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Study on Seismic Behavior of Lateral Force Resisting System

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Abstract — *Nowadays the provision of multi storied buildings is essential in metro cities to overcome land crisis. Construction of multi storied buildings is inevitable without using any lateral force resisting system. Provision of lateral force resisting system makes the structure earthquake resistant. This paper represents the study on seismic behavior of lateral force resisting system commonly used in India like Shear wall, Core wall and Bracing System. The seven different types of models are analyzed by using ETABS software at various storey heights (15 and 20 storey) situated in seismic zone III. The analysis is done by Response Spectrum Method and results are shown in terms of storey drift, storey displacement and base shear. The emphasis of this paper is to find the best suitable type of lateral force resisting structure among the various models which are analyzed under seismic excitation.*

Keywords*- Lateral force resisting system, Shear Wall, Core wall, Response Spectrum Method, ETABS*

I. INTRODUCTION

Lateral force resisting system plays an important role in the multistoried buildings which are situated in high seismic zones. Lateral force resisting system reduces the lateral forces acting during the earthquake and increases the stiffness of the structure. To make the structure earthquake resistant, the provision of lateral force resisting system is essential. During the earthquake, substantial horizontal forces are acting on the structures and cause severe damages to the structural elements leads to failure of structure. To avoid the damages from horizontal forces like seismic forces and wind forces, the provision of lateral force resisting system in the structure is must. Lateral forces can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important for the structure to have sufficient strength against vertical loads together with adequate stiffness to resist lateral loads. Hence the study on various types of lateral force resisting system is very important to know which type of system gives better performance under seismic activity. In this paper, the emphasis is given on the structures having lateral force resisting system in it like Shear Wall, Core Wall and RCC Bracings. Types of lateral force resisting system which are studied in this paper are as follows.

1.1 Reinforced Cement Concrete (RCC) Moment Resisting Frame

In building frame system, horizontal members (beams) with vertical members (columns) and joints of frame are resisting the earthquake forces, primarily by flexure. This system is generally preferred by architects because they are relatively unobtrusive compared to the shear wall or braced frames, but there may be poor economic risk unless special damage control measures are taken. They derive the lateral resistance from the rigidity of the connections.

1.2 Reinforced Concrete Shear Wall (SW)

Reinforced concrete buildings often have vertical plate like reinforced concrete walls called Shear Walls in addition to slabs, beams and columns. RC shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the buildings and thereby reduces damage to structure and its content. Since shear walls carry large horizontal earthquake forces, the overturning effects on them are large. Shear Walls in buildings must be symmetrically located in plan to reduce ill effects of twist in buildings. They could be placed symmetrically along one or both direction in plan. Shear Walls are more effective when located along exterior perimeter of the building such a layout increases resistance of the building to twisting.

1.3 Core Wall (CW)

The core of the high rise buildings comprises all of the vertical circulation elements such as elevators, fire stairs, mechanical shafts, toilets and elevator lobbies. Shear walls that provide lateral stability are also integrated in the core. Layout of the core is critical to the development efficiency and operational effectiveness of a high rise building, while also playing a significant role in the way the structure copes with lateral loads. In order to achieve maximum space efficiency, the core must be reduced to an acceptable ratio of the gross floor area, keeping in view the fire regulations and effective vertical transportation. Nowadays with changing technology in concrete construction, high strength concrete having high compressive strength can be used to reduce the thickness of service core walls, thus maximizing the useable floor area.

1.4 Bracing System (BS)

Braced frames are known to be efficient structural systems for buildings under high lateral loads such as seismic or wind loadings. The bracing members are arranged in many forms, which carry solely tension, or alternatively tension and compression. Such system reduces bending moment and shear forces in the columns. Bracings hold the structure stable by transferring the loads sideways down to the ground and are used to resist lateral loads, thereby preventing sway of the structure. Bracing system is one of the retrofitting techniques and it provides an excellent approach for strengthening and stiffening of existing buildings for lateral forces. The main advantage of this system is that it increases the stiffness of the building with a minimal added weight and decreases the bending moment and shear forces in columns.

These are the types of lateral force resisting systems which we are analyzing under seismic loadings by Response Spectrum Analysis. The seven different types of lateral force resisting system models are generated with the help of ETABS software and effectiveness has been check.

II. BUILDING DESCRIPTION

A residential building model having rectangular plan of 9 x 15 m are considered for analysis of structure at G+15 and G+20 storey heights. The building model is situated in seismic zone III and is assuming on medium soil type. The important features of this building are shown below.

