

Comparative Seismic Analysis of G+20 RC Framed Structure Building for Maximum Drift with and without Shear Wall

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ABSTRACT

High-rise design goals include stability, ease of maintenance, durability, and accommodation of the requirements in minimum space. Providing enough strength and stability against lateral stresses should be done precisely. Optimal sizing which is of prime importance for the economy accounts for optimal stiffness co-relationships among structural parts. High-rise structural system is prone to the effects due to lateral loads, axial forces, shear forces, base shear, maximum story drift, and tensile forces. In this paper, a comparative study is performed for G+20 Reinforced Concrete (RC) tie-column and tie-beam framed structures with and without the provision of shear walls. The analysis is performed in the software tool E-Tabs. The applied loads and load combinations are calculated and considered as per Indian Codal Provisions. The structure is considered to be located in seismic zone IV. The results of maximum drift values reveal that the maximum drift decreases when a structure is configured properly with a shear wall.

Keywords: Shear Walls; RC-Frame; Structural Response; Seismic Behavior; Maximum Drift

1 INTRODUCTION:

A building is subjected to a variety of forces, including lateral stresses induced by earthquakes, wind, and blasting. Lateral loads can generate increased strains, sideways movement, and even vibrations. Furthermore, the plan and design of a building should be sturdy enough to sustain vertical loads. Broadly a structural system comprises the following constituents:

- 1) *System of Structural Frames:* The structural system is a combination of frames, floor slabs, columns, and beams. These frames have sufficient stiffness and can resist gravity loads.
- 2) *Structural Wall Systems:* Structural walls also known as shear walls contain all vertical members in this type of structural system.
- 3) *Shear Wall and Frame Systems:* In the Shear Wall-Frame system, reinforced concrete shear walls interact with concrete frames to form a plan. A building will face minor non-structural damage if it is sufficiently stiff. Figure 1 depicts the floor layout of a building configured with a shear wall-frame structure.

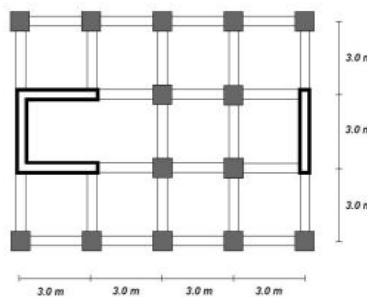


Figure 1: Shear Wall Floor Plan

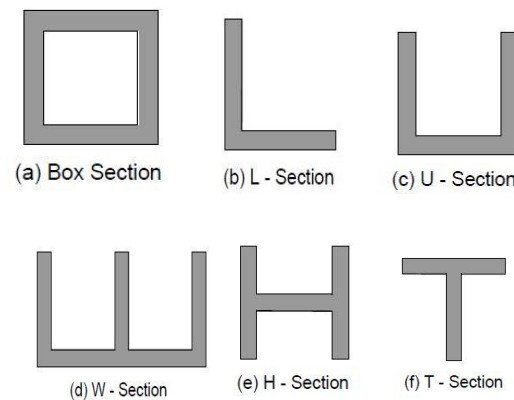


Figure 2: Typical Shear Wall Sections

Modeling the structural system is an important step while analyzing lateral loads in building structures. Many models are developed solely to demonstrate the behavior of a shear wall structure. With this aim, many researchers have conducted their studies on wall-frame structures and stated the shear walls to be more complicated than typical frame structures. Figure 2 shows the typical shear wall sections.

2 Past Literature Review

In multi-story buildings, the adaption of shear walls has been mandatory to attain higher resistance against lateral loads. The importance of determining the most effective, efficient and optimum size for shear walls cannot be over sighted [1]. Structures in high seismic zones may sustain significant damages. The most prevalent solutions for resisting lateral loads generated by earthquakes, wind, blasts, and other natural calamities are R.C. structures with ductile detailing and steel structures with bracings. E-TABS is used in computer-aided analysis to determine the most effective lateral load resisting system [2]. The seismic performance of a building frame can be improved by a well-designed system of shear walls. The study takes into account various configurations of RC moment resistant framed building structures. According to the findings, symmetrically placed shear wall arrangements that form a core will result in improved structural performance [3]. In the Indian construction scenario, high-rise spreading projects have grown extremely popular. Many major Indian cities are located in high-risk seismic zones, necessitating the reinforcement of buildings to withstand lateral stresses [4]. Priyanka Soni et al. performed structural analyses on multiple story structures at various locations and heights of the shear walls. The multi-story building was modeled and analyzed while taking into account all gravitational and lateral loads (Wind Load and Earthquake Load) [5]. They have Analyzed and designed a reinforced concrete rectangular shear wall to withstand the effects of an earthquake. Amar, et.al. used STAAD-Pro design software to depict the Shear Force and Lateral Force operating on the Office Building (G+5) in Seismic Zone IV [6].

