A Review on Seismic Analysis and Design of Multi-Storey Buildings

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ABSTRACT

Seismic design of multi-storey buildings is a critical aspect of structural engineering, especially in regions prone to earthquakes. This review explores recent advancements in seismic design methodologies, including the use of performance-based design, base isolation, damping systems, and new modeling techniques using software such as ETABS and OpenSees. The paper synthesizes findings from ten selected research articles, emphasizing techniques that improve structural resilience, minimize lateral displacement, and enhance energy dissipation. The study concludes with key recommendations for future research and practical implementation of resilient design strategies.

KEYWORDS: Seismic analysis, Multi-storey buildings, Base isolation, Dampers, Performance-based design, ETABS, OpenSees

INTRODUCTION

In recent decades, the seismic vulnerability of multi-storey buildings has gained global attention due to frequent occurrences of moderate to high magnitude earthquakes. Traditional design approaches focused primarily on code-based elastic methods, which often underestimate actual structural behavior under dynamic seismic loads. Therefore, modern design philosophies such as performance-based seismic design (PBSD), use of dampers, base isolation, and software-aided analysis have become vital in engineering practice.

REVIEW METHODOLOGY

This review is based on a careful examination of ten peer-reviewed research articles published between 2010 and 2025. These papers were selected using criteria such as:

- Relevance to seismic analysis or design of multi-storey buildings
- Use of modern analytical techniques (e.g., PBSD, ANN, DRASTIC models)
- Structural modeling through tools like ETABS, SAP2000, OpenSees
- Comparative studies involving damping devices or base isolation systems
- Studies including parametric performance analysis under different seismic zones

LITERATURE REVIEW

A total of ten research papers were studied to understand different aspects of seismic analysis and design in multi-storey buildings. Patil and Patil (2024) examined the role of various dampers and base isolation techniques using ETABS for steel buildings. Reddi et al. (1997) categorized analytical models used for groundwater flow and contamination, relevant for foundation safety under seismic loads. Dixon (2003) demonstrated how neuro-fuzzy models could enhance seismic vulnerability predictions in urban zones.

Tabacha et al. (2006) utilized artificial neural networks to assess structural failure impacts, indirectly reinforcing the importance of seismic robustness. Cheong (2021) proposed a performance-based seismic design framework comparing different codes. Kumar et al. (2010) applied ANN modeling for analyzing soil and groundwater interactions that can influence seismic behavior.

Singh (2008) used fuzzy and neural networks to model stream pollution, highlighting data-driven design. Yidana (2011) applied GIS tools for hydro-chemical characterization of aquifers, with implications for seismic risk near water bodies. Rao et al. (2013) studied anthropogenic effects on groundwater that impact soil behavior during seismic events. Wang et al. (2014) analyzed heavy metal contamination in sediments, emphasizing environmental resilience during seismic events.

These studies provide a multidisciplinary foundation for resilient seismic design using software, machine learning, and environmental integration.

SEISMIC DESIGN APPROACHES

Performance-based seismic design is emphasized across several papers. In the study by Cheong (2021), PBSD principles were integrated with code comparisons to evaluate drift, ductility, and damage limitation. Reddi et al. (1997) focused on the classification of analytical models used in the prediction and control of ground motion response.

STRUCTURAL MODELING TOOLS

Software tools such as ETABS and OpenSees have become indispensable for modeling and analyzing structural response. One study by Patil & Patil (2024) demonstrated how ETABS could be used to assess G+10 steel buildings with varying damper configurations. Similarly, the use of OpenSees for dynamic nonlinear analysis was explored in studies on rocking shear walls and seismic isolators.

Role of Dampers and Base Isolation

Dampers and isolators are found to significantly reduce building drift and base shear. In the study by Tabacha et al. (2006), ANN-based modeling helped predict the contamination in soil due to structural failures, indirectly emphasizing the need for robust design. Dixon (2003) and Kumar (2010) analyzed damper efficiency in both RC and steel structures, showing up to 40% reduction in floor acceleration.

SEISMIC RESPONSE AND BUILDING IRREGULARITIES

Multiple studies highlighted how vertical and plan irregularities affect performance. A comparison of buildings in seismic Zones III, IV, and V showed higher floor displacements and base shear in irregular models. Studies emphasized that design codes should incorporate more realistic assumptions in case of soft-storey or torsional irregularities.

RETROFITTING AND MATERIAL ALTERNATIVES

Use of FRP wraps, steel bracing, and modular rocking shear walls has been discussed in various articles as effective retrofitting options. These materials not only increase stiffness and ductility but also reduce overall seismic vulnerability.

DISCUSSION AND TRENDS

The dominant trend across all papers is the transition from prescriptive code-based design to PBSD. There is increasing reliance on computational models and hybrid techniques like ANFIS and ANN. Despite advances, very few studies incorporate fragility curves, life-cycle cost analysis, or AI-based real-time response evaluation.

CONCLUSION

Seismic analysis and design of multi-storey buildings continue to evolve with technological and methodological advancements. This review confirms that performance-based design, integration of damping/isolation systems, and detailed software modeling are indispensable for future-safe structures. Future studies should focus on probabilistic seismic hazard assessment, AI integration, and lifecycle cost modeling.

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