Table 1. Modeling data for building

Type of Frame	SMRF
Seismic Zone	III
Number of Storey	G+15 and G+20
Spacing between Columns (C/C)	3 m in each Direction
Floor Height	3 m for all Floors
Size of columns for (G+15)	450 mm x 450 mm
for (G+20)	600 mm x 600 mm
Size of Beams	230 mm x 450mm
Size of Bracings (assumed section value)	230 mm x 230mm
Depth of Slab	150 mm
Live Loads on Floor	3.0 kN/m^2
Live Loads on Roof	1.5 kN/m^2
Floor Finish	1.8 kN/m^2
Terrace Water Proofing	2.0 kN/m^2
Parapet Load	4 kN/m
Density of Concrete	25 kN/m^3
Density of Infill	20 kN/m^3
Response Spectra	As per IS 1893:2002
Response Reduction Factor (R)	5
Importance Factor (I)	1
Damping of the Structure	5 percent

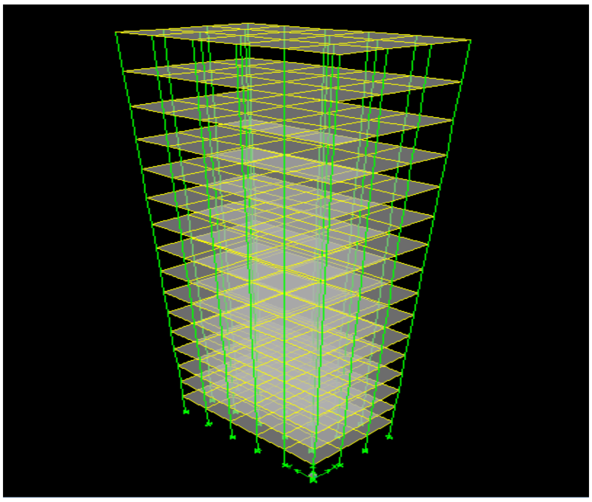

Figure 1. Model of RCC

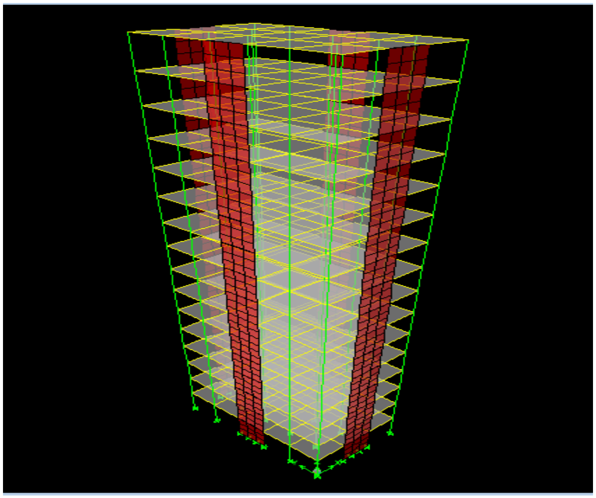

Figure 2. Model of SW

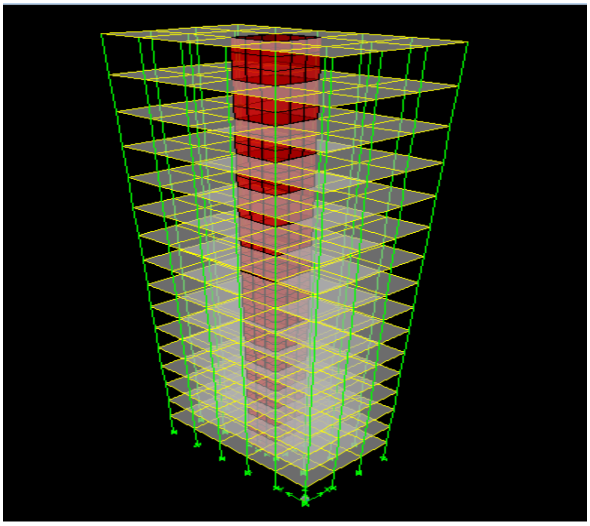

Figure 3. Model of CW

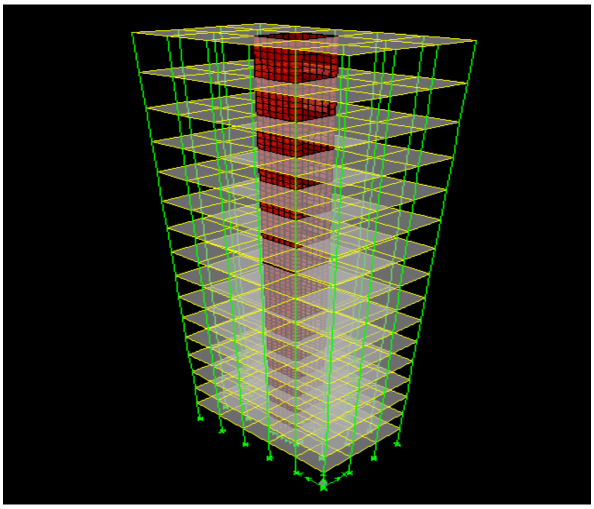

Figure 4. Model of CWO

