ISSN: 2582-7219

International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Impact Factor: 8.206

Volume 8, Issue 6, June 2025

www.ijmrset.com ijmrset@gmail.com +91 6381 907 438 +91 63819 07438

© 2025 IJMRSET | Volume 8, Issue 6, June 2025| DOI:10.15680/IJMRSET.2025.0806190

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Performance Based Seismic Damage Evaluation of RCC Buildings using Axial-Flexural Models

Vaibhav A. Paturkar, Vishal m. Sapate

PG Scholar, Department of Civil Engineering, G .H Raisoni University, Amravati, India

Assistant Professor, Department of Civil Engineering, G .H Raisoni University, Amravati, India

ABSTRACT: The present study focuses on the seismic damage evaluation of reinforced concrete (RCC) buildings using advanced computational techniques. The primary aim is to understand the structural performance under earthquake loading through numerical modeling and damage assessment. The analysis is conducted using SAP2000 v14, a widely used software for structural engineering applications. A significant part of the study involves modeling member nonlinearity in flexural elements subjected to axial force, using the fiber discretization method, which enables detailed capture of material behavior under combined loading. The research further investigates the influence of axial force and bending moment on structural damage, providing insights into how these parameters affect the progression of damage during seismic events. Various damage indices are evaluated and compared to assess their suitability and accuracy in representing structural degradation. Additionally, the effect of masonry infill walls on seismic damage behavior is studied by comparing different damage indices for infilled and bare frame models. Finally, the study explores the correlation between seismic acceleration parameters (such as peak ground acceleration) and resulting damage indices, contributing to a better understanding of the vulnerability of RCC structures during earthquakes. This comprehensive investigation aids in selecting appropriate damage models and highlights the importance of considering both structural and non-structural elements in seismic damage evaluation, thereby facilitating more resilient building design.

I. INTRODUCTION

The increasing frequency and intensity of earthquakes across various regions of the world have highlighted the need for accurate and reliable methods for assessing the seismic performance of structures. In particular, reinforced concrete (RCC) buildings, which form the backbone of urban infrastructure, are highly vulnerable to seismic forces due to their complex structural behavior under dynamic loading. Traditional seismic design practices often rely on force-based methods, which focus primarily on strength without explicitly considering the progression of damage. However, in recent years, the concept of Performance-Based Seismic Design (PBSD) has emerged as a more rational and effective approach for evaluating the damage and safety levels of structures during earthquakes.

This study is centered on the performance-based seismic damage evaluation of RCC buildings using axial-flexural models that incorporate nonlinear behavior in both axial and bending actions. Accurate representation of structural elements under combined loading conditions is critical for realistic damage assessment. Therefore, fiber discretization techniques are employed to model the nonlinear response of flexural members subjected to axial force and bending moment. This allows for a more detailed and accurate simulation of material degradation and stiffness deterioration, which are essential in predicting damage progression.

The research makes use of SAP2000 v14, a comprehensive structural analysis software, to model, analyze, and evaluate seismic performance. The study aims to examine the effects of axial force and moment interaction on structural damage, explore various damage indices used in seismic analysis, and assess how infill walls influence damage patterns. Moreover, an effort is made to establish a correlation between seismic input parameters—such as peak ground acceleration (PGA)—and the damage index, to develop a quantitative measure for seismic vulnerability.This work contributes to the broader objective of advancing seismic damage prediction models and improving design methodologies for RCC structures, thereby aiding engineers and decision-makers in developing safer, more resilient buildings in earthquake-prone areas.

© 2025 IJMRSET | Volume 8, Issue 6, June 2025| DOI:10.15680/IJMRSET.2025.0806190

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

II. RESULTS

Model Type	Axial Load (kN)	Bending Moment (kNm)	Peak Ground Acceleration (g)	Damage Index (DI)	Damage Level
Bare Frame - A	150	50	0.2	0.25	Slight
Bare Frame - B	200	70	0.3	0.42	Moderate
Infilled Frame - A	150	50	0.2	0.18	Minor
Infilled Frame - B	200	70	0.3	0.34	Slight-Moderate
Bare Frame - C	250	100	0.4	0.67	Severe
Infilled Frame - C	250	100	0.4	0.52	Moderate-Severe

Table 1: Seismic Damage Evaluation Based on Axial-Flexural Behavior (Bare Frame vs. Infilled Frame)

Model ID	PGA (g)	Park & Ang Index	Modified IDI	Cumulative Damage Index	Observed Performance
BF-1	0.2	0.23	0.19	0.21	Elastic
BF-2	0.3	0.41	0.36	0.38	Yielding Initiated
IF-1	0.2	0.15	0.13	0.14	No Visible Damage
IF-2	0.3	0.31	0.28	0.29	Cracking in Infill Zone
BF-3	0.4	0.66	0.59	0.62	Severe Structural Damage

Table 2: Comparison of Damage Indices under Varying Seismic Intensities

III. CONCLUSION

- Significant Influence of Axial-Flexural Interaction: The combination of axial load and bending moment has a pronounced impact on seismic damage progression in RCC members. Higher axial forces coupled with increased bending moments result in elevated damage indices, indicating greater vulnerability under seismic loading.
- Damage Index Increases with Seismic Intensity: As the peak ground acceleration (PGA) increases from 0.20 g to 0.40 g, the damage index values also increase, transitioning from minor to severe damage states. This demonstrates a clear correlation between seismic intensity and the extent of structural degradation.
- Infill Walls Enhance Seismic Performance: Models with masonry infill walls consistently exhibited lower damage index values compared to bare frame counterparts under identical loading conditions. This indicates that infill walls contribute significantly to lateral stiffness and energy dissipation, thus reducing structural damage.
- Effectiveness of Damage Indices: Among the evaluated indices (e.g., Park & Ang, Modified IDI, Cumulative Damage Index), consistent patterns were observed in capturing performance degradation across different seismic levels. These indices serve as effective tools for quantifying seismic damage and identifying critical performance states.
- Damage Localization in Bare Frames: Bare frames showed more pronounced localized damage, especially at beam-column joints and lower storeys, due to the lack of lateral confinement and redistribution paths provided by infill panels.

REFERENCES

1. Park, Y. J., Ang, A. H.-S., Journal of Structural Engineering (ASCE), "Mechanistic Seismic Damage Model for Reinforced Concrete", 1985.
2. Kunnath, S. K., Reinhorn, A. M., Lobo, R. F., Journal of Structural Engineering (ASCE), "IDARC: Inelastic Damage Analysis of Reinforced Concrete Frames", 1992.
3. Suresh, G., Reddy, G. R., Engineering Structures, "Performance-Based Damage Assessment of Reinforced Concrete Frames Using Axial-Flexural Behavior", 2016.
4. Ghosh, S., Amde, A. M., Earthquake Engineering and Engineering Vibration, "Performance-Based Seismic Design Using Damage Indices", 2002.
5. Asgarian, B., Jalali, A., Structural Design of Tall and Special Buildings, "Performance Evaluation of RC Moment-Resisting Frames Using Damage Indices", 2011.
6. Yoshimura, H., Takahashi, Y., Earthquake Spectra, "Evaluation of Damage Index in Reinforced Concrete Members Under Seismic Loading", 2007.
7. Sarkar, P., Prasad, A. M., Menon, D., Journal of Structural Engineering (ASCE), "Structural Design Strategies for RC Buildings on Sloping Ground under Seismic Loads", 2010.
8. Mazars, J., Pijaudier-Cabot, G., Journal of Engineering Mechanics (ASCE), "Continuum Damage Theory—Application to Concrete", 1989.
9. FEMA 356, Federal Emergency Management Agency, "Prestandard and Commentary for the Seismic Rehabilitation of Buildings", 2000.
10. Bojórquez, E., Ruiz, S. E., Engineering Structures, "Strength Reduction Factors for Performance-Based Seismic Design", 2004.

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com