iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 Issue: V Month of publication: May 2025

DOI: https://doi.org/10.22214/ijraset.2025.71354

Comparison of Performance of RCC Buildings with Varying Number of Columns and Shear Walls

Rajesh Ranjan Kumar[1], Mirza Aamir Baig[2]
[1]PG Student, Structural Engineering, KK University, Nalanda, Bihar
[2]Associate Professor, Department of Civil Engineering, KK University, Nalanda, Bihar

Abstract: As the frequency and intensity of natural hazards like earthquakes and cyclones increase, the demand for resilient and efficient high-rise buildings continues to grow. In these tall structures, seismic forces scale with the mass of the building, necessitating stronger and often heavier structural components. This presents a fundamental challenge for structural engineers: to strike a balance between strength and flexibility—ensuring safety without compromising cost-effectiveness. To manage seismic energy, the concept of ductility becomes vital. While reinforcement can enhance the ductility of framed structures, this solution becomes less practical with increasing building height. On the other hand, shear walls offer significant lateral stiffness, enhancing stability but often resulting in an overly rigid structural system. This rigidity, if not managed properly, can negatively affect the dynamic performance of the building under lateral loads.This study explores the seismic performance of various reinforced concrete structures across different heights, focusing on configurations with and without shear walls, as well as those featuring coupled shear walls. By analyzing and comparing these systems, we aim to understand their relative advantages and limitations. Numerical results are systematically plotted and tabulated to illustrate their behavioral trends under seismic loading.
Additionally, a real-world case study of a modern high-rise residential building is conducted to validate the findings and provide practical insights. The results highlight how the performance of tall buildings is significantly influenced by lateral forces such as wind and earthquakes.
Therefore, the study emphasizes the importance of determining an optimal ratio of shear walls to columns—a critical design parameter that ensures both stability and ductility in high-rise construction. This balanced approach is key to achieving structural integrity and performance in the face of increasingly demanding environmental conditions.
Keywords: Retrofitting, strengthening, steel, Jacketing, Shear wall

I. INTRODUCTION

From ancient times, towering structures have fascinated humanity—once erected for protection and later as places of worship. But since the 1880s, the purpose behind building tall has evolved dramatically, with high-rises now predominantly serving residential and commercial needs. In bustling city centers, commercial skyscrapers are often driven by the necessity for businesses to cluster together and remain close to key urban hubs. With limited land and high demand, building upward becomes the most viable option. Beyond their practical function, these tall buildings also serve as striking symbols of corporate identity and ambition, often becoming architectural landmarks that define a company's presence. On the residential front, the explosive growth of urban populations has placed immense pressure on limited space. In response, cities have turned to vertical development—transforming skylines and offering a practical solution to meet the ever-increasing demand for housing in densely populated areas.

Shear walls are key vertical structural elements designed to resist a combination of shear forces, bending moments, and axial loads transmitted from other parts of a building through gravity and lateral forces. In multi-story buildings, reinforced concrete components like shear walls and elevator shafts are essential for structural integrity and load distribution. An optimal structural design aligns the building’s center of mass with its centroid, minimizing torsional effects during lateral loading. Shear walls play a critical role in enhancing the stiffness of a structure, making them one of the most efficient solutions for resisting lateral forces such as those caused by wind or seismic activity. As illustrated in Figure 1.1, shear walls come in a variety of cross-sectional shapes—ranging from simple rectangles to more complex configurations like T, L, channel, box, and barbell shapes—each offering different benefits in terms of structural performance and architectural integration. In modern high-rise buildings, these walls often serve dual purposes: structurally, they provide the necessary rigidity to counteract lateral loads; functionally, they may house building services such as elevators within central cores, or serve to subdivide interior spaces. Openings in these walls—such as windows in exterior walls or doors and corridors in interior ones—are inevitable. The size and positioning of these openings are carefully considered, balancing architectural intent with structural requirements to ensure both functionality and safety.

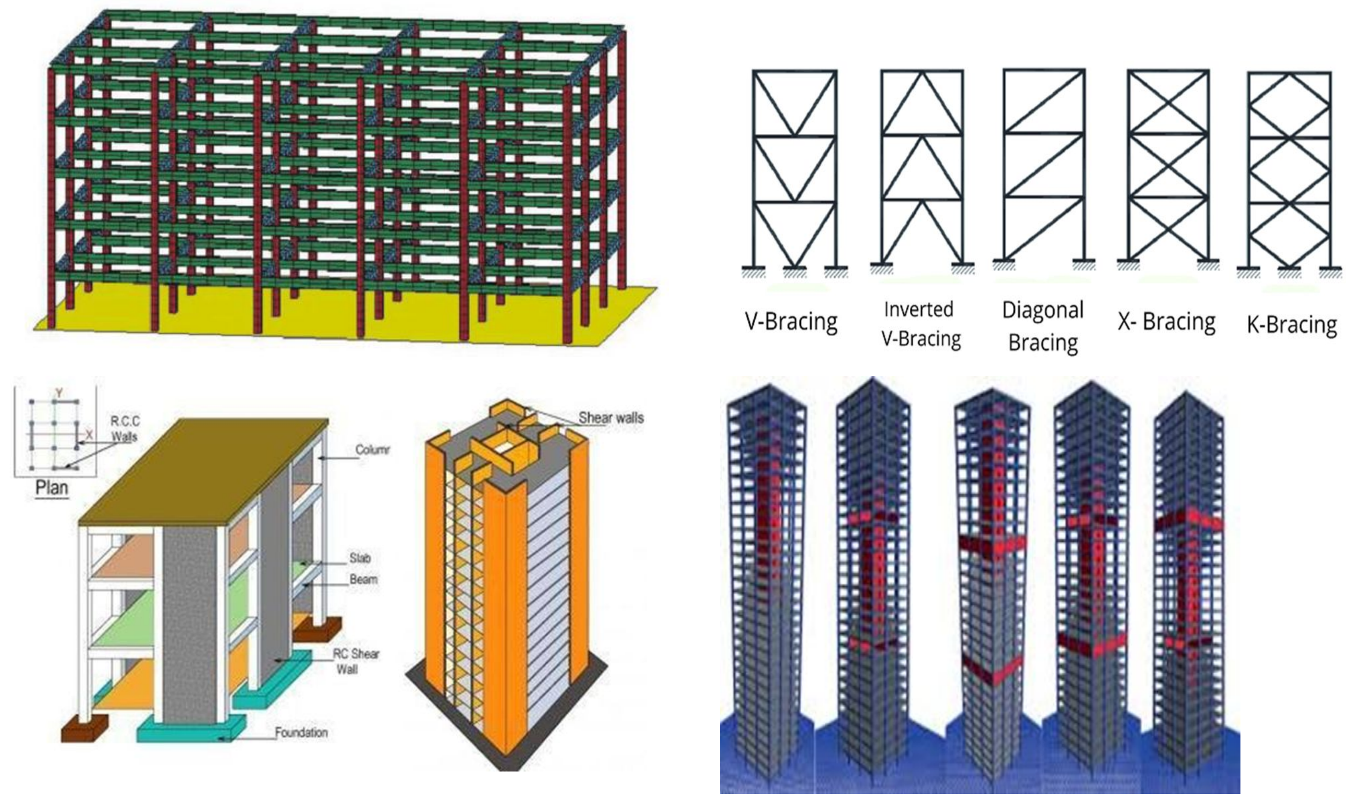


Fig. 1 Commonly used Structural Framing Systems

II. LITERATURE REVIEW

In seismically active areas, the seismic performance of reinforced cement concrete (RCC) buildings is essential because ground motions caused by earthquakes can damage their structural stability. An important factor in determining a building's seismic response is the arrangement and placement of structural components like shear walls and columns. The need for more intricate and vertical structures due to urbanization makes it more crucial than ever to optimize structural systems for seismic resistance. Stiffness, ductility, natural frequency, and dynamic behavior of RCC frames can all change when columns and shear walls are positioned differently. Insufficient or excessive provision of these components, however, may lead to ineffective operation, financial consequences, or disastrous failure during powerful ground motions. This research uses analytical techniques and performance-based evaluation criteria to compare the seismic performance of RCC buildings with different numbers of columns and shear walls. The results can help direct design plans for both new construction and the retrofit of existing buildings in seismically active areas to guarantee sustainability and safety. The improvement of reinforced cement concrete (RCC) buildings' seismic performance through structural optimization has been the subject of several studies during the last few decades. One of the most important factors in determining a structure's capacity to endure seismic forces is the distribution and integration of lateral load-resisting systems, like shear walls, and vertical load-resisting components, like columns.

III.OBJECTIVES

1) To evaluate the structural performance of shear wall systems and reinforced concrete framed buildings under various loading conditions, including gravity, wind, and seismic loads.
2) To investigate the impact of various shear wall configurations (size, shape, and location) on how multi-story buildings respond structurally.
3) To assess and compare shear wall systems with framed structures' overall structural stability and lateral stiffness.
4) To use analytical or finite element modeling to compare the internal force distribution, displacement, and drift in shear wall systems and framed structures.
5) To provide design recommendations based on performance comparison, helping engineers choose appropriate structural systems for specific building requirements.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

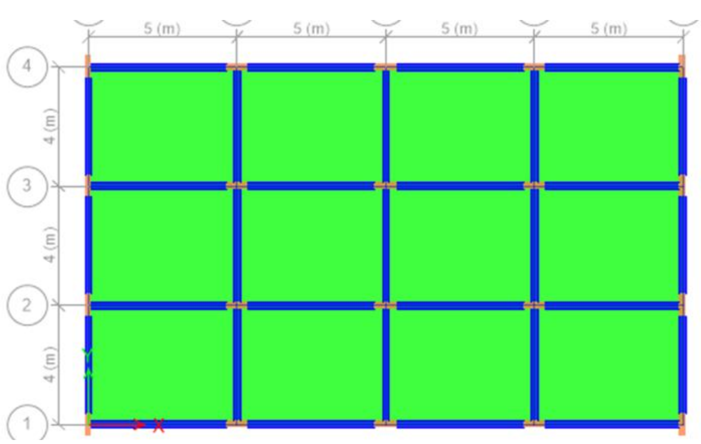
IV. DESIGN BASIS

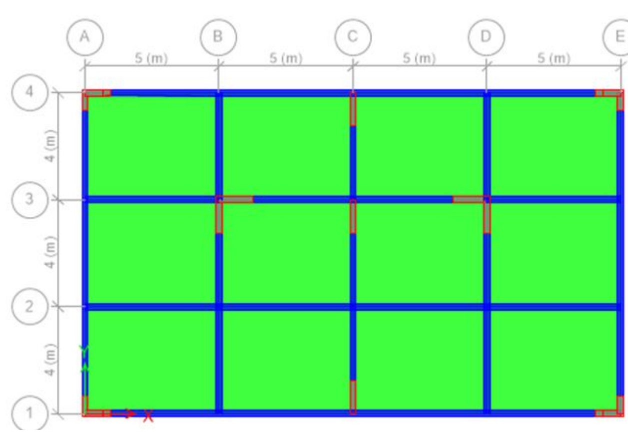
A. *Model Parameters*

Following ten types of models have been considered for analysis. It was attempted to choose models that are representative of actual building types that are being constructed nowadays. Type A is (G+ 10) storeys, Type B is (G+25) storeys, Type C is (G+35) storeys and Type D is (G+50) storeys.

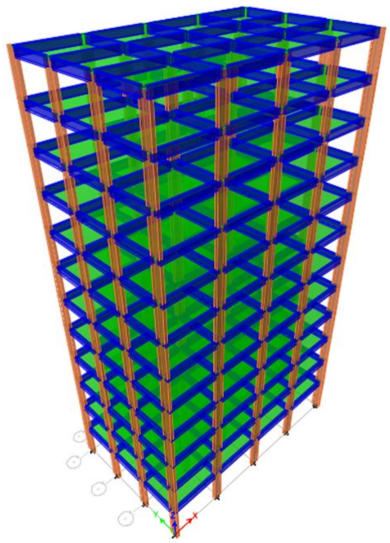
Table 1 Area of columns and Shear walls for considered models

% Area	No. of Columns	No. of Shear Walls	Column Sizes		Shear Wall Sizes		Column Area	Shear Wall Area	Total Area
	n	m	B	D	t	l	A_c	A_s	A_c+A_s
100% Columns	20	0	230	750	230	0	3450000	0	3450000
90% Columns	20	1	230	675	230	1500	3105000	345000	3450000
80% Columns	20	2	230	600	230	1500	2760000	690000	3450000
70% Columns	14	4	230	750	230	1125	2415000	1035000	3450000
60% Columns	12	4	230	750	230	1500	2070000	1380000	3450000
50% Columns	12	4	230	625	230	1875	1725000	1725000	3450000
40% Columns	10	6	230	600	230	1500	1380000	2070000	3450000
30% Columns	6	6	230	750	230	1750	1035000	2415000	3450000
20% Columns	6	8	230	500	230	1500	690000	2760000	3450000
10% Columns	4	10	230	375	230	1350	345000	3105000	3450000
0% Columns	0	12	230	0	230	1250	0	3450000	3450000

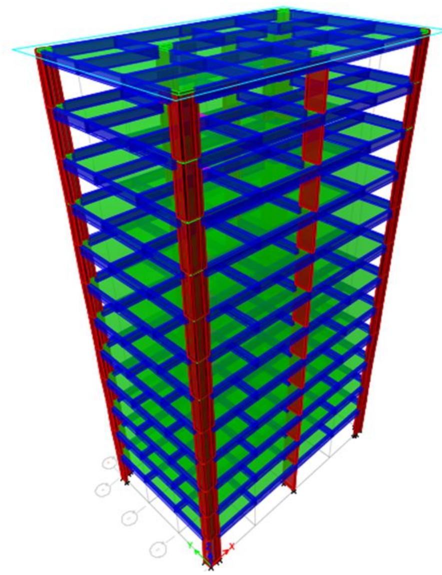




International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com



Frame With 100% Columns



Frame With 0% Columns

Fig. 2 Models considered for the study

V. METHODOLOGY

In order to conduct the current study, various model configurations must be examined in order to obtain seismic responses. Finite element package I is used to obtain results numerically. e. ETABS is used in this study. Following analysis, base shear, drift, and lateral displacement are the results. Finally, the results are compared, interpreted, and validated. Responses for regular configuration models are compared with results found in the literature in order to validate the results. ETABs is a versatile structural analysis tool that can be used for both static and dynamic analysis. A three-dimensional (40-story) model of the structures is used to perform nonlinear dynamic analysis.

VI. ANALYSIS AND DESIGN RESULTS

The structural performance analysis and interpretation of RCC structures with varying numbers of shear walls and columns. The models developed in ETABS are analyzed under both static and dynamic load scenarios to evaluate their behavior with respect to time period, storey drift, base shear, lateral displacement, and overall structural stability, as stated in the previous chapter. The major objective of this chapter is to help shed significant insight on the way various structural configurations, especially those with varying numbers of columns and shear walls, affect a building's response to seismic pressures.

Table 2 Comparison of Lateral Displacement in X Direction for Existing Structure

STOREY DISPLACEMENT (EQX)												
Story	Height	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	0%
Base	0	0	0	0	0	0	0	0	0	0	0	0
Story1	3.6	4.1	4.2	4.8	2.3	2.4	2.8	3.4	4.6	2.3	7.3	3.7
Story2	6.6	9	8.7	9.6	5.9	6.2	7.4	9.4	12.4	6.7	19.7	10.8
Story3	9.6	14	13.4	14.5	9.6	10.4	12.5	16.5	21.4	12.4	33.4	19.6
Story4	12.6	19.1	18	19.3	13.4	14.6	17.9	24	30.9	18.9	47.5	29.2
Story5	15.6	24	22.5	24.1	17.2	18.8	23.3	31.6	40.4	25.7	61.3	39
Story6	18.6	28.7	26.9	28.6	20.8	22.9	28.6	38.9	49.5	32.6	74.5	48.6
Story7	21.6	33.1	31	32.9	24.2	26.7	33.7	45.8	58.1	39.3	86.9	57.7
Story8	24.6	37.1	34.7	36.8	27.3	30.1	38.4	52.1	65.8	45.5	98.1	66
Story9	27.6	40.6	38	40.2	30.1	33.2	42.6	57.7	72.5	51.2	107.7	73.3
Story10	30.6	43.4	40.6	42.9	32.3	35.6	46.2	62.3	78	56.2	115.5	79.4
Story11	33.6	45.3	42.5	44.9	34	37.5	49.2	65.9	82.2	60.6	121.3	84.4
Story12	36.6	46.5	43.6	46	35.2	38.8	51.5	68.7	85.3	64.5	125.4	88.4

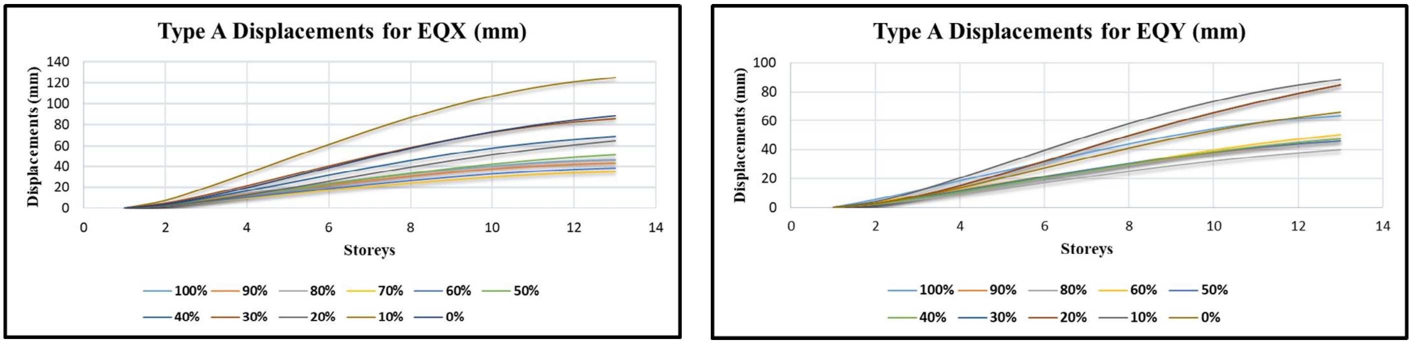


Fig. 3 Storey Vs lateral displacement in Xand Y direction for the Existing Structure

Table 3 Storey Displacement for Type A for SPEC X

STOREY DISPLACEMENT (SPEC X)											
Storey	**Height**	**100%**	**90%**	**80%**	**70%**	**60%**	**50%**	**40%**	**30%**	**20%**	**10%**	**0%**
Base	0	0	0	0	0	0	0	0	0	0	0	0
Story1	3.6	2.2	2.3	2.6	1.4	1.4	1.4	1.5	1	1	2.3	1.4
Story2	6.6	4.7	4.7	5.1	3.5	3.5	3.6	4.2	2.9	2.9	6.2	3.9
Story3	9.6	7.1	7	7.4	5.5	5.7	6	7.1	5.2	5.2	10.2	6.9
Story4	12.6	9.4	9.2	9.7	7.5	7.9	8.3	10.1	7.7	7.7	14.1	10.1
Story5	15.6	11.5	11.1	11.7	9.4	9.9	10.5	12.9	10.3	10.3	17.7	13.1
Story6	18.6	13.4	13	13.5	11.1	11.8	12.6	15.5	12.8	12.8	21.1	16
Story7	21.6	15.1	14.6	15.2	12.7	13.4	14.5	17.8	15.1	15.1	24	18.6
Story8	24.6	16.5	16	16.6	14	14.9	16.2	19.9	17.2	17.2	26.6	21
Story9	27.6	17.8	17.2	17.9	15.2	16.1	17.8	21.7	19.2	19.2	28.8	23
Story10	30.6	18.8	18.2	18.8	16.2	17.2	19.1	23.2	20.9	20.9	30.5	24.7
Story11	33.6	19.5	18.9	19.5	16.9	17.9	20.2	24.4	22.4	22.4	31.8	26.1
Story12	36.6	19.9	19.3	19.9	17.4	18.5	21	25.3	23.8	23.8	32.7	27.2