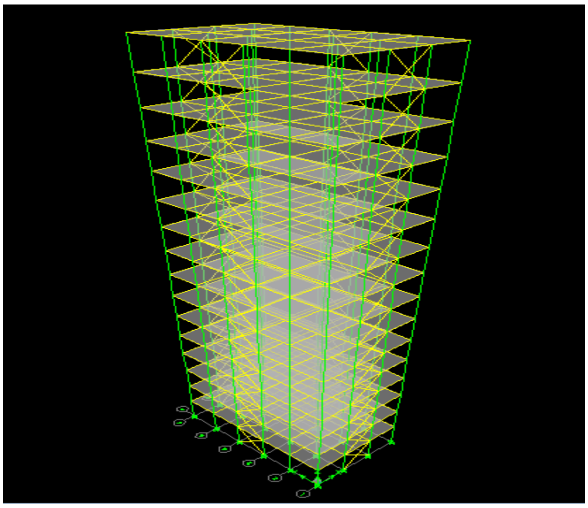

Figure 5. Model of BS

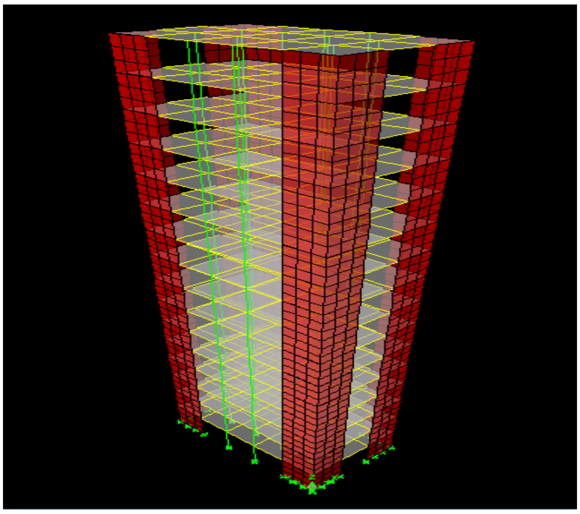

Figure 6. Model of SWC

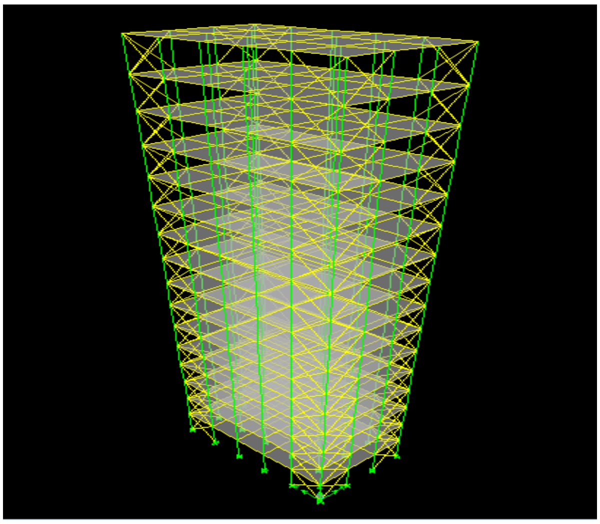

Figure 7. Model of BSC

Modeling of buildings is carried out in ETABS software. Beams and columns are modeled as two noded beam elements with six DOF at each node. The grade of concrete used is M25 and Fe500 grade of steel is taken. Shear wall are modeled using shell element. In bracing, the nodes are released at all corners for releasing the moment acting on it and act as a non structural element. RCC X type bracing is used in this paper because it gives better result than the other bracing systems. Response Spectrum Analysis is performed on various models of lateral force resisting elements. Based on analysis result parameters such as storey shear, storey displacement and base shear. Following are the different models have been considered for analysis.

