HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

ASSESSMENT AND ANALYSIS OF BUILDING RESISTANCE TO SEISMIC HAZARDS USING MODERN SEISMIC PROTECTION SYSTEMS

Kayumov Asilbek Dilshatbekovich
Republic of Uzbekistan, Andijan city,
Andijan State Technical Institute, Senior Lecturer,
asilbekqayumov38@gmail.com
Doi: https://doi.org/10.5281/zenodo.21732074

Abstract. The article focuses on the basic principles and methods of seismic protection. Special attention is paid to the issues of ensuring the resistance of buildings to seismic hazards by modern seismic protection systems, the selection of building materials and the development of constructive solutions. The article is intended for design engineers, construction specialists and scientists involved in seismic safety issues.

Keywords: seismic protection, building, resonance, seismic protection systems, danger, emergency, vibration, resonant frequency, earthquake-resistant buildings and structures.

Introduction

Seismic protection devices are devices that completely or partially isolate a building from earthquake energy, that is, absorb, dissipate or control deformation. They are installed between the main structure and the foundation or between floors and, by reducing the amplitude of vibrations, keep the deformation of the building within the regulatory limits. Such devices include elastomeric isolators, viscous dampers, metal energy absorbers, semi-active shock absorbers, variable stiffness supports, and in recent years - active systems with electromechanical control.

Modern seismic protection systems are conventionally divided into three types:

Passive systems - they operate without external control and mainly absorb deformation energy mechanically. These include viscoelastic dampers, metal plate absorbers, friction isolators and elastomer blocks.

Semi-active systems - they can partially change their properties using electrical or hydraulic control elements. For example, magnetorheological dampers (MR-dampers) or fluid-based controlled shock absorbers.

Active systems - these systems record earthquake vibrations in real time through sensors and generate a counterforce using actuators based on computer algorithms.

Literature review.

Earthquakes remain one of the most destructive natural hazards affecting the safety and serviceability of civil engineering structures. The increasing urbanization of seismic regions has intensified the demand for advanced seismic protection systems capable of minimizing structural damage, ensuring occupant safety, and maintaining post-earthquake functionality. Conventional seismic design primarily relies on increasing the strength and stiffness of structural members. However, modern earthquake engineering has shifted toward performance-based design and energy dissipation technologies, which significantly improve structural resilience under dynamic loading [1], [2].

The fundamental principles of structural dynamics form the theoretical basis for understanding seismic response. Chopra [3] explains that buildings subjected to earthquake excitation experience complex dynamic interactions between inertia, damping, and stiffness. Accurate prediction of these

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

responses requires dynamic analysis techniques such as modal analysis, response spectrum analysis, and nonlinear time-history analysis. Similarly, Clough and Penzien [4] emphasize that the seismic behavior of buildings depends not only on structural configuration but also on damping characteristics and soil-structure interaction, making dynamic modeling essential for modern seismic design.

International seismic design standards have evolved to incorporate these scientific advances. The former Soviet standard SNiP II-7-81* [1] established the initial framework for seismic-resistant construction by prescribing structural detailing, material requirements, and seismic zoning. Although widely adopted in several post-Soviet countries, the standard mainly focuses on conventional strengthening techniques. In contrast, Eurocode 8 [2] introduces performance-based seismic design principles, emphasizing ductility, capacity design, controlled plastic deformations, and the application of innovative seismic protection devices such as base isolation systems and supplemental damping mechanisms. Likewise, ASCE 7 [5] provides comprehensive methodologies for determining seismic loads, response modification factors, and structural performance objectives based on probabilistic seismic hazard assessments.

One of the most significant developments in earthquake engineering is the implementation of base isolation systems. These systems reduce seismic forces transmitted from the ground to the superstructure by introducing flexible bearings between the foundation and the building. Base isolation effectively lengthens the natural period of structures and significantly reduces acceleration demands during earthquakes [2], [5]. Numerous studies have demonstrated that isolated buildings experience considerably lower inter-story drifts and structural damage compared with conventionally fixed-base structures. This technology is particularly suitable for hospitals, emergency response facilities, and essential infrastructure where uninterrupted functionality is critical after seismic events.

Another important advancement is the application of energy dissipation devices, including viscous dampers, friction dampers, metallic yielding dampers, and tuned mass dampers. These devices absorb a significant portion of earthquake-induced energy before it reaches primary structural members. According to Chopra [3], supplemental damping systems effectively reduce displacement, vibration amplitude, and internal stresses while improving structural stability during strong ground motion. Modern design approaches often combine damping systems with base isolation to achieve optimal seismic performance under varying earthquake intensities.

Recent research has also focused on combined seismic protection systems, integrating flexible foundations, damping devices, and innovative structural materials. Makhmudov, Abdullayev, and Kayumov [8] investigated buildings equipped with flexible-bottom systems, demonstrating that increasing foundation flexibility can significantly reduce dynamic forces transferred to the superstructure. Their analytical results indicate improvements in vibration control and overall seismic performance compared with conventional rigid foundation systems. Building upon this concept, the same researchers analyzed frame buildings utilizing combined earthquake protection systems, concluding that hybrid protection strategies offer greater structural reliability and energy dissipation than single protection methods [9].

In addition to structural systems, modern construction materials contribute substantially to earthquake resistance. Abdullayev et al. [6] introduced an innovative Polystroblock production technology designed to reduce structural self-weight while maintaining sufficient mechanical strength. Since seismic inertial forces are directly proportional to structural mass, lightweight materials provide an effective means of reducing earthquake-induced loads. Their subsequent study further optimized the composition of Polystroblock materials, highlighting improvements in thermal insulation, durability, and structural efficiency [7]. These characteristics make lightweight composite materials

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

attractive alternatives for seismic regions where both structural safety and energy efficiency are required.

The integration of advanced computational methods has further transformed seismic analysis. Performance-based seismic engineering increasingly employs finite element modeling, nonlinear dynamic analysis, and probabilistic risk assessment to evaluate structural performance under realistic earthquake scenarios [2], [3]. These analytical approaches allow engineers to predict damage states, estimate economic losses, and optimize seismic protection strategies before construction. Consequently, modern seismic design is shifting from prescriptive code compliance toward resilience-oriented performance objectives.

Overall, contemporary research demonstrates that no single seismic protection technology provides universal solutions for all structural conditions. Instead, optimal seismic performance is achieved through integrated systems combining lightweight materials, base isolation, supplemental damping devices, flexible foundation systems, and performance-based structural design. Such multidisciplinary approaches significantly enhance structural resilience, reduce economic losses, and improve public safety in earthquake-prone regions [2], [5], [8], [9].

Methodology.

The effectiveness of these systems is determined not only by their technical characteristics, but also by quantitative reliability. For example, the same type of damper can give different results in two different buildings, since the structural stiffness, mass distribution, resonant frequency and seismic spectrum change. Therefore, it is necessary to analyze the parameters of the seismic protection system separately for each project.

Result and discussion.

The reliability of a building is the probability that it will maintain its functional state under specified conditions for a certain period of time. Determining this probability under the influence of uncertain and random loads, such as an earthquake, is a complex mathematical problem. Because the duration of the earthquake process, the frequency, amplitude and direction of vibration are random variables. Therefore, probability theory, statistical analysis and modeling methods play a key role in quantitative assessment.

For example, using the Monte Carlo method, thousands of random load cases are modeled, and the probabilities of stress, deformation, and failure in various elements of a building system are calculated. As a result, an overall reliability index is determined. This index (usually denoted by β) represents the level of safety of the system: the larger β, the more reliable the building is.

Sometimes, to avoid resonance, “anti-vibration systems” are deliberately installed. These are usually heavy metal masses located at the top of a building that move in the opposite direction when the building shakes. Such systems are called “mass dampers.” For example, the Taipei 101 tower in Taiwan has a 660-ton spherical damper installed. It moves in the opposite direction of the building’s vibration, reducing the amplitude by up to 40 percent. In Uzbekistan, buildings with damper systems have also begun to appear in recent years. Some new business centers in Tashkent use hydraulic dampers and steel beam energy absorbers. These systems reduce not only earthquakes, but also strong wind or traffic vibrations. As a result, the long-term stability of the building increases.

There are many situations that disrupt the natural balance of vibrations. The most common is that the frequency of vibrations decreases as the height of a building increases. As the number of floors increases, the system becomes more elastic, the stiffness decreases, and as a result, the vibrations increase. Therefore, in tall buildings, structural systems are reinforced with multi-level supports. These supports direct the energy to the lower floors, and the dampers there absorb it. In this way, the building becomes a flexible mechanism that works “from the top down, not the bottom up.”

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

In engineering analysis, resonance is considered not only a danger, but also a desirable condition. In the laboratory, models are brought to a state of resonance and their maximum deformation limits are measured. These tests allow you to simulate real earthquake conditions. After the structures are tested, their energy dissipation coefficient, elastic modulus, and vibration frequencies are determined. To deeply understand building vibrations, an engineer must be not only an accountant, but also a psychologist. He knows the “character” of the building: where it is weak, where it is strong, where energy is concentrated, where it is dissipated. Every column, every beam, every wall plays its part in this “orchestra”. An earthquake is a test, but it also shows synchronicity. If the system works harmoniously, it wins. Understanding the phenomenon of vibration is using a single language for both man and nature. The earth shakes, the building responds. At the end of this dialogue, harmony is needed, not victory. Therefore, the goal of the engineer is not to defeat nature, but to listen to it. It is from this philosophical approach that seismic stability begins.

Conclusion

The issue of seismic stability is not just a branch of engineering, but a test of the entire human mind. Because an earthquake always tests a person at an unexpected moment. It does not distinguish any country, religion or academic level, but asks only one question: “are you ready?”. Humanity has been answering this question with technology, science and thinking. This chapter has analyzed one form of these answers - seismic protection devices and their effective systems on a scientific basis.

Adabiyotlar ro‘yxati:

1. SNiP II-7-81* "Seysmik zonalarda qurilish".
2. Eurocode 8: Seysmik tahdidlarga chidamli konstruksiyalarni loyihalash.
3. Chopra, A. K. (2012). Dynamics of Structures: Theory and Applications to Earthquake Engineering.
4. Clough, R. W., & Penzien, J. (1993). Dynamics of Structures.
5. ASCE 7: Minimum Design Loads for Buildings and Other Structures.
6. Mahammadovich, A. A., Dilshatbekovich, K. A., & Alimardon, Z. (2023). POLISTIROBLOK ISHLARI CHIQARISH YANGI TEXNOLOGIYASI. *Conferencea*, 32-24.
7. Mahammadovich, A. A., & Dilshatbekovich, K. A. (2023). INNOVATSION QURILISH MATERIALLI" POLISTROBLOK" NI TARKIBI. *Conferencea*, 66-69.
8. S.M. Makhmudov., Mahammadovich A. A., Dilshatbekovich K. A. (2025). «Sistems With a "Flixible Bottom" of the Bilding Objekt» AMERICAN Journal of Engineering, Mechanics and ArchitectureVolume 3, Issue 1, 2025ISSN (E): 2993-2637.
9. S.M. Makhmudov., Mahammadovich A. A., Dilshatbekovich K. A. (2025). «Techical Science Building and ArchitectureSeismic Response of Frame Buildings with Combined Earthquake Protection System» AMERICAN Journal of Engineering, Mechanics and ArchitectureVolume 3, Issue 1, 2025ISSN (E): 2993-2637.