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Seismic Vulnerability Analysis of Different Building Slabs in Varied Soil Conditions with and Without Bracing

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Abstract

The escalating human and economic losses caused by natural disasters in the past decades have raised concerns among researchers regarding the need to re-evaluate existing buildings to minimize casualties. In light of the vulnerability exposed by previous earthquakes, the seismic assessment of structures has become imperative, with particular emphasis on post-earthquake evaluations. This research project aims to propose an approach for evaluating the seismic vulnerability of buildings. Seismic fragility curves will be developed through nonlinear dynamic analysis, taking into account appropriate failure mechanisms. These fragility curves serve as essential tools for decision-makers in assessing seismic losses, both in pre-earthquake disaster planning and post-earthquake recovery programs. Fragility curves indicate the probability of failure as a function of peak ground acceleration. The primary objective of seismic fragility assessment is to estimate the likelihood of exceeding a specific damage level in a building due to seismic hazards, thereby predicting its vulnerability. In this study, seismic fragility analysis will be conducted on three different types of buildings, each having different slab designs and situated in diverse soil conditions.

***Key Words*: seismic analysis, Bracing, Flat slab, Grid slab, Fragility Curve, Pushover Analysis, Soft soil, medium soil, Hard soil.**

1. INTRODUCTION

In recent years, the world has witnessed a surge in natural disasters, particularly earthquakes, resulting in significant human and economic losses. These catastrophic events have underscored the urgent need for re-evaluating existing structures to enhance their resilience and minimize casualties. As a response to the escalating vulnerability exposed by past earthquakes, seismic assessment of buildings has become a paramount concern. This research project delves into the critical realm of seismic vulnerability analysis, with a focus on post-earthquake evaluations, aiming to provide a comprehensive approach to assessing the seismic vulnerability of buildings. This assessment involves the development of seismic fragility curves through nonlinear dynamic analysis, incorporating relevant failure mechanisms. These fragility curves serve as indispensable tools for decision-makers, aiding in the assessment of seismic losses, both in pre-earthquake disaster planning and post-earthquake recovery programs. By quantifying the probability of failure as a function of peak ground acceleration, fragility curves facilitate the estimation of the likelihood of structures exceeding specific damage levels due to seismic hazards, effectively predicting their vulnerability.

The primary objective of this study is to conduct seismic fragility analysis on three distinct types of buildings, each characterized by different slab designs, and situated in varied soil conditions. This multifaceted investigation encompasses a wide range of structural scenarios, providing valuable insights into the interplay between building configurations, soil characteristics, and seismic vulnerability. By comprehensively examining these factors, this research contributes to a deeper understanding of the complex dynamics that govern the response of buildings to seismic events, enabling us to develop more effective strategies for mitigating the impact of earthquakes on our built environment.

Over the past few decades, India has borne the brunt of several devastating earthquakes, among which stand out the 2001 Bhuj earthquake, the 2011 Sikkim earthquake, and the 2015 Nepal earthquake. These seismic events have exposed the vulnerability of many reinforced concrete (RC) structures, resulting in extensive structural damage and tragic loss of life due to collapsing buildings. Consequently, the primary source of seismic losses during these earthquakes has been building damage.

The occurrence of these earthquakes has underscored the critical importance of assessing and evaluating the structural integrity of various building types in our country, more so than ever before. Figure 1 vividly depicts a building structure that succumbed to the forces of an earthquake. To avert such catastrophic collapses in the future, it is imperative to accurately determine seismic vulnerability.

Figure 1 Failure in the 2001 Bhuj earthquake

2. LITERATURE REVIEW

[1] Adhikari, R., Rupakhety, R., Giri, P., Baruwal, R., Subedi, R., Gautam, R. and Gautam, D., 2022. Seismic fragility analysis of low-rise RC buildings with brick infills in high seismic regions with alluvial deposits. *Buildings*, *12*(1), p.72

The introduction adequately sets the stage by presenting the background, importance, and scope of the research. The authors effectively highlight the significance of studying seismic fragility in the specified context, making a compelling case for the research.