RCC : Reinforced Concrete moment resisting frames

SW : Shear wall located at center of exterior bays

CW : Core wall located at center of the building

CWO : Core wall with opening at center of the building

BS : RCC X type bracing located at center of exterior bays

SWC : Shear Wall located at corner of the building

BSC : RCC X type bracing located at corner of the building

III. RESULT AND DISCUSSION

3.1 Storey Drift

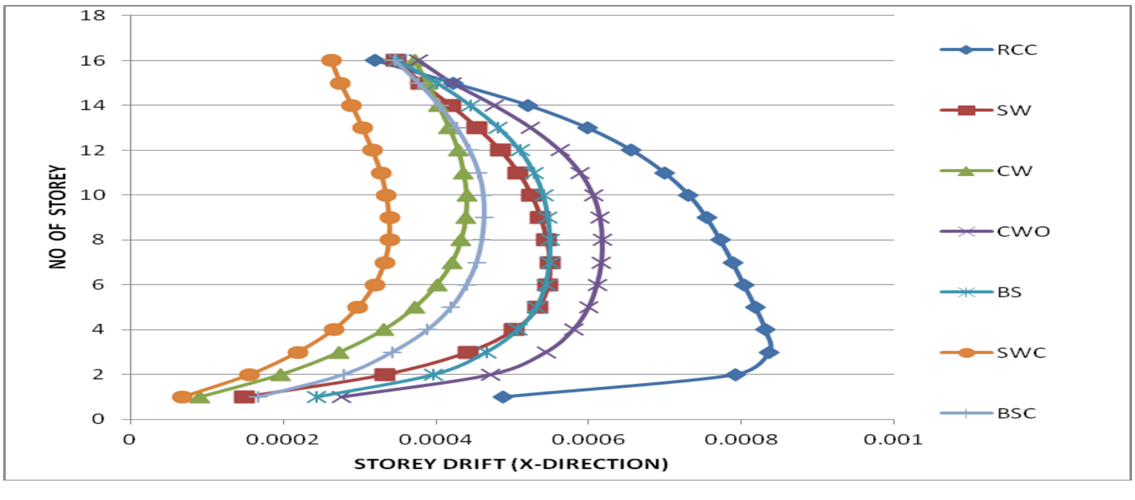

Figure 8. Storey Drift in X-Direction for G+15

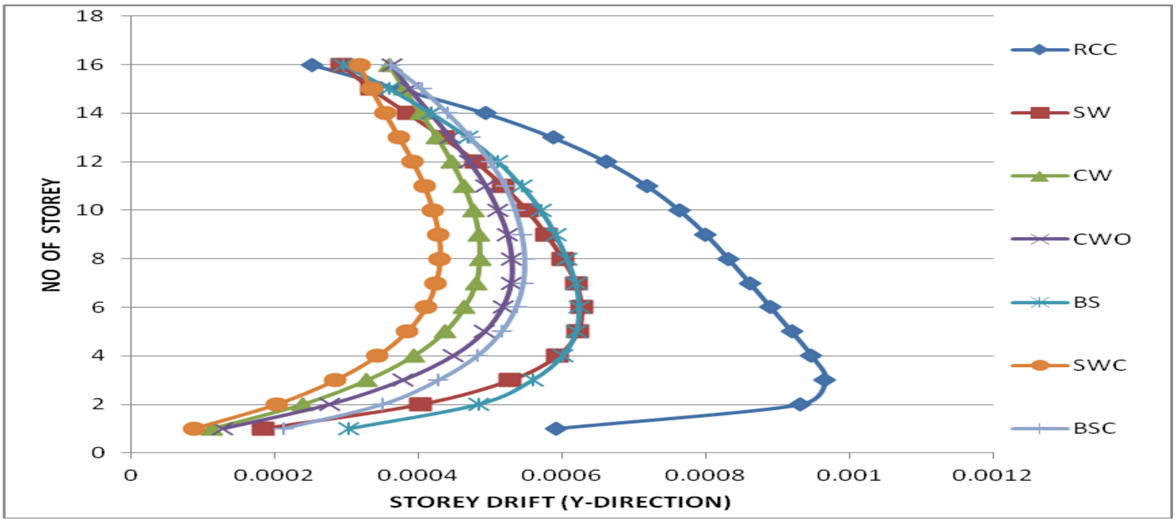

Figure 9. Storey Drift in Y-Direction for G+15

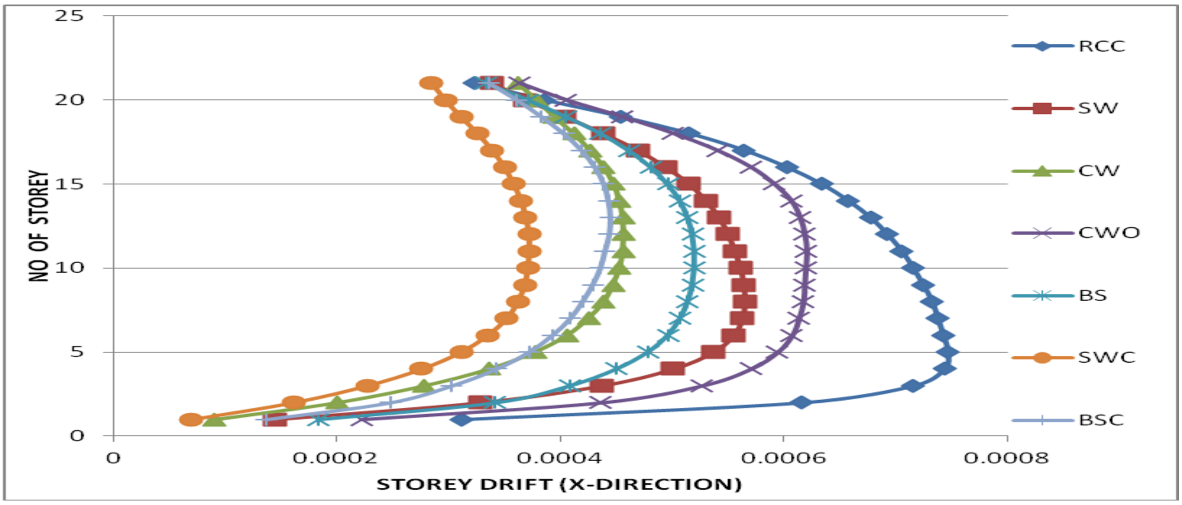

Figure 10. Storey Drift in X-Direction for G+20

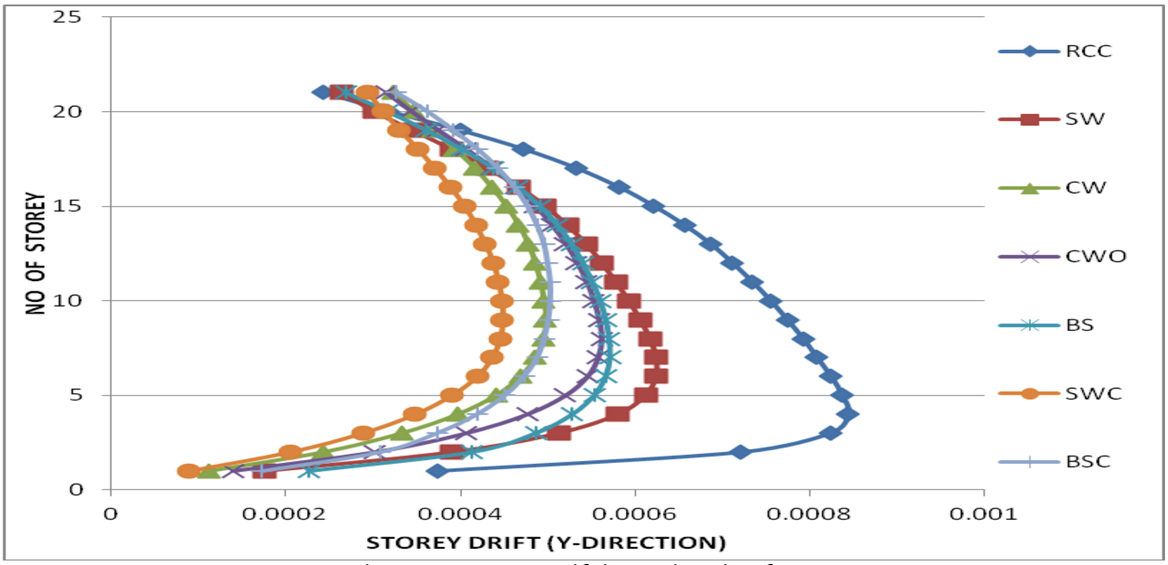

Figure 11. Storey Drift in Y-Direction for G+20

3.2 Storey Displacement

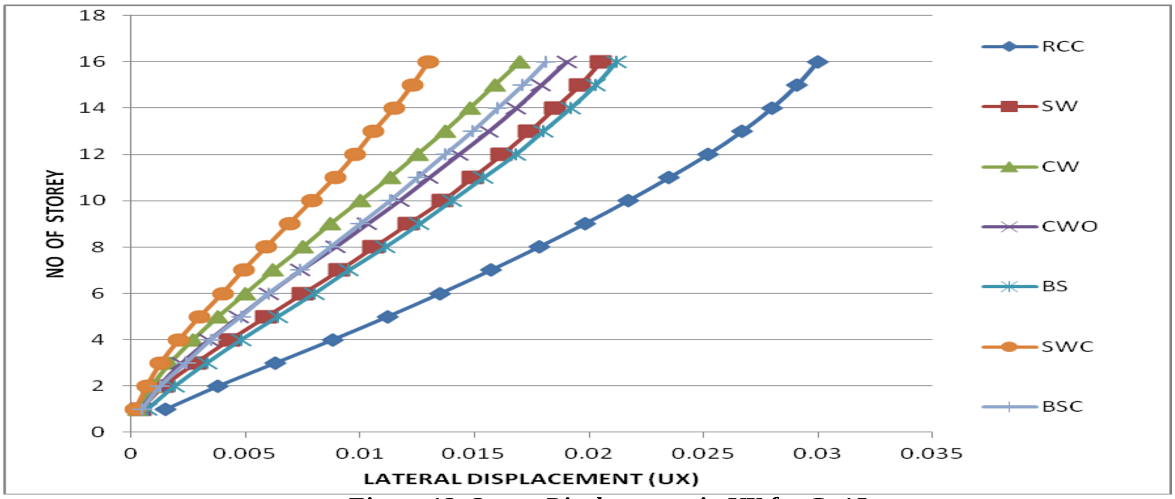

Figure 12. Storey Displacement in UX for G+15

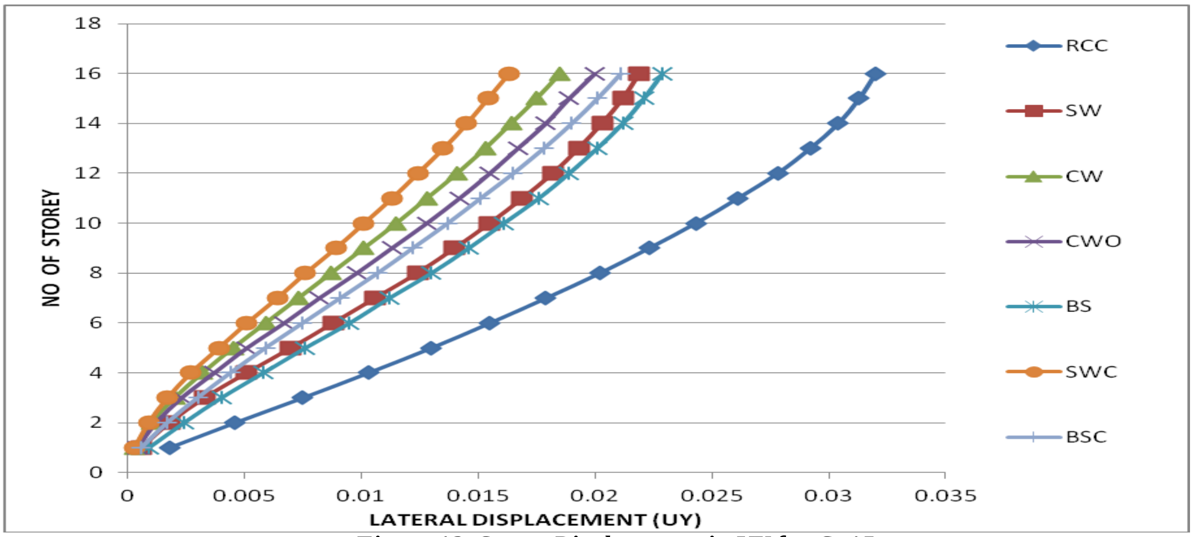

Figure 13. Storey Displacement in UY for G+15

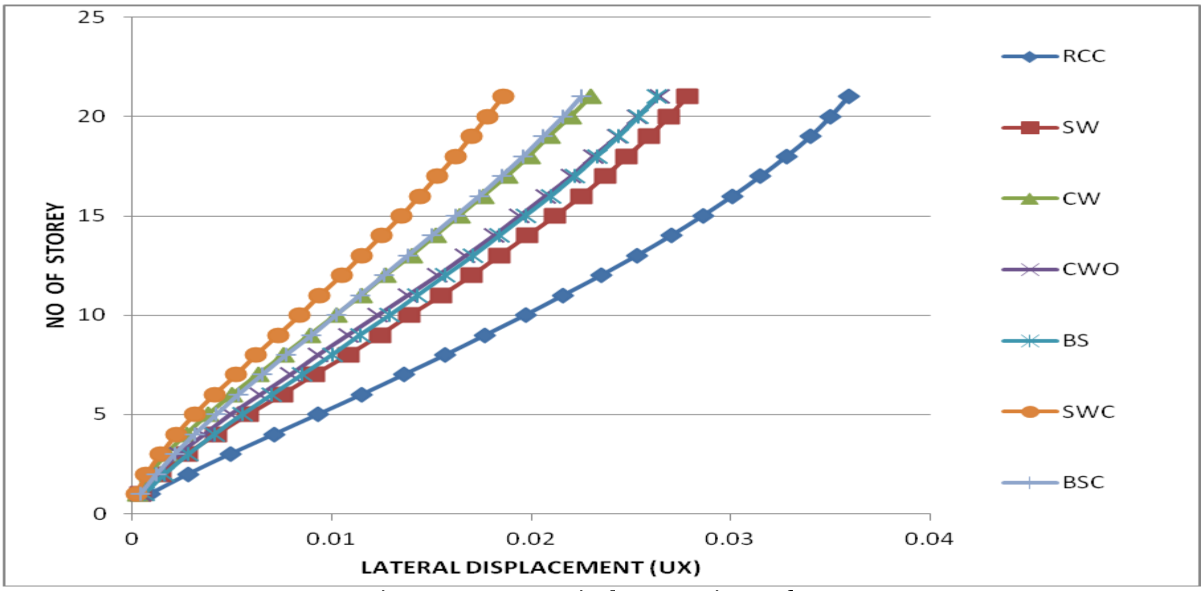

Figure 14. Storey Displacement in UX for G+20

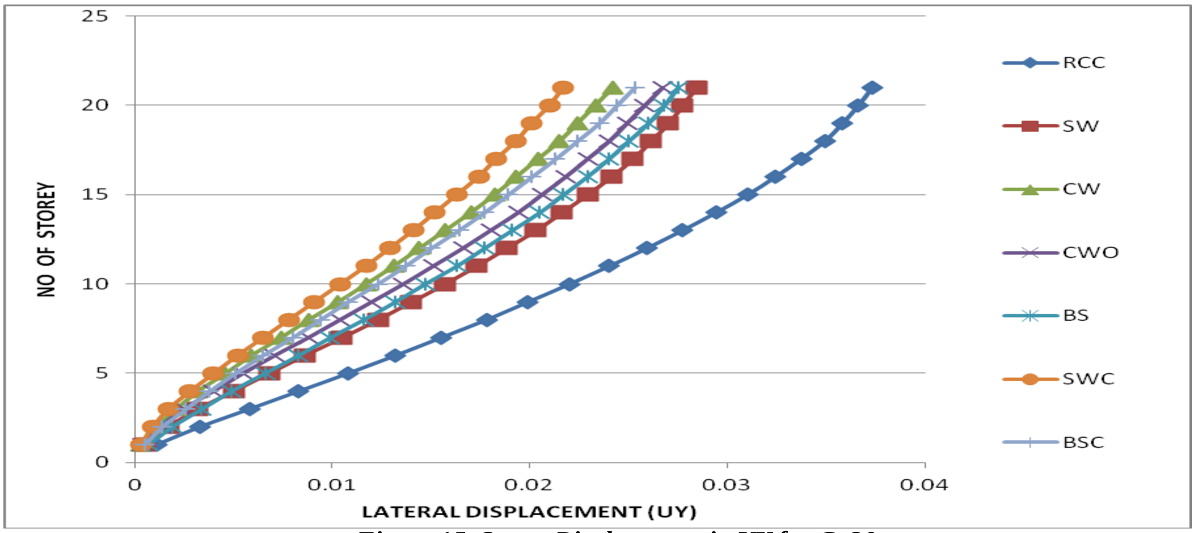

Figure 15. Storey Displacement in UY for G+20

3.3 Base Shear

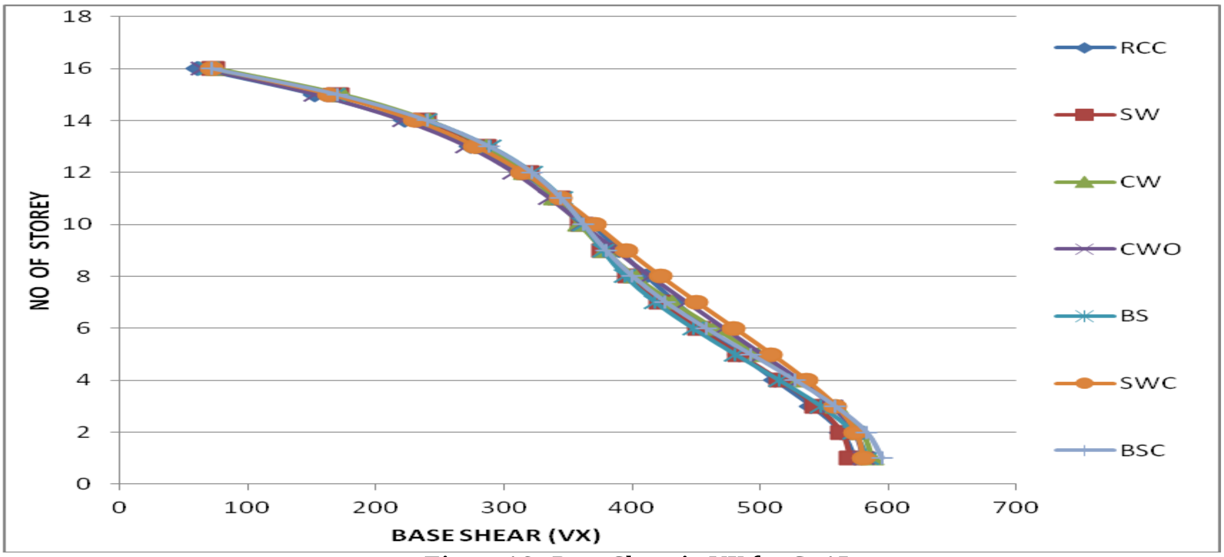

Figure 16. Base Shear in VX for G+15

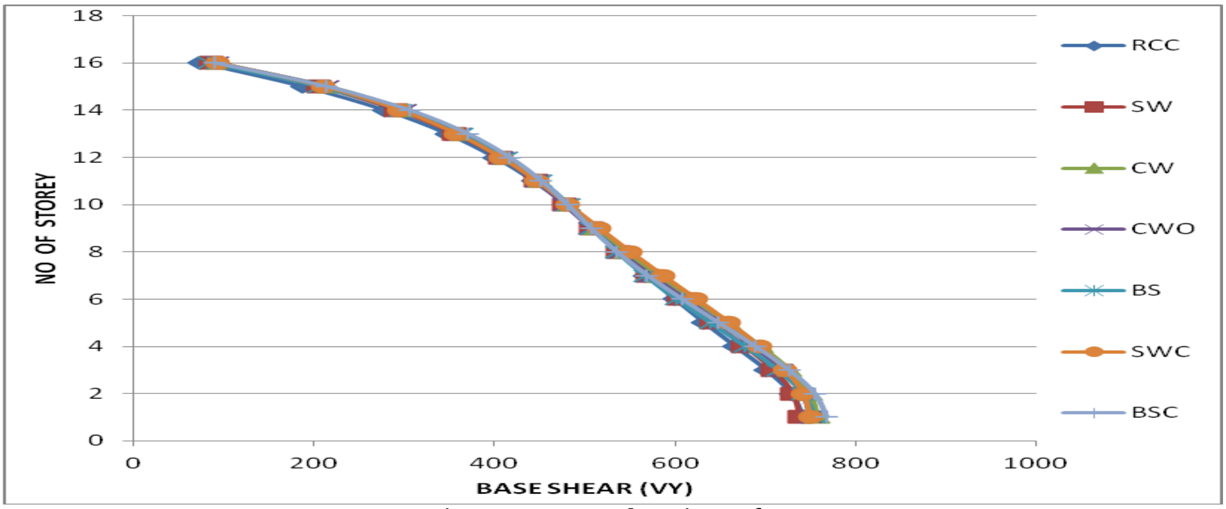

