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Influence of Shear Wall on Seismic Response of a Structure

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Abstract: Structural analysis is the science of determining the effects of different loads on structures. Structural stability and stiffness are a main concern in any high-rise structures. Shear walls are structural members that are mainly responsible for resisting lateral loads predominant on structures. They are mainly responsible to increase the stiffness, reduce story drift and displacement. In order to have a comprehensive understanding about the contribution of shear wall, following research is carried out. This research involves comparing two G+16 structures; one without a shear wall and one with it. The structure has 4 bays of 3m each along X direction and Z direction. In this, we will see how shear wall resists lateral sway and reduces story drift and increases stiffness. As the height increases, the shear wall absorbs more lateral load than the frame. The software to be used for analysis is STAADPro.
Keywords: STAADPro, Stiffness, storey displacement, storey drift.

I. INTRODUCTION

An earthquake is a sudden slipping or movement of a portion of the Earth's crust or plates, caused by a sudden release of stresses. Earthquake epicentres are usually less than 25 miles below the Earth's surface and are accompanied and followed by a series of vibrations. This release of energy and stress cause elastic impulses and waves. These waves are known as seismic waves and classified as body waves- travels within the body of earth and surface waves over the surface of the earth. Based on the peak ground acceleration or movement, there are certain zones of the earth, named as seismic zones. In India, there are four zones, namely II, III, IV, V – last one being the most devastating [4]. The waves are either vertical or horizontal. But the most dominant of these two are the horizontal ones. A structure should have enough ductility and stiffness to resist these lateral forces. Shear walls are those elements that provide additional ductility and stiffness to the structure. They are usually placed at various locations in a building starting from the foundation level to the parapet level. They also reduce shear and moment demands on beams and columns. They should be provided throughout the height of the structure [3].

A. Objective

1) To study the behaviour of shear walls to lateral loading.
2) To compare the seismic response of two buildings; one with shear wall and one without it.

II. LITERATURE REVIEW

The philosophy of seismic design Figure - 1 can be summarized as follows:

1) In case of minor but frequent impacts, the main elements of the building that support the horizontal and vertical forces should not be damaged. However, non-load-bearing construction parts can suffer repairable damage.
2) In the event of moderate but occasional impacts, the main elements may suffer repairable damage, while the other extra parts of the building may also be damaged to such an extent that they even have to be replaced after the earthquake; In severe but rare shakes, the main members can be severely damaged and the building should not fail or collapse. [5]

In order to reduce the effect of lateral loads on the buildings, shear walls are provided.

III. PROBLEM STATEMENT

The plan and elevation of a G+16 storey residential building is shown in figure. The building is located in Zone IV. The type of the soil is in courted as medium stiff and proposed to design the building in SMRF.
Structural Specifications: Response Reduction factor-5
Importance factor- 1
Soil Strata- Medium stiff
Damping ratio- 5%

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Structural Element	*Size*
Beam	0.30m to 0.50m
Column	0.35m to 0.75m
Sear Wall	0.30m thickness

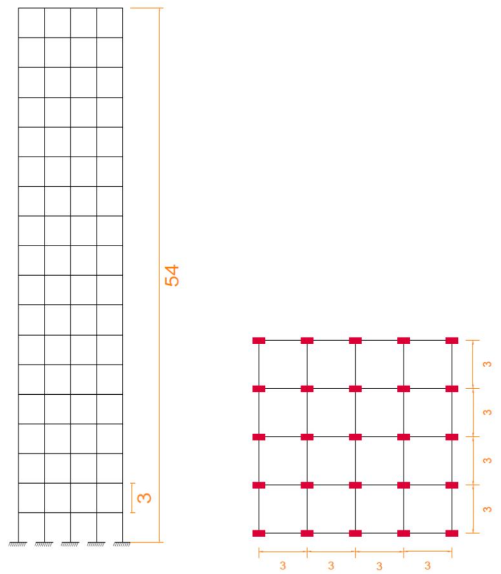

Figure 1: Plan and Elevation of G+16 building

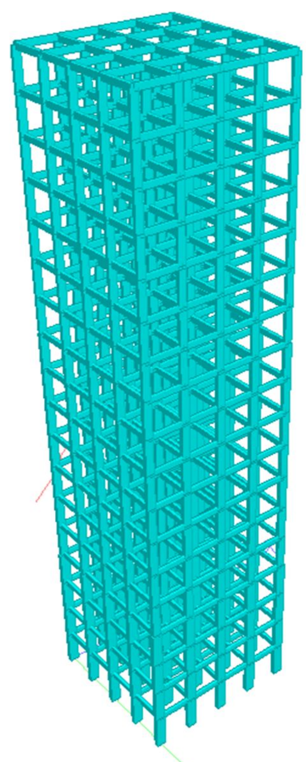

Figure 2a: Without shear wall

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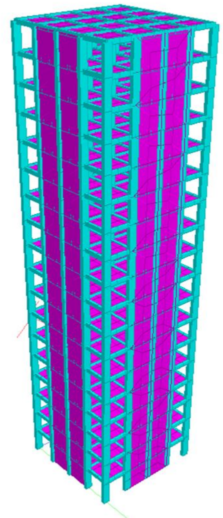

Figure 2b: With shear wall

IV. METHODOLOGY

Here, we will see the difference between two buildings; one with shear walls and one without them and we are going to see the values of their respective storey displacement and storey drift. The software to be used in order to analyse the structure is STAADPro. It is usually observed that shear walls reduce storey displacement and storey drift and increases stiffness [1]. There are many modern solutions to reduce the effect of lateral loads but shear wall is the most traditional and economical of some of them. The vertical and the horizontal shear reinforcement in the shear wall takes up the lateral force and reduces its effect on other load bearing elements.

V. RESULTS

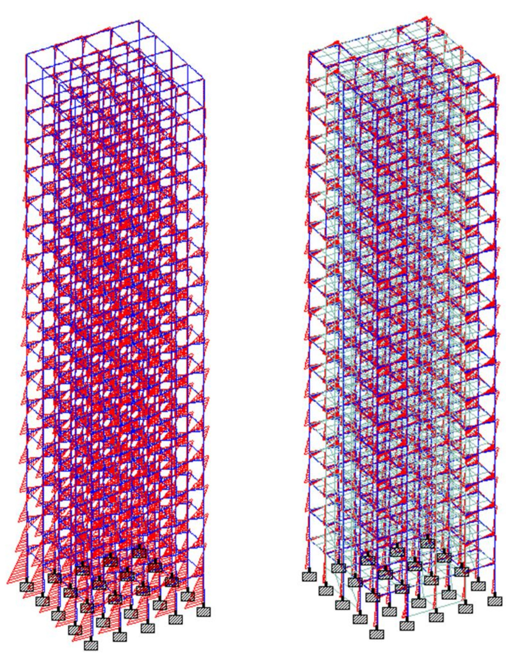

Figure 3a: Stresses in beams and columns in the absence of shear wall. Figure 3b: Stresses in beams and columns in the presence of shear wall.

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Table 1: Results for various parameters with and without shear wall

Parameter	Without Shear Wall	With shear wall
Max Fx	4793.55 kN	4179.89 kN
Min Fx	-1042.50 kN	-1144.87 kN
Max Fy	191.72 kN	235.00 kN
Min Fy	-192.00 kN	-235.00 kN
Max Fz	132.00 kN	83.63 kN
Min Fz	-132.00 kN	-83.63 kN
Max Mx	1.23 kN-m	24.05 kN-m
Min Mx	-1.23 kN-m	-24.05 kN-m
Max My	213.92 kN-m	135.65 kN-m
Min My	-213.92 kN-m	-135.65 kN-m
Max Mz	333.31 kN-m	243.97 kN-m
Min Mz	-333.31 kN-m	-220.10 kN-m

VI. STOREY DISPLACEMENT

A. *Storey Drift*

It is the lateral displacement of the storey relative to the base & is the absolute value of displacement of the storey under action of the lateral forces [2]. It is the difference in lateral deflection between two adjacent stories. Story drift ratio is the storey drift divided by the storey height [2].

Table 2a: Values of displacement and storey drift in the X and Z direction without shear wall.

HEIGHT	WITHOUT SHEAR WALL			
	DISPLACEMENT		STORY DRIFT	
	X	Z	X	Z
0 m	0.00 mm	0.00 mm	0.00 mm	0.00 mm
3 m	3.85 mm	3.76 mm	3.85 mm	3.76 mm
6 m	11.64 mm	11.66 mm	7.78 mm	7.90 mm
9 m	20.96 mm	21.23 mm	9.32 mm	9.57 mm
12 m	30.96 mm	31.04 mm	10.05 mm	9.81 mm
15 m	42.58 mm	42.67 mm	11.62 mm	11.63 mm
18 m	54.56 mm	55.00 mm	11.98 mm	12.33 mm
21 m	66.71 mm	66.71 mm	12.15 mm	11.71 mm
24 m	78.90 mm	78.90 mm	12.19 mm	12.19 mm
27 m	91.00 mm	91.21 mm	12.11 mm	12.31 mm
30 m	102.91 mm	102.67 mm	11.91 mm	11.46 mm
33 m	114.53 mm	114.23 mm	11.61 mm	11.56 mm
36 m	126.83 mm	126.61 mm	12.30 mm	12.38 mm
39 m	138.47 mm	138.27 mm	11.64 mm	11.65 mm
42 m	149.26 mm	148.98 mm	10.78 mm	10.71 mm
45 m	159.01 mm	159.01 mm	9.75 mm	10.03 mm
48 m	167.53 mm	166.93 mm	8.52 mm	7.92 mm
51 m	174.64 mm	174.36 mm	7.11 mm	7.43 mm
54 m	180.28 mm	180.00 mm	5.64 mm	5.64 mm

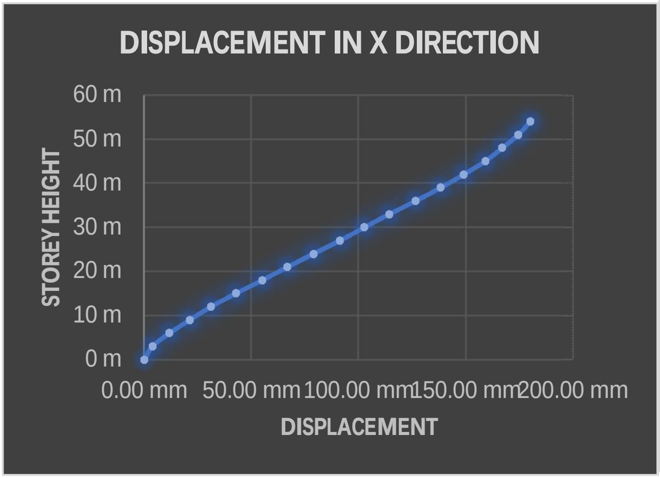

Figure 4a: Displacement in X direction

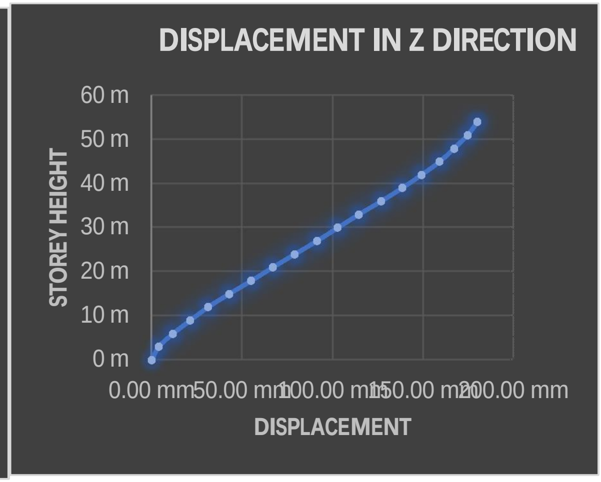

Figure 4b: Displacement in Z direction

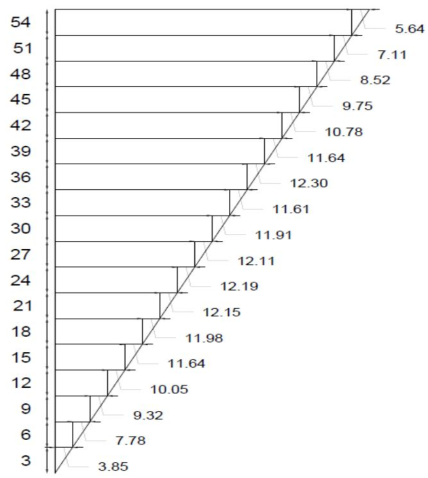

Figure 5a: Storey drift in X direction

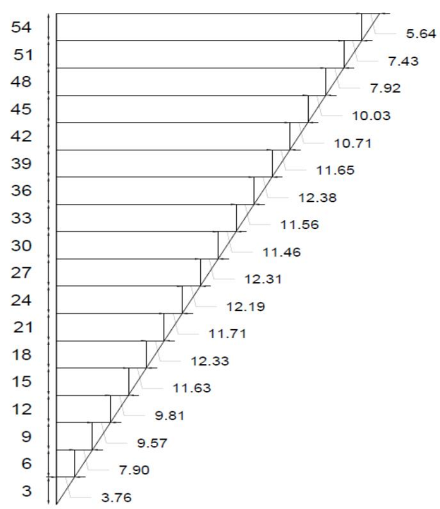

Figure 5b: Storey drift in Z direction

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Table 2b: Values of displacement and storey drift in X and Z direction with shear wall

	WITH SHEAR WALL			
	DISPLACEMENT		STORY DRIFT	
HEIGHT	X	Z	X	Z
0 m	0 mm	0.00 mm	0.00 mm	0.00 mm
3 m	1 mm	0.66 mm	0.60 mm	0.66 mm
6 m	2 mm	2.08 mm	1.35 mm	1.42 mm
9 m	4 mm	4.14 mm	1.92 mm	2.06 mm
12 m	6 mm	6.75 mm	2.42 mm	2.61 mm
15 m	9 mm	9.80 mm	2.83 mm	3.05 mm
18 m	12 mm	13.21 mm	3.16 mm	3.41 mm
21 m	16 mm	16.90 mm	3.41 mm	3.69 mm
24 m	19 mm	20.81 mm	3.60 mm	3.91 mm
27 m	23 mm	24.86 mm	3.73 mm	4.05 mm
30 m	27 mm	29.00 mm	3.81 mm	4.14 mm
33 m	31 mm	33.18 mm	3.84 mm	4.18 mm
36 m	34 mm	37.35 mm	3.82 mm	4.17 mm
39 m	38 mm	41.48 mm	3.78 mm	4.13 mm
42 m	42 mm	45.54 mm	3.70 mm	4.06 mm
45 m	46 mm	49.50 mm	3.61 mm	3.96 mm
48 m	49 mm	53.35 mm	3.51 mm	3.86 mm
51 m	53 mm	57.12 mm	3.41 mm	3.77 mm
54 m	56 mm	60.71 mm	3.23 mm	3.59 mm

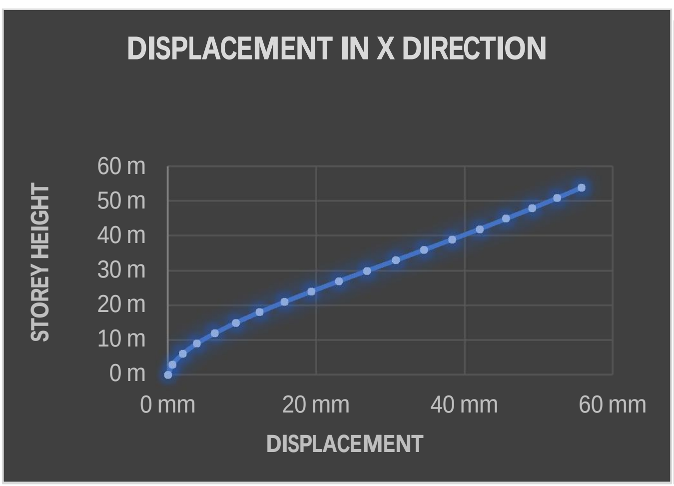

Figure 6a: Displacement in X direction

Figure 6b: Displacement in Z direction

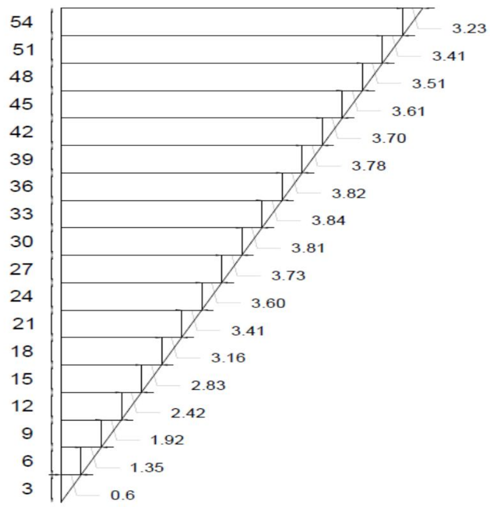

Figure 7a: Storey drift in X direction

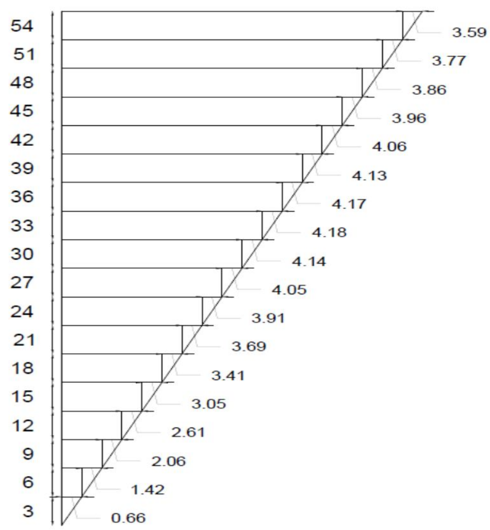

Figure 7b: Storey drift in Z direction

VII. CONCLUSION

A. The storey displacement reduces from 180.28 mm to 56 mm in X direction and 180 mm to 60.71 mm in Z direction at 54 m height when shear wall is introduced in the frame.
B. The relative storey drift reduces when shear wall is induced.
C. The base shear reduces by 12.80% after introducing a shear wall.
D. The maximum bending moment is reduced by 27.02%.

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