iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** VII **Month of publication:** July 2025

DOI: https://doi.org/10.22214/ijraset.2025.72939

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 VII July 2025- Available at www.ijraset.com

Linear Dynamic Analysis and Seismic Response Evaluation of High Rise Structures with Shear Walls Base Isolation and Composite Framing Systems

Vikram Kesharwani[1], Lavina Talawale[2]
[1]*Research Scholar*, [2]*Assistant Professor*
[1]*M.tech (Structural Engineering)*
[1, 2]*Dept. of Structural Engineering, SKSITS, Indore (M.P.), India*

Abstract: An earthquake is a naturally occurring movement of the ground that results in a disaster and damages structures. Waves are produced by seismic activity in the earth's crust. Through the foundation, these waves reach the structures. Therefore, inertia force is triggered in the structure as a result of the seismic movements, which damages the entire building or just a portion of it.

The most recent advancement in seismic-resistant architecture is base isolation, which lessens the impact of ground movement even though it may not completely control it. By extending the time that a structure vibrates, base isolation helps to reduce earthquake forces. Additionally, because of base isolation, the structural response accelerations are lower than the ground acceleration. In addition to the foundation isolation, earthquake-resistant buildings also incorporate shear walls. In addition to slabs, beams, and columns, reinforced concrete (RC) buildings frequently have shear walls, which are vertical plate-like RC walls. These walls are often continuous throughout the height of the building, beginning at the foundation. It lessens the impact of earthquakes and their aftereffects. However, several nations have long recognized the superior earthquake-resistant performance of composite beams and columns. Because of its lower seismic weight, the steel and concrete composite structure is growing in popularity. The linear dynamic analysis of an RCC structure with an energy dissipation device in zone IV is examined in this paper, along with a comparison to a composite structure. Because linear dynamic analysis calculates the structure's response to ground motion in the time domain, all phase information is preserved.

Three distinct models were subjected to response spectrum analysis using CSI ETABS v21; multiple values for each model were determined from the structure. The building is situated in seismic zone IV. The response of the building is analyzed using three models. For a G+25 RC frame structure with a shear wall, the outcomes of frequency, time period, displacement, drift, story overturning moment, and story stiffness are compared.

Keywords: Seismic Analysis, Base Isolation, Composite Structure, RCC with Shear Wall, Response Spectrum Analysis, ETABS, G+25 Building.

I. INTRODUCTION

Seismic activities pose a serious threat to tall structures in earthquake-prone regions. Recent advancements in structural engineering focus on incorporating innovative materials and design techniques to mitigate seismic damage. This study examines the comparative seismic behavior of RCC structures with shear walls, RCC structures with base isolation, and composite structures for a 25-storey building.

II. NEED OF BASE ISOLATION

Base isolation is a widely used technique to enhance earthquake resistance in buildings. It allows the structure to move independently from ground motion, reducing seismic forces on the superstructure. This helps in minimizing structural damage and inter-story drift. Base isolation lowers base shear, reduces reinforcement needs, and extends the building's lifespan. It is especially important for critical structures in earthquake-prone regions, where it is often a mandatory design requirement.

III. NEED OF COMPOSITE STRUCTURE

Composite structures are increasingly preferred over conventional RCC structures due to their superior seismic performance and structural efficiency. They offer high design flexibility, greater strength-to-weight ratio, and faster construction timelines, making them ideal for modern long-span architectural designs. Their high strength, stiffness, and ductility make them suitable for earthquake-prone regions. Composite members, combining steel and concrete, reduce the risk of brittle failure and allow for easier structural modifications and repairs. Additionally, encased steel frames can serve as temporary shoring systems during construction, enhancing safety and speed.

IV. RESEARCH GAP

Previous studies have focused on either base-isolated or composite structures independently. However, limited research is available on comparative performance evaluation of RCC with shear wall, base-isolated RCC, and composite structures under the same loading and seismic conditions.

V. OBJECTIVES

This study analyzes a G+25 story building in Seismic Zone IV using ETABS v21 software. It compares the seismic performance of RC frame with shear walls, RC frame with base isolation, and composite structures. The focus is on evaluating parameters like base shear, overturning moment, story drift, and deflection under response spectrum analysis.

- To evaluate and compare seismic parameters like time period, displacement, drift, base shear, and overturning moment for all three structural systems.
- To identify the most efficient system for high-rise buildings in seismic zone IV.

VI. LINEAR DYNAMIC ANALYSIS

Linear dynamic analysis, such as the response spectrum or other static procedures, is suitable when the influence of higher vibration modes is minimal, which is often the case for low-rise, regular structures. However, for tall buildings, irregular structures, or those with complex torsional behavior, a dynamic analysis approach becomes essential. In this method, the building is represented as a Multi-Degree of Freedom (MDOF) system, characterized by a linear elastic stiffness matrix and an equivalent viscous damping matrix. Seismic input is applied through modal spectrum analysis or time history analysis, with internal forces and displacements calculated assuming linear elastic behavior. A key advantage of linear dynamic methods over static methods is their ability to account for higher mode effects. However, since they are based on linear elastic assumptions, their accuracy decreases when significant nonlinearity occurs, which is generally addressed by applying force reduction factors. Linear dynamic analysis calculates the structure's response in the time domain, preserving all phase information. To simplify the computational process, modal decomposition techniques can also be used to reduce the number of degrees of freedom involved.

