MODELING OF ONE-STORY BRICK BUILDINGS AND TESTING WITH SEISMIC PLATFORM

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Abstract: The article highlights the issues of modeling brick buildings, preparing for seismic tests, recording the acceleration of vibrations, determining the spectral density of vibrations and plotting graphs, analyzing vibrations by frequencies, the amplitude of vibrations, as well as the problem of determining the recording of accelerations using Fourier variables.

Keywords: Brick building, modeling, seismic platform vibration, frequency, seismic resistance calculation

INTRODUCTION

It is not permitted to apply buildings and structures to the production of results obtained by theoretical research until they are substantiated by the results of experimental studies and the results of experimental work on the effects of seismic forces. Experimental research on buildings and structures around the world requires a lot of money and effort to test natural objects. It is important to identify important indicators in their miniature models instead of real objects with less labor and investment, in solving such topical issues. That is why in the testing of buildings and structures, often in practice, research is carried out through simulation. The main indicator in simulation is the modeling multiplier, and in this experiment, the modeling multiplier was obtained at a ratio of 1/5, taking into account that the material used in the model is closer to the real situation, as it is selected in the same way as the real object [1, 2]. Two models of the same size, brick buildings selected for the test work have been built, the first being a traditional type of braced building model, the second a building model with a seismic protection element placed along its perimeter between the foundation block and the foundation cushion.

The similarity of a natural object and a model can be explained by the fact that the quantities that represent them are related to a scale called the similarity coefficient. Achieving a model from a natural object index and vice versa is done by multiplying this coefficient. For example, if the mass of a natural object is expressed by m_a,, its length l_a, and its velocity υ_a, its dynamic similarity model is expressed as follows. The similarity coefficients for the main indicators are as follows:

$$m_m = \frac{m_a}{k_m};\ l_m = \frac{l_a}{k_l};\ v_m = \frac{v_a}{k_v} \tag{1}$$

where: m_m l_m υ_m – the mass, length, and acceleration of the model, respectively; k_m k_l k_υ – coefficients of similarity of mass, length and velocity of the model; in the international system of measurements there are three basic units of measurement called SI primary quantities: length - L [m], mass - m [kg], time - T [s].

In the method of geometric modeling, the choice of material will not be a problem, because materials such as natural are also used for the model.

The dimensions of the building selected for this purpose in the natural state were as follows: width a=4000 mm, length b=5000 mm, floor height h=3000 mm, total height N=4800 mm (Figure 1).

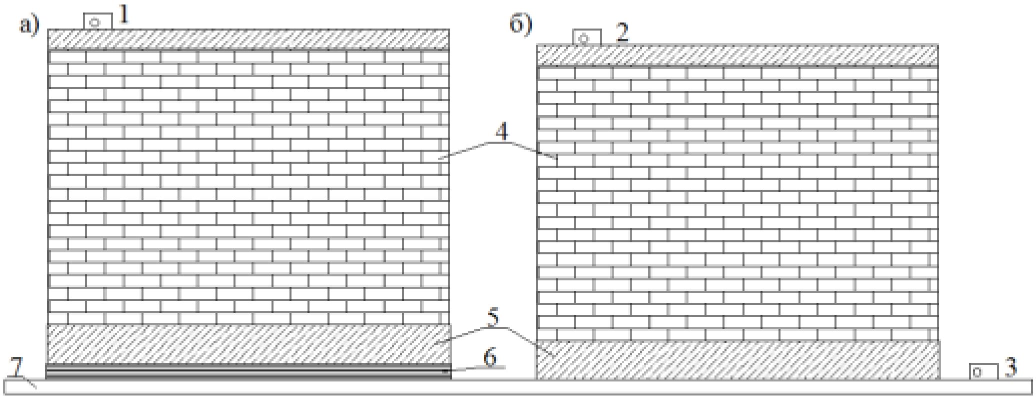

Figure 1. *General appearance diagrams of buildings installed on the test stand: a- building with seismic insulation layer; b - model of a building with a base; Sensors mounted on the roof of the building 1,2; 3 - sensor mounted on the platform; 4 brick wall; 5 foundations; 6 seismic isolation; 7-vibroplatform SP-116.*

The geometrical dimensions of the building structures have been obtained as follows (Table 1) in order to test and conduct experimental studies on the effects of seismic forces on a single-storey brick building (Table 1).