Tall buildings must be designed with strength, serviceability, stability, and human comfort in mind. The investigation is restricted to multi-story reinforced concrete commercial structures in four seismic zones [7]. When a structure is shaken by an earthquake. The structure shakes in all three directions as a result of this motion [8]. Due to dominant lateral loads, tall structures experience unusual loading effects and extremely high loading values. The stiffness co-relation of structural elements is taken into account while sizing. As a result, compared to standard design options, there is a cost savings [9]. It is necessary to determine the seismic reactions of such structures to develop earthquake-resistant structures. A more significant methodology for structural seismic analysis is time history analysis. A dynamic analysis of a G+12 multistory practiced RCC building is performed, taking into account the earthquakes in Koyna and Bhuj [10]. Hence, the concept of structural engineering as well as the basic understanding of theoretical and practical knowledge of planning and designing are required for the analysis and design of robust and durable multi-story buildings [11].

3 MODELLING & ANALYSING BUILDING STRUCTURES:

The two most important components in a structure's analysis and design are selecting an acceptable structural modeling method that depicts the system's actual behavior and deciding on the analyzing technique to be used for the structure. As

stated in the objective of the study, two types of buildings are considered, i.e., with and without the provision of a shear wall as shown in figure4. The modeling is performed in ETABS Software and demonstrates the 3-D view of the G+20 story RC plan building model. using the following two basic concepts:

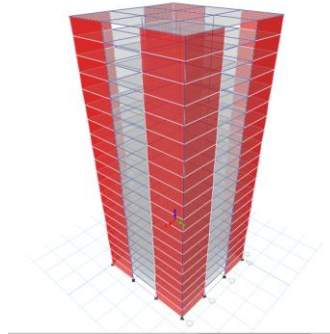


Figure 3: 3-D View of G+20 RC Frame Building with shear walls

- 1) Analyses of the Maximum Story Drift: Inter-storey drift is described as the ratio of lateral displacement of one floor of a multi-story building concerning the floor just above or below and the height of a building. The drift is found to be maximum in the top story of any building structure. Maximum drift is defined as the ratio of roof displacement (maximum displacement) to the total height of a building. Table 1 depicts the adopted data to model the building structure.

Table 1: Structural Data of the designed model

Type of structure	RC Framed G+ 20 Stories
Zone	IV
Zone Factor	0.24
Importance Factor	1
Response Reduction Factor	5
Each floor height	3 meters
Thickness of wall	200 mm
Thickness of slab	200 mm
Weight of Floor finish	1.1 kn/m ²
Column size	750mm X 750mm
Beam size	450mm X 250mm

- 2) **Model Design:** Building model design contains designing the column, beam and slab elements; whose specifications are specified in Table 1. Two structural systems are considered to compare the behavior of a structure under the effect of lateral loads: structural systems without a shear wall (model 1) and structural systems with a shear wall (model 2) as elaborated in Figure 4. The results obtained through analyzing these structural systems are acquired in the form of maximum story drift.

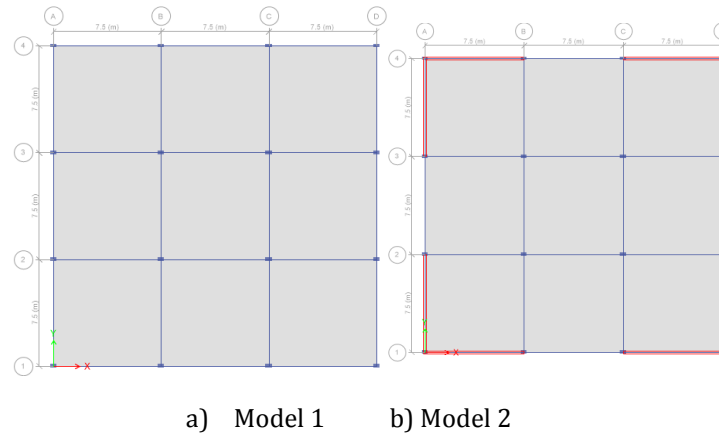


Figure 4: Building Model 1 without Shear Wall & Model 2 configured with Shear Wall

Note: The dimensions of beam, column, and slab elements for (Model 1 and Model 2) are considered similar to determine the effect of shear wall provision when the structure is applied with lateral loads. The applied loads and load combinations may vary in these two models according to Indian Codal Provisions.

