Static & Dynamic Analysis of a Multi-storied Structure Under Wind and Seismic Excitations

K. Arun Akhil, M. Manish Reddy, G. Sri Harsha

Abstract:--- An RCC multi-storeyed structure is considered where wind and seismic forces are applied to study the behavior of the structure under these excitations. Response spectrum analysis and Time History analysis is applied to study the performance of the structure. Various parameters such as base shear, base moments, story drift, inter-story drift were determined. The capacity of the structure is increased by adding shear wall and bracings in order to reduce the vibrations and analysis is done between the structures with and without a shear wall, with and without bracings.

Index Term: seismic loads, wind loads, story drift, response spectrum analysis, time history analysis.

I. RESEARCH SIGNIFICANCE

Static and Dynamic analysis for a structure is done to determine the effect of loads on the structure and their components. It is also necessary to know whether the structure can withstand external and internal stresses caused due to the wind and seismic excitations.

II. INTRODUCTION

Day by day increase in the population leads to an increase in usage of tall structures. The seismic waves that reach the earth's surface cause an earthquake[1]. Earthquake causes different shaking intensities at different locations and the damage included in buildings at these locations is also different[2]. It is essential to estimate and specify these lateral forces on the structure in order to design the structure to resist an earthquake[3]. Structures are designed to resist these sudden forces and should have enough stiffness and strength to control displacement at supports. Even the plan configuration of the building depends upon how the structure reacts on loading[4]. To know the damage caused due to earthquake, design and analysis of a structure is to be done before the construction of the structures. The forces caused due to the earthquake are random in nature and they are not predictable. Hence ETABS software is used to analyze the structures where its features contain powerful graphical interface coupled with unmatched modeling, analytical, and design procedures, all integrated using a common database[5]. The analysis is done in two ways (i.e., Response spectrum analysis and

Time history analysis) to study the performance of the structure by applying earthquake loads. The comparison is done for the structure with and without a shear wall, with and without bracings.

III. OBJECTIVES

1. To analyze a multi-storeyed structure (8 stories) by Response spectrum analysis and Time history analysis.
2. To compare the analytical results between the regular structure and structure with bracings and shear walls.
3. To analyze the damage caused due to earthquake loads

A. Linear Analysis

It is a type of analysis where a linear relation holds between forces applied vs displacements. It is applicable only loads applied are well within the elastic range of deformation and it is also applicable for Superposition principle. In this analysis, the model stiffness matrix is constant, and the analyzing process is relatively short compared to the nonlinear analysis of the same structure.

B. Non-Linear Analysis

It is a type of analysis where a nonlinear relation holds between forces applied vs displacements. It is applicable only when applied loads are beyond the elastic range of deformation and It is not applicable for the superposition principle. Nonlinear effects occur from large deformations, material nonlinearity, and contact between the materials.

C. Response Spectrum Analysis

Response spectrum analysis is also known as the linear dynamic analysis method. For a given earthquake motion and the percentage of critical damping, a typical response spectrum gives a plot of earthquake-related responses such as acceleration, velocity, and deflection for a complete range or spectrum of building periods[6].

D. Time History Analysis

Time history analysis is also known as Non-linear dynamic analysis method. In Time History analysis structural response is computed at several subsequent time instants. In response spectrum analysis the time evaluation of response cannot be computed. So, Time History analysis is equipped.

Revised Manuscript Received on April 09, 2019.
K. Arun Akhil, UG Student, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Guntur - 522502, India.
M. Manish Reddy, UG Student, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Guntur - 522502, India.
G. Sri Harsha, Assistant Professor, Department of Civil Engineering, Koneru Lakshmaiah Education Foundation, Guntur - 522502, India.

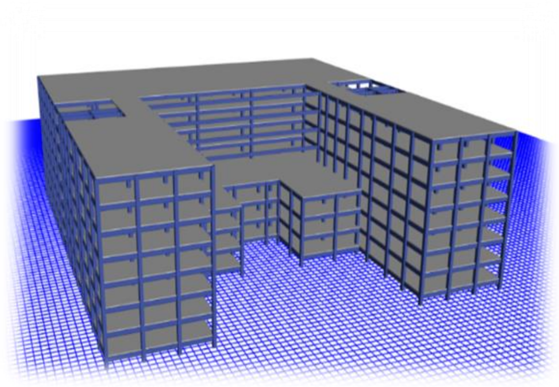

Fig.1: 3D View of the Building

Table 1: Specifications of Structure		
S. No	**Parameters**	**Values**
1	No of Stories	8
2	Height of the Building	22.5m
3	Story Height	3m
4	Base Story Height	1.5m
5	Plan Dimensions	64.5m x 58.5 m
6	Horizontal Aspect Ratio	2.9
7	Vertical Aspect Ratio	1
8	Beam Dimensions	400 x 500mm
9	Column Dimensions	450 x 550mm
10	Earthquake Zone	III
11	Zone Factor	0.24
12	Importance Factor	1
13	Response Reduction Factor	5 %
14	Slab Thickness	250mm
15	Wall Thickness	250mm

IV. MATERIAL PROPERTIES

Table 2: Material data		
S.No	**Properties**	**Values**
1	Grade of Concrete	M 30
2	Grade of Steel	Fe 415
3	Density of Concrete	25 kN/m^3
4	Modulus of Elasticity of Concrete	27386 N/mm^2
5	Density of Steel	78.5 kN/m^3
6	Modulus of Elasticity of Steel	2 x10^5 N/mm^2

Table 3: Loads				
S.No	**Name**	**Type**	**Self-Weight Multiplier**	**Loading Criteria**
1	Dead	Dead	1	
2	Live	Live	0	
3	FFL	Superimposed Dead	0	
4	Eq +X	Seismic	0	IS1893: 2002
5	Eq -X	Seismic	0	IS1893: 2002
6	Eq +Y	Seismic	0	IS1893: 2002
7	Eq -Y	Seismic	0	IS1893: 2002
8	Wind +X	Wind	0	IS875(Part3) 1987
9	Wind -X	Wind	0	IS875(Part3) 1987
10	Wind +Y	Wind	0	IS875(Part3) 1987
11	Wind -Y	Wind	0	IS875(Part3) 1987

V. INTERPRETATION OF RESULTS

The following tables and graphs show a detailed comparison of values with different parameters for the regular, braced and shear walled structures.

A. Comparison of Shear and Moment

Table 4: Shear Force (kN)			
Column No	**Regular Structure**	**Braced Structure**	**Shear Wall Structure**
1	135.9042	127.7141	24.2849
2	122.4727	114.6628	11.0435
3	109.2313	101.4214	2.1979
4	31.0035	26.9547	7.2414
5	25.8035	21.7547	2.0414
6	20.6035	16.5547	3.1586
7	8.4884	18.6629	3.3109
8	8.4884	18.6629	3.3109
9	8.4884	18.6629	3.3109
10	11.5894	6.9811	3.0095
11	11.5894	6.9811	3.0095
12	11.5894	6.9811	3.0095
13	11.5894	6.9811	3.0095
14	11.5894	6.9811	3.0095

Table 5: Bending Moment (kN-m)			
Column No	**Regular Structure**	**Braced Structure**	**Shear Wall Structure**
1	38.1167	25.0268	6.5697
2	2.2168	1.3186	0.6891
3	42.5503	27.6639	7.948
4	4.7766	3.4877	1.1741
5	0.2563	0.1542	0.077
6	5.2892	3.7961	1.328
7	2.1017	1.031	1.564
8	0.0133	0.6173	0.0829
9	2.0751	2.2656	1.3982
10	2.2483	1.6781	2.3003
11	0.051	0.8973	0.0983
12	2.3503	3.4728	2.1036
13	2.2483	1.6781	2.3003
14	0.051	0.8973	0.0983

A. Comparison of Maximum Torsion

Table 6: Maximum Torsion (kN/m^2)			
Column No	**Regular Structure**	**Braced Structure**	**Shear Wall Structure**
1	0.0297	0.1006	0.1288
2	0.0297	0.1006	0.1288
3	0.0297	0.1006	0.1288
4	0.0064	0.0113	0.0259
5	0.0064	0.0113	0.0259
6	0.0064	0.0113	0.0259
7	0.0053	0.0301	0.0566
8	0.0053	0.0301	0.0566
9	0.0053	0.0301	0.0566
10	0.1026	0.5245	0.3537
11	0.1026	0.5245	0.3537
12	0.1026	0.5245	0.3537
13	0.1026	0.5245	0.3537
14	0.1026	0.5245	0.3537

C. Comparison of Lateral Forces

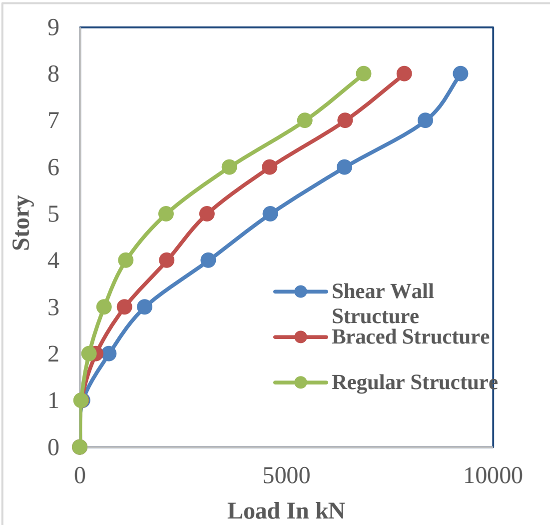

Fig.2: Lateral loads in X direction

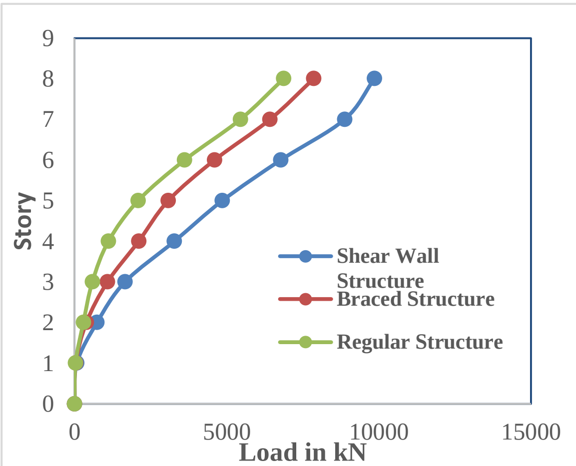

Fig.3: Lateral loads in Y direction

A. **Base Shear**

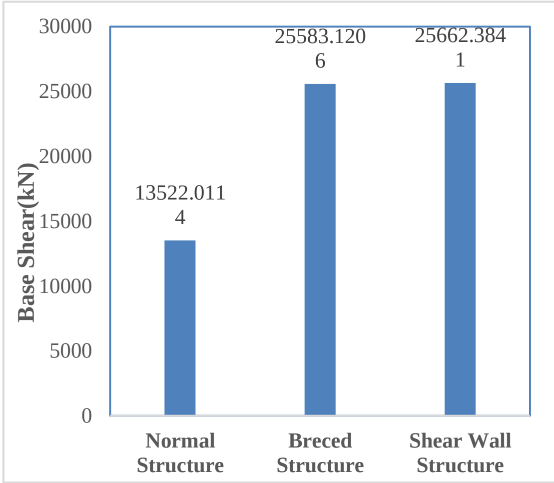

Fig.4: Base Shear in X Direction

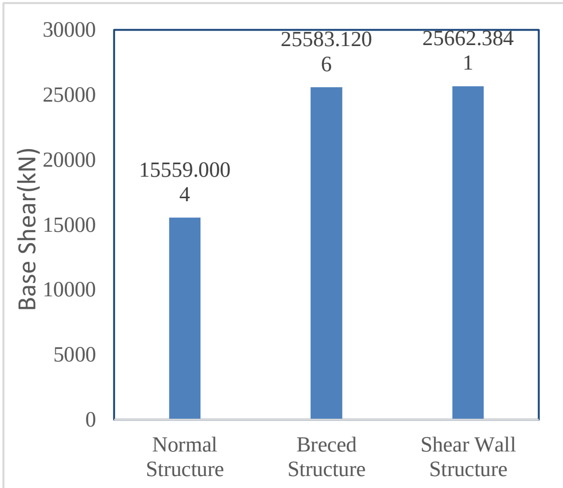

Fig.5: Base Shear in Y Direction

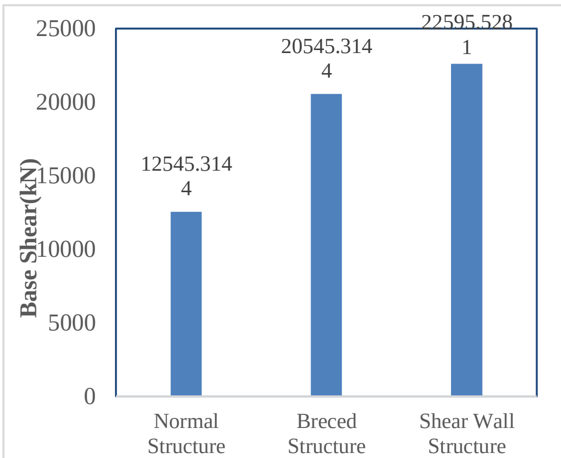

Fig.6: Base Shear using Response Spectrum Analysis

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

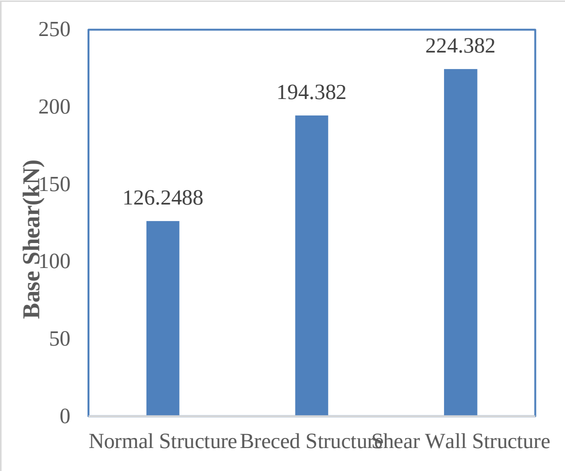

Fig.7: Base Shear using Time History Analysis

A. Story Shear

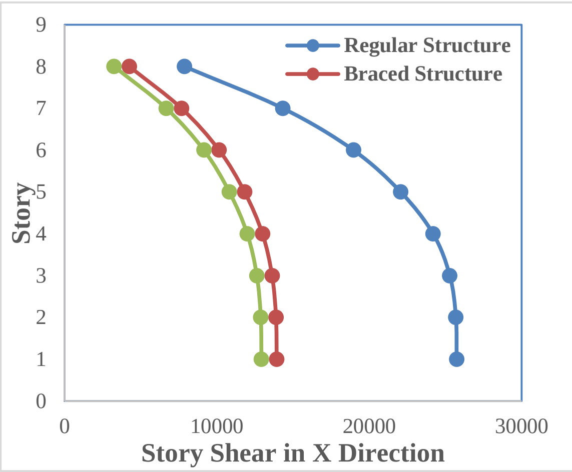

Fig.8: Story Shear in X Direction

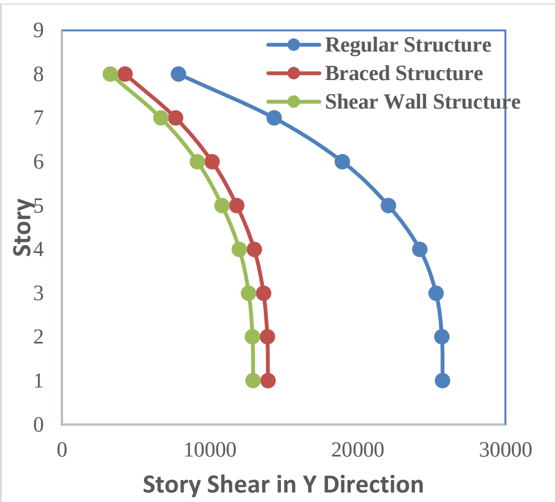

Fig.9: Story Shear in Y Direction

A. Story Stiffness

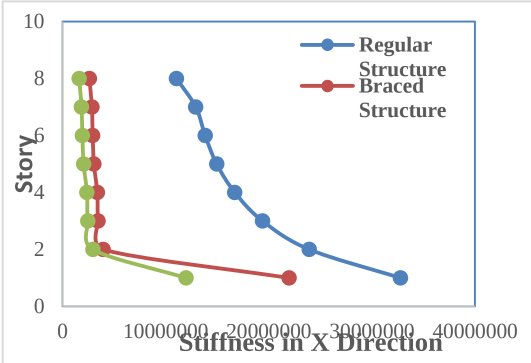

Fig.10: Story Stiffness in X direction

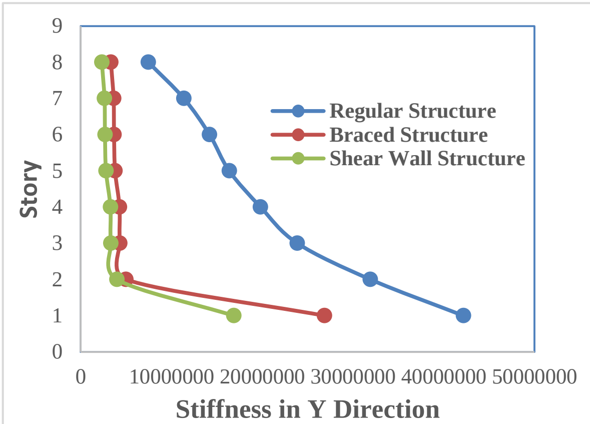

Fig.11: Stiffness in Y direction

A. Story Drift

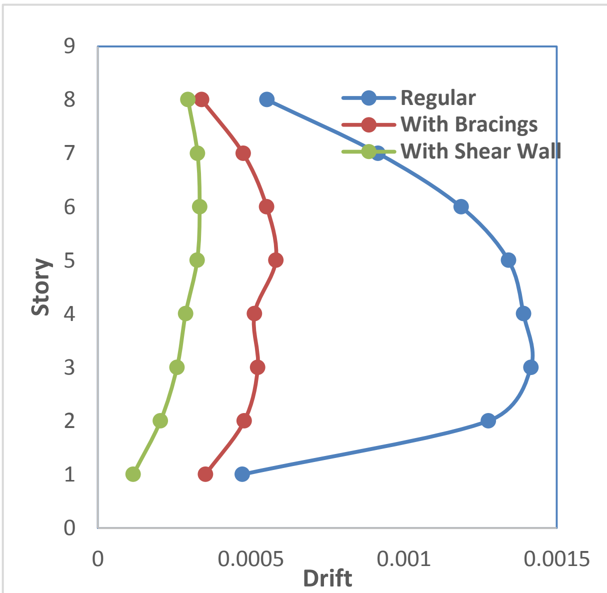

Fig.12: Story Drift in X Direction

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication

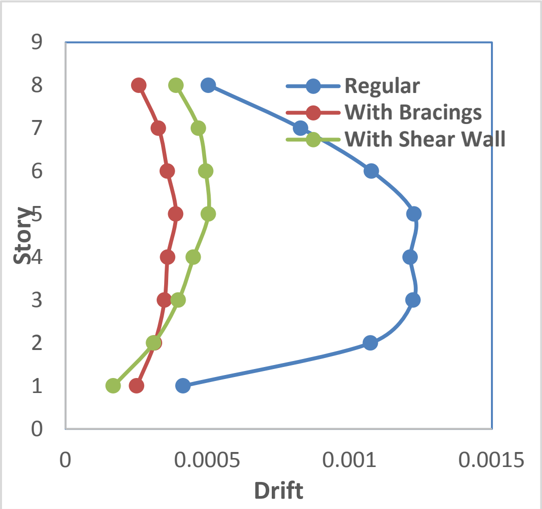

Fig.13: Drift due to Seismic Y

VI. CONCLUSIONS

The following conclusions were drawn after the detailed analysis

- Lateral forces in X-Direction were increased by 27%, 56% respectively for the Braced structure and Shear Wall structure when compared to Regular structure.
- Lateral forces in Y-Direction were increased by 28%, 50% respectively for the Braced structure and Shear Wall structure when compared to Regular structure.
- Base Shear in X-Direction was increased by 89%, 90% respectively for the Braced structure and Shear Wall structure when compared to Regular structure.
- Base Shear in Y-Direction was increased by 64%, 65% respectively for the Braced structure and Shear Wall structure when compared to Regular structure.
- Base Shear calculated using Response Spectrum Analysis was increased by 64%, 80% respectively for the Braced structure and Shear Wall structure when compared to Regular structure.
- Base Shear calculated using Time History Analysis was increased by 54%, 78% respectively for the Braced structure and Shear Wall structure when compared to Regular structure.
- Story Shear in X-Direction was reduced by 46%, 51% respectively for the Braced structure and Shear Wall structure when compared to Regular structure.
- Story Shear in Y-Direction was reduced by 46%, 51% respectively for the Braced structure and Shear Wall structure when compared to Regular structure.
- Story Stiffness in X-Direction is reduced by 70%, 81% respectively for the Braced structure and Shear Wall structure when compared to Regular structure.
- Story Stiffness in Y-Direction is reduced by 67%, 77% respectively for the Braced structure and Shear Wall structure when compared to Regular structure.
- Drift in X-Direction is reduced by 55%, 74% respectively for the Braced structure and Shear Wall structure when compared to Regular structure.

Drift in Y-Direction is reduced by 65%, 57% respectively for the Braced structure and Shear Wall structure when compared to Regular structure.

Based on the above points it is concluded that there is a huge difference for Braced structure and Shear Walled structure when compared to regular RCC structure. So, either Braces or Shear Walls are necessary in order to minimize the damage during an Earthquake.

REFERENCES

1. G. S. Harsha and H. Sudarsana Rao, “shear wall analysis & design optimization in high rise buildings,” vol. 4, no. 8, pp. 333–341, 2015.
2. A. S. Patil and P. D. Kumbhar, “Time History Analysis of Multistoried Rcc Buildings for Different Seismic Intensities,” *Int. J. Struct. Civ. Eng. Res.*, vol. 2, no. 3, pp. 195–201, 2013.
3. G. Mindaye, “Seismic Analysis of a Multistorey RC Frame,” pp. 17209–17221, 2016.
4. Y. K. K. Jain, V. N. S. Nikhil, and P. P. Raju, “Analysis of a commercial building using ETABS,” *Int. J. Civ. Eng. Technol.*, vol. 8, no. 4, pp. 1438–1444, 2017.
5. R. R. Bhandarkar, U. M. Ratanpara, and M. Qureshi, “Seismic Analysis & Design of Multistory Building Using Etabs,” vol. 5, no. 2, pp. 78–90, 2017.
6. R. Mohan, “Dynamic Analysis of RCC Buildings with Shear Wall Dynamic Analysis of RCC Buildings with Shear Wall,” no. September, pp. 2–6, 2015.

AUTHORS PROFILE

K. Arun Akhil is doing his Bachelor of Technology in Civil Engineering at Koneru Lakshmaiah Education Foundation (Deemed to be University), Vaddeswaram, Guntur district, Andhra Pradesh, India. His research interests include Seismic Analysis of RC structures, Biaxial Cobiaxial Slabs, Concrete materials.

M. Manish Reddy is doing his Bachelor of Technology in Civil Engineering at Koneru Lakshmaiah Education Foundation (Deemed to be University), Vaddeswaram, Guntur district, Andhra Pradesh, India. His research interests include Seismic Analysis of RC structures, Concrete materials.

Mr. G. Sri Harsha is working as Assistant Professor in Department of Civil Engineering at Koneru Lakshmaiah Education Foundation (Deemed to be University), Vaddeswaram, Guntur district, Andhra Pradesh, India. He is pursuing Ph.D. in Koneru Lakshmaiah University and completed Master of technology in Structural Engineering from JNTU Ananthapur in 2015. His research interests include Structural Dynamics, Earthquake resistant Structures and Concrete Materials. He has published 7 research papers in various international journals and conferences and guided 5 students in masters and 14 students in bachelors. He is a lifetime permanent member of ICI (Indian Concrete Institute), IAENG & ISRD

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication