Nigmetov, J Archit Eng Tech 2018, 7:1
DOI: 10.4172/2168-9717.1000214

Review Article | Open Access

Assessment of the Category of Technical Condition and Seismic Stability of Historic Structures Using the Method of Dynamic Geophysical Tests

Nigmetov GM*

Associate Professor Defence and Emergencies, Institute for Civil Defence and Emergencies, Moscow, Russia

Abstract

Protection of historical buildings is an important international task. Historical buildings, in addition to aging wear, are subjected to periodic and continuous dynamic effects from earthquakes and passing by road and rail transport and from effects of exhaust gases. Most historical objects are constructively made of local materials: adobe, brick and stone blocks, they have mixed structural schemes and do not possess the necessary seismic resistance. The authors of this article propose the technology of dynamic and geophysical testing of structures for assessing the category of technical condition and seismic stability. This article gives examples of the application of this technology to assess the state of historical objects.

[illegible]: Buildings; History; Earthquakes; Seismic; Seismic wave

[illegible]

Builders of historical buildings, as they could, tried to resist the destructive e ects of static and dynamic loads. To increase the stability and seismic stability of structures they invented original design solutions, while harmoniously used ground and local conditions. To protect against earthquakes, they skillfully used the terrain and ground conditions [1-3]. For example, structures were equipped with ditches around them, or multi-layered foundations were used to protect the structures from seismic waves. An interesting fact is that most of the historical buildings that have survived in our time are on hills and have strong [4-6] rocky grounds at the base. One of such ancient structures on a rocky hill is the Antique Temple Parthenon in Athens. e temple was built on a high rocky hill, and the dimensions of the hill along the length, width and height are proportional to the size of the structure and about 4 times larger than the size of the temple [7-9].

e ancient builders paid much attention to the geometric proportions of the structures [1] When designing structures, they took into account the proportions of the hills on which the construction was erected. In the case of the Parthenon, the size of the hill is proportional to the size of the temple. Since the dynamics of the structure depends not only on its dimensions but also on its design and strength. e value that takes into account the geometric and strength parameters of the structure is called rigidity (Figure 1) [2-6].

[illegible]

e builders of historical buildings apparently understood well the signi cance of rigidity on the bearing capacity of structures and their seismic resistance. In addition, they used certain principles to reduce the seismic e ect transmitted through the soil to structures they created, structures whose structural systems proportionally combined mass and rigid parameters. It is clear that the constructive solution of the structure depended on its dimensions. Sensitive parameters of rigidity of constructive systems are oscillations. e vibrations of the structure depend on its mass and rigidity.

e solution of the di erential equation describing the oscillations of a beam of length L has the following form [5,6]:

$$\frac{\quad}{\quad}\sqrt{\frac{\quad}{\quad}} \qquad (1),$$

Where,

T_1: Period of oscillation of the beam, sec;

l: Length of the beam, m;

m: Mass per unit length of the beam, kg/m;

E Moment of inertia of the beam section, m^4.

[illegible]

e author suggests for engineering calculations, to determine the normative values of the periods of oscillations of structures of di erent

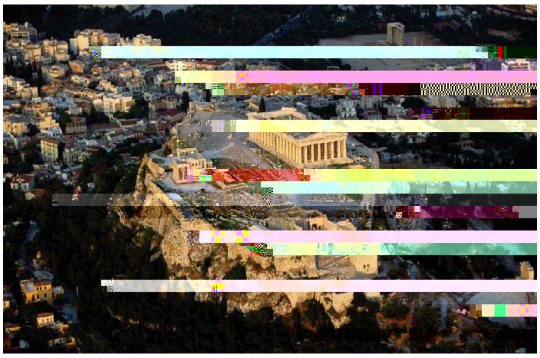

Figure 1: The Parthenon temple in Athens in the photograph clearly shows the proportional relationship between the size of the hill and the temple.