VII. MODELLING AND ANALYSIS

Linear dynamic analysis was performed on three different structural models using CSI ETABS v21 software. Various structural parameters were evaluated for RC frame with shear walls, RC frame with base isolation, and composite structures. The analysis of the G+25 story RC frame structure with shear walls, base isolation system, and composite structure was carried out in accordance with IS 1893:2016 seismic design guidelines. Each of these structural models was created and analyzed to study and compare their seismic performance under dynamic loading.

Model 1: G+25 RC frame structure with Shear wall.
Model 2: G + 25 RC frame structure with Base isolation.
Model 3: G+ 25 Composite Structure.

Table 7.1 Data used for analysis of RC frame structure

SN.	Particulars	Dimension / Value
1	Plan dimension	25 x 25 m
2	Height of the bottom story	3.6 m
3	Total Height of building	75.6 m
4	Height of parapet	1.2m

5	Thickness of slab	200mm
6	Seismic zone Importance factor Zone factor Damping factor	IV 1.2 .24 5%
7	Floor finish Live load at all floors Wall load Parapet wall Density of concrete Density of steel Density of brick	2.0 KN/m^2 2.0 KN/m^2 12 KN/m 5.96 KN/m^2 25 KN/m^3 7850 KG/m^3 20 KN/m^3
8	Grade of Concrete Grade of reinforcing steel Soil condition	M30 HYSD500 Medium
9	Grade of beam and column Size of beam Size of column	M30 300 x 500 mm 1000 x1000 mm

Table 7.2 Data used for analysis of composite structure

S. No.	Particulars	Dimension/value
1	Plan Dimension	25x25 m
2	Total height of the building	75.6 m
3	Height of bottom story	3.6 m
4	Height of each story	3 m
5	Height of parapet	1.2 m
6	Thickness of slab Thickness of profiled deck Thickness of walls	200 mm 75-100 mm 230 mm
7	Seismic zone Importance factor Zone factor Damping ratio	IV 1.2 0.24 5%
8	Floor finish Live load at all floors Wall load Parapet wall Density of concrete Density of steel Density of brick	2.0 KN/m^2 2.0 KN/m^2 12 KN/m 5.96 KN/m^2 25 KN/m^3 7850 KG/m^3 20 KN/m^3
9	Grade of concrete in column Grade of deck Grade of reinforcing steel Soil condition	M30 M20 HYSD500 Medium soil

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 VII July 2025- Available at www.ijraset.com

A. *Design Data For LRB*

Table 7.3 Data used for LRB design

1	Seismic zone factor, Z	0.3	(UBC 97, Vol-2, Table 16-I & Zone Map)
2	Seismic Source Type	B	
3	Near source factor, Na	1	(UBC 97, Vol-2, Table 16-S)
4	Near source factor, NV	1	(UBC 97, Vol-2, Table16T)
5	ZNv	0.3	
6	Maximum capable earthquake response coefficient, Mm	1.5	(UBC 97, Vol-2, Table A-16-D)
7	Soil Profile Type	SD	(UBC 97, Vol-2, Table 16-J)
8	Seismic coefficient, $CV = CVD$	0.54	(UBC 97, Vol-2, Table 16-R)
9	Seismic coefficient, Ca	0.36	(UBC 97, Vol-2, Table 16-Q)
10	Choose Response Reduction Factor, R for SMRF	8.5	(UBC 97, Vol-2, Table 16-N)
11	For SMRF/IMRF/OMRF Structural System Above the Isolation Interface, RI	2	(UBC 97, Vol-2, Table A-16-E)
12	Effective Damping (βd or βm)	0.15	15% Damping []
13	Damping coefficient, Bd or Bm	1	Interpolate (UBC 97, Vol-2, Table A-16-C)

B. *Maximum load obtained after dynamic analysis on column is being taken for design of LRB*

Table 7.4 Design Data for LRB OF G +25 for lateral load of 20500 KN

Rotational Inertia	0.731550068	KN/m
For U1 Effective Stiffness	20624555.58	KN/m
For U2 & U3 Effective Stiffness	20624.5556	kN-m
For U2 & U3 Effective Damping	0.15	
For U2 & U3 Distance from End-J	0.00490	m
For U2 & U3 Stiffness	157650.0916	KN/m
For U2 & U3 Yield Strength	772.8317928	KN

C. Descriptions Of Models

All three models which are considered for analysis are shown below.