Table 1. *Geometric dimensions of building structures.*

№	Name of constructive elements	Size of the plan, mm		Weight, кг	
		natural	model	natural	model
1	Foundation	4000 × 5000	800 × 1000	10500	46
2	Brick wall	4000 × 5000	800 × 1000	23330	168
3	Slab	4000 × 5000	800 × 1000	14800	38
	Total			48630	252

The load-bearing wall structure of the building model prepared for the experimental test work was brick, the dimensions of the model brick were 50×24× 3 mm, which was reduced to a scale of 1:5 of the actual standard brick. Sample bricks have been prepared on the basis of brick kiln technology in the brick kiln of "Uychi Brick Factory" Namangan region and their average density, water absorption and compressive strength in terms of physical and mechanical properties were determined and compared with physical and mechanical properties of natural standard brick [3, 4, 5, 6].

Modern construction is directly related to increasing the efficiency of construction production, reducing the cost and labor intensity of technological processes, consumption of materials and energy resources, as well as the use of new progressive materials. In this regard, it can be said that one of the modern construction materials of the future is dispersed reinforced concrete. Such concretes are a wide range of composite materials and are broadly used today in various industries.

THEORETICAL RESEARCH

The first of the building models have been considered to be rigged to the foundation floor. In the second model, a seismic protection device is installed between the foundation and the grid of the building. During the experiment, accelerations were recorded at the base and peak of the building, i.e., the roof. The registration of the record was recorded on a computer. A computer-generated amplitude spectral density construction program was defined by the following expression [7, 8]:

$$S(f) = \frac{1}{T} E\left[\left|X(f)\right|^2\right] \tag{2}$$

where, $S(f)$ – f spectral density by frequencies; T – oscillation period; E – are the mean values of all expected $X(f)$ and are determined using the acceleration records $a(t)$ using the Fourier variables.

It is known that seismic accelerations, including microseismic, are random functions of time involving many different frequency oscillations. The recorded acceleration is expressed as the Fourier series [4; 102-107 p.].

$$a(t) = \sum_{-\infty}^{\infty} c_n e^{in\omega_1 t} \tag{3}$$

In order to change in acceleration occurs in the positive frequency range, only the real part of the solution is taken into account in the calculations using expression (2), i.e.

$$a(t) = 2\,\mathrm{Re}\left[\sum_{-\infty}^{\infty} c_n e^{in\omega_1 t}\right] \tag{4}$$

where,

$$a(t) = \frac{a_0}{2} + a_1 \cos\omega_1 t + a_2 \cos\omega_2 t + \ldots b_1 \sin\omega_1 t + b_2 \sin\omega_2 t + \ldots \tag{5}$$

where: $\omega_1 = \frac{2\pi}{T}$, $\omega_n = n\omega_1$, $c_0 = \frac{a_0}{2}$, t – *time*

Using the Fourier variables, X (f) is defined in the following view [5; S.69–70]:

$$X(f) = X_R(f) + iX_1(f) \tag{6}$$

In expression (5) $X_R(f)$ - is the real part, $X_1(f)$ - is the abstract part, which is represented by the following expressions.

$$\left.\begin{aligned} X_R(f) &= \int_{-\infty}^{\infty} a(t)\cos 2\pi f t\,dt \\ X_1(f) &= \int_{-\infty}^{\infty} a(t)\sin 2\pi f t\,dt \end{aligned}\right| \tag{7}$$

In this case, the expressions of the Fure variables given in Table 2 were used.