***Corresponding author:** Nigmetov GM, Associate Professor Defence and Emergencies, Institute for Civil Defence and Emergencies, Moscow, Russia, Tel: +7 499 216 99 40; E-mail: tagirmaks@mail.ru

Received September 07, 2017; **Accepted** January 02, 2018; **Published** Janaury 15, 2018

Citation: Nigmetov GM (2018) Assessment of the Category of Technical Condition and Seismic Stability of Historic Structures Using the Method of Dynamic Geophysical Tests. J Archit Eng Tech 7: 214. doi: 10.4172/2168-9717.1000214

design in accordance with the following empirical dependence:

$$T \quad k\frac{\quad}{\sqrt{\quad * \quad}} \qquad (2),$$

Where,

D: Length of the side of the structure in the horizontal plane, along which the period of oscillations is determined, m;

H: Height of the structure, m;

k: Coe cient that takes into account the structural design of the structure, for a block structure, equal to 0.3;

g: Acceleration of gravity, m/s^2 (Figure 2 and Table 1).

[illegible]

Figure 2: Ancient temple of the Roman garrison in the village, Garni in Armenia.

[illegible]

e author suggests criteria by which you can determine the degree of damage to the structure. It is proposed to use a relative value indicating the percentage increase in the period of natural oscillations of the structure:

$$T \quad \frac{T \quad T}{T} * \quad \% \qquad (3),$$

Where,

[T]: Normative value of the period of natural oscillations of the structure along the directions X, Y, Z;

T: Period of natural oscillations of the structure in the directions X, Y, Z (Table 2).

e greatest damages of the structure are expected at close values of the periods of natural oscillations of the soil base and the structure. To exclude resonant phenomena in the "soil-structure" system, the condition under which the oscillations created by the soil massifs should di er by 60% or more from the oscillations of the structure must be met. Such an example of collapse due to the coincidence of the values of the periods of oscillations of the soil and the structure and the insu cient rigidity of the structure to perceive the seismic load is the collapse of the dome of the Church of Santa Maria del Su rajo in the town of Aquila in the province of Abruzzi in Italy.

For the construction of the Church of Santa Maria del Su rajo in the city of Aquila in the Republic of Italy, the relationship between the periods of construction and soil is 1-1.6, which is less than 2 and corresponds to the resonant state, which apparently contributed to the collapse of the dome. Structures under the in uence of seismic waves, have direction of motion of the wave. Traces of seismic waves on the stone pavement near the church showed that the waves moved parallel to the facade of the temple. Just the largest damage the dome received in the direction of motion of the front of seismic waves.

- A computer with a so ware package for analyzing seismic vibration signals. During the dynamic tests of the soil-structure system,

Citation: Nigmetov GM (2018) Assessment of the Category of Technical Condition and Seismic Stability of Historic Structures Using the Method of Dynamic Geophysical Tests. J Archit Eng Tech 7: 214. doi: 10.4172/2168-9717.1000214

Δd, we apply the relation connecting the values of displacements, accelerations and periods:

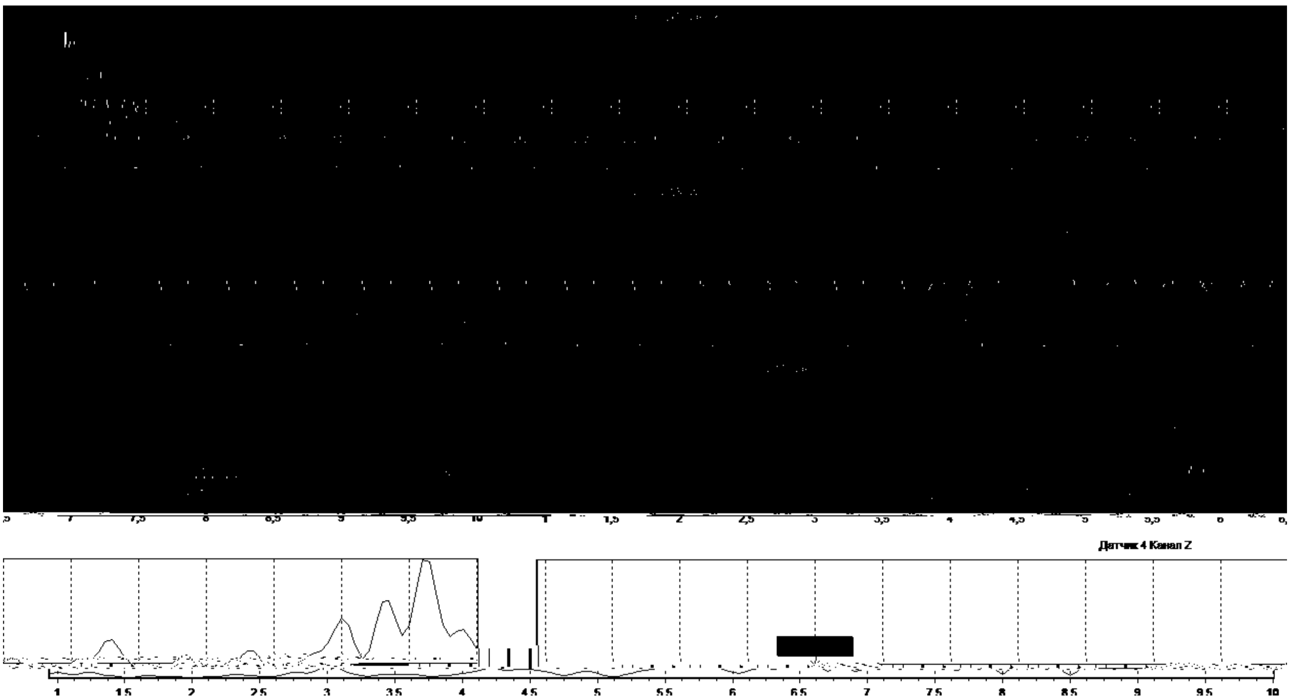

Figure 10: The spectrum of the natural oscillations of the building of the Church of St. John (1 sensor - the ground, 2 - the zero level of the building, 3 - the bell tower of the church, 4 - the cornice of the opening in the altar part of the church) along the Z axis.

№	Ax, m/s²	Ay, m/s²	Az, m/s²	Conclusion
1	2,596	1,75	1,75	Seismic resistance 1,75 m/s²

Table 3: Maximum acceleration in the axes that can withstand the construction.

K_1: Coe cient considering allowable damage k_1 [3];

k_ϕ: Coe cient that takes into account the dissipative properties of the structure [3];

$\beta(T)$: Coe cient of dynamism of the structure [3];

T: Experimentally obtained values of periods of natural oscillations of the structure.

e author on the basis of calculated-experimental data has established that when the sti ness is reduced by more than 30%, the seismic resistance signi cantly decreases.

Using the obtained dynamic parameters, the maximum permissible accelerations that could be sustained by the seismic action along the X, Y and Z axes were calculated (Table 3).

C

According to the results of geophysical tests, the prevailing periods of natural oscillation of the soil base are in the interval 0.22÷0.45s.

Possible resonance phenomena the maximum acceleration of ground base oscillation is 0.24 g.

e structure has an earthquake resistance of at least 0.175 g.

De ciency of seismic resistance is 0.065 g.

It is required to carry out engineering measures to seismically strengthen the structure. us, the proposed integrated technology for assessing the category of technical condition and seismic stability of historic structures can be used to diagnose and monitor structures, taking into account the dynamic impact on the construction of soils at their base.

References

1. Grube GR, Kutschmar A, Romanik BV, Gegenwart BZ, Bildhandbuch E, et al. (2003) Designs from the Romanesque to the Present: A picture manual.
2. Kirikov BA (1990) The oldest and newest seismic resistant structures. Moscow "Nauka".
3. Paul CJ (1971) Engineering Flatures of the San Fernando Earthequake Fabrinary 9, 1971. California Institute of Technology, Pasdena California, pp: 174.
4. Kirikov BA (1993) Selected pages of the history of seismic resistant construction. Moscow. Publisher Mir.
5. Timoshenko SP (2007) Vibration problems in engineering. URSS.
6. Korobko VI, Korobko AV (2003) Control of quality of the building constructions: nhe vibro-acoustic technologes. Moscow 2003 Publishing House of the International Association Building Higher Educational Institute.
7. Nigmetov GM, Chubakov M ZH (2011) Problemy monitoring buildings and structures, Seismic construction. Safety of buildings, p: 4.
8. Code of rules. SP 14.13330.2014 Construction In Seismic Areas Of Snip Ii-7-81 Moscow 2016.
9. Probability estimates of seismic loads on structures. Moscow "Science", 1987.