Impact Factor:	ISRA (India) = 6.317	SIS (USA) = 0.912	ICV (Poland) = 6.630
	ISI (Dubai, UAE) = 1.582	РИНЦ (Russia) = 3.939	PIF (India) = 1.940
	GIF (Australia) = 0.564	ESJI (KZ) = 9.035	IBI (India) = 4.260
	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

QR – Issue QR – Article

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2021 **Issue:** 09 **Volume:** 101

Published: 06.09.2021 **http://T-Science.org**

Nemat Bakhromovich Shaumarov
Tashkent State Transport University
researcher

Karomat Kakhramonovna Shukurova
Tashkent Architectural and Civil Engineering Institute
researcher

FORECAST OF THE TECHNICAL CONDITION OF A FOUR-STOREY RESIDENTIAL BUILDING AFTER AN EARTHQUAKE. CALCULATION FOR SEISMIC EFFECTS ACCORDING TO THE METHOD OF STATES

Abstract*: Especially often there is a high damageability of the walls of the upper floors of buildings with a relatively good preservation of the lower floors. Hence, it follows that the normative calculations do not accurately take into account the distribution of the seismic load along the height. The best agreement with reality can be obtained when calculating the impact of earthquake accelerograms.*

Key words*: earthquake, seismic impact, efforts, accelerogram, tests, deformation, stiffness, experiment.*

Language*: English*

Citation: Shaumarov, N. B., & Shukurova, K. K. (2021). Forecast of the technical condition of a four-storey residential building after an earthquake. Calculation for seismic effects according to the method of states. *ISJ Theoretical & Applied Science, 09 (101),* 187-191.

Soi: http://s-o-i.org/1.1/TAS-09-101-12 ***Doi***: crossref https://dx.doi.org/10.15863/TAS.2021.09.101.12

Scopus ASCC*: 2215.*

Introduction

The consequences of strong earthquakes in Uzbekistan, the CIS and in foreign countries show that stone buildings designed and calculated according to modern standards are significantly less earthquake resistant than other types of buildings.

When calculating structures for the impact of earthquake accelerograms, seismic forces are several times higher than the normative ones. Therefore, if to determine the state of a building designed according to the norms, we proceed from calculations for accelerograms, then in most cases the result will be an emergency state or complete destruction. Currently, there are observations of the behavior of buildings designed and built in accordance with the current standards and experienced the impact of earthquakes of design intensity. At the same time, it was found that the final state of buildings differs significantly both from the design forecast and from the results of the calculation for the impact of accelerograms. An urgent task of the theory of seismic resistance is the development of methods that would be based on the use of real seismic effects and would lead to the most accurate correspondence of the predicted state of buildings with observations.

One of the reasons for the discrepancy between the calculation results and reality is that the parameters of structures in the initial, undeformed state are usually taken as the initial prerequisites.

The experience of field tests of structures testifies to the variability of their dynamic characteristics in different stages of deformation. There are various approaches to taking this factor into account when determining seismic effects, with the main attention being paid to reducing the rigidity of structures in the regime of large deformations. This phenomenon makes it possible to adapt structures to high-frequency earthquakes [1].

Recently, special studies have established that at certain stages of the dynamic process, a sharp increase in the energy dissipation coefficient can occur with a relatively small change in stiffness. As a result, in the regime of large deformations, both periods and decrements of oscillations increase several times.

For many years in the CIS and abroad, numerous experimental studies of the dynamic properties of structures in laboratory and natural conditions have been carried out, as a result of which extensive material has been accumulated on the behavior of buildings and structures under high-intensity loads. Full-scale vibration tests, which are carried out by Moscow and republican institutes with the help of special equipment, are of particular importance. The results of these tests have a high degree of reliability and make it possible to solve many problems of seismic resistance of structures on an experimental basis. Currently, these materials are not fully used in studies on the seismic resistance of structures, where analytical methods prevail, based on various hypotheses about the properties of materials and structures. In this work, an attempt is made, in the order of a first approximation, to take into account the results of static tests of samples of walls and fragments of walls and dynamic, mainly vibration tests of a building in nature, published in the literature when calculating the structure of a building for the effect of accelerograms. Regardless of the results obtained, it can be assumed that the research carried out will be of interest in the order in which the question is posed.

In the works [2,3,4,5,6,7,8], the change in stiffness and energy dissipation during testing of structures from dynamic impacts in the limiting state was investigated. At the same time, the following characteristics of structures in a state of cracking have been established.

a) The oscillation period of structures increases several times compared to the initial one. Extensive material on the results of vibration tests of buildings up to the stage of cracking is presented in [3, 10], where an increase in the oscillation period up to 2.5 times was obtained. The same results were recorded in [2]. Vibration tests of a reinforced concrete model of a frame building before destruction, described in [4], led to an increase in the oscillation period in the limiting state by 5 times against the initial state. Consequently, depending on the degree of approach to the limiting state, the period of oscillations increases within 2.5-5 times.

b) In the limiting state, the energy dissipation coefficient and the associated vibration decrement increase significantly. In work [6], the final value of the decrement of fluctuations is $\delta = 0.75$. In [10], during vibration tests, the highest value of the vibration decrement is also $\delta = 0.75$. In [5], the value $\delta = 1.0$ was obtained.

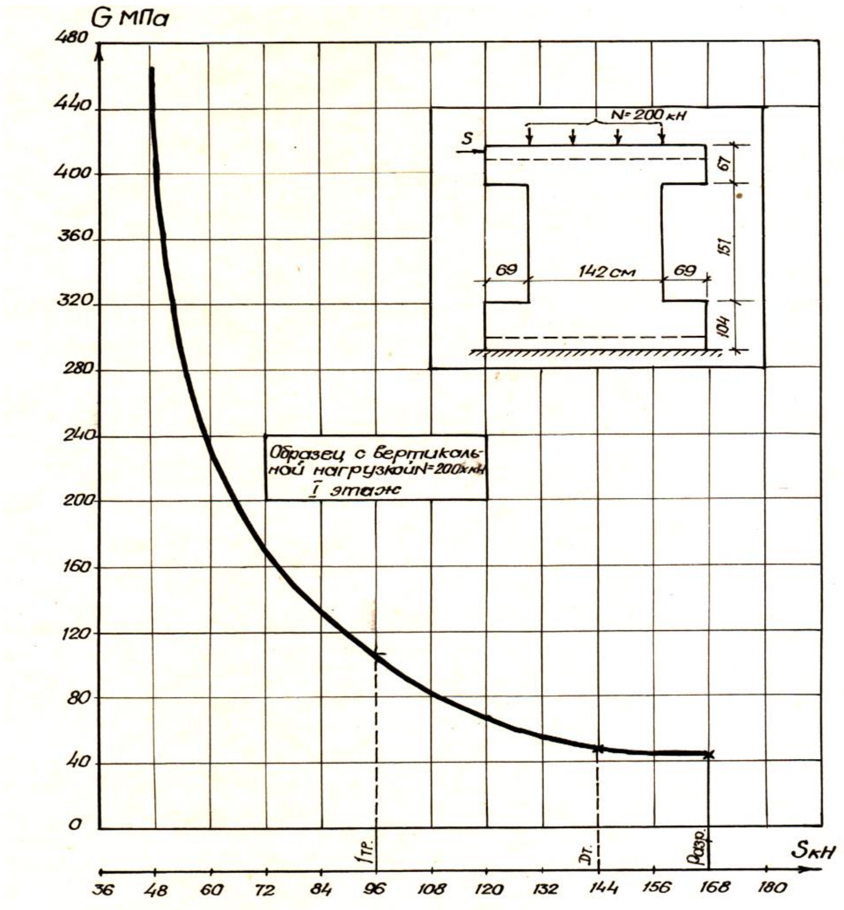

Fig. 1. Dependence of the conventional shear modulus on the value of the horizontal load

In work [4], the highest recorded value is δ = 0.66. In studies of structures before destruction, described in [9], δ = 1.0 ÷ 1.25 was obtained.

c) The diagram of the dependence of the shear modulus on the load shown in (Fig. 1) shows that for complex structures the characteristic state is the formation of cracks in the brickwork.

In this case, the deformation is no longer elastic - plastic.

Based on the diagram, it can be seen that the unloading module is much smaller than the initial module and the structure after removing the load does not return to the initial state. These features of deformation of structures at the stage of cracking are noted in [3]. In [12], this property is used to determine the technical condition of buildings after an earthquake. In these works, it was established that the period of oscillations of structures after unloading approximately coincides with the period of oscillations noted in the last stage of loading. The stage of cracking during vibration tests of buildings was investigated in [10], where the analysis of the mechanism of change in stiffness was made.

d) In theoretical studies of nonlinear oscillations of complex systems under the action of a cyclic load, the method of equivalent linearization based on power balance or harmonic balance is often used [12]. The possibility of applying the linearization method to the determination of seismic effects is considered in [12, 7], where it is shown that the seismic spectra of the response of equivalent linear systems closely coincide with the spectra of the original hysteresis systems.

On the basis of the listed results of experimental and theoretical studies, a method for calculating a four-storey building for the impact of earthquake accelerograms, based on equivalent linearization and conventionally called the "method of states", is proposed. Its difference from the technique adopted in [12] and [9] is that the parameters of an equivalent linear system are values directly determined experimentally, and not calculated analytically. The stiffness of the building is determined by the empirical deformation curve shown in (Fig. 2). The decrement of oscillations in the initial state was taken equal to 0.3, which is consistent with the results of field experiments given in the above works. For the deformed state of structures outside of cracking, on the basis of the data given in paragraph b, as well as [12], δ = 1.0 is taken, which corresponds to the average of the indicated values. All the states considered below, except for the first one, turned out to be in the stage of crack formation, therefore, the vibration decrement for them is taken to be equal to unity.

The calculation is made according to the following scheme. The loads and efforts under the action are determined according to the law of accelerograms according to the initial state of the structure [12]. These efforts are several times higher than the normative ones, therefore the corresponding state of the structures goes far beyond the limit according to the norms. But this state corresponds to significantly increased against the initial periods of oscillations and damping coefficients. The monotonous relationship between the loading intensity and the dynamic parameters allows a second calculation to be made according to the correspondingly changed dynamic characteristics. At the same time, the loads and efforts will decrease in comparison with the first calculation, which will correspond to the transition of the structure to another state, closer to the initial one. If now one more calculation is made according to the dynamic indicators of the third state, then the seismic forces will increase in comparison with the second calculation, but will be less than according to the first calculation. Therefore, as a result of the third calculation, a fourth deformed state is obtained, located between the second and third. Continuing this process further, we will obtain a number of successive deformed states, of which each subsequent one is located between the two previous ones.

On this basis, one could assume that with an unlimited continuation of the process, it will converge to a certain limit, which could be taken as a calculated, predicted state. In fact, such convergence cannot be achieved due to the fact that the response spectra of individual accelerograms are not monotonic functions of the oscillation period. To a certain extent, the smoothing of the spectra is achieved by averaging the calculation results over several accelerograms, but a completely monotonic dependence of the reaction on the rigidity of the structure is not achieved. In addition, there is a certain limit of the "sensitivity" of the process, which consists in the fact that with insufficiently large changes in the rigidity of the structure, the reaction to the impact of the accelerogram practically does not change.

For these reasons, using the process of successive approximations, it is possible to select only a certain area of possible states of the building after an earthquake.

This result is quite consistent with the physical content of the phenomenon under study, in view of the fact that not all factors affecting the result of seismic action are taken into account in the calculations. Under these conditions, "exact" solutions do not make sense and the tasks should be limited to obtaining approximate estimates that lead to more meaningful results and better agree with reality than the calculation based on the initial state.

The process of successive approximations is carried out under the assumption of elastic work of structures at all stages of deformation. The possibility of such an approach for obtaining approximate solutions is justified by the results of vibration tests of structures and models, which show that in the mode of large vibration amplitudes there are resonance frequencies that coincide with the calculated ones in terms of stiffness corresponding to the deformation diagram.

Based on the calculation for some preliminary conclusions, the refinement of which requires additional study of the dynamic behavior of structures in limiting states.

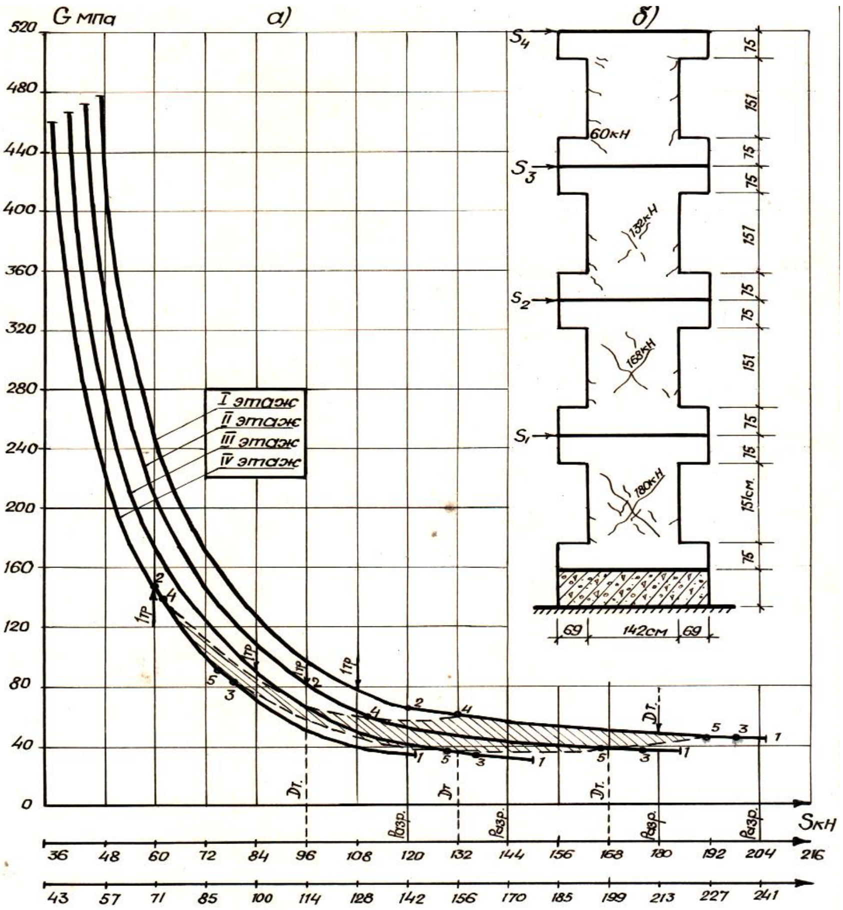

Fig. 2. Possible state of the walls after a 9-point earthquake
a) the area of possible states; b) the greatest possible damage

Conclusions

1. The results of the calculation show that the possible states of the complex structures of the walls in all floors are within the limits of the deformation graph, therefore, it can be concluded that the building does not collapse during a nine-point earthquake.

2. The technical condition of the building after an earthquake can be roughly described as follows:

Ground floor. Horizontal and diagonal cracks appear and develop in the walls. In (Fig. 2) diagonal cracks are shown in two directions, since during earthquakes of average duration the number and magnitude of the maximum seismic loads in both directions are approximately the same.

Second floor. The maximum load is approximately the same as the load causing the first diagonal cracks. Consequently, the walls of the second floor are characterized by the development of horizontal cracks along the edges and minor diagonal cracks.

Third floor. The condition is the same as the second floor.

Fourth floor. There are no diagonal cracks, horizontal cracks along the edges are present on both sides. The acting load is much less than the destructive one.

3. To assess the seismic resistance of a building, compare its post-earthquake condition with regulatory requirements. In this case, damage to individual structural elements or their displacement is possible, which does not threaten the safety of people or the safety of valuable equipment. An increase in strength can be achieved by increasing the thickness of the walls of the first floor to 51 cm or by increasing the adhesion of the mortar to the bricks.

4. Calculations for the impact of accelerograms based on the initial state of structures lead to such magnitude of seismic impacts that are several times higher than the calculated standard loads.

5. Consequently, there is a clear discrepancy between reality and calculations for the impact of accelerograms in the usual setting. The calculation according to the "Method of states" in this case led to a result close to the normative one, but it has an advantage over it in terms of a more detailed analysis of the consequences of seismic impact and a more accurate determination of the seismic resistance of buildings.

References:

1. Aisenberg, Ya.M. (1996). *Structures with disconnected connections for seismic regions*. (pp.73-76). Moscow: "Stroyizdat".
2. Avanesov, G.A. (1998). Elastoplastic work of reinforced concrete structural elements and frame systems under seismic influences. *"Construction and architecture of Uzbekistan"*, No. 4, Tashkent, pp. 16-17.
3. Artyushin, D.V. (1999). *Strength of masonry walls under the combined action of vertical and horizontal forces:* Author's abstract. dis. Cand. tech. sciences. (pp.25-27). Penza.
4. (1998). *KMK 2.03.07-98 "Stone and reinforced stone structures"*. Tashkent.
5. (1996). *KMK 2.03.01-96 "Concrete and reinforced concrete structures*. Tashkent.
6. Bokhonskiy, A.I. (1997). *On the vibrations of viscoplastic systems. - In collection: Seismic resistance of buildings and structures.* (pp.87-93). Tashkent: "Fan".
7. (1996). *KMK 2.01.03-96 " Construction in seismic regions*. Tashkent.
8. Yakovlev, A.I. (1988). *Calculation of fire resistance of building structures*. (p.143). Moscow: Build from dates.
9. Romanenkov, I.G., & Levites, F.A. (1991). *Fire protection of building structures*. (p.320). Moscow: Build from dates.
10. (1999). *International Organization for Standardization. Fire-Resistance Tests — Elements of Building Construction*, Part 1: General Requirements. International Organization for Standardization.
11. (2006). *China Association for Engineering Construction Standardization. Technical Code for Fire Safety of Steel Structures in Buildings (CECS200-2006)*. China Plan Press.
12. (n.d.). *Guoqiang LiPeijun Wang Fire-Resistance of Isolated Compressed Steel Components*.