Table 2. *Fourier row replacement expressions.*

X(t)	*X(f)*
$\cos 2\pi f_0 t$	$\frac{1}{2}[\delta(f - f_0) + \delta(f + f_0)]$
$\sin 2\pi f_0 t$	$\frac{1}{2i}[\delta(f - f_0) + \delta(f + f_0)]$
$\frac{\sin t}{t}$	$\begin{cases} \pi & (-\frac{1}{2\pi} \le f \le \frac{1}{2\pi}) \\ 0 & \text{иначе} \end{cases}$
$\frac{1}{1+t^2}$	$\begin{cases} \pi e^{-2\pi f} & f \succ 0 \\ \pi e^{2\pi f} & f \prec 0 \end{cases}$
$e^{-c\|t\|} \cos 2\pi f_0 t$	$\frac{c}{c^2 + 4\pi^2 (f - f_0)^2} + \frac{c}{c^2 + 4\pi^2 (f + f_0)^2}$

Using the modeling scale, the results of experimental studies calculated for a real building, as well as the results of displacement, acceleration and spectral density processed in the program "Matlab" are calculated graphically according to the table above. Prior to a series of experimental studies, vibrations are generated by means of a small hammer with a steel hammer to check the operation of the measuring complex, and the operating condition of the system is checked.

A total of 27 experiments were performed during the experimental experiments. The types and repetition of the experiments are given in Table 3 below.

Table 3. *Experiments on a single-storey building model.*

Types of model construction to be tested	Number of experiments	Measuring points and built-in sensors
In low frequency oscillations		
Seismic platform stand, i.e. on the base of the building	3	At the base of the building - one and three-axis sensors
Fixed base building model	3	At the level of the cover - a three-axis sensor
Building model with seismic protection layer	3	At the level of the cover - a three-axis sensor
In medium frequency oscillations		
Seismic platform stand, i.e. on the base of the building	3	At the base of the building - one and three-axis sensors
Fixed base building model	3	At the level of the cover - a three-axis sensor
Building model with seismic protection layer	3	At the level of the cover - a three-axis sensor
In high frequency oscillations		
Seismic platform stand, i.e. on the base of the building	3	At the base of the building - one and three-axis sensors
Fixed base building model	3	At the level of the cover - a three-axis sensor
Building model with seismic protection layer	3	At the level of the cover - a three-axis sensor

A SET OF MEASURING DEVICES AND THEIR PREPARATION FOR EXPERIMENTAL WORK

Tests of a 1/5 scale model of a natural one-story brick building under the influence of dynamic forces were carried out using models of two buildings of the same size using a single-axis seismic platform SP-116 in the laboratory building of the Turin Polytechnic Institute in Tashkent (Figure 2).

The overall dimensions of the Vibrostend device table are 2400×2300×250 mm, which is designed to generate oscillations in the horizontal direction in the frequency range 0.15 ÷ 20 Hz [3].

a)

b)

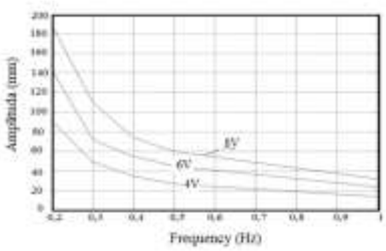

Figure 2. *Seismic platform test stand (a) and connection graphs between frequency and amplitudes (b).*

The process of building a single-story brick building model and preparing it for experimental research is shown in Figure 3 below.

a) *b)* *c)*

Figure 3. *Built-in models of buildings (a), the state of installation of measuring sensors at characteristic points (b) and the process of excitation of small vibrations (c)*

RESULTS AND ANALYSIS OF EXPERIMENTAL TESTS

In experimental studies, a reduced model of a brick building was given a harmonic external vibrational motion at different displacement amplitudes and their corresponding vibrational frequencies. According to him, the external impact is given in the form of displacements, the amplitude values of which are 10 mm and 20 mm. The frequency of the excitation power in external oscillations ranges from 1 Hz to 10 Hz. Using the measurement complex, models of seismically insulated and non-seismically insulated buildings were tested for low, medium, and high frequency external vibrations, and graphs were obtained using the spectral densities of displacement, acceleration, and frequency at characteristic points. They are shown in Figures 3, 4, 5 below.

