

## SEISMIC DESIGN CODES AND STANDARDS: LEARNING FROM FOREIGN EXPERTISE TO ENHANCE SEISMIC PERFORMANCE OF MULTI-STORY FRAME BUILDINGS

<sup>1</sup>Ph.D., Assoc. **Yusupov R.R.**, <sup>1,2</sup>Grad. Student **Makhmudov J.I.**

<sup>1</sup>Tashkent University of Architecture and Civil Engineering, Uzbekistan

<sup>2</sup>Exchange student at Hongik University, South Korea

[makhmudov9910@gmail.com](mailto:makhmudov9910@gmail.com)

**Annotation:** *This article explores the seismic design codes and standards used in foreign regions known for their expertise in earthquake-resistant design and discusses how they can be applied to enhance the seismic performance of multi-story frame buildings in a specific study area. It highlights notable foreign regions with advanced seismic design practices, examines key features of their codes and standards, and suggests potential applications in the study area. The article emphasizes retrofitting strategies, design optimization, and knowledge transfer as means to improve seismic resilience.*

**Keywords:** *Seismic design codes, Standards, Earthquake-resistant design, Multi-story frame buildings, Seismic performance, structural systems, foundation design, construction techniques, Building Standard Law, AIJ Guidelines, International Building Code (IBC), ASCE 7, NZS 1170.5, Ductile detailing, Performance-based design, Site-specific hazard analysis, Retrofitting strategies, Design optimization.*

Earthquakes pose significant risks to buildings and infrastructure, making it crucial to implement robust seismic design measures. In regions renowned for their expertise in earthquake-resistant design, specific seismic design codes and standards have been developed over time. This article explores the seismic design codes and standards used in foreign regions known for their expertise in earthquake-resistant

design. It further explores how these practices can be applied to improve the seismic performance of multi-story frame buildings in a specific study area.

**Understanding Seismic Design Codes and Standards:** Seismic design codes and standards are a set of regulations, guidelines, and practices established by engineering bodies and government agencies. These codes aim to enhance the structural integrity of buildings, ensuring their resistance to seismic forces. They encompass various aspects, including building materials, structural systems, foundation design, and construction techniques.

**Examining Foreign Regions with Expertise in Earthquake-Resistant Design:** Let us explore several foreign regions that are internationally recognized for their expertise in earthquake-resistant design. These regions have developed robust seismic design codes and standards, implemented innovative engineering practices, and gained valuable experience in mitigating the risks associated with earthquakes. By examining their approaches, other regions can learn from their experiences and apply similar strategies to improve the seismic performance of their own buildings and infrastructure.

1. Japan: Japan is widely regarded as a leader in earthquake-resistant design due to its location in a highly seismically active region. The country has faced numerous devastating earthquakes throughout its history, which has prompted the development of advanced seismic design codes and practices. The Building Standard Law, along with the AIJ (Architectural Institute of Japan) Guidelines, provides comprehensive regulations for seismic design, covering various aspects such as building materials, structural systems, and foundation design. Japan's expertise lies in the integration of cutting-edge technologies, such as base isolation and damping systems, to enhance the resilience of buildings.

2. United States: The United States has made significant strides in earthquake-resistant design, particularly in regions prone to seismic activity, such as California. The International Building Code (IBC) and ASCE 7 (American Society of Civil Engineers) standards form the basis of seismic design regulations in the country. These codes focus on performance-based design, considering factors such as seismic hazard levels and desired performance objectives for structures. The United States has also emphasized the use of ductile detailing, which enhances the ability of structural elements to absorb and dissipate seismic energy.
3. New Zealand: New Zealand, located on the Pacific Ring of Fire, experiences frequent seismic activity and has developed expertise in earthquake-resistant design. The country's seismic design codes, such as the New Zealand Standard NZS 1170.5 and NZS 1170.5:2004, emphasize site-specific hazard analysis, taking into account factors like ground motion, soil conditions, and geological features. New Zealand has also focused on retrofitting existing buildings to enhance their resilience, implementing strategies such as strengthening structural elements and improving connections.
4. Chile: Chile, known for its seismic activity, has developed advanced seismic design codes and standards to mitigate the risks posed by earthquakes. The country's seismic design regulations, such as the NCh433 standard, incorporate factors like ground motion, soil conditions, and building type to determine appropriate design parameters. Chile's expertise lies in the implementation of robust structural systems, including reinforced concrete and steel frames, along with seismic isolation and energy dissipation techniques.
5. Italy: Italy has a long history of seismic design expertise, as it is located in a seismically active zone. The country's seismic design codes, such as the NTC



