Effect of Shear Wall on Seismic Performance of High Rise Building Adopting Linear Dynamic Analysis

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Abstract- *RC shear wall is a structural member which is used to resist lateral forces coming from wind and earthquake. Shear wall generally used in the high earthquake-prone area as they resist large lateral loads and gravity loads. When the shear wall is placed in an active position in a high rise building, they can be very efficient in resisting lateral loads originating from wind and earthquake. In the present study, G+20 high rise residential building is analysed using ETABS v17.0.1 software by linear dynamic method, i.e. response spectrum analysis method. All analyses are carried out as per Indian standard codebooks, especially IS 1893: 2016 (Part-I). The building is situated in Seismic Zone IV, and by changing the position of the shear wall, the different parameters like storey drift, storey displacement and base shear are determined. Then all results are compared in terms of storey drift, storey displacement & base shear and finally concluded the effective position of shear wall in the building. Response spectrum method is used to measures the addition of each mode of vibration to express the maximum seismic response of the structure.*

Keywords- Shear wall, High Rise Building, ETABS, Response Spectrum Analysis.

I. INTRODUCTION

High rise building is the essential structures for day to day life. For earthquake resistant design of high rise building improper construction practices and ignorance were done in our country, most of the existing structures will affect in the future earthquake. To prevent the failure of structure, serviceability and safety life, the effective structural system should be provided with all parameters of seismic analysis. The high rise building with reinforced concrete shear walls is designed because of high stiffness, ductility and high resisting capacity to lateral force. There are different cross-sections of the shear wall like T- shape, C-shape, H-shape, I-shape and rectangular shape. The positing of shear wall affects the behaviour of building in an earthquake. For effective and overall performance of the building, it is crucial to place a shear wall in the right vicinity so that they are symmetrical and the torsional impact is avoided.Shear walls are rapid in construction; shear walls don't need any extra plastering or finishing as the wall itself gives such a high level of precision, that it doesn't require any plastering. The slenderness ratio of a wall is a function of adequate height divided by either radius of gyration or proper thickness of the wall. The position of the shear wall is decided by its functional requirements. Building sites, client opinion and architectural aspects lead the location of the shear wall that are undesirable from the structural point of view. In some cases, the deflection in high rise building for different position of shear wall is calculated. In results, it is observed that the deflection of a tall building with a shear wall placed at a corner in X-direction and Y-direction is less as compared to the other different models in Chittiprolu and kumar [8]. The provision of lateral stiffness is a significant consideration in the design of a tall building in different seismic zones. First of all, the deflection should be maintained at a deficient level for the proper functioning of the non-structural element.

In Comparative Study of Reinforced Concrete Shear Wall Analysis in Multi-storied Building with Openings by Non-linear Methods", to study seismic response of the G+10 RC shear wall building with and without provision of opening. Developed an advanced mathematical model and analysed the RC shear wall building by using different non-linear seismic analysis methods like time history and pushover analysis method. These methods vary in respect to accuracy, clarity and transparency of the theoretical background by Kulkarni and Satpute [3]. Non-linear static procedures were developed with the aim of reducing the inadequacy and limitations of linear methods. All procedures include performance-based concepts having more attention to damage control. The analysis is carried out by using standard analysis software SAP2000. The correlation of these models for different specifications like storey displacement, storey drift and base shear has been presented by RC shear wall building with and without opening.

The damping values are taken as 2 or 5 percent as per IS code for the purpose of dynamics of steel and reinforced concrete buildings. In this analysis, the number of modes is to be taken in the analysis should be such that the summation of total modal masses of all different modes is considered at least 90% of the total seismic mass of the structure. The location of the shear wall in multi-storeyed building is determined by creating different models and analyse by considering parameters like storey displacement, base shear, maximum storey drift, natural period and total cost etc. the shear wall in shorter span at the corner of the building is economical as compared with shear wall at a different location.

Analysis of Asymmetrical Building with Shear Wall under Seismic Loading", in the unsymmetrical building with the placement of external and internal shear wall under the two different support conditions, i.e. fixed and hinge is analysed by using elastic half-space approach method. A globally available software package STAAD Pro 2008 has been used for analysis purpose. The changes in the bending moment with a decrease up to 78% were observed. The storey drifts also show a deviation of up to 23% for the internal columns when soil-structure interaction (SSI) was integrated into the analysis by Gagandeep and Tiwary [1]. They have analysed the asymmetrical model of G+15 storey, and STAAD Pro used the stiffness matrix method for analysis purposed. There are three different methods like Elastic half-space approach, finite element method and Winkler method used for the analysis. The Analysis of G+25 RCC Structure with shear wall under the effect of seismic loads using software STAAD Pro V8i, the focus is to give the lateral stability to the G+25 RCC building by Thakur and Singh [11]. In this project, G+25 high rise building structure which is asymmetric in its plan. The shear wall is placed at different locations, i.e. at centre, intermediate, corner and core. The results are analysed based on base shear, storey displacement, storey drift, moment and shear force in AkshayUmare and Kuril [2]. Models compare with the conventional building without provision of a shear wall. After analysing all the results are tabulated, it is seen that shear wall placed at corner gives the effective result and is capable to resists larger seismic forces compared to other locations. There is no enormous uniformly of opinion in determining elastic failure due to the complex nature of the failure. By using IS 456-2000 and STAAD Pro software finally concludes with results of most of the stress are found to be desire as for analysing the stress of shear wall. It is designed as per IS 456-2000 it is used for low rise building and also IS 1893 Part-I is used for the seismic analysis of high rise building with shear wall and without shear wall and results are compared in terms of displacement and base shear.

In some cases, it should prevent excessive cracking, loss of stiffness and avoid redistribution of load to any other non-structural members by Azam and Hosur [10]. ETABS software is quick, easy and gives more accurate results for complex and tallest building; it is the best tool for structural engineer in the construction industry, and also this software has a different method for analysis. The shear wall should have ductility to avoid brittle failure under the lateral loads. In the response spectrum method, the response of the building has an extensive range of periods compiled in a single graph. This method should be performed using the design spectrum, which is in a specified code by Shah and Patel [7]. Worked on the "Seismic Analysis of Multi Storied Building with Shear Walls of Different Shapes", in this paper the work is deal with improvement in the shape of shear walls in symmetrical and asymmetrical high rise building. In symmetrical buildings, the centre of rigidity and centre of gravity coincide, so that the shear walls are placed symmetrically to achieve maximum economy. In this work, a two different high rise building with varying shapes of shear walls is considered for the analysis. The multi-storey building with G+14 and G+29 storey are analysed for its storey displacement, storey drift and base shear using globally well-known analysis and design software ETABS version 16.2.0 by Santhosh and Mathew [4]. For the analysis of the building considered seismic loading with two different Zones, Zone- III & Zone-V. The analysis of the building is carried out by using dynamic analysis method that is Response spectrum analysis method. A core eccentrically located concerning the building shapes has to carry torsion, bending and direct shear. These shear walls resist lateral forces because they have high rigidity as deep beams, reacting to shear and flexure against the overturning. There are different types of a shear wall, as U, W, H and T shape shear wall.

The Analysis of RCC Building with Shear Walls at Various Locations and in Different Seismic Zones", the analysis of RCC building has been carried out by altering the locations of shear walls in the building. Also, the effect of variations in different seismic zones as per IS codes has been calculated. The seismic analysis is performed by using linear dynamic analysis in that response spectrum method is used. The globally well-known analysis and design software ETABS v16.2.0 is used. Seismic performance of the building has been explored based on parameters like storey drift, and base shear in Eswaramoorthi [5]. The building is situated in seismic zone IV, and the analysis is carried out by using a static coefficient method. Design of Multistoried Regular R.C. Buildings with and without Shear walls, for obtaining economy in reinforced concrete building structures, design of critical section is correctly done to get acceptable concrete sizes and optimum steel consumption in structural members by Vaidya [9]. In this study, an attempt has been made to model G+12, G+15 and G+18 storey building with and without shear walls by using a static analysis method for seismic zone III. Globally accepted ETABS version 9.74 software is used for the static analysis Soni and Pajgade [6]. This study aim is to determine the comparative seismic performance of buildings in terms of storey drift, base shear, storey displacement and cost analysis.

Some of the papers studies about the analysis of different types of buildings with different cases such as symmetrical building, asymmetrical building having a different storey, etc. From the different papers, it is observed that the shear wall should be provided throughout the height of building for the effective results. It is observed that placing a shear wall in the periphery of the structure which gives effective results. The zone factor plays an important role while analysing the building. Shear wall with different shapes can be used for the analysis of the building, based on base shear and storey drift U and W shaped shear wall shows better performance in different seismic zones and also shear wall at core is effective to resist lateral loads as compared to the other locations. Hence it was concluded that placing of shear wall in a high rise building resists the lateral forces effectively than building without a shear wall.

II. METHODOLOGY

2.1 Objective:

- To determine the effective location of the shear wall.
- To determine storey displacement, storey drift and base shear of G+20 high rise building with and without shear wall by using the response spectrum analysis method.
- Results are compared in terms of storey displacement, storey drift and base shear of three different models with different location of the shear wall.

2.2 Preliminary data:

Table 1: Preliminary data for analysis

Type of frame-	(SMRF)	Thickness of wall-	300 mm
Building plan dimension-	27.5 m x 9.8 m	Beam size [B1]-	230 x 600 mm
No. of storey-	20	Beam size [B2]-	300 x 750 mm
Floor to floor height-	3.3	Column size [C1]-	300 x 900 mm
Grade of Concrete-	M40	Density of Concrete-	25 kN/m³
Grade of Steel-	Fe500	Density of Steel-	78.5 kN/m³
Thickness of slab-	150 mm	Density of ACC block-	6.50 kN/m³

2.3 Loads and seismic data:

Table 2: Loads and seismic data for analysis

Live load-	2.5 kN/m²	Zone factor-	0.24
Floor finish-	1.1 kN/m²	Importance factor-	1.2
Wall load-	4.03 kN/m	Response reduction factor-	5
Wind Speed-	39 m/s	Soil type-	II (Medium soil)
Seismic Zone-	IV	IS code-	IS 1893: 2016 (Part-I)

2.4 Load combinations:

Table 3: Different load combinations

Sr. No.	Load Combinations	Sr. No.	Load Combinations
1	DL	10	1.5(DL-EQY)
2	LL	11	0.9DL+1.5EQX
3	SIDL	12	0.9DL-1.5EQX
4	EQ-X	13	0.9DL+1.5EQY
5	EQ-Y	14	0.9DL-1.5EQY
6	1.5(DL+LL)	15	1.2(DL+0.5LL+EQX)
7	1.5(DL+EQX)	16	1.2(DL+0.5LL-EQX)
8	1.5(DL-EQX)	17	1.2(DL+0.5LL+EQY)
9	1.5(DL+EQY)	18	1.2(DL+0.5LL-EQY)

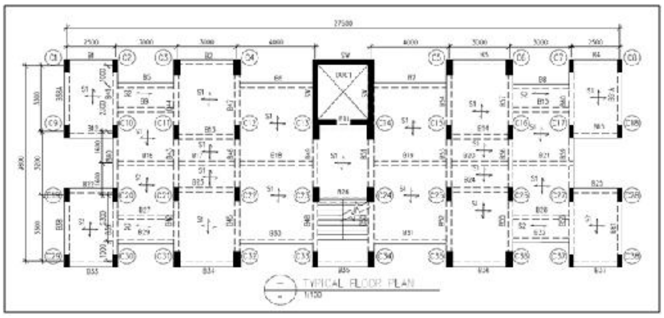

Fig. 1 Typical RCC floor plan

2.5 Plan details:

2.5.1 G+20 high rise building without shear wall

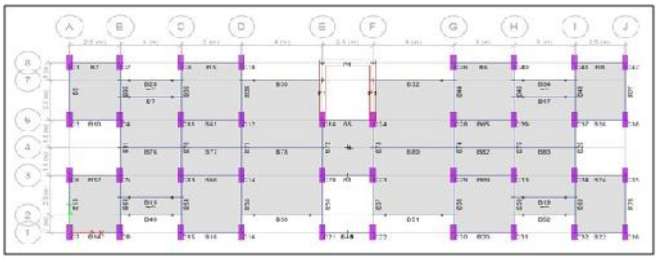

Fig. 2 Floor plan of building without shear wall

2.5.2 G+20 high rise building with shear wall at corner & periphery

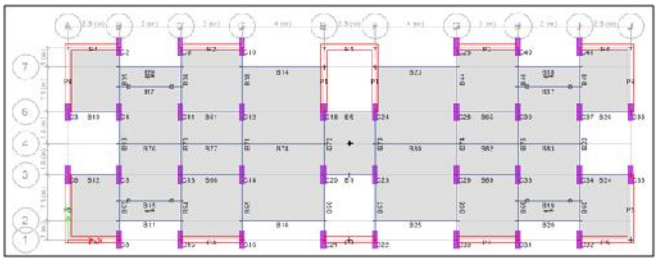

Fig. 3 Floor plan of building with shear wall at corner & periphery

2.5.3 G+20 high rise building with shear wall at core

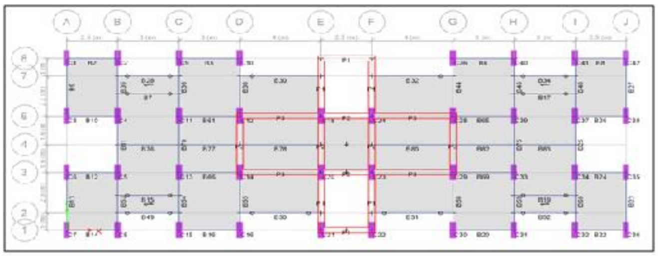

Fig. 4 Floor plan of building with shear wall at core

III. RESULTS AND DISCUSSIONS

3.1 MODEL-1 (G+20 high rise building without shear wall)

3.1.1 Storey Displacement-

The maximum storey displacement of the G+20 high rise building without shear wall is 29.5 mm in X-direction & 22 mm in Y-direction, as shown in Fig. 5 and 28.5 mm in X-direction & 21.2 mm in Y-direction, as shown in Fig. 6.

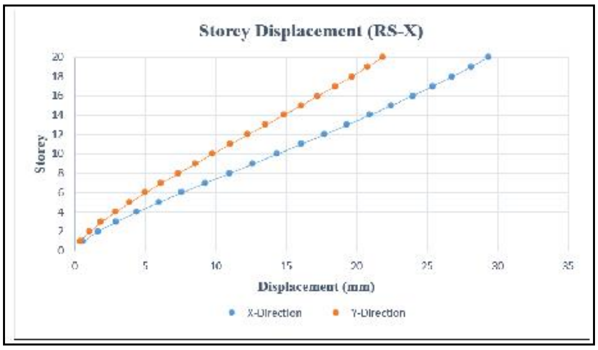

Fig. 5 Storey displacement in RS (X-direction)

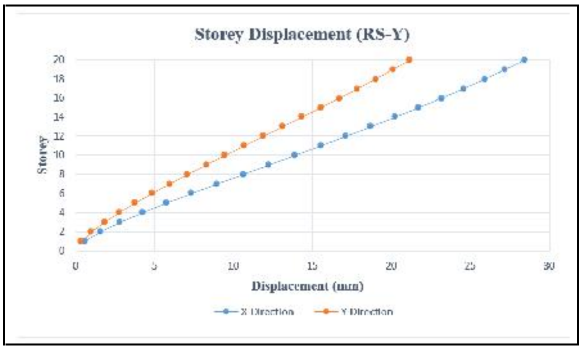

Fig. 6 Storey displacement in RS (Y-direction)

3.1.2 Storey Drift-

The maximum storey drift of the G+20 high rise building without shear wall is 0.000551 in X-direction & 0.000408 in Y-direction, as shown in Fig. 7 and 0.000534 in X-direction & 0.000395 in Y-direction, as shown in Fig. 8.

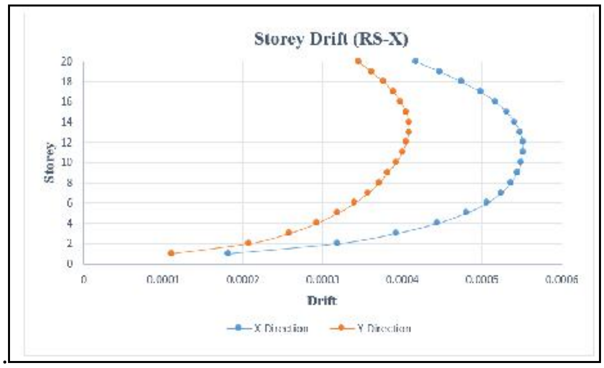

Fig. 7 Storey drift in RS (X-direction)

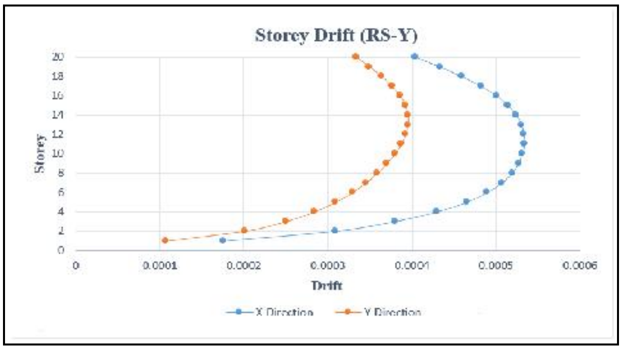

Fig. 8 Storey drift in RS (Y-direction)

3.1.3 Base Shear-

The maximum base shear of the G+20 high rise building without shear wall is 1150 kN in X- direction & 1700 kN in Y-direction, as shown in Fig. 9. The elevation of building without shear wall, as shown in Fig. 10.

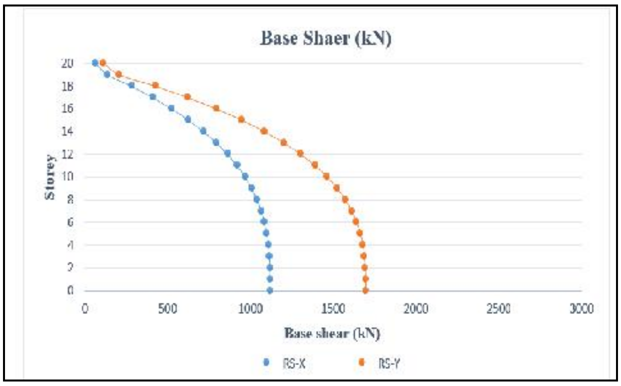

Fig. 9 Base shear

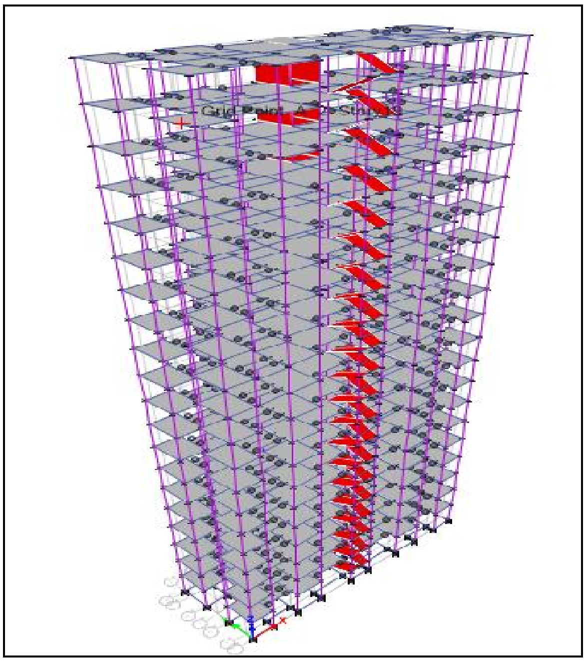

Fig. 10 Building without shear wall

3.2 MODEL-2 (G+20 high rise building with shear wall at corner & periphery)

3.2.1 Storey Displacement-

The maximum storey displacement of the G+20 high rise building with shear wall at corner & periphery is 20.1 mm in X-direction & 16.7 mm in Y-direction, as shown in Fig. 11 and 21.5 mm in X-direction & 18 mm in Y-direction, as shown in Fig. 12.

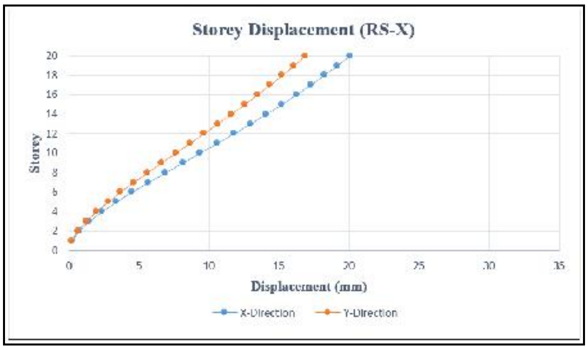

Fig. 11 Storey displacement in RS (X-direction)

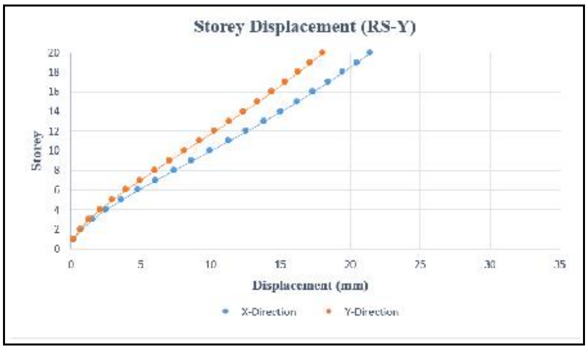

Fig. 12 Storey displacement in RS (Y-direction)

3.2.2 Storey Drift-

The maximum storey drift of the G+20 high rise building with shear wall at corner & periphery is 0.000320 in X-direction & 0.000390 in Y-direction, as shown in Fig. 13 and 0.000401 in X-direction & 0.000336 in Y-direction, as shown in Fig. 14.

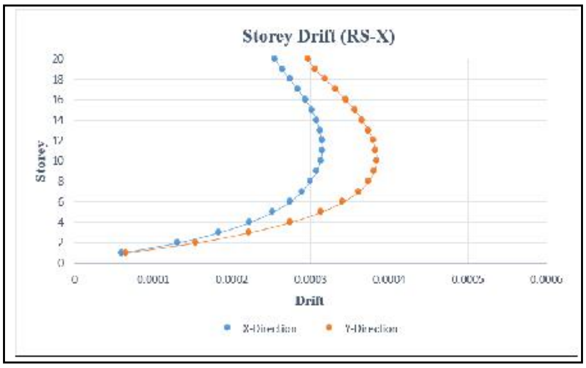

Fig. 13 Storey drift in RS (X-direction)

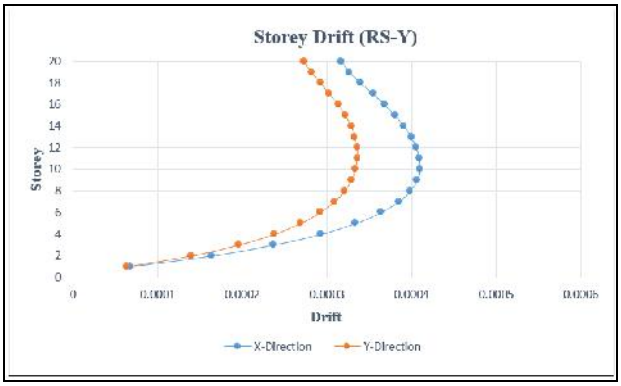

Fig. 14 Storey drift in RS (Y-direction)

3.2.3 Base Shear-

The maximum base shear of the G+20 high rise building with shear wall at corner & periphery is 2000 kN in X-direction & 2400 kN in Y-direction, as shown in Fig. 15. The elevation of building with shear wall at corner & periphery, as shown in Fig. 16.

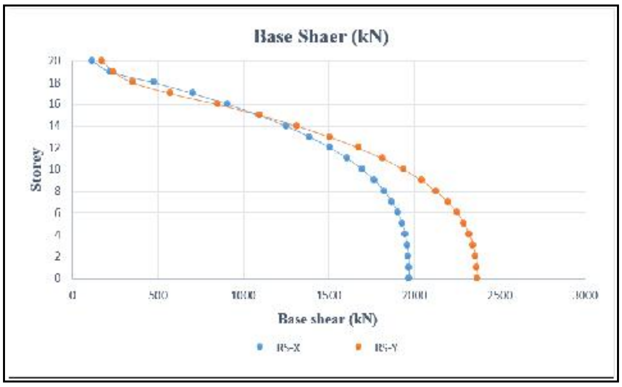

Fig. 15 Base shear

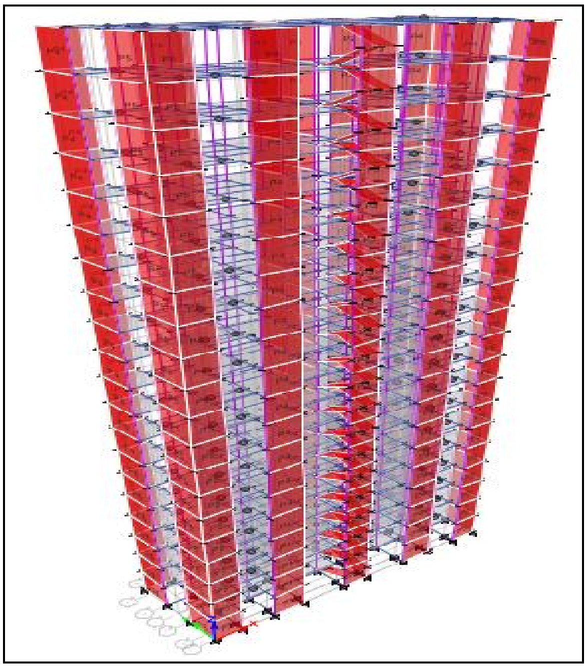

Fig. 16 Building without shear wall at corner & periphery

3.3 MODEL-3 (G+20 high rise building with shear wall at core)

3.3.1 Storey Displacement-

The maximum storey displacement of the G+20 high rise building with shear wall at core is 14.8 mm in X-direction & 17.5 mm in Y-direction, as shown in Fig. 17 and 14.2 mm in X-direction & 16.5 mm in Y-direction, as shown in Fig. 18.

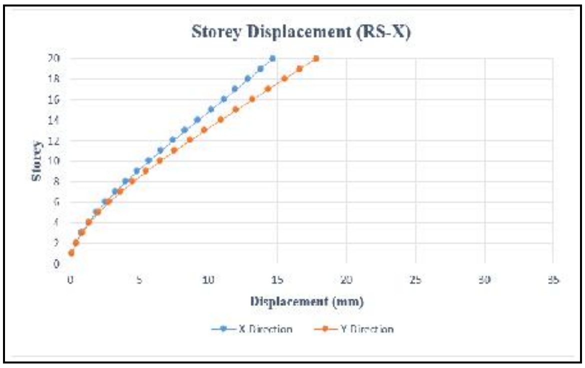

Fig. 17 Storey displacement in RS (X-direction)

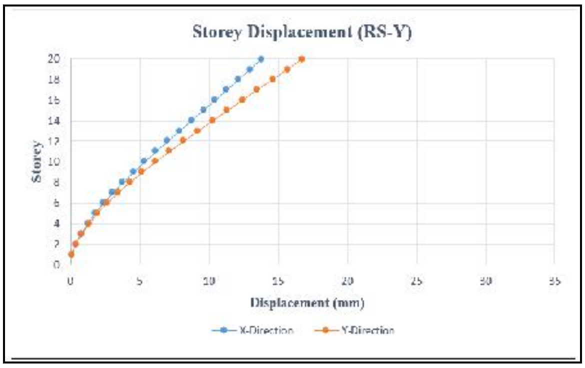

Fig. 18 Storey displacement in RS (Y-direction)

3.3.2 Storey Drift-

The maximum storey drift of the G+20 high rise building with shear wall at core is 0.000282 in X-direction & 0.000350 in Y-direction, as shown in Fig. 19 and 0.000265 in X-direction & 0.000313 in Y-direction, as shown in Fig. 20.

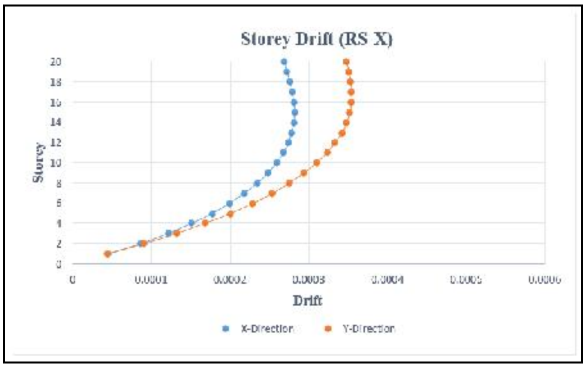

Fig. 19 Storey drift in RS (X-direction)

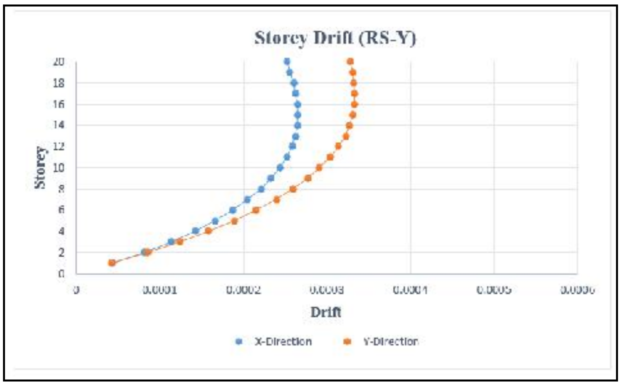

Fig. 20 Storey drift in RS (Y-direction)

3.3.3 Base Shear-

The maximum base shear of the G+20 high rise building with shear wall at core is 3300 kN in X-direction & 2800 kN in Y-direction, as shown in Fig. 21. The elevation of building with shear wall at core, as shown in Fig. 22.

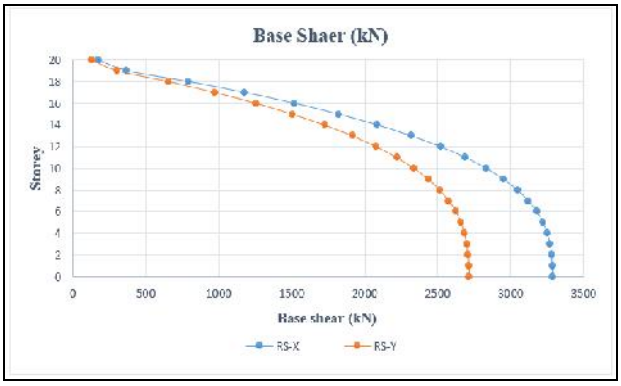

Fig. 21 Base shear

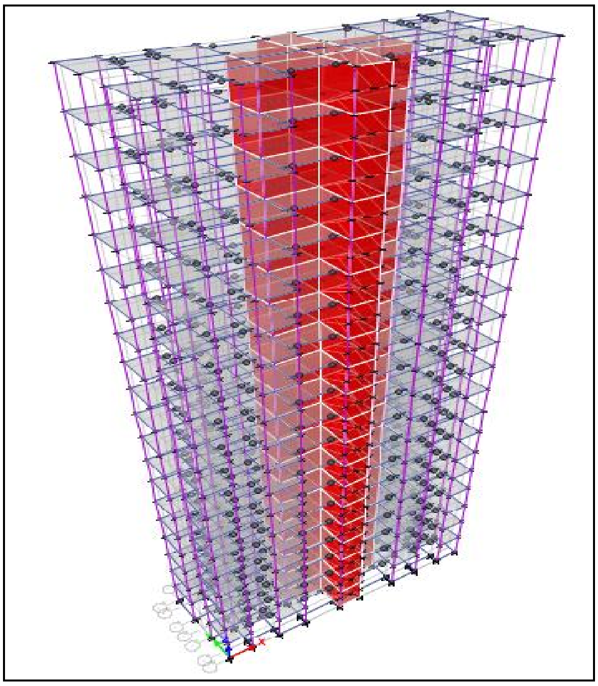

Fig. 22 Building without shear wall at core

3.4 Comparison of all three models (MODEL-1, MODEL-2 & MODEL-3)

3.4.1 Storey Displacement-

Graphical representation of storey displacement in terms of RS-X and RS-Y, as shown in Fig. 23. The storey displacement is maximum in MODEL-1 as compared to MODEL-2 and MODEL-3, and also MODEL-3 has minimum storey displacement as compared to the other two models.

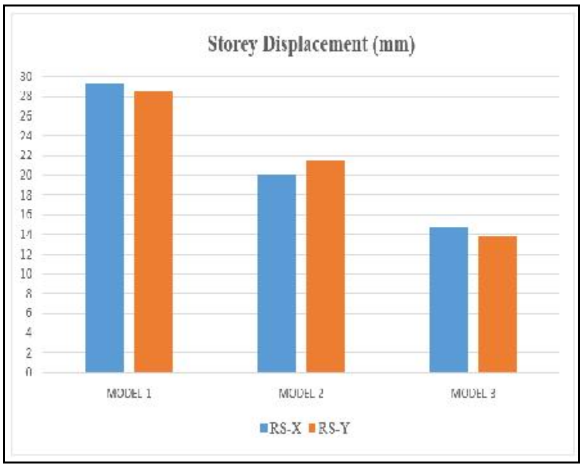

Fig. 23 Comparison of storey displacement

3.4.2 Storey Drift-

Graphical representation of storey drift in terms of RS-X and RS-Y as shown in Fig. 24. The storey drift is maximum in MODEL-1 as compared to MODEL-2 and MODEL-3, and also MODEL-3 has minimum storey drift as compared to the other two models.

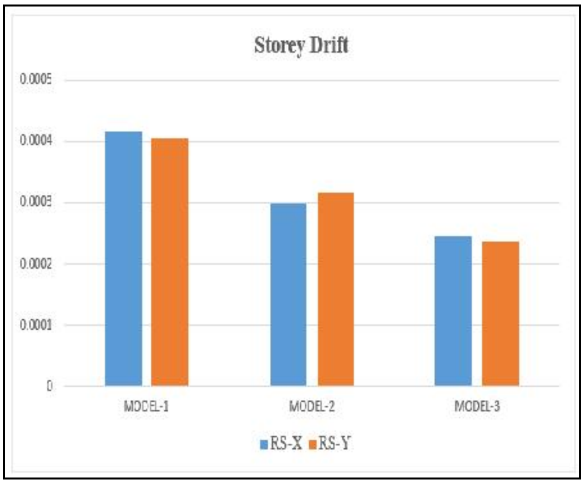

Fig. 24 Comparison of storey drift

3.4.3 Base Shear-

Graphical representation of base shear as shown in Fig. 25. The base shear is maximum in MODEL-3 as compared to MODEL-1 and MODEL-2, and also MODEL-1 has minimum base shear as compared to the other two models.

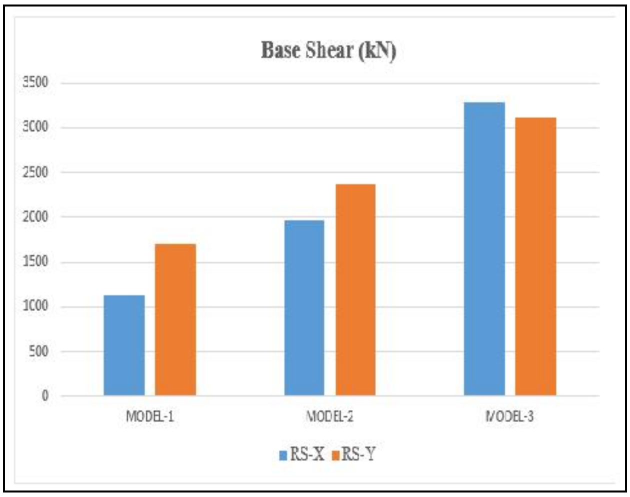

Fig. 25 Comparison of base shear

IV. CONCLUSION

In this study, we analysed the G+20 high rise building with shear wall at a different location, by using ETABS software and results are compared in terms of storey displacement, storey drift and base shear.

From the above results, some conclusions are made they are as follows.

- An economic point of view the size of members like beam and column can be reduced in structure with shear wall as compared to the structure without shear wall.
- If the shear wall is provided in a building, the depth of the beam is get reduced, automatically clear head of the room is increased.
- As per results, the storey displacement is maximum in a building without shear wall as compared to building with shear wall. The shear wall is provided at the core; it reduces maximum storey displacement as compared with the shear wall which is provided at a corner and periphery.
- As per results, the storey drift is maximum in building without shear wall as compared to building with shear wall. The shear wall is provided at the core; it reduces maximum storey drift as compared with the shear wall which is provided at corner and periphery.
- The base shear is maximum in building with a shear wall is provided at the core as compared to building with shear wall at corner and periphery. The value of base shear is very less in a building without shear wall.

- As per the analysis, it is concluded that the position of a shear wall at core gives minimum storey displacement, storey drift and maximum base shear as compared other two models. The effective location of shear wall in high rise building is at the core.

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