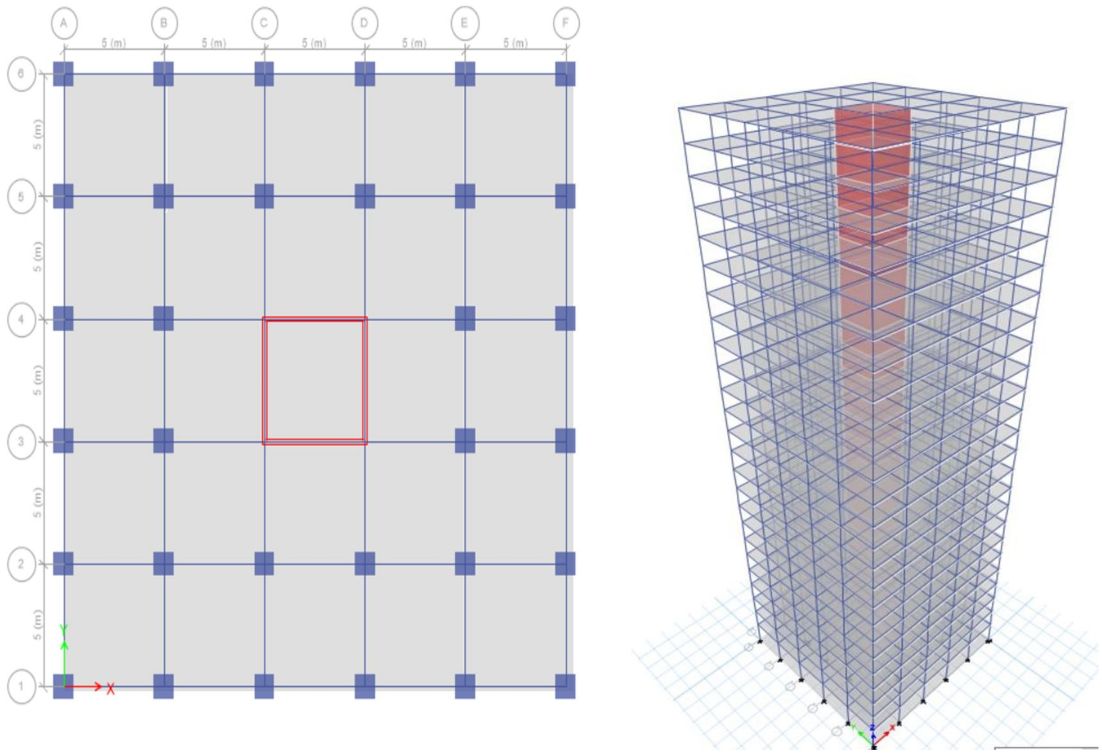


Figure 7.1 Showing plan and elevation view of G+25 Story RCC structure with shearwall.

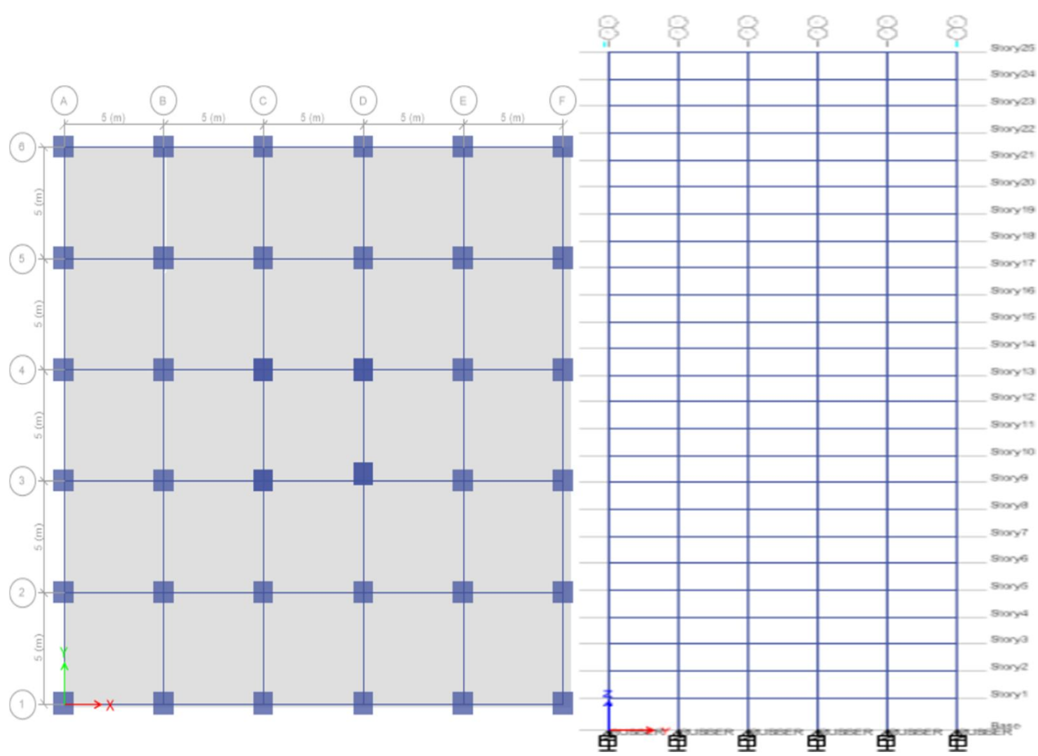


Figure 7.2 Showing plan and elevation view of G+25 Story RC frame structure with baseisolation.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VII July 2025- Available at www.ijraset.com

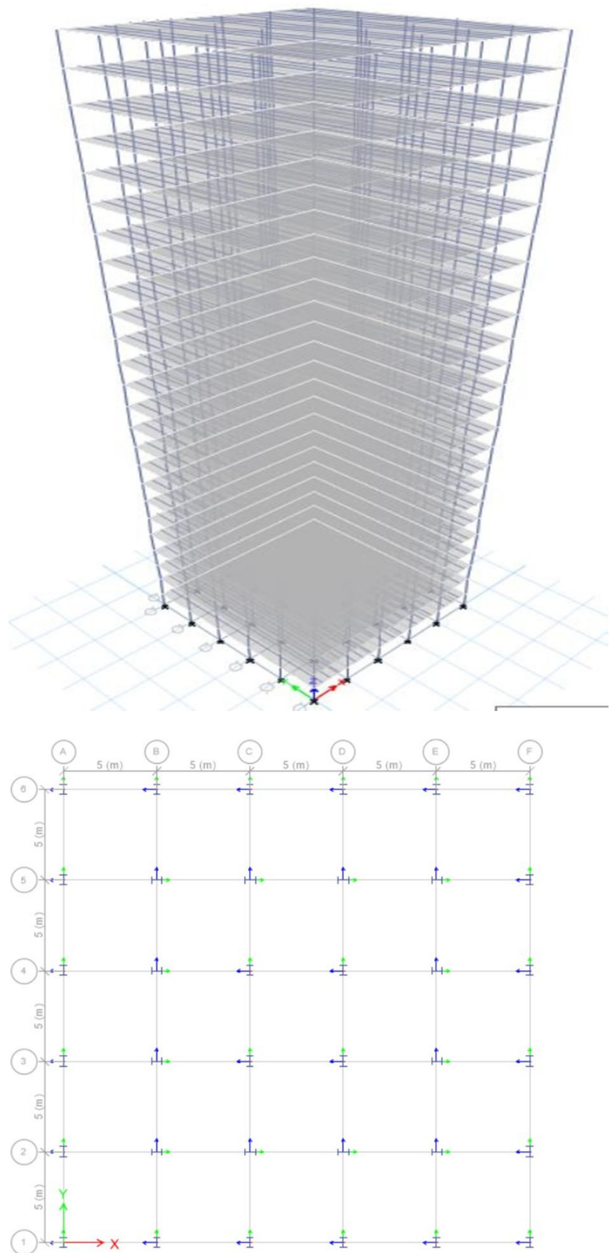


Figure 7.3 Showing plan and elevation view of G + 25 Story composite structures.

VIII. RESULTS AND DISCUSSION

A. *Free Vibration Analysis*

The study of a system's dynamic dynamics in the frequency domain is known as modal analysis. It is the discipline that measures, computes, and analyzes the structure's dynamic response during exciting. In structural engineering, modal analysis determines the different times at which a structure will naturally resonate by calculating its total mass and stiffness. In seismic engineering, these vibrational durations are crucial.

Building a mathematical model of a system's behavior by identifying its intrinsic dynamic properties—such as natural frequencies, damping coefficients, and modal shapes—is known as modal analysis. The information regarding the qualities is referred to as modal data, and the mathematical model that is developed is known as the system's modal. G+ 25-story RC frame structures with shear walls, RC frame structures with base isolation, and composite structures are subjected to free vibration analysis in order to get dynamic structural behavior. The modal time period is 4.93 seconds in model 2, 4.08 seconds in model 1, which is a G +25 RC frame construction with a shear wall at the core, and 4.356 seconds in model 3.

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 VII July 2025- Available at www.ijraset.com

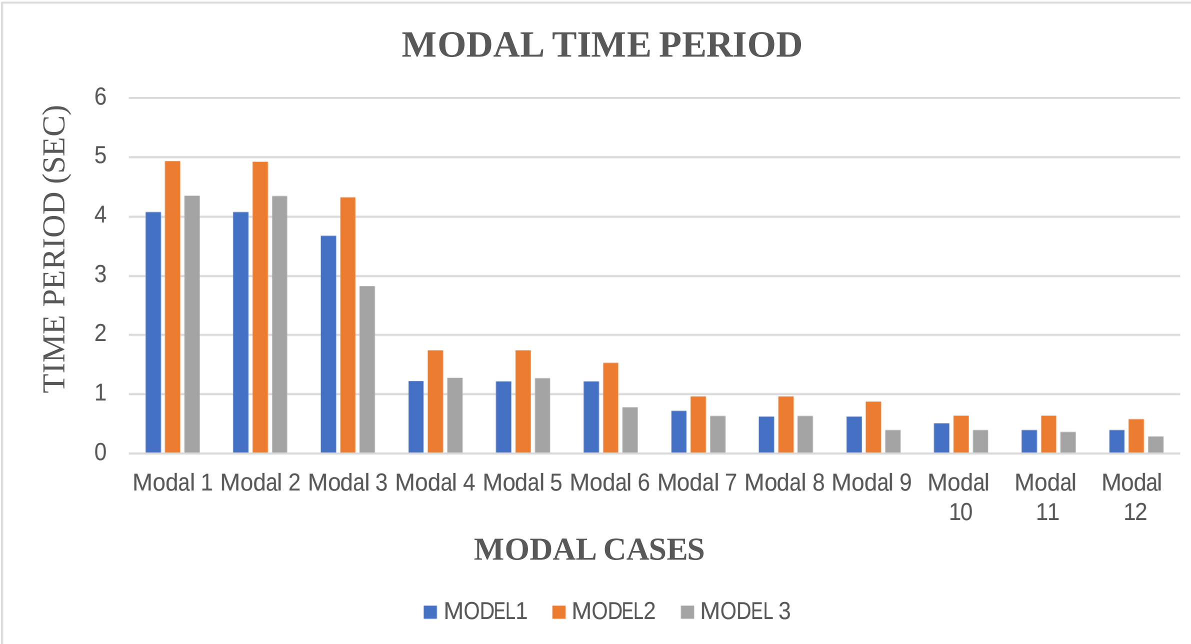


Figure 8.1 Showing modal time period of all three models.

B. Response Spectrum Analysis (IS: 1893-2016)

The Response Spectrum analysis is carried out as per Indian Standard and Story Displacement, Story Shear, Story Overturning Moment, Story Stiffness is discussed for allG+25 story model.

1) Story Displacement

According to the linear dynamic analysis, the base isolated frame had the most displacement, followed by the composite and the RCC frame with shear wall. This is a result of greater adaptability to seismic shock wave absorption. Model 2 has the largest story displacement (85.786 mm), while Model 1 has the smallest (58.956 mm). Model 3's story displacement is 64.12 mm.