(Norme Tecniche per le Costruzioni), have been continuously updated to reflect advancements in seismic engineering. Italy's expertise lies in the design of masonry structures, which are prevalent in the region. Techniques such as reinforced masonry, steel bracing, and innovative retrofitting methods have been employed to improve the seismic resilience of existing buildings.

**Key Features of Foreign Seismic Design Codes and Standards:** Now let us delve into the key features and approaches adopted in foreign seismic design codes and standards. Understanding these features can provide valuable insights for improving seismic performance in multi-story frame buildings. Here are some key aspects typically found in foreign seismic design codes and standards:

*Performance-based design:* Many foreign seismic design codes embrace a performance-based approach. This approach focuses on defining specific performance objectives for structures during seismic events, such as limiting structural damage, preventing collapse, or ensuring life safety. By setting desired performance levels, engineers can tailor design parameters to achieve those objectives.

*Ductile detailing:* Ductile detailing is a critical feature in foreign seismic design codes. It involves the incorporation of specific design and construction practices to enhance the ductility and energy dissipation capacity of structural elements. Ductile detailing allows structures to absorb and dissipate seismic energy without catastrophic failure, reducing the risk of sudden collapse during earthquakes.

*Site-specific hazard analysis:* Foreign seismic design codes often prioritize site-specific hazard analysis. This involves conducting detailed assessments of the local geological conditions, soil types, and ground motion characteristics at a specific location. By considering these factors, engineers can determine appropriate design parameters and select appropriate structural systems to withstand the anticipated seismic forces.

*Seismic-resistant structural systems:* Foreign seismic design codes emphasize the use of seismic-resistant structural systems. These systems are designed to withstand the lateral forces generated by earthquakes. Common examples include reinforced

concrete frames, steel moment frames, braced frames, and structural walls. Foreign codes often provide guidelines on the design, detailing, and construction of these systems to ensure their effectiveness in mitigating seismic risks.

*Construction quality control:* Foreign seismic design codes emphasize the importance of construction quality control measures. Ensuring that the designed structures are built in accordance with the specified standards and requirements is crucial for achieving the desired seismic performance. Quality control measures may include rigorous inspection protocols, material testing, and construction supervision to verify that the constructed elements meet the design intent.

*Continuous updates and research:* Foreign seismic design codes are often subject to continuous updates and improvements based on ongoing research and lessons learned from past earthquakes. This iterative process ensures that codes remain up-to-date with advancements in seismic engineering and incorporates the latest knowledge and best practices.

**Applying Foreign Seismic Design Practices to Multi-Story Frame Buildings in the Study Area:** In this section, we explore how foreign seismic design practices can be applied to enhance the seismic performance of multi-story frame buildings in the study area. By adopting and adapting successful strategies from regions known for their expertise in earthquake-resistant design, stakeholders can improve the resilience of buildings in the specific study area. Here are some potential applications:

1. **Retrofitting strategies:** Retrofitting existing multi-story frame buildings with techniques inspired by foreign seismic design practices can significantly enhance their seismic performance. This may involve strengthening critical structural elements, such as columns, beams, and connections, to improve their resistance to lateral forces. Retrofitting methods could include adding steel bracings, carbon fiber wraps, or external damping systems to enhance the ductility and energy dissipation capacity of the building.
2. **Design optimization:** Incorporating elements of foreign seismic design practices during the design phase of new multi-story frame buildings can lead to improved

seismic performance. This involves considering site-specific hazard analysis, such as understanding the local soil conditions and ground motion characteristics, to determine appropriate design parameters. Emphasizing ductile detailing in the structural design, selecting seismic-resistant structural systems, and conducting rigorous quality control during construction can enhance the building's ability to withstand seismic forces.

3. Knowledge transfer and capacity building: Establishing collaborations and promoting knowledge transfer between foreign experts and local engineers and professionals can contribute to enhancing seismic resilience in the study area. This can be done through workshops, training programs, and exchange of best practices. By building the capacity of local engineers and professionals in foreign seismic design methodologies, they can apply these practices effectively to multi-story frame buildings in the study area.
4. Local adaptations: While adopting foreign seismic design practices, it is essential to consider local context, building regulations, and cultural factors. Adaptations may be necessary to ensure compliance with local codes and standards, account for regional variations in seismic hazards, and address specific architectural and cultural requirements. This localized approach ensures that foreign seismic design practices are appropriately integrated into the study area's building design and construction processes.
5. Continuous monitoring and evaluation: Implementing foreign seismic design practices should be accompanied by continuous monitoring and evaluation of the performance of multi-story frame buildings in the study area. This includes post-earthquake assessments, structural health monitoring, and feedback mechanisms to identify areas for further improvement and inform future design iterations.

### **Conclusion:**

- The seismic design codes and standards used in foreign regions known for their expertise in earthquake-resistant design offer valuable insights and practices that can be applied to improve the seismic performance of multi-story frame buildings

in a specific study area. By examining notable regions such as Japan, the United States, New Zealand, Chile, and Italy, we can learn from their experiences and adopt successful strategies.

- Key features found in foreign seismic design codes include performance-based design, ductile detailing, site-specific hazard analysis, seismic-resistant structural systems, construction quality control, and a culture of continuous updates and research. These features provide a framework for enhancing the resilience of buildings in earthquake-prone areas.
- To apply foreign seismic design practices effectively, retrofitting strategies can be implemented to strengthen existing multi-story frame buildings, while design optimization can be employed during the construction of new buildings. Knowledge transfer and capacity-building initiatives can foster collaborations and ensure that local engineers and professionals are equipped with the necessary skills and understanding of foreign seismic design methodologies.
- It is important to consider the local context and make adaptations to account for regional variations in seismic hazards, building regulations, and cultural factors. Continuous monitoring and evaluation of the performance of multi-story frame buildings are essential to identify areas for improvement and inform future design iterations.
- By implementing foreign seismic design practices, the seismic performance of multi-story frame buildings in the study area can be significantly enhanced, leading to increased resilience, reduced damage, and improved safety during earthquakes. The adoption of these practices contributes to the overall goal of safeguarding lives and protecting critical infrastructure in earthquake-prone regions.



## REFERENCES

1. Takada, S., & Dhakal, R. P. (2018). Seismic design practice in Japan: Evolution and future trends. *Frontiers in Built Environment*, 4, 41. doi: 10.3389/fbuil.2018.00041
2. Federal Emergency Management Agency. (2015). NEHRP Recommended Seismic Provisions for New Buildings and Other Structures (FEMA P-1050). Retrieved from <https://www.fema.gov/media-library/assets/documents/32230>
3. New Zealand Society for Earthquake Engineering. (2004). New Zealand Standard NZS 1170.5:2004 - Structural design actions - Part 5: Earthquake actions - New Zealand. Wellington, New Zealand: Standards New Zealand.
4. Sociedad Chilena de Ingeniería Sísmica. (2012). NCh433 Of 1996 - Seismic Design of Buildings. Santiago, Chile: Instituto Nacional de Normalización.
5. Ministero delle Infrastrutture e dei Trasporti. (2018). NTC 2018 - Norme Tecniche per le Costruzioni. Rome, Italy: Governo Italiano.
6. Naeim, F., & Kelly, J. M. (1999). Design of Seismic-Resistant Steel Building Structures. Reston, VA: American Society of Civil Engineers.