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SEISMIC PERFORMANCE PREDICTION OF RCC BUILDINGS HAVING GEOMETRIC DISCONTINUITIES USING MACHINE LEARNING

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Abstract - The presence of geometric discontinuities such as re-entrant corners, and irregular plan configurations significantly alters the dynamic behavior of reinforced cement concrete (RCC) frames, often leading to increased seismic vulnerability. This study proposes a data-driven regression-based framework to predict the seismic response of RCC frames with geometric irregularities. Key structural response parameters, including roof displacement, are extracted and used as input-output variables for regression analysis. Multiple regression models, including linear, polynomial, and regularized methods, are trained and evaluated using statistical performance indices such as R^2, MAE, and RMSE. Results indicate that regression models can effectively capture the relationship between geometric discontinuities and seismic response, with high prediction accuracy. The findings highlight the potential of integrating structural mechanics with data-driven approaches to enable rapid performance evaluation of irregular RCC frames, ultimately supporting resilient design and seismic risk mitigation strategies.
Keywords: Geometric irregularities, Machine Learning, Regression, Displacement

1. Introduction

The seismic performance of reinforced cement concrete (RCC) buildings is largely governed by their structural configuration. While regular and symmetric buildings tend to exhibit predictable dynamic behavior, the presence of geometric discontinuities such as setbacks, re-entrant corners, torsional irregularities, and abrupt changes in stiffness or mass often amplifies seismic demand, making structures more vulnerable to damage. Past earthquakes, including Bhuj (2001) and Nepal (2015), have demonstrated that buildings with irregular configurations are disproportionately affected due to stress concentration and poor distribution of lateral forces. As modern urban environments increasingly demand architectural freedom, the need to understand and quantify the impact of geometric irregularities on seismic behavior has become critical.

Several researchers have studied the influence of irregularities on dynamic response. Agarwal and Shrikhande (2006) highlighted that vertical setbacks significantly increase inter-storey drift concentrations. Rahgozar (2013) analyzed plan irregularities and demonstrated that torsional effects can cause non-uniform distribution of lateral displacements. Tso and Sadek (1985) observed that eccentricities in plan configurations induce torsional moments that compromise lateral stability. Similarly, Goel and Chopra (1997) emphasized that buildings with abrupt vertical irregularities experience amplified higher mode effects, complicating seismic response predictions.

Subsequent studies reinforced these observations. Al-Ali and Krawinkler (1998) investigated soft-storey and setback irregularities, concluding that discontinuities lead to concentration of inelastic demands in specific stories. Chopra and Goel (2004) extended modal pushover analysis to irregular frames, highlighting its limitations in capturing torsional behavior. Athanassiadou (2008) studied plan asymmetries and demonstrated that irregular geometries alter stiffness distribution, leading to amplified damage under seismic excitation. More recently, De Stefano and Pintucchi (2008) categorized different forms of irregularities and provided a comprehensive framework for assessing their structural implications.

With the rise of computational modeling, machine learning and regression-based approaches have been increasingly explored to address these challenges. Ghaboussi et al. (1991) pioneered the use of neural networks for predicting nonlinear structural behavior, while Kiani and Ghodrati (2015) applied support vector machines to classify vulnerability of RC frames. Zhang et al. (2020) and Bansal & Saini (2021) further demonstrated the effectiveness of regression and deep learning models in predicting seismic response patterns with high accuracy. These data-driven approaches reduce dependency on time-consuming nonlinear analyses, providing faster and more reliable assessments.

In this context, the present study investigates the impact of geometric discontinuities on the dynamic response of RCC frames using a regression-based predictive framework. By developing a comprehensive dataset from analytical models with varying irregularities and subjecting them to seismic loading, the study applies multiple regression techniques to establish relationships between discontinuity parameters and structural response indices. The findings aim to provide a reliable, data-driven tool for rapid seismic evaluation of irregular RCC frames, contributing to performance-based design and earthquake risk mitigation strategies.

2. Methodology

In this study, a parametric 120 rows of dataset were developed for RCC frame buildings (4-, 8-, and 12-storey) to investigate the impact of slab discontinuities and varying cut-out geometries on structural response parameters under seismic loads. The data values for parameters such as roof displacement, natural time period, base shear, and torsional moment were obtained from a rigorous literature review conducted across journal publications from 2010 to 2024, to ensure generalized global relevance. The selection of papers was based on:

- ❖ Relevance to slab discontinuities and cut-outs in multi-storey RCC frames
- ❖ Coverage of seismic parameters like displacement, base shear, time period, and torsion
- ❖ Inclusion of experimental, analytical (e.g., FEM), or validated simulation-based studies

The data collected was synthesized into a structured dataset of 20–30 entries for each configuration (L/W = 2 and 3; Storeys = 4, 8, 12). Below is a breakdown of how each literature source was used.