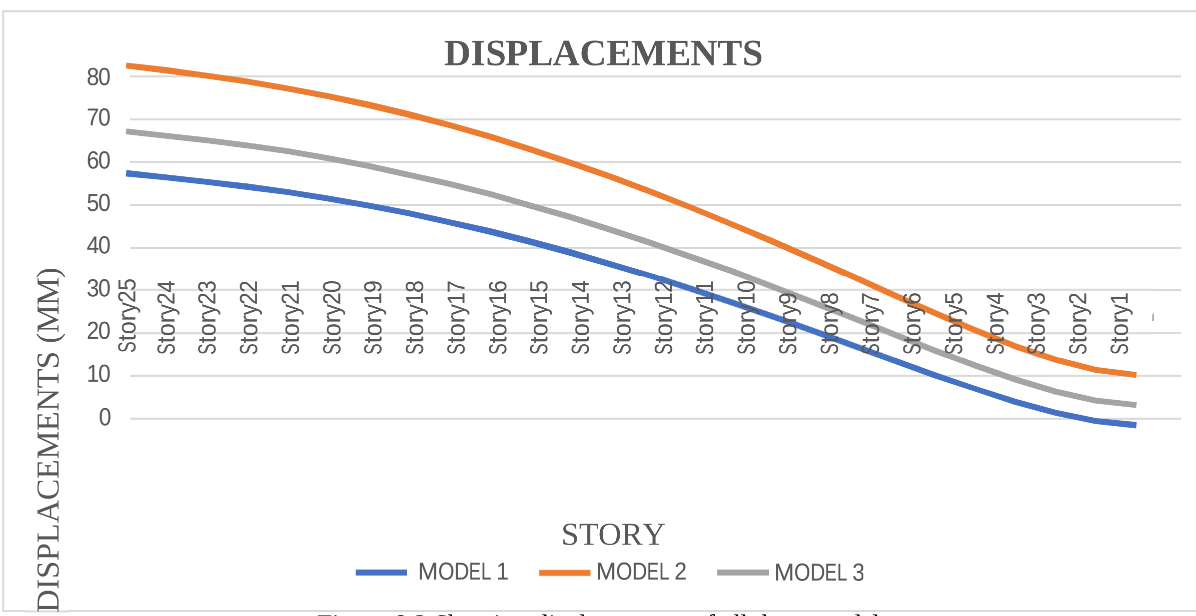


Figure 8.2 Showing displacements of all three models.

2) Maximum Story Overturning Moment

The story shear multiplied by the distance to the center of mass above the elevation under consideration yields the overturning moments. Model 1 has the highest story overturning moment (130235.69 KN-M), while Model 2 has the lowest (116373.34 KN-M). In model 3, the story-overturning point is 124470.64 KN-M.

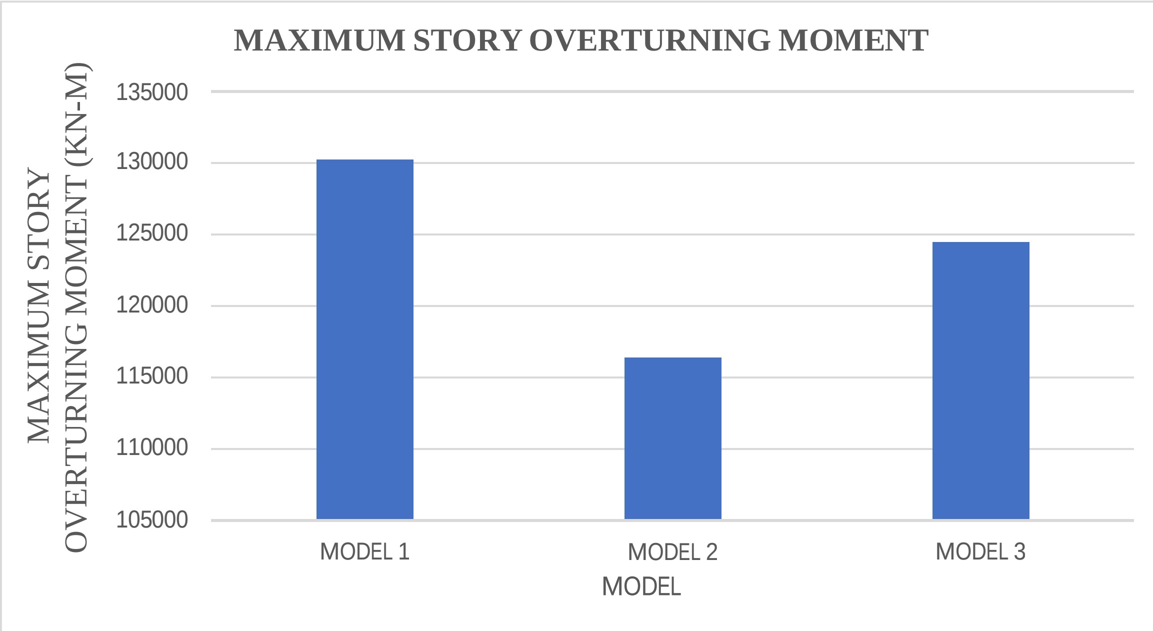


Figure 8.3 Showing maximum story overturning moment for all three models.

3) Story Drift

Story displacement is the absolute value of the story's displacement under the influence of lateral pressures, while story drift is the difference in displacements between two consecutive stories divided by the height of that story.

Model 1 has the least amount of story drift, whereas Model 2 has the most. Following analysis and all design checks in accordance with IS: 1893 (2016), story drift meets design requirements and its value is less than 0.004 times that of story height.

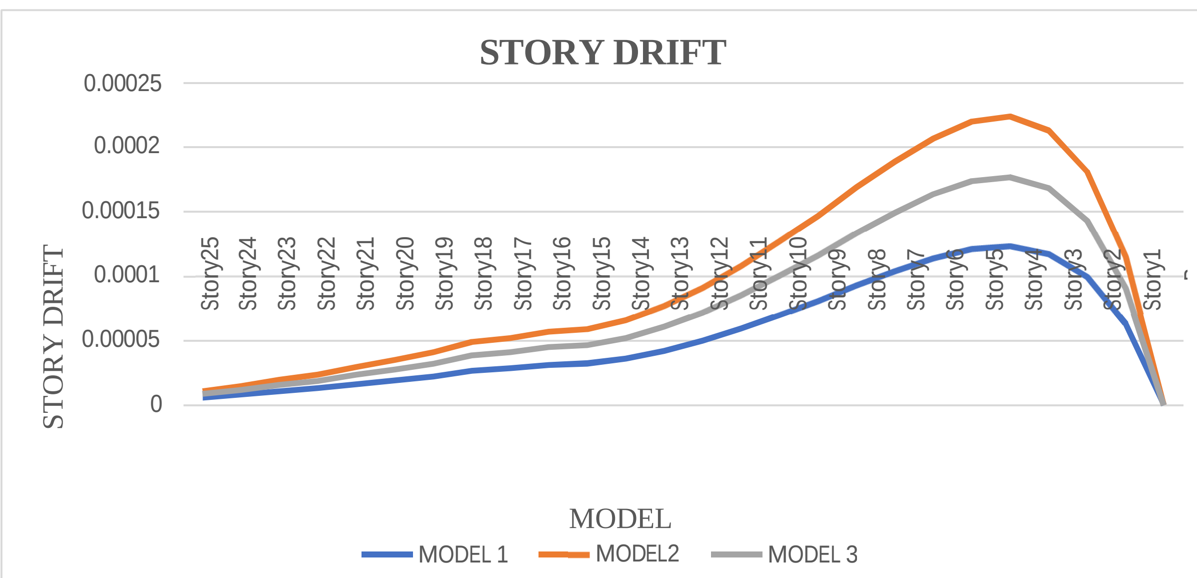


Figure 8.4 Showing story drift for all three models.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VII July 2025- Available at www.ijraset.com

4) Base Shear

The maximum anticipated lateral force that will result from ground motion during an earthquake at a structure's base is known as base shear.

The ground began to move as a result of seismic activity. Lateral force is created in the opposing direction of motion as a result of ground movement. Base shear is the term used to describe the produced lateral force at the base of the structure as a result of seismic motion. Model 1 has the highest base shear (1514.36 KN), while Model 2 has the lowest (853.66 KN). Model 3's base shear is 1366.87 KN.

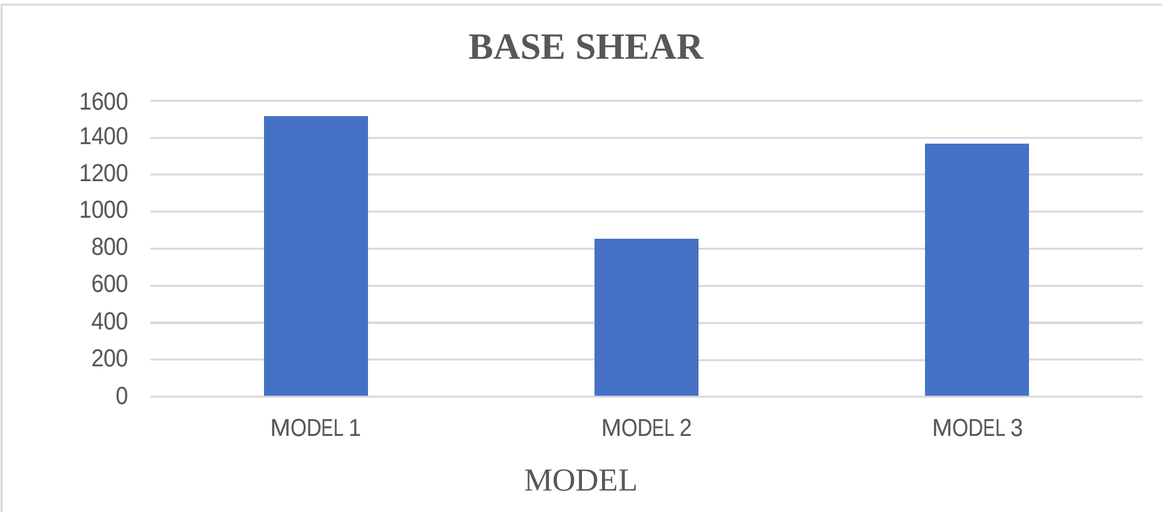


Figure 8.5 Showing base shear for all three models.

5) Story Stiffness

The rigidity of a structural member is referred to as "stiffness" in structural engineering. Generally speaking, this refers to how well an element can withstand deformation or deflection when a force is applied. G+25 story RC frame structures with shear walls, RC frame structures with base isolation, and composite structures are subjected to response spectrum analysis. Model 1 has the highest story stiffness, measuring 120627.1 KN/M, while Model 2 has the lowest; measuring 91676.5 KN/M. Model 3's tale stiffness is 102533.5 KN/M.