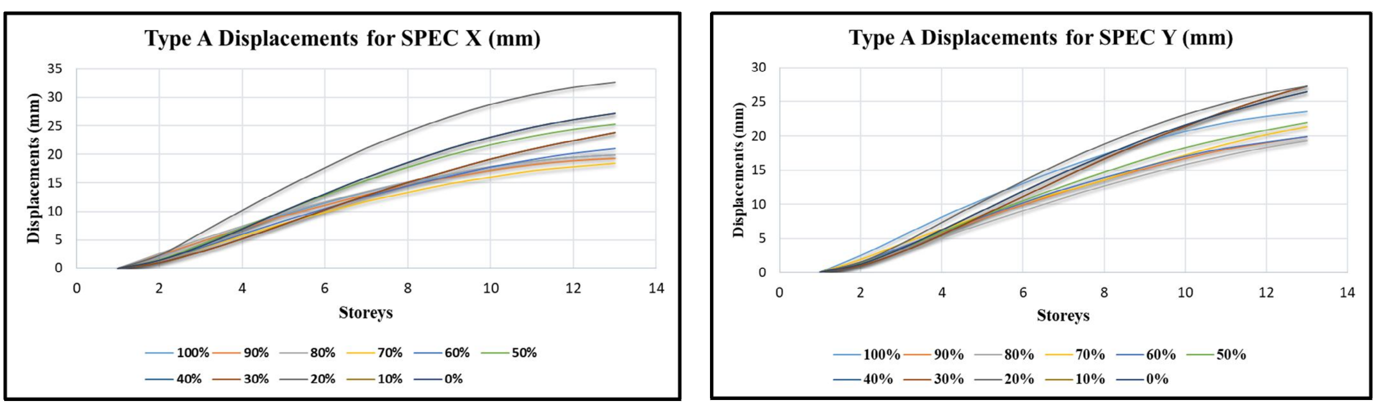


Fig. 4 Storey Vs lateral displacement in Xand Y direction for the Existing Structure

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue V May 2025- Available at www.ijraset.com

Table 4 Time Period of Buildings

TIME PERIOD OF BUILDINGS								
	X DIRECTION				Y DIRECTION			
COLUMN %	TYPE A	TYPE B	TYPE C	TYPE D	TYPE A	TYPE B	TYPE C	TYPE D
HEIGHT	36.6	81.6	111.6	156.6	36.6	81.6	111.6	156.6
DEPTH	20	20	20	20	12	12	12	12
PERIOD USED	1.12	2.04	2.58	3.32	1.12	2.04	2.58	3.32
INFIL PERIOD	0.74	1.64	2.25	3.15	0.95	2.12	2.90	4.07
0%	0.69	0.9	0.99	1.09	0.56	0.74	0.81	0.89
10%	**0.88**	1.13	1.23	1.35	0.7	0.91	1	1.1
20%	**0.8**	1.08	1.19	1.32	0.8	1.08	1.19	1.32
30%	**0.86**	1.11	1.22	1.34	0.67	0.89	0.98	1.09
40%	**0.92**	1.24	1.37	1.52	0.92	1.24	1.37	1.52
50%	**0.85**	1.11	1.22	1.34	0.85	1.11	1.22	1.34
60%	**1.13**	1.52	1.68	1.87	0.92	1.24	1.37	1.52
70%	**0.83**	1.1	1.21	1.33	0	0	0	0
80%	0	0	0	0	**1.13**	1.52	1.68	1.87
90%	0	0	0	0	**1.6**	**2.15**	2.38	2.64

Table 5 Summary of Displacements

LOADS	**TYPE A**			**TYPE B**			**TYPE C**			**TYPE D**		
	MIN	MAX	OPTIMUM	MIN	MAX	OPTIMUM	MIN	MAX	OPTIMUM	MIN	MAX	OPTIMUM
EQX	60%	10%	20%	70%	10%	20%	70%	10%	20%	60%	10%	20%
EQY	80%	10%	0%	50%	10%	0%	50%	10%	30%	50%	10%	0%
SPEC X	70%	20%	50%	70%	10%	20%	60%	10%	30%	60%	10%	40%
SPEC Y	80%	20%	50%	0%	10%	20%	50%	10%	30%	50%	10%	40%
WLX	70%	20%	30%	60%	30%	10%	60%	100%	0%	60%	100%	0%
WLY	80%	20%	0%	40%	100%	20%	40%	100%	10%	0%	100%	30%

VII. CONCLUSIONS

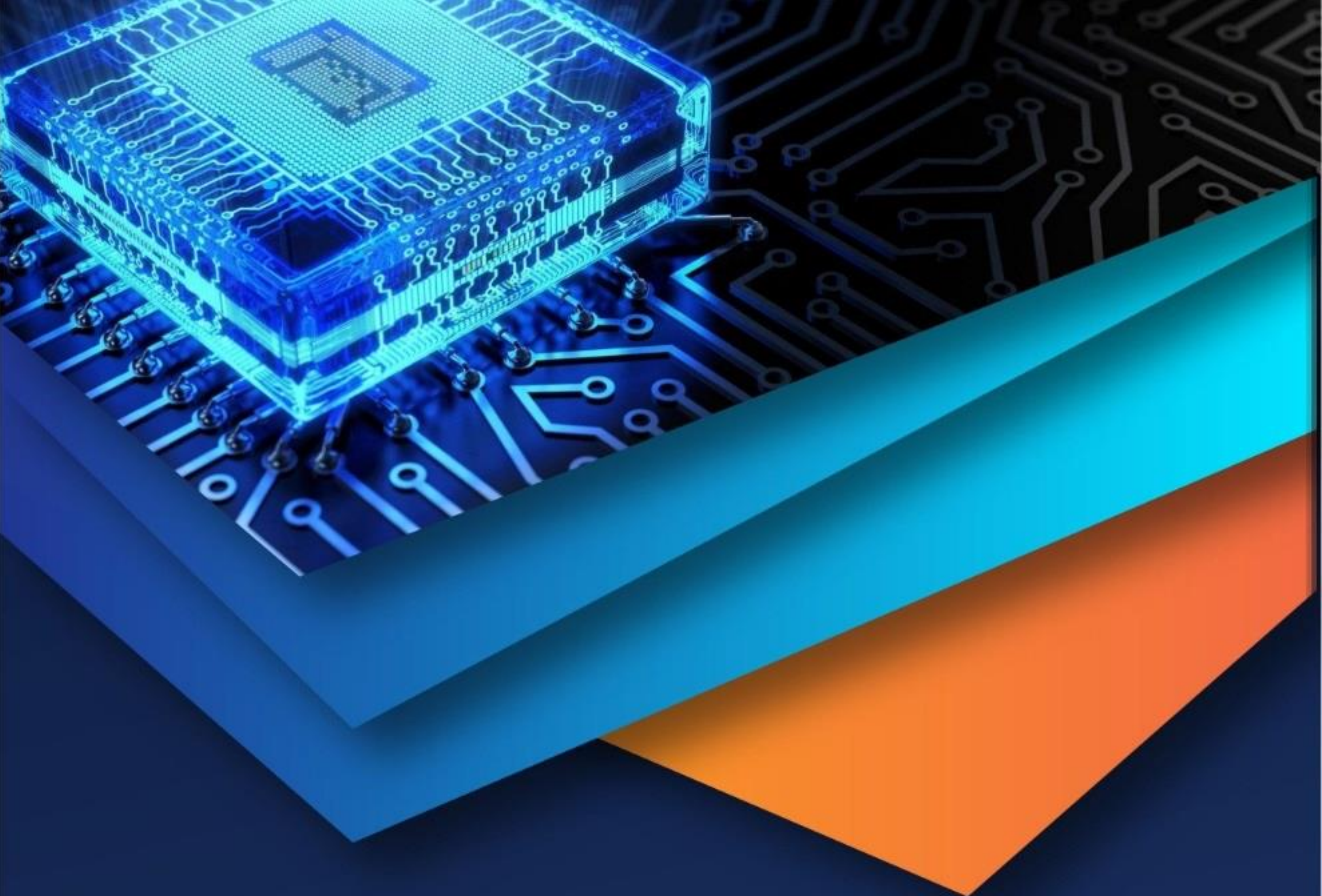
An attempt has been made, however, to choose models that are representative of the kind of structures that are being constructed currently. Developing an exhaustive inventory of buildings that includes all building types is outside the scope of this study. Most structures respond reasonably predictably to gravity stresses, but lateral loads need to be considered. Three basic load instances have been looked at in detail here. The above is a summary of the findings from the analysis of seismic loads, both static and dynamic. Static analysis has been conducted using the building's fundamental time period and empirical calculations from IS 1893: 2016. Additionally, wind loads in structures have been investigated, and the results have been complied.