6 RESULTS

For a G+ 20 RC Framed structure located in Seismic Zone IV, a comparative study is performed adopting response spectrum analysis in Software tool - E-tabs. Multiple locations for the provision of shear walls are considered. As per the Indian Seismic Provisions, a story drift in the structural system with partial safety factor 1 should not exceed 0.004 times the height of a structure. The obtained results of drift presented in Figures 5-8 indicates that the maximum value of drift is within the permissible limit of maximum story drift. Figure 5-6 illustrates the maximum story drift in the x-direction as defined by blue color and the maximum story drift in the y-direction as defined by red color. Figure 7-8 depicts the building's maximum drift when it is configured with shear walls.

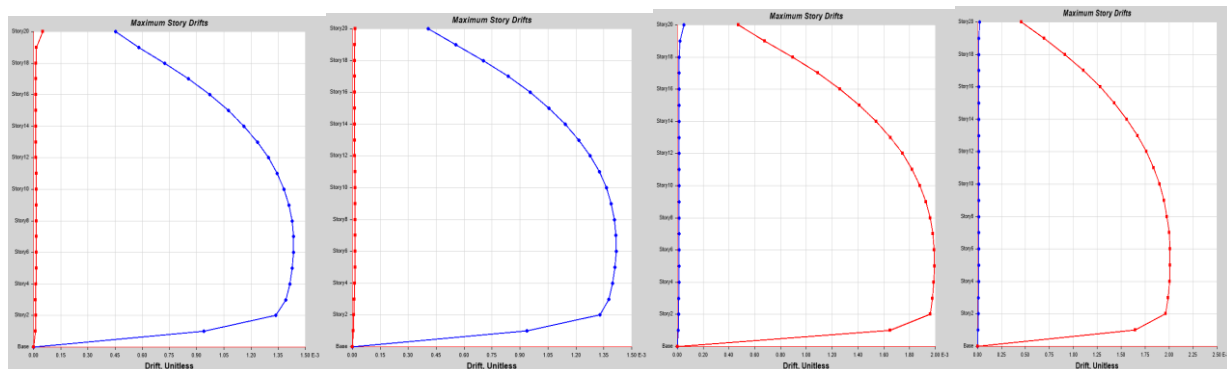


Figure 5: Story Drift for Load Combination 1.5(DL+EQ_x+EQ_y) (Model-1)

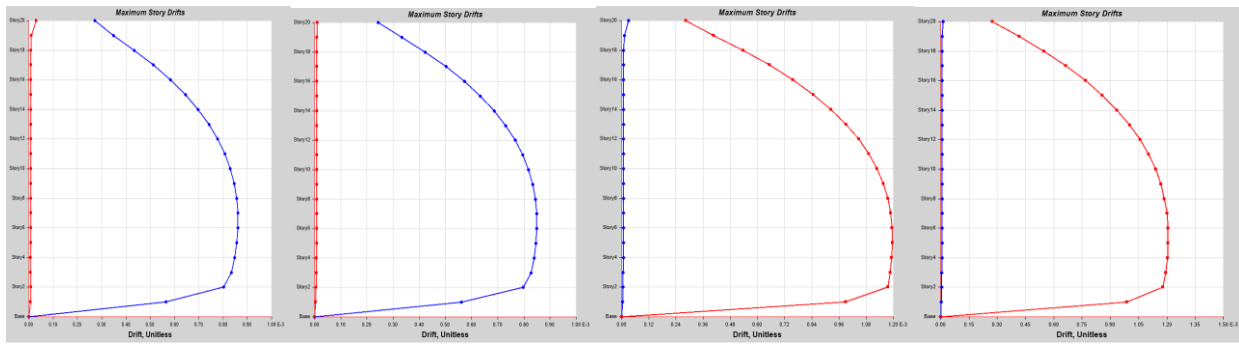


Figure 6: Story Drift for Load Combination $0.9(DL \pm EQ_x \pm EQ_y)$ (Model-1)

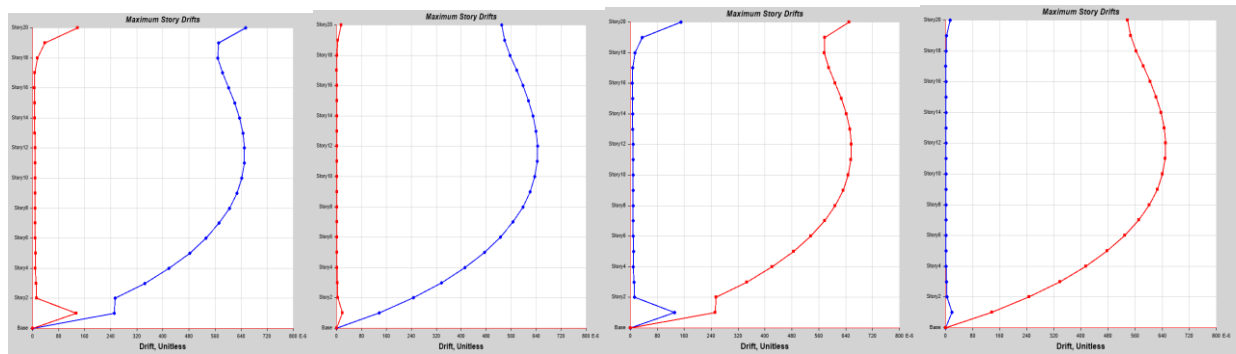


Figure 7: Story Drift for Load Combination $1.5(DL \pm EQ_x \pm EQ_y)$ (Model-2)

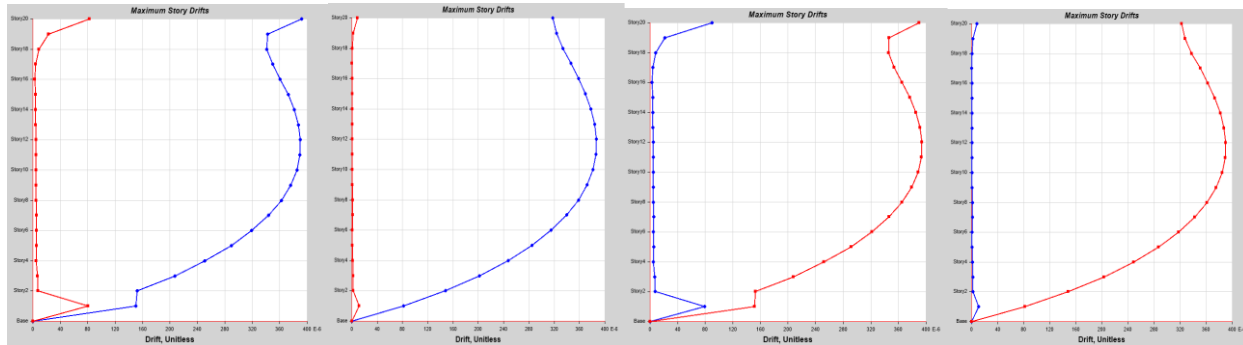


Figure 8: Story Drift for Load Combination $0.9(D \pm EQ_x \pm EQ_y)$ (Model-2)

6.1.3 Maximum story drift for load combinations:

Figures 9 illustrate the maximum story drift for load combinations in the X-direction for models 1 and 2, respectively, and Figure 10 shows the maximum story drift in the Y-direction for models 1 and 2 with a load combination of $1.5(DL \pm EQ_x \pm EQ_y)$. Similarly, Figures 11 illustrates the maximum story drift for load combinations in the X-direction for models 1 and 2, respectively, and Figure 12 shows the maximum story drift in the Y-direction for models 1 and 2 with a load combination of $0.9(DL \pm EQ_x \pm EQ_y)$. Providing shear wall maximum drift value decrease by 12-15% in the x-direction and 8-10% in the y-direction.

Note: Blue & grey line for M-1, orange and yellow line for M-2 for different load combination scenarios.

