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STUDY OF COMPARISON BETWEEN TWO ATRIUM BUILDINGS IN VARIOUS SEISMIC ZONES WITH AND WITHOUT SHEAR WALLS

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Abstract - *This work is concerned with the analysis of atrium building structure to determine the importance of shear wall in high-rise building. Shear walls provide large strength and stiffness to buildings in the direction of their orientation, which reduces lateral sway of the building and thereby reduces damage to the structure and its contents. The present paper considered two atrium buildings (G+9) with and without shear walls having the same plan area. Each building is subjected to different seismic zones. The parameters selected for the comparison are nodal displacement and bending moment. Results were traced in tabular format for all parameters value and observed against selected zone like V, IV, III and II.*

Key Words: **Atrium Building, High-Rise Building, Shear Wall, Wind Load Analysis, Seismic Analysis, Nodal Displacement, Bending Moment**

1. INTRODUCTION

Humans are always fascinated with uniquely designed buildings. In architecture, an atrium is a large open-air or sky-light covered space surrounded by a building. Atria were a common feature in Ancient Roman dwellings, providing light and ventilation to the interior. Modern atria, as developed in the late 19th and 20th centuries, are often several stories high, with a glazed roof or large windows, and often located immediately beyond a building's main entrance doors.

To analyze the high-rise building some useful software's like STAAD Pro, ETABS etc. are widely used by the designers and researchers in this field. In traditional calculation of model of high-rise building, the following factors affecting the earthquake design of structures are different seismic zones, damping factor of the structure, importance of the building, type of soil, natural frequency of the building, different seismic zones, etc.

Any sudden shaking of the ground caused by the movement of tectonic plates is called earthquake. This shaking may cause building damage. When the ground shakes, the building foundation vibrate in a manner that's similar to the surrounding ground. The Indian subcontinent has a history of devastating earthquakes.

Shear walls provide large strength and stiffness to buildings in the direction of their orientation, which reduces lateral sway of the building and thereby reduces damage to the structure and its contents. Shear wall is a vertical structural element that resists lateral forces in the plane of the wall through shear and bending. The behavior of shear walls depends on the material used, the wall thickness, length & position of the wall in the building frame. Their thickness can be above 150 mm or below 400 mm in tall buildings; they are like vertical-oriented wide beams that carry the earthquake load towards the foundation. This wall resists the lateral loads that are imposed on the structure due to wind, earthquake, or sometimes due to hydrostatic or lateral earth pressure. Shear wall buildings are a common choice in many earthquake prone countries. They reduces earthquake damage in structural and nonstructural elements such as glass windows and construction materials. Buildings with shear walls have shown very good performance during earthquakes in high seismic areas. Shear walls designed to resist gravity/vertical loads and earthquake/wind lateral loads. These types of walls are structurally combined with the roof or floor. These walls resist the shear forces that try to push the walls up and the lateral forces of air that push the walls in and out of the structure.

In this paper, analysis of two G+9 storey atrium buildings against seismic load and wind load as per IS:875 part (III) and IS 1893 part(I)-2016 using STAAD Pro has been conducted to compare the maximum nodal displacement and maximum bending moment of the structures. The plan dimension remains same for all the models i.e., 20m X 20 m. Seismic zone was varied for each model. In the seismic zoning map given in the earthquake resistant design code IS 1893 (Part 1) 2016 assigns four levels of seismicity for India in terms of zone factors. According to that, here we consider four cities Visakhapatnam (Zone II), Kolkata (Zone- III), Dehra Dun (Zone- IV), Shillong (Zone-V) with a constant wind speed of 50 m/s. The models are subjected to dead loads, live load, seismic load and wind load. The member forces are calculated using load combinations as per IS 456:2000.

2. PRELIMINARY DATA OF THE STRUCTURE CONSIDERED FOR ANALYSIS OF MODELS USED BY STAAD PRO

Various IS Codes like IS 1893:2016(Part 1) and IS 456:2000 , IS 875 PART (I), IS 875 PART (II), IS 875 PART (III) were used for design purpose. The required sizes of beams and columns for analysis and design purpose is calculated.