1) Type A buildings, rigid 10 storey structures, have minimum displacement when column percentage is maximum. The maximum displacement occurs when column percentage is 10%-20%. Increasing shear walls doesn't limit displacements but loses structure ductility. An optimal level of ductility is achieved by providing 50% columns and 50% shear walls.
2) Type B 25-story buildings experience vibration-induced displacement, with minimum displacement at 40%-70% column percentage and maximum at 10%-30%. Shear walls help in reducing displacements, but increasing shear walls can also reduce structure ductility. An optimal level of ductility can be achieved by providing 20% columns and 80% shear walls, making 80% shear walls the most economical choice for Type B buildings.

3) Type C 35-story buildings are ductile and effective against higher vibration modes. The minimum displacement occurs when column percentage is 40%-70%, while maximum displacement occurs when column percentage is 10%-20%.
4) Type D 50-story structures are highly ductile, affecting vibration significantly. They vibrate predominantly in the displacement response spectrum, with minimum displacement at 50%-60% column percentage. The optimal level of ductility is achieved with 40% columns and 60% shear walls, shifting from type C structures where shear wall demand reduces.

REFERENCES

[1] Reddy K. R. C., Sandip A. Tupat (2012). "The effect of zone factors on wind and earthquake loads of high-rise structures" International Journal of Structural Engineering, 12(2), 145–158. https://doi.org/10.1016/j.ijse.2023.02.005.
[2] Jain. S K and Navin C Nigam (2014) "Historical developments and current status of Earthquake Engineering in India, Proceedings of the 12th World Conference on Earthquake Engineering, Auckland, New Zealand.
[3] Mohapatra, A.K. & Mohanty, W.K. (2012) "An Overview of Seismic Zonation Studies in India" Earth-Science Reviews, 96(1–2), 67–91.
[4] Dean Kumar B. & Swami B.L.P. (2023) "Wind effects on tall building frames-influence of dynamic parameters" Indian Journal of Science and Technology, 3(5), 583–587.
[5] Varalakshmi V., Shiva Kumar G., Sunil Sarma R. (2014) "Analysis and Design of G+5 Residential Building" International Journal for Multidisciplinary Research (IJFMR), 2023.
[6] Bagheri Bahador, Firoozabad Salimi Ehsan, and Yahyaei Mohammadreza (2024) "Comparative Study of the Static and Dynamic Analysis of Multi-Storey Irregular Building"
[7] Location on storey drift of multistorey building subjected to lateral loads" International Journal of Engineering Research and Applications, 2(3), 1786–1793.
[8] Yousuf Mohammed & shimpale P.M. (2013) "Dynamic Analysis of Reinforced Concrete Building with Plan Irregularities" International Journal of Engineering Research and Applications, 2(6), 1786–1793.
[9] Anshuman. S, Dipendu Bhunia, Bhavin Ramjiyani (2011) "Solution of Shear Wall Location in Multi-Storey Building"
[10] Seyed M. Khatami, Alireza Mortezaei & Rui C. Barros (2012) "Comparing Effects of Openings in Concrete Shear Walls under Near-Fault Ground Motions" ACI Structural Journal, 109(5), 637–646.
[11] Hatzigeorgiou, G.D. and A.A. Liolios, Nonlinear behaviour of RC frames under repeated strong ground motions. Soil dynamics and earthquake engineering, 2010. 30(10): p. 1010-1025.
[12] Potter, S.H., et al., An overview of the impacts of the 2010-2011 Canterbury earthquakes. International Journal of Disaster Risk Reduction, 2015. 14: p. 6-14.
[13] Scott, B., Park. R and Priestley. MJ N_Stree—strain Behavior of Concrete Confined by Overlapping H0ops at and HigIl Strain Rates. Joum81 of The American Concrete Institute, 1982. 79: p. 13-27.
[14] Zameeruddin, M., & Sangle, K. K. (2021). Performance-based seismic assessment of reinforced concrete moment resisting frame. Journal of King Saud University-Engineering Sciences,33(3), 153-165.
[15] Bush T. D., Wyllie L. A. and Jirsa, J. O. Observations on two seismic strengthening schemes for concrete frames. Earthquake Spectra, 2000, 7, No.4, 511-527.



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY