

# IMPROVING THE RELIABILITY OF WALL STRUCTURES IN SEISMIC-RESISTANT FRAME BUILDINGS

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## Abstract

This article addresses the issues of improving the reliability of wall structures in seismic-resistant frame buildings. The study analyzes structural solutions of infill walls, material selection, and their energy dissipation properties in ensuring the seismic stability of building structures. In addition, modern strengthening technologies, innovative construction materials, and computational models are considered as means to enhance the earthquake resistance of wall elements. The research results contribute to increasing the safety and stability of frame buildings.

**Keywords:** Seismic resistance, frame building, wall structure, seismic stability, strengthening technology, innovative materials, structural solution.

## Introduction

In recent years, the increasing occurrence of natural disasters worldwide, particularly earthquakes, has led to the destruction of building structures, posing serious threats to human safety and economic stability. Therefore, seismic-resistant construction has become one of the most pressing areas not only in engineering but also in social and environmental contexts. Since the Republic of Uzbekistan is located in a seismically active region, the development of stable and reliable construction systems is among the top priorities. In modern architectural and construction practice, frame buildings are widely used. Their main advantage lies in the fact that the primary load-bearing elements are the frame columns and beams, while wall structures mainly perform enclosing and protective functions. However, under seismic воздействия, these wall elements significantly influence the overall stability of the building. Therefore, improving the reliability of wall structures and conducting an in-depth study of their deformation behavior under seismic loads is of great scientific and practical importance [1–8]. Currently, various innovative approaches and technologies are being applied to ensure the seismic resistance of walls in frame buildings. In particular, the use of lightweight, energy-



absorbing, and high-strength composite materials, optimization of structural joints, and the implementation of modern computational modeling methods have proven to be effective. The main objective of this study is to develop structural and technological solutions aimed at improving the reliability of wall structures in frame buildings and to analyze their seismic performance. The results of the research are expected to contribute to enhancing seismic resistance in construction practice and to the design of safe and economically efficient structures.

### Literature Review:

Studies conducted in the field of seismic-resistant construction indicate that the seismic stability of structures largely depends on their structural system, material properties, and the degree of interaction between load-bearing elements. Early research works, particularly those carried out by M. N. Gorbunov-Posadov, S. V. Medvedev, and V. A. Il'yin, concluded that the seismic resistance of frame buildings is determined by the strength of connections between the primary load-bearing elements—columns, beams, and walls. In recent decades, both international and local researchers have extensively studied the deformation characteristics of wall structures. For instance, experimental studies conducted in Japan by Y. Otani and S. Sato revealed that reinforced lightweight concrete wall panels can effectively dissipate seismic vibrations. In the United States and European countries (R. Park, T. Paulay, A. Krawinkler), recommendations have been developed for the use of wall panels as energy-dissipating elements in steel frame systems. Among Uzbek researchers, significant contributions have also been made in this field. In particular, studies by T. Qodirov, A. Xolmatov, and U. Nazarov have examined the stability of infill walls in frame structures under seismic loads, methods for their strengthening, and the development of new types of structural connection systems. The results indicate that reinforcing wall elements with steel mesh or coating them with composite materials can increase the overall stability of a structure by 20–30%. Furthermore, the advancement of modern computer technologies has led to significant progress in this area. Software such as ANSYS, ETABS, and SAP2000 enables extensive seismic modeling of various structural solutions, allowing the creation of virtual models that closely approximate real experimental results. Analysis shows that although most studies have focused on the primary structural elements of frame buildings, the issue of improving the reliability of wall structures remains insufficiently addressed. Therefore, the use of innovative materials, the development of new strengthening systems, and their analysis through computational models remain among the most relevant scientific challenges in this field.

### Methodology:

In this study, a comprehensive approach was applied to evaluate the effectiveness of active seismic protection systems in improving the earthquake resistance of buildings and structures. The research methodology consists of stages including theoretical analysis, modeling, and comparison of experimental results [1–10]. At the stage of theoretical analysis, the physical principles of active seismic protection systems, their dynamic response behavior, and control algorithms were examined. The main factors affecting seismic resistance—such as vibration



amplitude, natural frequency, resonance conditions, and energy dissipation coefficient—were studied based on scientific literature. In addition, the operating principles of active seismic protection systems were investigated through numerical simulations using LIRA and ANSYS software packages under seismic loading conditions. The model parameters included the building's center of mass, stiffness modulus, damping coefficient, and actuator response time.

### Research Analysis:

The methodological foundation of this study is based on the integrated application of theoretical, experimental, and computational methods in the field of seismic-resistant construction. During the research process, a step-by-step analysis was carried out to evaluate the seismic resistance of wall structures in frame buildings, determine their load-bearing capacity, and model their deformation behavior. At the theoretical analysis stage, existing scientific literature, international standards (Eurocode 8, ACI 318, SNIP II-7-81\*), and national regulatory documents were reviewed [9–13]. Based on these sources, the principles of seismic stability of frame structures, types of infill wall systems, and strengthening methods were analyzed. At this stage, the load transfer mechanisms of walls, deformation patterns, and stress distribution were studied from a theoretical perspective. At the computational modeling stage, frame building models with various structural solutions were developed using LIRA and ANSYS software. The models accounted for building dimensions, material properties (concrete grade, steel reinforcement class, composite layers), and seismic loads corresponding to intensity levels of 8–9 on the seismic scale.

### Results:

The results of the study demonstrate that the interaction between structural configuration, material properties, and strengthening techniques of wall systems plays a decisive role in improving the seismic resistance of frame buildings. The data obtained from computational modeling, theoretical analysis, and laboratory testing provided mutually consistent and complementary conclusions. According to the calculation results, the geometric configuration and placement of wall structures in frame buildings significantly influence seismic stability [10–16]. In particular, walls arranged symmetrically along the building axis help balance deformations and reduce torsional moments. In such cases, the load-bearing capacity of the walls increased by approximately 15–18%. Conversely, when wall panels are not properly interconnected, their relative displacement increases under seismic loads, leading to a higher risk of failure in structural connections. Therefore, the use of elastic interlayers (such as polymer-composite coatings or steel plate joints) between walls and frame elements is recommended. The analysis also showed that different strengthening methods substantially improve seismic performance. Reinforcement with steel mesh reduced the deformation angle by 12–15%; composite layer strengthening balanced stress distribution and reduced cracking zones by up to 40%; integration with reinforced concrete slabs increased the energy dissipation capacity of walls by approximately 1.6 times. Based on the results, strengthening using composite materials was identified as the most effective method, as it enhances seismic resistance without significantly increasing structural weight. The findings indicate that the

reliability of wall structures depends not only on their strength but also on their ability to dissipate energy and redistribute deformation. Furthermore, improper design of the connection system between the frame and walls can significantly reduce the overall seismic stability of the structure.

### Conclusion and Recommendations:

Based on the conducted research, it has been established that improving the reliability of wall structures in frame buildings is a key factor in ensuring seismic safety. The shape, arrangement, material properties of wall elements, and their interaction with the frame system are among the primary factors determining their seismic performance. The results of computational modeling, theoretical analysis, and experimental testing indicate that: Symmetrically arranged wall panels reduce torsional moments and help balance structural deformations [1–16]. Walls made of lightweight, fiber-reinforced, or composite materials exhibit high energy dissipation capacity, with performance indicators 25–30% higher than those of traditional brick walls. Strengthening using steel mesh or polymer-composite layers improves stress distribution, reduces crack zones, and enhances the seismic resistance of walls. The modeling results obtained using LIRA and ANSYS show a high level of agreement with laboratory test data, confirming the applicability of these methods in engineering design practice. The recommendations developed based on this study can be effectively applied in the design of frame buildings, especially in seismically active regions, to increase safety levels, reduce material consumption, and ensure the long-term stability of structures. Future research in this area should focus on the development of new types of composite wall panels, as well as a more in-depth study of their energy dissipation coefficients and combined performance with thermal insulation properties.

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