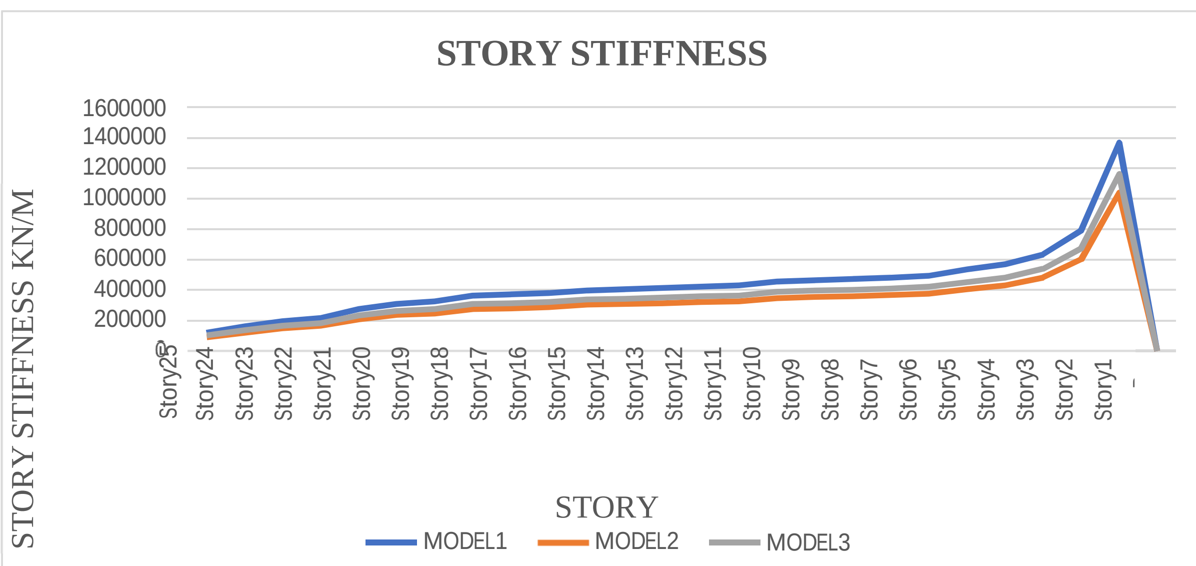


Figure 8.6 Showing story stiffness for all three models.

IX. CONCLUSION

A. *Time Period*

- The modal time period is 4.93 seconds in model 2, 4.08 seconds in model 1, which is a G +25 RC frame construction with a shear wall at the core, and 4.356 seconds in model 3.
- Model 2's modal time period is 13.17% longer than Model 3's and 20.83% longer than Model 1's.
- The ductility of the structure greatly rises due to base isolation in model 2, which causes the time period to grow and the frequency to drop.

B. *Story displacement*

- Model 2 has the largest story displacement (85.786 mm), while Model 1 has the smallest (58.956 mm). Model 3's story displacement is 64.12 mm.
- Model 2's story displacement is 33.789% greater than Model 3's and 45.81% greater than Model 1's.
- Displacement falls with increasing rigidity and vice versa.

C. *Maximum Story Overturning Moment*

- Model 1 has the highest story overturning moment (130235.69 KN-M), while Model 2 has the lowest (116373.34 KN-M). Model 3 has the lowest story overturning moment (124470.64 KN-M).
- Model 1's maximum story overturning moment is 11.91% higher than Model 2's and 4.63% higher than Model 3's.

D. *Story Drift*

- Model 1 has the least amount of story drift, whereas Model 2 has the most. Following analysis and all design checks in accordance with IS: 1893 (2016), story drift meets design requirements and its value is less than 0.004 times the story height.
- The drift ratio falls as the structure's stiffness rises and vice versa.

E. *Base Shear*

- Model 1 has the highest base shear, 1514.36 KN, while Model 2 has the lowest, 853.66 KN. Model 3's base shear is 1366.87 KN.
- Model 2's base shear is reduced by 43.62% compared to Model 1 and 37.54% compared to Model 3.
- Base shear rises in tandem with a structure's bulk.

F. *Story Stiffness*

- Model 1 has the highest story stiffness, measuring 120627.1 KN/M, while Model 2 has the lowest; measuring 91676.5 KN/M. Model 3's tale stiffness is 102533.5 KN/M.
- Model 2's story stiffness is 11.57% lower than Model 1's and 11.84% lower than Model 3's.
- The structure's stiffness decreases as its ductility increases, and vice versa.