The literature review is comprehensive, demonstrating a thorough understanding of the existing body of knowledge on seismic vulnerability and fragility analysis. It provides a solid foundation for the current study by identifying gaps and justifying the need for further investigation.

The paper outlines the methodology used for seismic fragility analysis, detailing the criteria for building selection, data collection, and analytical techniques. The clarity in explaining the research methodology enhances the credibility of the study and facilitates potential replication.

The presentation of results is clear, with appropriate visuals such as graphs, charts, and tables to support the findings. The discussion interprets the results effectively, linking them back to the research objectives and providing insights into the implications of the findings. However, it would be beneficial to include a more detailed comparison with existing studies or standards for context.

[2] Pisode, M., Surana, M., Haldar, P. and Singh, Y., 2017. Comparative assessment of seismic fragility of RC frame buildings designed for older and revised Indian standards. *ISET J Earthq Technol*, *54*(1), pp.17-29.

The introduction aptly sets the context by highlighting the importance of seismic fragility assessment and the significance of comparing buildings designed under older and revised Indian standards. The research objectives are clearly stated, creating a well-defined framework for the study.

The literature review demonstrates a robust understanding of the historical context of seismic design standards in India. The incorporation of relevant studies and the identification of gaps in the existing knowledge contribute to the paper's overall strength. It would be beneficial to include recent developments or changes in seismic design philosophy globally for a more comprehensive perspective.

The paper outlines the methodology clearly and concisely, detailing the selection criteria for buildings, data collection processes, and the specific seismic fragility analysis techniques employed. The transparency in describing the methodology enhances the credibility of the research.

The presentation of results is commendable, with appropriate visual aids to support the findings. The discussion effectively interprets the results, drawing connections between the seismic performance of buildings designed under older and revised standards. The paper excels in elucidating the practical implications of the findings for seismic resilience in India.

[3] SAI, K.S., RAMA, R.G. and MARKANDEYA, R.P., 2016. Seismic fragility analysis of regular and setback RCC frames-A few hypothetical case studies

The introduction establishes the context by emphasizing the relevance of comparing regular and setback RCC frames in seismic vulnerability. The research objectives are clearly stated, setting a clear direction for the study. It would be beneficial to provide a brief overview of the motivation behind choosing setback frames and their prevalence in construction.

The literature review provides sufficient background on the seismic behavior of regular and setback RCC frames. It would be valuable to include more recent studies or advancements in the understanding of seismic performance, especially those related to setback structures. This could help anchor the study in the current state of knowledge.

The paper outlines the methodology effectively, detailing the selection criteria for frames, the seismic fragility analysis approach, and the key parameters considered. The clarity in explaining the methodology enhances the reproducibility of the study and builds confidence in the research.

The presentation of results is clear, with appropriate visual aids supporting the findings. The discussion interprets the results effectively, drawing comparisons between regular and setback RCC frames. However, the paper could benefit from a

more in-depth analysis of the reasons behind observed differences in seismic fragility, possibly exploring the impact of setback configurations on structural behavior.

[4] Seismic Fragility Analysis of Regular and Vertical Setback R/C Frame Buildings; Authors: Pavani Taliakula, Dr. V.A. Prasad

The introduction adequately establishes the context and significance of comparing regular and vertical setback R/C frame buildings in seismic vulnerability. The research objectives are clearly articulated, providing a solid foundation for the study. It would be beneficial to briefly touch upon the prevalence of vertical setbacks in real-world construction and their potential advantages or challenges.

The literature review provides a reasonable background on the seismic behavior of R/C frames, but it could benefit from more recent studies or advancements in understanding seismic performance, especially those related to vertical setback structures. Including such information would strengthen the connection between the study and the current state of knowledge.

The paper effectively outlines the methodology, detailing the criteria for building selection, seismic fragility analysis approach, and key parameters considered. The clarity in describing the methodology enhances the reproducibility of the study and builds confidence in the research.

The presentation of results is clear, with appropriate visual aids supporting the findings. The discussion interprets the results effectively, drawing comparisons between regular and vertical setback R/C frame buildings. However, the paper could benefit from a deeper analysis of the observed differences in seismic fragility, possibly exploring the impact of vertical setback configurations on structural behavior.

[5] Comparative Study on Seismic Fragility Analysis of RCC Building in Different Soil Conditions; Authors: Rajdeep V. Dangar, Prof. B. R. Patel

The introduction sets the context by emphasizing the significance of studying seismic fragility in the context of different soil conditions. The research objectives are clearly stated, creating a well-defined framework for the study. It would be beneficial to include a brief rationale for the selection of specific soil conditions and their relevance to real-world scenarios.

The literature review provides a reasonable background on the seismic behavior of buildings in different soil conditions. However, to enhance the depth of the review, it would be valuable to incorporate recent studies or advancements related to the interaction between soil characteristics and the seismic response of structures.

The paper outlines the methodology effectively, detailing the criteria for selecting different soil conditions, the seismic fragility analysis approach, and the key parameters considered. The clarity in describing the methodology enhances the reproducibility of the study and builds confidence in the research.

The presentation of results is clear, with appropriate visual aids supporting the findings. The discussion interprets the results effectively, drawing comparisons between seismic fragility in different soil conditions. To add depth to the analysis, the paper could explore how specific soil characteristics contribute to variations in fragility.

3. Objective of review

Our objectives in conducting this analysis are as follows:

- Evaluate the Probability of Structure Collapse: Assess the probability of structure collapse based on peak ground motion.
- Determine the Effect on Conventional and Flat Slab Structures: Evaluate the difference in the effect of earthquakes on conventional and flat slab structures, considering various soil conditions.
- Prepare Fragility Curves: Create fragility curves for different soil conditions to understand the relationship between ground acceleration and the probability of damage.
- Compare Fragility Curves: Compare the fragility curves of conventional and flat slab structures to identify variations in vulnerability.

4. CONCLUSIONS

The conclusion succinctly summarizes the main findings and their implications. It also suggests avenues for future research, contributing to the ongoing discourse in the field. The conclusion reinforces the significance of the study and its potential impact on building design and construction practices in seismic-prone areas.

The conclusion provides a succinct summary of the key findings and their implications for seismic design practices in India. The identification of limitations and suggestions for future research adds depth to the conclusion. The paper successfully reinforces the importance of adopting updated seismic design standards for enhanced structural performance.

The conclusion summarizes the key findings and their implications for seismic design considerations, emphasizing the significance of setback configurations. It would be beneficial to provide concrete recommendations for design improvements or modifications based on the observed differences in fragility between regular and setback frames.

The conclusion provides a concise summary of the key findings and their implications for seismic design considerations, emphasizing the significance of vertical setbacks. It would be valuable to offer specific recommendations or insights for designers and engineers based on the observed differences in fragility between regular and vertical setback frames.

The conclusion provides a concise summary of the key findings and their implications for seismic design considerations, emphasizing the influence of soil conditions. It would be beneficial to offer specific recommendations or insights for designers and engineers based on the observed differences in fragility among various soil types.

REFERENCES

[1] Adhikari, R., Rupakhety, R., Giri, P., Baruwal, R., Subedi, R., Gautam, R. and Gautam, D., 2022. Seismic fragility analysis of low-rise RC buildings with brick infills in high seismic region with alluvial deposits. *Buildings*, *12*(1), p.72

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[4] Seismic Fragility Analysis of Regular and Vertical Setback R/C Frame Buildings; Authors: Pavani Taliakula, Dr. V.A. Prasad

[5] Comparative Study on Seismic Fragility Analysis of RCC Building in Different Soil Conditions; Authors: Rajdeep V. Dangar, Prof. B. R. Patel