Table -1: Description of Structural Items Required for the Design Models

SL NO.	Description	Structural Properties
1	Number of Stories	G+9
2	Floor to Floor Height	3.3m
3	Plinth Height	0.6m
4	Size of Column	0.65m X 0.65m
5	Size of Beam	0.3m X 0.5m
6	Size of Tie Beam	0.3m X 0.5m
7	Slab Thickness	0.14m
8	Thickness of Shear Wall	0.3m
9	External wall Thickness	0.25m
10	Internal wall Thickness	0.125m
11	Depth of Foundation	1.5m
12	Seismic Zones	ALL ZONES OF INDIA
13	Type of Soil	Medium Stiff
14	Atrium Area	100 Sqm.
15	Floor Area	300 Sqm.

Table -2: Description of various combination of loads assigned in the members of the models

SL NO.	Description	
1	Member Load on Peripheral Beam (Excluding Self Wt.)	13.85 KN/m
2	Member Load for Internal Beam (Excluding Self Wt.)	6.93 KN/m
3	Member Load on Peripheral Roof Beam (Excluding Self Wt.)	5.66 KN/m
4	Floor Load due to 20mm Floor Finish	0.4 KN/m^2
5	Floor Load due to 13mm Ceiling Plaster	0.265 KN/m^2
6	Floor Load due to 10mm Marble	0.267 KN/m^2
7	Live load considered For Roof	1.5 KN/m^2
8	Live load considered For Floors	3 KN/m^2
9	Wind speed considered	50 m/s

Table -3: Description of density of materials used in the study

SL NO.	Description	Density
1	Concrete	25.00 KN/m^3
2	Plaster	20.4 KN/m^3
3	Marble	26.7 KN/m^3
4	Floor Finish	20.00 KN/m^3
5	Brick Work	18.85 KN/m^3
6	Compressive Strength of Concrete	25.00 N/mm^2
7	Tensile Strength of Steel	500.00 N/mm^2

Table -4: Description of member properties

SL NO.	Description	
1	Young's modulus of concrete(M25) (E)	25000.00 N/mm2
2	Poisson's ratio of concrete	0.17
3	Co-efficient of thermal expansion of concrete	8x10-6 /°C
4	Co-efficient of thermal expansion of steel	12x10-6 /°C
5	Poisson's ratio of Steel	0.3
6	Young's modulus of Steel	200000 N/mm2
7	Grade of concrete	M25
8	Grade of steel	Fe 500

3. FIGURES

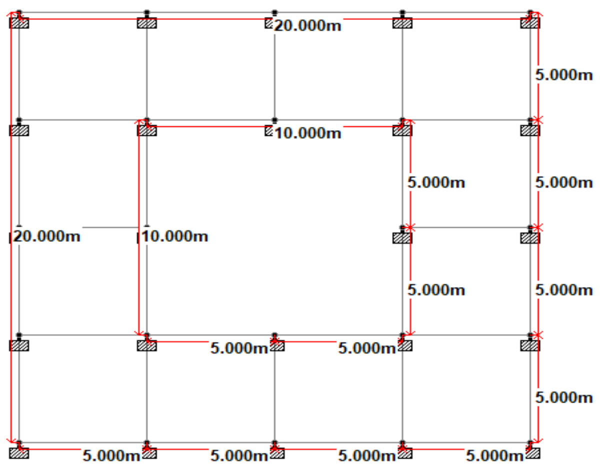

Figure -1: Plan

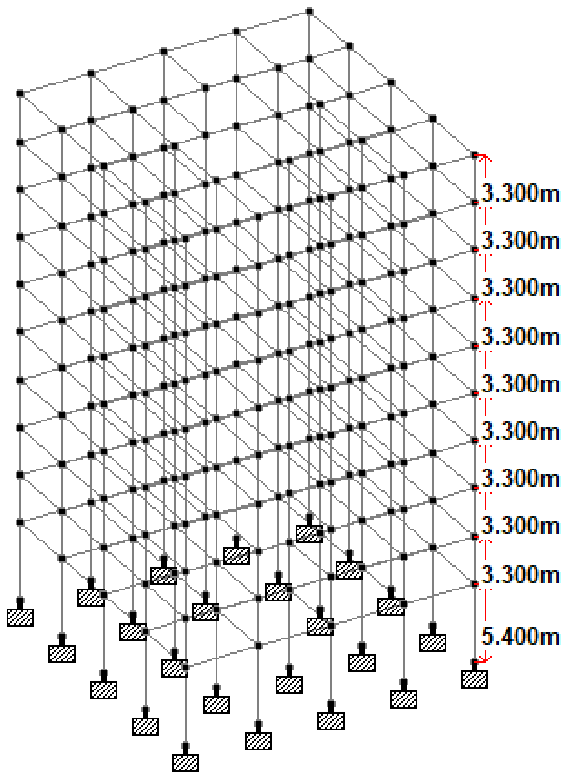

Figure -2: Elevation

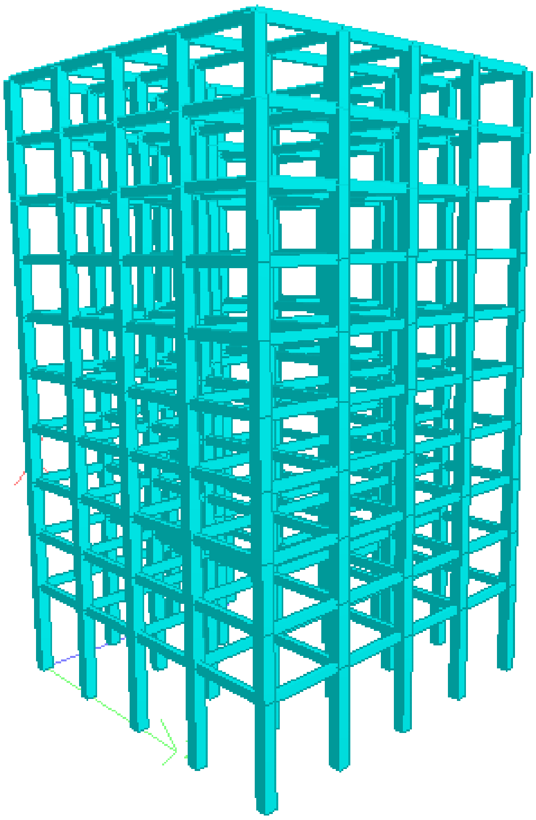

Figure -3: Model-I [Without Shear wall]

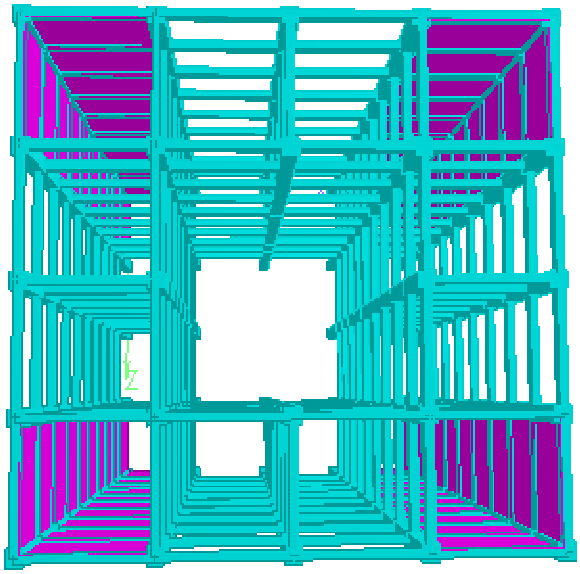

Figure -4: Model-II [Shear wall at every corners]

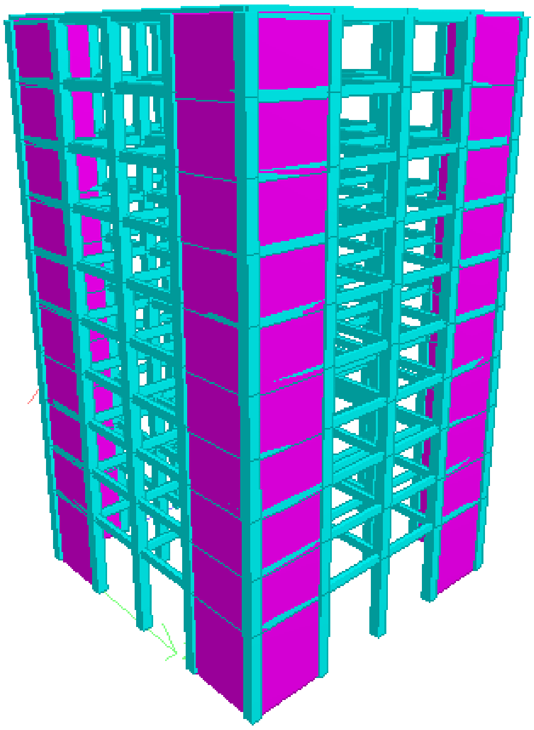

Figure -5: Model-II [Shear wall at every corners]

4. RESULT & DISCUSSION

4.1 Check for maximum nodal deflection under different seismic zones

The details of the variation of nodal deflection in with and without shear wall Atrium building for different load conditions and for different seismic zones has been tabulated in Table 6 and Chart 1 respectively.

Table 6 -: Variation of maximum nodal displacement under different seismic zones for Atrium with and without shear Wall

MAXIMUM DISPLACEMENTS IN MM		
SEISMIC ZONES	ATRIUM WITH SHEAR WALL	ATRIUM WITHOUT SHEAR WALL
ZONE II	25.19	57.386
ZONE III	25.19	57.386
ZONE IV	26.777	63.120
ZONE V	40.065	94.666

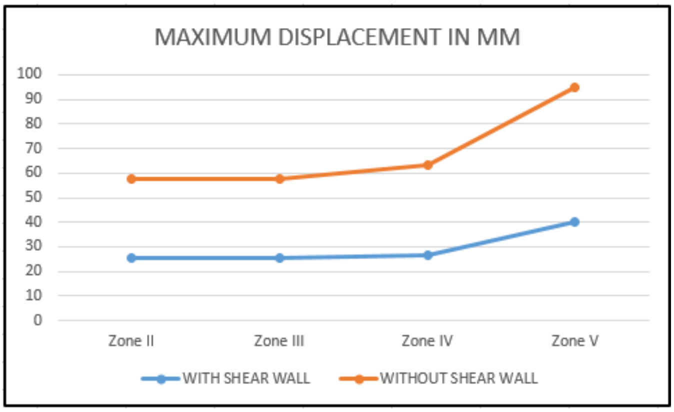

Chart -1 -: Maximum Displacement

4.2 Check for maximum bending moment under different seismic zones

The details of the variation of bending moment in with and without shear wall Atrium building for different load conditions and for different seismic zones has been tabulated in Table 7 and Chart 2 respectively.

Table 7 -: Variation of maximum bending moment under different seismic zones for Atrium with and without shear wall

MAXIMUM BENDING MOMENT IN KN-M		
SEISMIC ZONES	ATRIUM WITH SHEAR WALL	ATRIUM WITHOUT SHEAR WALL
ZONE II	275.987	417.292
ZONE III	275.987	417.292
ZONE IV	275.987	417.292
ZONE V	372.202	524.087

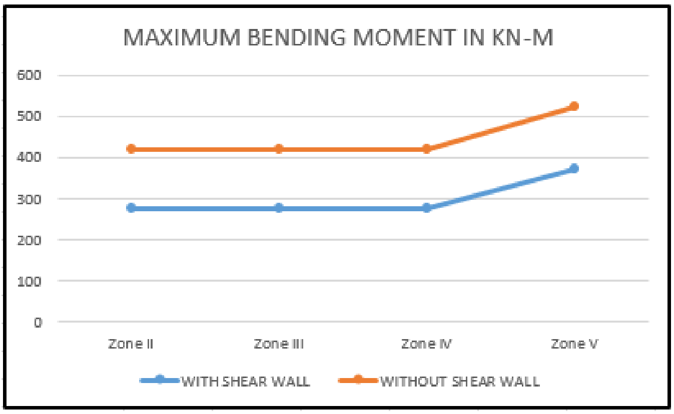

Chart -2: Maximum Bending Moment

5. CONCLUSIONS

In this study, analysis of G+9 storey Atrium buildings with and without shear walls against seismic load and wind load as per IS:875 part (III) and IS 1893 part(I)-2016 using STAAD Pro has been conducted to compare the nodal displacement and bending moment of the structures.

The conclusion drawn from the study of G+9 Atrium building that providing shear walls substantially reduces the lateral displacement and bending moment due to earthquake and wind loading. Also the stability and stiffness of the structure will increase with the optimum placement of shear walls.

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