a) *b)* *c)*

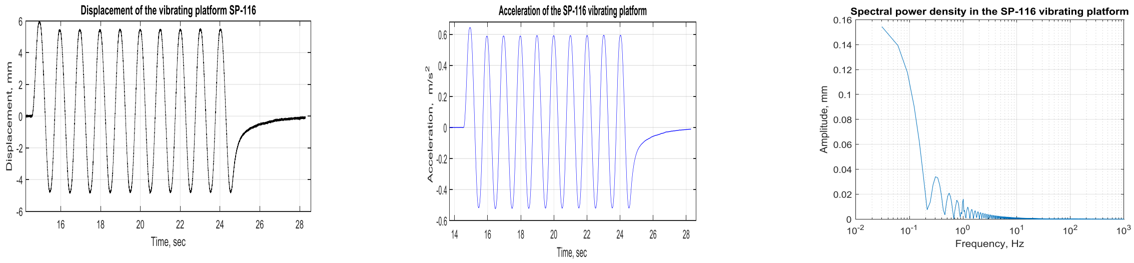

Figure 3. *Graphs of displacement (a), acceleration (b) and spectral density of frequencies (c) of a seismic platform, ie the amplitude of the displacement of the floor of the building is 10 mm, the oscillation frequency is 1 Hz and the pressure in the hydraulic transmission is 10 Mpa*

a) *b)*

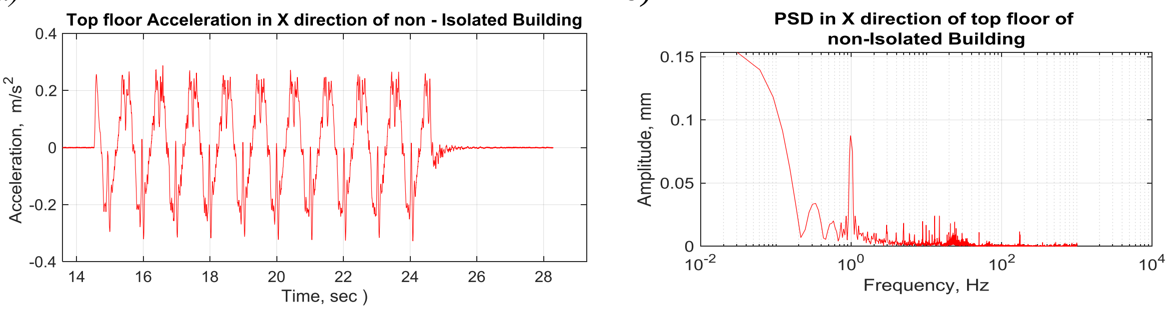

Figure 4. *Graphs of acceleration (a) and spectral density of frequencies (b) at amplitude of ground displacement 10 mm, vibration frequency 1 Hz and pressure in hydraulic transmission 10 MPa at the closed level of the building with a solid base*

a) *b)*

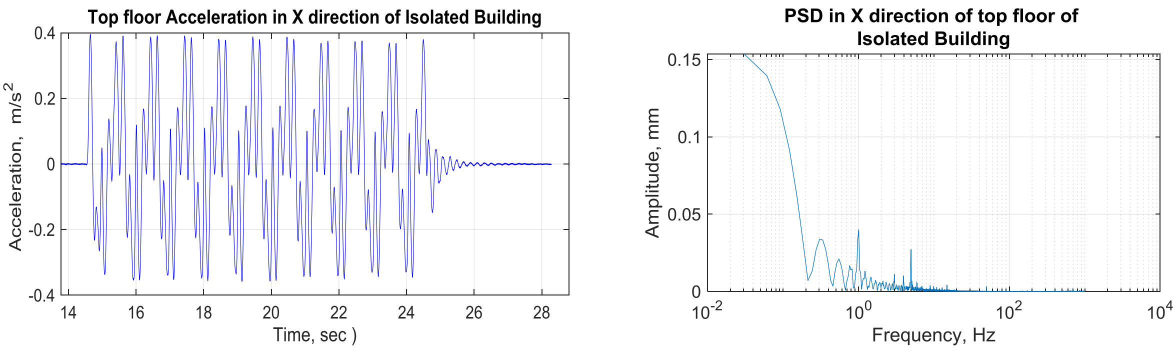

Figure 5. *Graphs of acceleration (a) and spectral density of frequencies (b) at a closed level of the building with a seismic insulation layer with an amplitude of ground displacement of 10 mm, vibration frequency of 1 Hz and a pressure of 10 MPa in the hydraulic*

The values of the acceleration and vibration cycles according to the constructed graphs are given in Tables 4, 5, 6, 7:

Tables 4. *The amplitude value of the ground displacement is 10 mm and the pressure in the hydraulic drive is 10 Mpa.*

The vibration frequency of the platform	Basis, i.e. platform		Rigid fastened base		A building with a seismic protection layer	
	Period, sec	Acceleration, m/s^2	Period, sec	Acceleration, m/s^2	Period, sec	Acceleration, m/s^2
1 Hz	1	0,63	1	0,3	1,1	0,36
2 Hz	0,44	0,56	0,55	1,2	0,58	1,1
3 Hz	0,33	0,48	0,34	1,48	0,36	4
4 Hz	0,25	0,38	0,27	1,8	0,28	3
5 Hz	0,2	0,3	0,21	2	0,23	1,8
6 Hz	0,16	0,25	0,18	2,5	0,2	2
7 Hz	0,14	0,2	0,148	3	0,152	1,6
8 Hz	0,125	0,09	0,125	3,8	0,13	2
9 Hz	0,11	0,075	0,11	4	0,14	1,7
10 Hz	0,1	0,05	0,12	5	0,15	1,8

Tables 5. *The amplitude value of the ground displacement is 10 mm and the pressure in the hydraulic drive is 50 MPa.*

The vibration frequency of the platform	Basis, i.e. platform		Rigid fastened base		A building with a seismic protection layer	
	Period, sec	Acceleration, m/s^2	Period, sec		Period, sec	Acceleration, m/s^2
1 Hz	1	1	1,1	0,56	1,2	0,52
2 Hz	0,44	0,8	0,57	1,6	0,62	2,2
3 Hz	0,33	0,65	0,35	2,2	0,37	4,1
4 Hz	0,25	0,55	0,26	4	0,28	3,5
5 Hz	0,2	0,35	0,21	4,8	0,23	3,2
6 Hz	0,16	0,31	0,176	5,6	0,184	3
7 Hz	0,14	0,22	0,14	6	0,16	2,5
8 Hz	0,125	0,175	0,126	7,5	0,14	3,2
9 Hz	0,11	0,165	0,12	4,8	0,134	3

10 Hz	0,1	0,17	0,11	6	0,12	2,2

Tables 6. *The amplitude value of the ground displacement is 20 mm and the pressure in the hydraulic drive is 10 MPa.*

The vibration frequency of the platform	Basis, i.e. platform		Rigid fastened base		A building with a seismic protection layer	
	Period, sec	Acceleration, m/s^2	Period, sec		Period, sec	Acceleration, m/s^2
1 Hz	1	1,8	1,1	1	1,2	1,2
2 Hz	0,44	1	0,56	2,1	1,22	3
3 Hz	0,33	0,525	0,35	235	0,36	4
4 Hz	0,25	0,5	0,26	2,25	0,28	3,4
5 Hz	0,2	0,35	0,19	4,2	0,24	3,8
6 Hz	0,16	0,275	0,17	5,5	0,19	2,75
7 Hz	0,14	0,2	0,145	6	0,156	2,3
8 Hz	0,125	0,14	0,14	6,2	0,16	2,4

Tables 7. *The amplitude value of the ground displacement is 20 mm and the pressure in the hydraulic drive is 50 MPa.*

The vibration frequency of the platform	Basis, i.e. platform		Rigid fastened base		A building with a seismic protection layer	
	Period, sec	Acceleration, m/s^2	Period, sec		Period, sec	Acceleration, m/s^2
1 Hz	1	2	1,05	1	1,15	1,1
2 Hz	0,45	1,8	0,51	3	0,54	5,6
3 Hz	0,33	0,6	0,35	2,6	0,42	3
4 Hz	0,25	0,85	0,26	5	0,28	4,2
5 Hz	0,2	0,6	0,21	5,4	0,24	4
6 Hz	0,16	0,45	0,17	5,8	0,18	3
7 Hz	0,14	0,4	0,162	6	0,175	3,6
8 Hz	0,125	0,275	0,14	6,2	0,19	4

According to the numerical results, the ground acceleration value a_{max}=0.56 m/s^2 at low frequency oscillations with amplitude value of ground displacement 10 mm and pressure in hydraulic transmission 10 MPa at low frequency oscillations a_{max}=0.56 m/s^2, vibration period T=The acceleration of 0.55 s was a_{max}=1.2 m/s^2. After the seismic protection layer was applied to the building model, the vibration period was T = 0.58 s and the acceleration was a_{max}=1.1 m/s^2. At medium frequency oscillations, when f = 6 Hz, the acceleration value of the ground was a_{max}=0.25 m/s^2, the oscillation period was T=0.18 s in the case of the building model, and the acceleration was a_{max}=2.5 m/s^2. After installing the seismic protection layer on the building model, the vibration period was T=0.2 s and the acceleration was a_{max}=2 m/s^2. At high frequency oscillations, the acceleration value of the ground at f=10 Hz was a_{max}=0.05 m/s^2, while the acceleration period of the oscillation period T=0.12 seconds in the rigid state of the building model was a_{max}=5 m/s^2. After installing the seismic protection layer on the building model, the vibration period was T=0.15 seconds and the acceleration was a_{max}=1.8 m/s^2.

When the amplitude value of the ground displacement was 10 mm and the pressure in the hydraulic drive was 50 MPa, the value of acceleration of the ground at low frequency oscillations f=2 Hz was a_{max}= 0.8 m/s^2. The oscillation period was T = 0.57 s and the acceleration was a_{max}=1.6 m/s2 in the fixed position of the building model. After installing the seismic protection layer on the building model, the vibration period was T = 0.62 seconds and the acceleration was a_{max}= 2.2 m/s^2. In medium frequency oscillations at f = 6 Hz, the acceleration value of the ground was a_{max}=0.31 m/s2, the vibration period was T=0.176 s in the idle state of the building model, and the acceleration was a_{max}=5.6 m/s^2. After installing the seismic protection layer on the building model, the vibration period was T = 0.184 seconds and the acceleration was a_{max}=3 m/s^2. At high frequency oscillations, when f = 10 Hz, the acceleration value of the ground was a_{max}=0.17 m / s2, the vibration period was T=0.11 seconds and the acceleration was a_{max}=6 m/s^2 when the building model was firmly fixed. After installing the seismic protection layer on the building model, the vibration period was T=0.12 seconds and the acceleration was a_{max}=2.2 m/s^2.

The amplitude value of the ground displacement is 20mm and the acceleration value of the ground at low frequency oscillations f = 2 Hz with a pressure of 10 MPa in the hydraulic transmission was a_{max}=1 m/s^2, the vibration period T = 0.56 seconds in the idle state of the building model and the acceleration a_{max}=2.1 m/s^2. After installing the seismic protection layer on the building model, the vibration period was T=1.22 seconds and the acceleration was amax = m/s^2. At medium frequency oscillations, when f = 5 Hz, the acceleration value of the ground was a_{max}=0.35 m/s^2, the oscillation period was T=0.19 s and the acceleration was a_{max}=4.2 m/s^2 in the rigid state of the building model. . After the seismic protection layer was installed on the building model, the vibration period was T=0.24 seconds and the acceleration was a_{max}=3.8 m/s^2. At high frequency oscillations, the acceleration value of the ground at f=8 Hz was a_{max}=0.14 m/s^2, the oscillation period was T=0.14 s at accelerated state of the building model, and the acceleration was a_{max}=6.2 m/s^2. After the seismic protection layer was installed on the building model, the vibration period was T = 0.16 s and the acceleration was a_{max}=2.4 m/s^2.

The amplitude value of the ground displacement is 20 mm and the acceleration value of the ground at low frequency oscillations f=2 Hz with a pressure of 50 MPa in the hydraulic transmission was a_{max}=1.8 m/s^2, the oscillation period T=0.51 seconds in the idle state of the building model, and the acceleration a_{max}=3 m/s^2. After the seismic protection layer was installed on the building model, the vibration period was T=0.54 seconds and the acceleration was a_{max}=5.6 m/s^2. At medium frequency oscillations, when f=5 Hz, the acceleration value of the ground was a_{max}=0.6 m/s^2, the vibration period was T=0.21 s in the case of a loosely fixed building model, and the acceleration was a_{max}=5.4 m/s^2. After installing the seismic protection layer on the building model, the vibration period was T=0.24 seconds and the acceleration was a_{max}=4 m/s^2. At high frequency oscillations, the acceleration value of the ground at f=8 Hz was a_{max}=0.275 m/s^2, the oscillation period was T=0.14 s and the acceleration was a_{max}=6.2 m/s^2 when the building model was firmly fixed. After installing the seismic protection layer on the building model, the vibration period was T=0.19 seconds and the acceleration was a_{max}=4 m/s^2.
The inertial force acting on the floor surface was determined using the following expression [6; 94 - 97-p.]:

$$S_{ik} = y_{ik} m_k p_i^2 = m_k \ddot{y}_{i\,ik}^{\,2}, \tag{8}$$

where: $y_{i\kappa}$ is the displacement that occurs at the point K and the points where the masses are considered when it oscillates freely along the i-tone; m_κ - floor mass; p_i is the frequency, $\ddot{y}_{i\,ik}^{\,2}$- the acceleration that occurs at the point K and the points at which the masses are considered when oscillating freely along the i-tone

RESULTS: Based on experimental studies of buildings, recommendations for testing them for seismic effects and modeling them to study real operating conditions were developed.

World construction practice shows that brick buildings are severely damaged by strong 7-9 magnitude earthquakes, so the necessary recommendations have been developed to increase their seismic resistance through the use of seismic protection elements.

Using a seismic platform designed to generate horizontal oscillations based on modeling of two buildings of the same size and structure, the amplitude spectral density, frequency spectral density, oscillation period, acceleration records in low-frequency oscillations are determined using Fourier variables. it was found that the effectiveness of seismic insulation was low, and that high-frequency vibrations reduced the value of the seismic force acting on the building by up to two times.

CONFLICTS OF INTEREST

No conflict of interest was declared by the authors

REFERENCES

1. Wanebo, John E., et al., “Systemic Administration of the Endothelin-A Receptor Antagonist TBC 11251 At tenuates Cerebral Vasospasmafter Experimental Subarachnoid Hemorrhage: Dose Study and Review of End othelin-based Therapies in the Literatureon Cerebral Vasospasm”, *Neurosurgery*,1409-1417, (1998).

2. Egarmin, K. A., et al., "Analysis of stress in frame nodes of a single-storey steel framework in high seismic loads conditions with the use of SCAD software", Stroitel'stvo Unikal'nyh Zdanij i Sooruzenij, (2015).

3. Matsagar, Vasant A., Jangid, R. S., “Influence of isolator characteristics on the response of base-isolated structures”, Engineering structures, 1735-1749, (2004).

4. Beards, C., “Structural vibration: analysis and damping”, Elsevier., (1996).

5. Kelly, James M., “Analysis of fiber-reinforced elastomeric isolators”, Journal of Seismology and Earthquake Engineering, 19-34, (1999).

6. Juraev, B. G., “Selection of Geometric Dimensions of Active Seismic Protection of Buildings”, International Journal of Advanced Research in Science, Engineering and Technology, (2021).

7. Razzakov, Sobirjon J., Baxtiyor G. Juraev, and Elyorbek S. Juraev. "Sustainability of walls of individual residential houses with a wooden frame." Structural Mechanics of Engineering Constructions and Buildings 14.5 (2018): 427-435.

8. Juraevich, Razzakov Sobirjon, Holmirzaev Sattar Abdujabbarovich, and Juraev Bahtiyor Gulomovich. "The study of seismic stability of a single-storey building with an internal partition with and without taking into account the frame." European science review 7-8 (2016): 217-220.

9. Research of trailing coverings of wide-span unique buildings by the modelling method AU Solijonovich European science review, 272-274 2018

10. Ways of enhancing energy efficiency within renovation of apartment houses in the republic of Uzbekistan S Sayfiddinov, U Akhmadiyorov International Journal of Scientific and Technology Research 9 (2), 2292-2294 2020

11. The effect of a complex additive on the structure formation of cement stone in conditions of dry hot climate and saline soils R Narov, U Akhmadiyorov E3S Web of Conferences 264, 02064 2021