Figure 17. Base Shear in VY for G+15

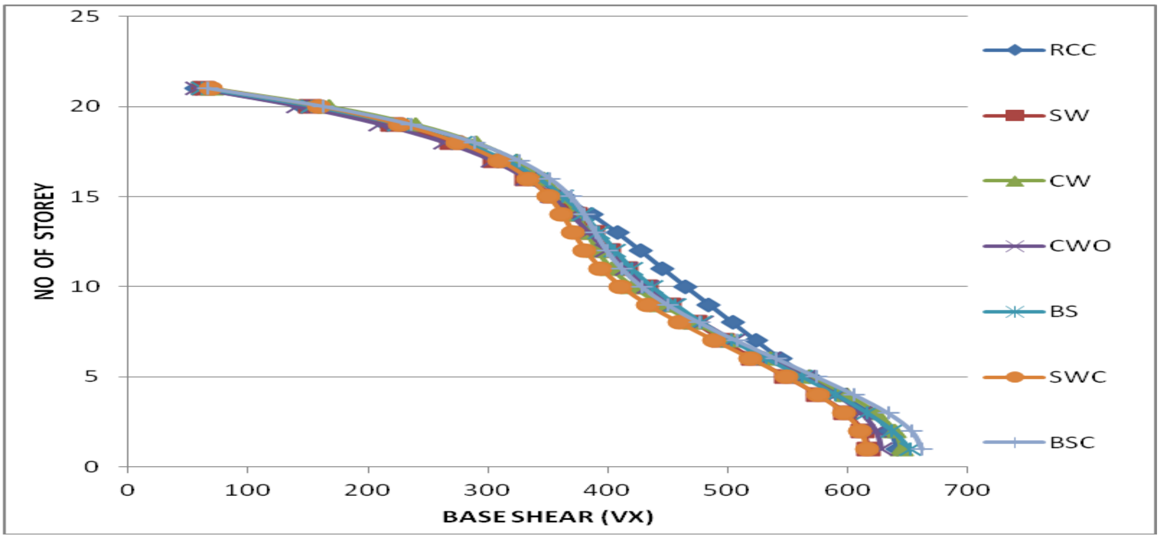

Figure 18. Base Shear in VX for G+20

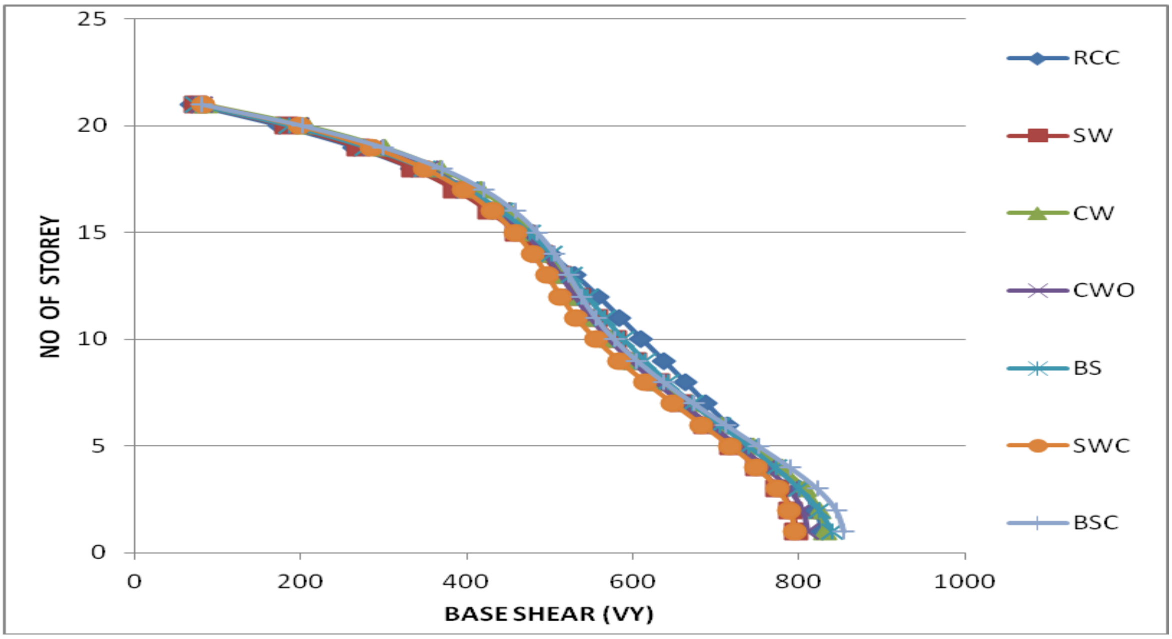

Figure 19. Base Shear in VY for G+20

For G+15 and G+20 storey buildings, the model of Shear Wall located at corner of the building (SWC) gives minimum storey drift and storey displacement values in both X and Y direction under the seismic analysis. The RCC moment resisting frame (RCC) model gives the maximum values of storey drift and storey displacement for G+15 and G+20 storey buildings in both X and Y directions. The base shear values are maximum in the model of RCC Bracing System located at corner of the building (BSC) for G+15 and G+20 storey buildings. In G+15 storey building, the model of Shear Wall located at center of the exterior bays of the building (SW) gives the minimum values and for G+20 storey building, the model of Shear Wall located at the corner of building (SWC) gives the minimum values.

IV. CONCLUSION

From the analysis results, the conclusion is drawn below

- The maximum storey drift occurs in the model of RCC moment resisting frame and minimum values are found in the model of SWC at G+15 and G+20 storey height.
- RCC moment resisting frame model gives maximum storey displacement values and SWC model gives minimum values for both storey heights.

- Base shear increases drastically as the height of storey increases. Base shear values are found maximum in the model of BSC and minimum in SW model of building for G+15 and G+20 storey heights.
- The most suitable system among the seven models is SWC under the seismic loadings shows from the comparative analysis results.
- Shear wall at corner gives better result than located at center of the exterior bays under seismic activity.
- Core wall gives better performance to resist the seismic forces than the model having opening provided in the core wall buildings.

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