X. FUTURE SCOPE

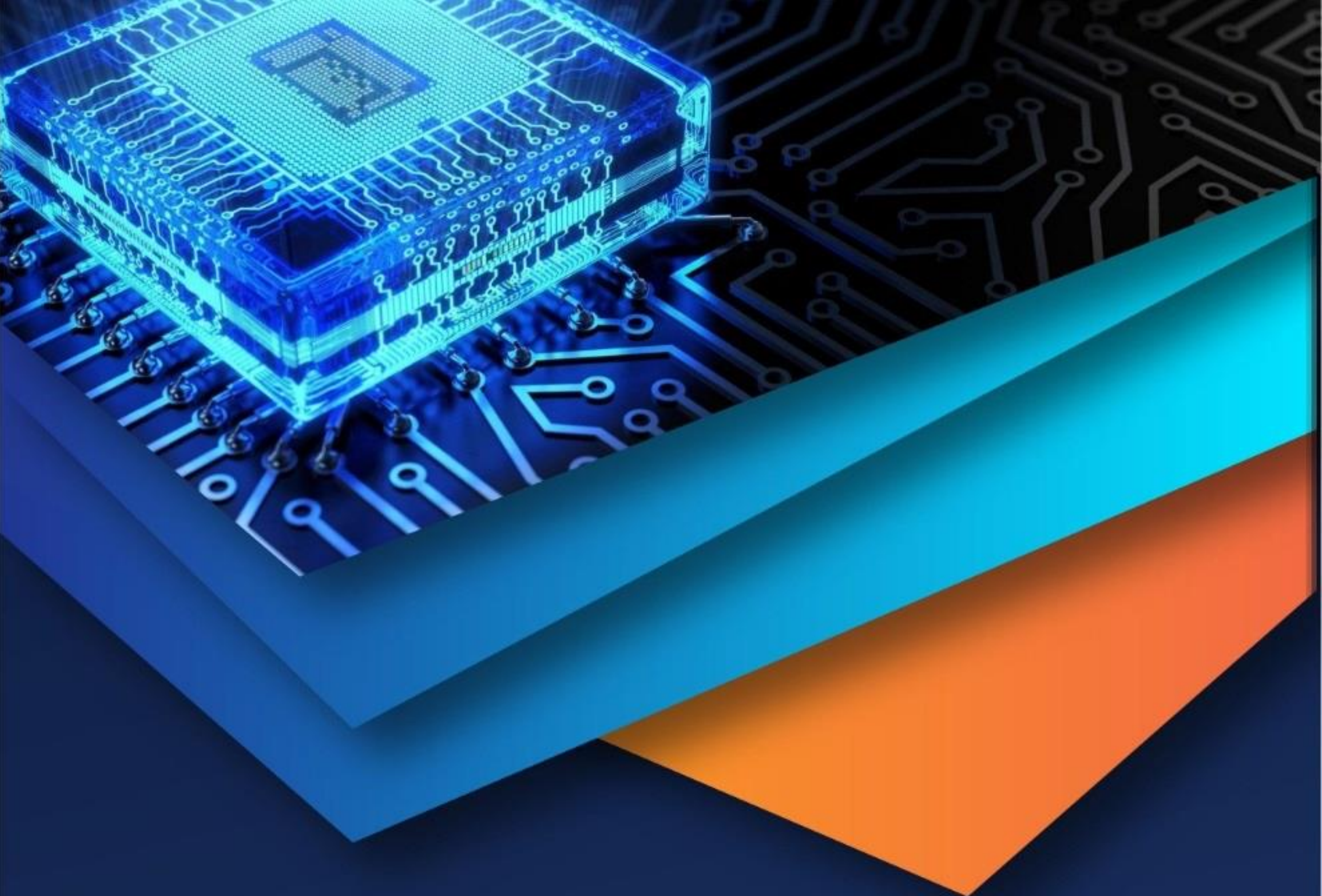
G+25 story composite structure, RC frame structure with base isolation, and RC frame structure with shear wall.

1) It is possible to conduct performance-based seismic analysis and verify its performance criteria using FEMA 356.
2) This study's expansion to include additional RCC-framed structures. Base isolation over steel structure performance.
3) Analogous results when the structure's height is changed.
4) High Damping Rubber Bearings can be used to test the performance of similar structures.
5) LRB and other lateral load resisting systems, such as shear walls and bracings, can be used to compare the costs of structures that are 30, 35, and 40 stories.
6) RC frame structures with shear walls and those with optimized sections can be subjected to nonlinear dynamic analysis.

REFERENCES

[1] Jagadale S, Shiyekar M.R. and Ghugal Y.M. July-2019 "Comparative Study of Steel, RCC and Composite Frame Building". ISSN: 2395-0072, Volume 6, Issue 7, IRJET.
[2] Rana M 2019 "comparative study in steel structure on better resistance against lateral load" ISSN: 2764-1322X, Volume 5, Issue 5, IJARIIT

[3] Patel K, Thakkar S. 2019 “Analysis of CFT (Concrete Filled Steel Tube), Rcc and Steel Building Subjected to Lateral Loading”, Elsevier.
[4] Savadi S. and Hosur V.2019 “Comparative Study of RCC, Steel and Composite Structures for Industrial Building”. ISSN: 2395- 4396, VOLUME 5, issue 4, IJARIIE.
[5] Bhanu P.M. (2021) “Comparative Study of Composite RCC and Steel Structure” International Journal of Advanced Engineering Research and Studies III (I): 88–93.
[6] Nassani D.E. and Mustafa W.A. (2021). “Seismic Base isolation in reinforced Concrete structures.” international magazine of studies studies in technology, Engineering and era, 2(2), 1-thirteen.
[7] IS: 456-2000 (Indian Standard Plain Reinforced Concrete Code of Practice)– Fourth Revision.
[8] IS: 1893-2002 (part-1), Criteria for earthquake resistant design of structures, fifth revision, Bureau of Indian Standards, New Delhi, India.
[9] Bureau of Indian Standards: IS:875-1987, (part 1), Dead Loads on Buildings and Structures, New Delhi, India.
[10] IS: 875-1987 (part-2) for Live Loads or Imposed Loads, code practice of Design loads (other than earthquake) for buildings and structures.
[11] Duggal SK. Earthquake Resistant Design Structures. Oxford university press YMCA library building, New Delhi, 2010.
[12] IBC (2000). “International constructing Code”, worldwide Code Council, Inc., Virginia, U.S.A.
[13] IS: 13920 (2016). “Ductile layout and detailing of reinforced concrete systems subjected to seismic forces-code of practice.” Bureau of Indian requirements, New Delhi, India.
[14] IS: 1893 (element I, 2002). “Standards for earthquake resistant layout of systems, element 1: general provisions and buildings [CED 39: Earthquake Engineering]”, Bureau of Indian standards, New Delhi, India.
[15] IS: 1893 (part I, 2016). “Standards for earthquake resistant design of systems, component 1: trendy provisions and homes [CED 39: Earthquake Engineering]”, Bureau of Indian standards, New Delhi, India.



doi crossref

10.22214/IJRASET

INDEX COPERNICUS

45.98

ISRA JIF

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY