unit, at height approximately 0,5m. special linings of wooden bars, stone locks with a special solution (figure 3) were placed. In an antiquity in some cases builders with the purpose to weaken the impact of earthquake on buildings tried to isolate buildings from their basis by the device of soft linings at a level of top of the base. The greatest application has found a cane in these purposes and close to them cereals. Several layers of woven canes were set up. There are some variants of accommodation seismic isolation pillows, but the



Fig. 4. a) The General view of wooden bars with metal elements. Islam Khoja madrasah (Khiva)



Fig. 4. b) The General view of wooden bars with metal elements. Nazlumkhan suluw mausoleum (Khojeyli city)

These special seismic isolation layers promote absorption of energy of waves extending vertically on a wall, and also sharp reduction of cutting off efforts during earthquakes. At laying bricks, were applied a usual laying by horizontal lines as well as «on an edge» and «book-matched». The usual laying works as horizontal lines on a bend provides distribution of pressure from the concentrated force on a platform in width not more than the heights of a laying; in a laying in "book-matched" the brick basically works on compression and transfer of pressure come from under a corner equal to an inclination of the brick-is usual approximately 45°, - hence, distribution of pressure come from to the platform in the width equal to double height. The people of Katqala fortress (dates back to the 6th century BC) laid reed which function as hydro isolation and seismic isolation on the fundament of this wall to stabilize the building against the natural disasters. (See figure 5).



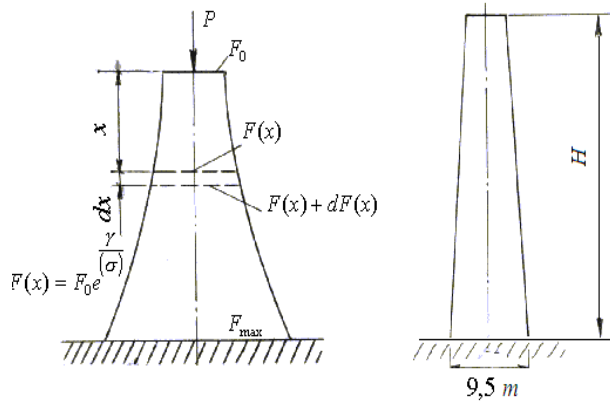
Fig. 5. Base laying type of «book-matching» and antiseismic wooden bars (reed). Kat Qala (fortress).

Monuments of Khiva many times were exposed to seismic influences and constantly are exposed to influences of technogenic character owing to what in old buildings there are damages of different character. Now the estimation of a damage rate of monuments of Khiva is made visually. Results of numerous supervisions show that besides visual damages there

are latent deformations appear and continuously accumulated in buildings and they are principal causes of destruction of buildings. Seismicity of Khiva area is 7 points. From here it is visible that as the basis under a building and a construction will serve loam, therefore it is required to provide antiseismic and anticorrosive arrangements. Today it is not known the exact technique on which ancient architects made calculations on durability and that top of theoretical knowledge which they have achieved. But they at construction gave special attention to interaction of the seating and the foundation on which arising seismic loadings on buildings or constructions during earthquakes depend. [4] When such crucial construction as the Minaret of Islam Khoja was constructed in an area potentially dangerous from seismically point of view the responsibility before architects is doubled (figure 5). From the engineering point of view, the minaret is a unique construction and it is very difficult to predict its behavior during earthquake. With increase in height of a minaret, its inertial weight and consequently seismic loadings arising during earthquake load also increases. In this case, architects have found wise decisions - vigorous reduction of the size of diameter on height of a minaret. It has enabled to provide due stability. Under modern laws of mechanics of a firm deformable body it is known that when the law of change of the areas of cross-section sections of a body becomes: that such bodies are a core of equal resistance. It is known that in the core of equal resistance during pressurization in all sections of a pressure happen are identical. At ground level external diameter of a minaret of 9,5 m. and on the highest point of 3 m i.e., this way architects have achieved due stability and on the other hand in what that degrees have achieved a core of equal resistance.



Fig. 5. A) Islam Khoja minaret



b) scheme of Islam Khoja minaret

In a laying of a socle of the minaret at height about 1,0 m from a surface of the ground, the waterproofing lining round or oval shape buildings are less damaged and more durable against the earthquakes. Before building the fundament, the builders moisture the pan (cotlovan) a lot to firm the fundament ground as it provided fundament ground's sink and density. By this way, they prevented uneven sink of ground fundamentals of the building and the seismic actions distributed evenly onto the longitude of the walls during the earthquake. The scientists of Khorezm Mamun academy dug the veranda near Islam Khoja tower to study the features of the fundament and its ground on April 10, 2017. According to the studies, the fundament is well preserved and will preserve its firtness for the next millennium (in case of no powerful earthquakes).



Fig. 6. a)-fundament of Islam Khoja Minaret

of marble blocks about 21 cm. thickness is fixed and under it - which roofing felt carries out functions of seismic protection in the form of seismic-isolation sliding belt in the base. The reason of the clay laid on the fundament of Ichan Qala fortress is the plastic feature of the clay used in the building of the walls. It reduced the dangerous high frequency seismic movement against the building. The builders of the fortress took measurement concerning the fundament of the building such as surrounding it with a lake and a drain trench. It saves the wall from the erosion caused by the rise of capillary of ground water through the fundament onto the wall except the defense system against the enemies. It also reduces the influence of exterior waves to the building during the earthquake as the



b) seismic isolation from marble block

CONCLUSION

The fundament is one of the important elements in the building process. It made ancient builders to pay great attention to it. They laid stone blocks made of special clay or reed or logs 0.5-1.0 meter height to make seismic isolation. They are wise measurements by scientific point of view which endured against natural disasters for centuries. These special layers, used as anti seismic measurement, prevent the vertical waves over the wall and reduce the horizontal seismic powers which influence the wall through the fundament during the earthquake, (fig.6, b) Summarizing work, it is possible to draw following conclusions: The basic mission of ancient architects of Khorezm was maintenance of sufficient stability of constructions to influences of many factors of natural or artificial origin which create for them threat in the most various forms. By means of dynamic method of research, it is possible to define real dynamic characteristics (the periods, forms and decrements of fluctuations) of ancient constructions. It is necessary to note that the accepted

method of tool research of monuments of architecture in the similar plan is used firstly in Uzbekistan.

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