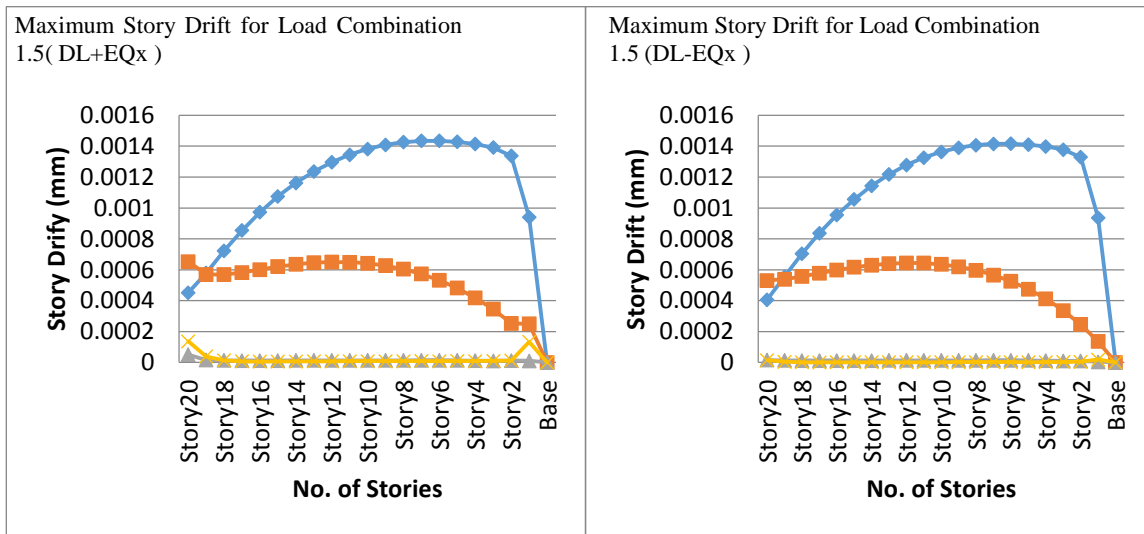


Figure 9: Maximum Story Drift for Load Combination 1.5(DL±EQ_x) Model 1& 2

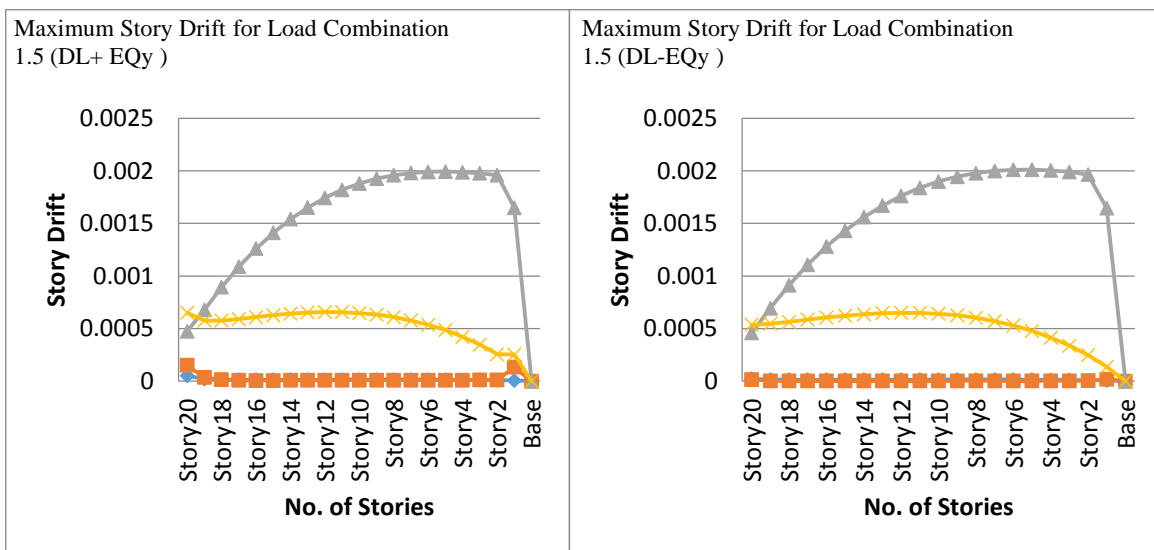


Figure 10: Maximum Story Drift for Load Combination 1.5(DL-EQ_y) Model 1& 2

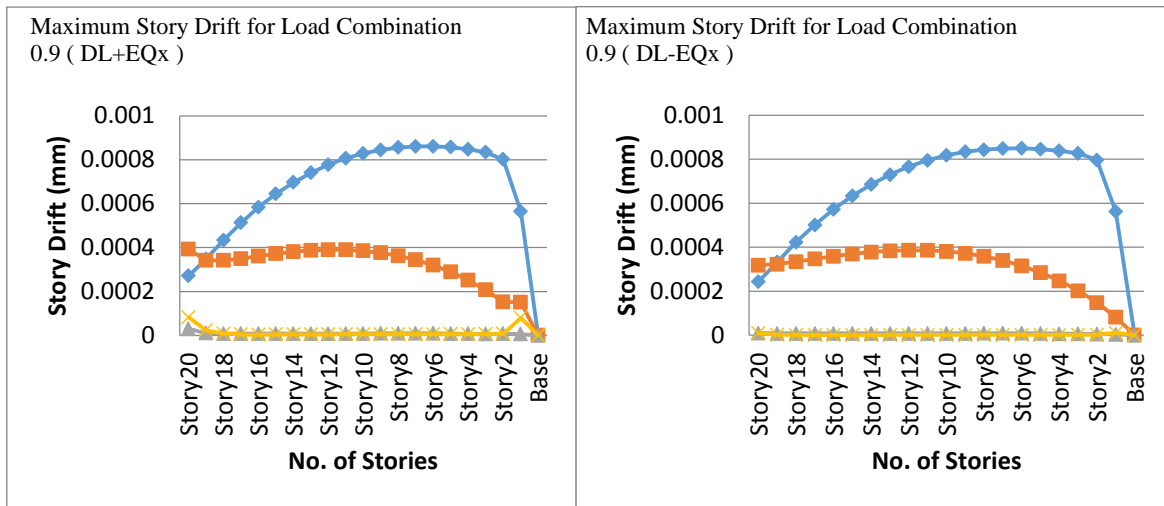


Figure 11: Maximum Story Drift for Load Combination 0.9(DL-EQ_x) Model 1 & 2

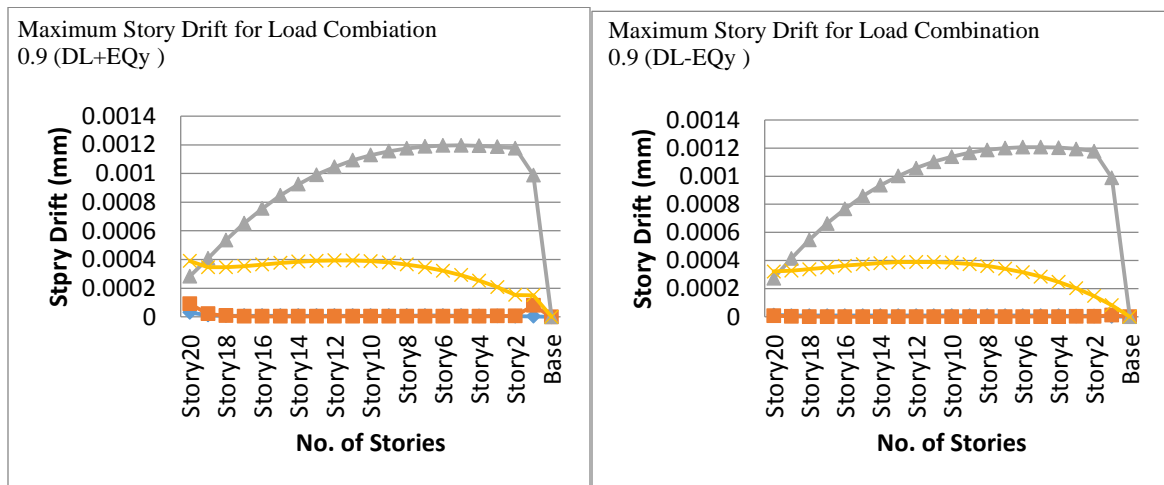


Figure 12: Maximum Story Drift for Load Combination 0.9(DL-EQ_y) Model 1 & 2

7 CONCLUSIONS

Following salient observations are derived from the analysis of G+20 story RC frame building with and without the provision of shear walls:

1. The inclusion of a shear wall in an RC Frame Structure minimizes Story Drift, making it safer compared to an RC Frame Structure without a shear wall. Shear walls in a multi-story building minimize the Story Drift.
2. The appropriate location of shear walls significantly reduces the structure's maximum drift. Summarily provision of properly designed shear walls is the essential need for RC Framed structures in higher earthquake zones.

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