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# QUANTITATIVE ASSESSMENT OF THE RELIABILITY OF THE SYSTEM "FOUNDATION - SEISMIC ISOLATION FOUNDATION - BUILDING"

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**Annotation.** Seismic resistance of buildings and structures is a factor that must be taken into account, especially during construction in seismically active regions. The purpose of this article is to develop methods for quantitatively assessing the reliability of the system "foundation - foundation with devices for a damping layer (seismic isolation and seismic protection) - building". The implementation of this goal will make it possible to make a reasonable choice of the most reliable option for seismic isolation and seismic protection devices, taking into account the characteristics of all elements of the system.

**Key words:** seismic isolation; seismically isolated buildings and structures; seismic resistance damping layer, active seismic isolation.

# КОЛИЧЕСТВЕННАЯ ОЦЕНКА НАДЕЖНОСТИ СИСТЕМЫ «ОСНОВАНИЕ – ФУНДАМЕНТ С СЕЙСМОИЗОЛЯЦИЕЙ - ЗДАНИЕ»

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**Аннотация.** Обеспечение сейсмостойкости зданий и сооружений - фактор, который необходимо учитывать, особенно при строительстве в сейсмически-

активных районах. Цель настоящей статьи заключается в разработке методик количественной оценки надежности системы «основание – фундамент с устройствами демпферующего слоя (сейсмоизоляции и сейсмозащиты) – здание». Реализация этой цели позволит осуществлять обоснованный выбор наиболее надежного варианта устройств сейсмоизоляции и сейсмозащиты с учетом особенностей всех элементов системы.

**Ключевые слова:** сейсмоизоляция, сейсмоизолированные здания и сооружения; сейсмостойкость, демпфирующий слой, активная сейсмоизоляция.

## "ПОЙДЕВОР-СЕЙСМИК ИЗОЛЯЦИЯЛИ ПОЙДЕВОР - БИНО" ТИЗИМИНИНГ ИШОНЧЛИЛИГИНИ МИҚДОРИЙ БАҲОЛАШ

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**Annotatsiya.** Бино ва иншоотларнинг сейсмик чидамлилиги, айниқса сейсмик фаол ҳудудларда қурилиш вақтида ҳисобга олиниши керак бўлган омил ҳисобланади. Ушбу мақоланинг мақсади "пойдевор - дампинг қатлами (сейсмик изоляция ва сейсмик ҳимоя) учун қурилмалар билан пойдевор - бино" тизимининг ишончлилигини миқдорий баҳолаш усулларини ишлаб чиқиш. Ушбу мақсадни амалга ошириш тизимнинг барча элементларининг хусусиятларини ҳисобга олган ҳолда сейсмик изоляция ва сейсмик ҳимоя воситаларининг энг ишончли вариантини оқилона танлаш имконини беради.

**Kalit so'zlar:** seysmik izolyatsiya; seysmik izolyatsiyalangan binolar va inshootlar, seysmik qarshilikni pasaytirish qatlami, faol seysmik izolyatsiya.

**The urgency of the problem.** Ensuring the seismic resistance of the "foundation - foundation - structure" systems in order to reduce damage from seismic effects is the most important problem of modern construction science and practice. The consequences of earthquakes are massive loss of life, huge material damage associated with the destruction of infrastructure, housing, industrial and transport facilities. In the last 50 years alone, as a result of devastating earthquakes, the number of human victims has reached more than 5 million; material damage is estimated at tens of billions of dollars. Up to 87 percent of the territory of the Republic of Uzbekistan belongs to seismically active regions with seismicity from 7 to 9 points according to the seismic scale adopted in the Republic. This circumstance necessitates the further development of the theory and practice of ensuring the seismic resistance of systems, including the base, foundation and building structures of buildings.

Currently, the problem of increasing the seismic resistance of foundations, foundations and building structures of buildings is solved by two methods - traditional and with the use of special seismic protection and seismic isolation devices. Traditional methods include increasing the strength characteristics of soil foundations, using more advanced design solutions, using modern technologies, high-strength materials, strengthening the supporting building structures of the buildings and structures in use, as well as taking into account the incoming initial information regarding the predicted seismic effects and the behavior of building elements under extreme impacts. Along with this, over the past 15-20 years, the use of unconventional methods of increasing the seismic resistance of structures, implemented in various designs of seismic foundations, dynamic absorbers of seismic vibrations, systems with degrading stiffness, has become increasingly widespread. Development of theoretical and experimental foundations of this direction is contained in the works Ya.M. Aisenberg, I. I. Goldenblat, S. E. Erzhanova, Zh. Zhunusov, B. G. Korenev, I. L. Korchinsky, V. S. Polyakov, V. T. Rasskazovsky, A. S. Ushakova, A.G. Tyapina, L.M. Reznikova, E. Rosenbluta, O. A. Savinova, A. M. Uzdin, T. R. Rashidova, S. T. Uzlov, Yu. A. Hamburg, T U.Artikova, G.H. Khojimetova, H.Z.Rasulova, I. Muborakova, K.N. Abdullabekova, T.N. Chachava, G. Shulman, J.M. Kelly, D. Lee, V. Robinson , R. Skinner, D. Smith, W. W. Chang et al.

Currently, dozens of different design options for such devices have been proposed. However, the lack of a uniform methodology for assessing their reliability, the fan-like nature of the design models of objects and seismic effects complicate the comparison of the results obtained and complicate the choice of the most effective version of seismic isolation and seismic protection devices.

A characteristic and important feature of the problem of comparative assessment of the reliability of foundations, foundations and building structures of structures with various options for seismic isolation and seismic protection devices is the incompleteness and unreliability of the initial information, both in relation to seismic effects and in relation to the properties and behavior of building elements with a combination of static and seismic loads.

As you know, the purpose of using any design of seismic isolation and seismic protection devices is to fulfill two basic requirements: to reduce inertial loads on the base, foundation and building structures and to limit the displacement of the building relative to the base. However, it is no less important, and ultimately the determining condition for the choice of seismic isolation and seismic protection devices, is to ensure the reliability of all these elements that form the building system. Until now, there are no methods for quantitatively assessing the reliability of such systems, which make it possible to compare various options for seismic isolation and seismic protection devices and select the most reliable one. This circumstance is one of the reasons hindering the use of various devices for seismic isolation and seismic protection - despite the fact that the results of theoretical and experimental (including field) studies in this area convincingly prove their effectiveness. The development of such techniques on the basis of an appropriate methodological base is an important and urgent problem, the solution of which will make it possible to make a reasonable choice of the most reliable option for seismic isolation and seismic protection devices, taking into account the characteristics of all elements of the building system.

The purpose of this article is to develop methods for quantitatively assessing the reliability of the system "foundation - foundation with devices for a damping layer (seismic isolation and seismic protection) - building". The implementation of this goal will make it possible to make a reasonable choice of the most reliable version of seismic isolation and seismic protection devices, taking into account the characteristics of all elements of the system. The structure can be more robust, but not necessarily cost effective because both weight and inertial seismic loading can increase even more. New effective methods of seismic protection are required. Such solutions imply a change in mass and stiffness, damping of the system depending on its movements and speeds. To date, more than 100 patented designs for seismic isolation of buildings and structures are known. During earthquakes, foundation structures are rarely damaged. Despite this, the importance of foundations in ensuring the seismic resistance of buildings is great. Foundations are the first to perceive seismic shocks and transmit them to the upper parts of the building. The system "foundation-foundation-building" affects the change in the dynamic properties of the building, which accordingly changes the magnitude of the seismic loads acting on it. At the base of the walls of the preserved architectural monuments, soft pads (at the level of the top of the foundations) were found made of reed cushions, plastic clays and other local materials. The architects of Central Asia strengthened the weakened junction between the foundation and the plinth. The thickness of the seam here reached the height of a brick. During the construction of mausoleums in rocky soil, the pits were filled with loose earth, sand, and the foundation was erected along them. With this solution, the concentration of stresses in the foundations decreased, and the ground pad partially damped high-frequency ground vibrations during earthquakes. Other engineering solutions were used to reduce the impact of earthquake-vibrating foundations on the underground parts of buildings. Roller supports, foundations with spherical ends were proposed.

This article will consider the types of passive seismic protection of building foundations. Deformed model of the problem of systems of passive seismic protection of foundations according to the principle of their operation. (Fig. 1)

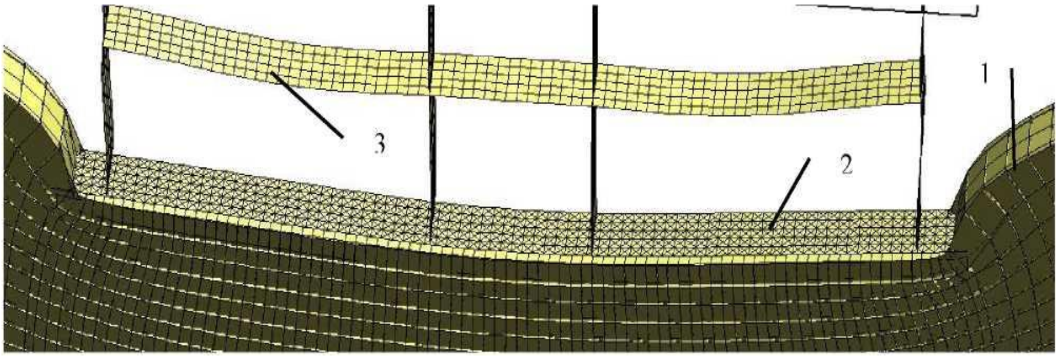


Fig. 1

Drawing. 1 - Deformed model of the problem: 1 - base; 2 - foundation with damper layer devices (seismic isolation); 3 – building

In seismic damping systems, including dampers and dynamic absorbers, the mechanical energy of the vibrating structure is transferred to other types of energy, which leads to vibration damping, or is redistributed from the protected structure to the absorber.

In seismic isolation systems, the mechanical energy received by the structure from the base is reduced by detuning the vibration frequencies of the structure from the prevailing frequencies of the impact. Consider a foundation structure consisting of two layers connected by damping layers (seismic isolation). Suppose that the damping layer is such that it does not transfer shear forces. In this case, the design scheme of the foundation structures can be considered as two foundation beams between which an earthquake-insulating layer is located. The earthquake foundation is a classic example of seismic isolation with a series of elastic and damping elements. Under relatively weak influences, when the horizontal load on the support part does not exceed the friction forces, the system operates in a linear region; when the load increases, the friction force is overcome and the upper foundation beam slips relative to the lower one. It should be noted that traditional seismic isolation devices, including seismic isolation supports, have a significant common drawback: they dismember the integral building-foundation system into separate parts, which leads to a weakening of the system in favor of seismic isolation of a certain part of this system. In this case, mutual displacements arise between the insulated and non-insulated parts, and to limit these mutual displacements, dampers are installed that dissipate the energy of the seismic effect. Consider structures that, together with the foundation, form a single integral spatial multi-connected system, which, even when separated from the base, retains geometric invariability. The seismic isolation device should relate to this entire integral system, and not to a separate part of it. An example of such a constructive solution can be a building (structure), combined with a solid spatial foundation platform, between which and the dropped base there is a sliding layer that reduces friction. In this case, a powerful seismic wave slips under the platform, i.e. the level of large horizontal seismic impacts (including asymmetric, torsional, etc.) on the platform and thereby on the topside is significantly reduced. The integrity and multi-connectivity of buildings with a foundation allows one to perceive vertical shocks as well. In this case, possible horizontal displacements will take place not between separate parts of the buildings (ie, the integrity is not disturbed), but between the system “building-foundation with devices of a damping layer-foundation”. Small (on the order of several centimeters) displacements can be permissible when planning territories, and stops (dampers, return devices, etc.) will be installed to limit large displacements. Thus, the sliding layer forms an earthquake-isolating protective device that does not violate the integrity of the building-foundation-foundation system.

**Conclusions.** Conventional measures for seismic protection of buildings and structures are mainly reduced to increasing the bearing capacity of elements and structures. Such seismic protection is carried out in accordance with the building codes "Construction in seismic regions" [5]. At the same time, the measures performed do not reduce seismic loads on buildings and structures, and only take into account.

In this article, modern methods of seismic isolation of foundations of buildings and structures were analyzed analytically .. Calculations made by Ya.M. Eisenberg [2] showed that the relative horizontal seismic displacements of floors in seismically insulated buildings are significantly lower than in non-insulated buildings. Accordingly, the damage caused by strong earthquakes in seismically insulated buildings is much lower than in non-insulated buildings. Seismic protection measures can significantly reduce economic losses. With proper design, systems for seismic suppression and seismic isolation of foundations and buildings as a whole can increase the reliability of the structure, the safety of equipment, comfort for residents, and most importantly, there is no need for recovery work after strong earthquakes.

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