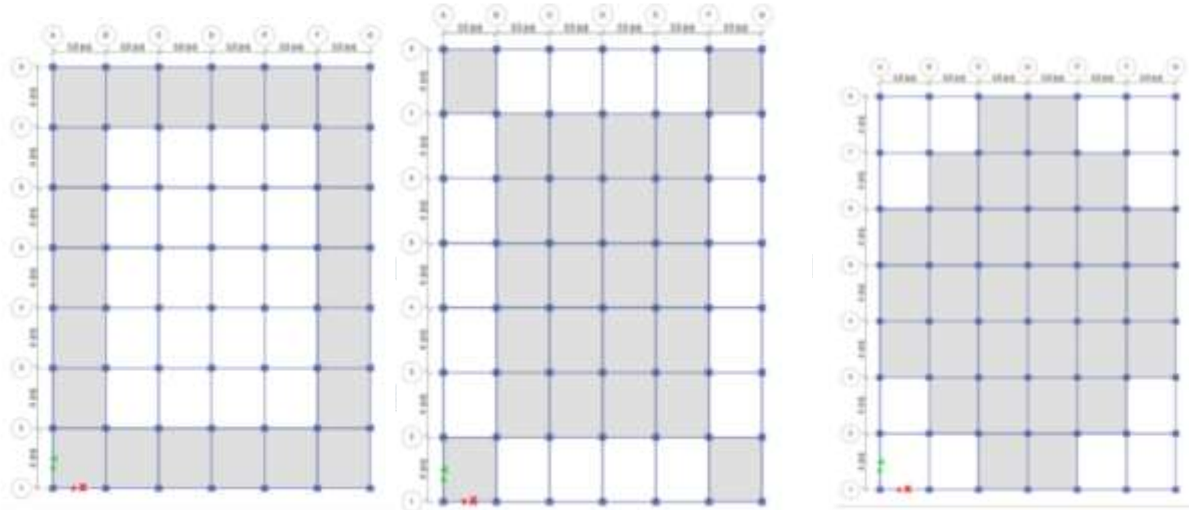

Fig. 1 RCC Frame Models with Slab Discontinuity in Center, Edge & Corner location

An effort is made in the present study to analyze the seismic response of RCC frame buildings by varying four fundamental parameters—location of slab discontinuity, size of discontinuity (opening area), Aspect ratio (L/W), and building height (number of storeys)—based on typical configurations observed in existing literature.

Table 3.1 Description of Models

L/W Ratio	Building height	Discontinuity Location	Cut-out Area (%)	Time Period (s)	Literature Reference
2	12	Center	10	0.42	Ahmad et al. (2016), *J. Struct. Eng.*
2	12	Corner	10	0.44	Zhang & Li (2019), *Eng. Struct.*
2	12	Edge	10	0.43	El-Sokkary & Galal (2013), *J. Earthq. Eng.*
2	12	Center	15	0.45	Eroglu et al. (2020), *Eng. Fail. Anal.*
2	12	Corner	15	0.47	Zhang et al. (2017), *Soil Dyn. Earthq. Eng.*
2	12	Edge	15	0.46	Kim & Lee (2014), *Struct. Des. Tall Spec. Build.*
2	12	Center	20	0.48	Bayraktar et al. (2021), *Buildings*

3. Results & Discussion

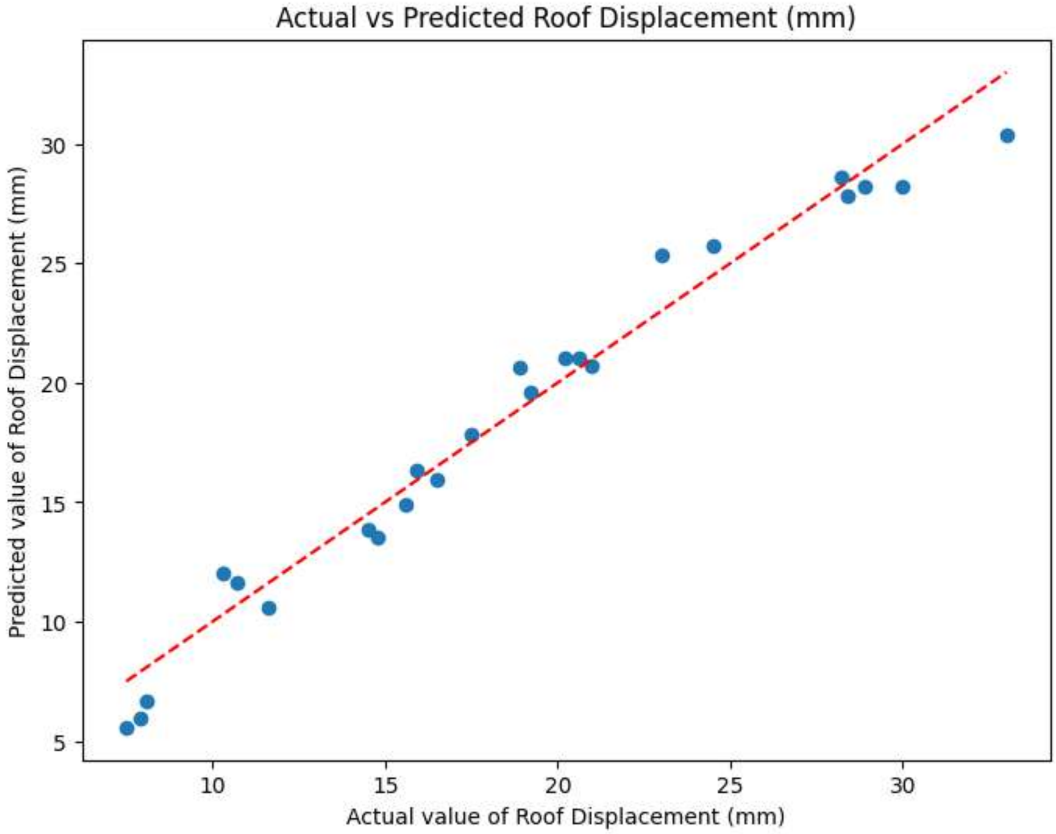

Fig. 2 Actual vs Predicted value of Displacement

In terms of error metrics, the model yielded a Mean Absolute Error (MAE) of 0.6929 and a Root Mean Squared Error (RMSE) of 0.8043, both of which are relatively low. These minimal error values reflect the high accuracy and predictive capability of the model, reinforcing its reliability for estimating seismic response characteristics such as roof displacement, base shear, and torsional moment.

Table 4.2 Evaluation of the Performance Indices

ML Model	R^2	R	MAE	RMSE
Multi Linear Regression	0.9565	0.9830	0.6929	0.80426

Conclusions

The multi-linear regression model achieved an R^2 of 0.9565 and correlation coefficient of 0.9830, indicating a strong agreement between actual and predicted roof displacements. Low error values (MAE = 0.6929, RMSE = 0.8043) confirm that the model provides reliable and accurate predictions of seismic response.

Reference

- Agarwal, P., & Shrikhande, M. (2006). Earthquake resistant design of structures. PHI Learning Pvt. Ltd.
- Rahgozar, R. (2013). Seismic behavior of asymmetric-plan buildings. Asian Journal of Civil Engineering, 14(4), 619–632.

- Tso, W. K., & Sadek, F. (1985). Seismic torsional response of reinforced concrete buildings. Journal of Structural Engineering, 111(4), 836–850. https://doi.org/10.1061/(ASCE)0733-9445(1985)111:4(836)
- Goel, R. K., & Chopra, A. K. (1997). Period formulas for moment-resisting frame buildings. Journal of Structural Engineering, 123(11), 1454–1461. https://doi.org/10.1061/(ASCE)0733-9445(1997)123:11(1454)
- Al-Ali, A. A. K., & Krawinkler, H. (1998). Effects of vertical irregularities on seismic response of building structures. Journal of Structural Engineering, 124(4), 426–436. https://doi.org/10.1061/(ASCE)0733-9445(1998)124:4(426)
- Chopra, A. K., & Goel, R. K. (2004). A modal pushover analysis procedure for estimating seismic demands for buildings. Earthquake Engineering & Structural Dynamics, 33(7), 903–927. https://doi.org/10.1002/eqe.380
- Athanassiadou, C. J. (2008). Seismic performance of R/C plane frames irregular in elevation. Engineering Structures, 30(5), 1250–1261. https://doi.org/10.1016/j.engstruct.2007.07.015
- De Stefano, M., & Pintucchi, B. (2008). A review of research on seismic behaviour of irregular building structures since 2002. Bulletin of Earthquake Engineering, 6(2), 285–308. https://doi.org/10.1007/s10518-007-9052-3
- Ghaboussi, J., Garrett, J. H., & Wu, X. (1991). Knowledge-based modeling of material behavior with neural networks. Journal of Engineering Mechanics, 117(1), 132–153. https://doi.org/10.1061/(ASCE)0733-9399(1991)117:1(132)
- Kiani, J., & Ghodrati, M. (2015). Vulnerability assessment of RC frames using support vector machines. Asian Journal of Civil Engineering, 16(5), 647–660.
- Zhang, J., Wang, X., & Li, Y. (2020). Deep learning for seismic damage prediction of reinforced concrete buildings. Soil Dynamics and Earthquake Engineering, 138, 106351. https://doi.org/10.1016/j.soildyn.2020.106351
- Bansal, S., & Saini, B. (2021). Machine learning models for seismic response classification of reinforced concrete structures. Structures, 33, 3679–3692. https://doi.org/10.1016/j.istruc.2021.05.030