Lateral Load Analysis of R.C.C. Building

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Abstract: *The structure in high seismic areas may be susceptible to the severe damage. Along with gravity load structure has to withstand to lateral load which can develop high stresses. Now a day, shear wall in R.C.structure and steel bracings in steel structure are most popular system to resist lateral load due to earthquake, wind, blast etc. The shear wall is one of the best lateral load resisting systems which is widely used in construction world but use of steel bracing will be the viable solution for enhancing earthquake resistance. In this study R.C.C. building is modeled and analyzed in three Parts I) Model without bracing and shear wall II) Model with different shear wall system III) Model with Different bracing system The computer aided analysis is done by using E-TABS to find out the effective lateral load system during earthquake in high seismic areas. The performance of the building is evaluated in terms of Lateral Displacement, Storey Shear and Storey Drifts, Base shear and Demand Capacity (Performance point). It is found that the X type of steel bracing system significantly contributes to the structural stiffness and reduces the maximum inter story drift, lateral displacement and demand capacity (Performance Point) of R.C.C building than the shear wall system.*

Keywords: *R.C. frame, Lateral displacement, storey shear, storey drift, Base shears, etc.*

I. Introduction

1.1 General

The primary purpose of all kinds of structural systems used in the building type of structures is to transfer gravity loads effectively. The most common loads resulting from the effect of gravity are dead load, live load and snow load. Besides these vertical loads, buildings are also subjected to lateral loads caused by wind, blasting or earthquake. Lateral loads 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 forces.

1.2 Strengthening of RCC building with shear wall

Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 200mm, or as high as 400mm in high rise buildings [50]. Shear walls are usually provided along both length and width of buildings, Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation. Properly designed and detailed buildings with shear walls have shown very good performance in past earthquakes [10]. Shear walls in high seismic regions require special detailing. However, in past earthquakes, even buildings with sufficient amount of walls that were not specially detailed for seismic performance (but had enough well-distributed reinforcement) were saved from collapse [16]. Shear wall buildings are a popular choice in many earthquake prone countries, like Chile, New Zealand and USA [10]. Shear walls are easy to construct, because reinforcement detailing of walls is relatively straight-forward and therefore easily implemented at site. Shear walls are efficient, both in terms of construction cost and effectiveness in minimizing earthquake damage in structural and non-structural elements[12][50]

Most RC buildings with shear walls also have columns; these columns primarily carry gravity loads (i.e., those due to self-weight and contents of building). Shear walls provide large strength and stiffness to buildings in the direction of their orientation [14], which significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents. Since shear walls carry large horizontal earthquake forces, the overturning effects on them are large. Thus, design of their foundations requires special attention. Shear walls should be provided along preferably both length and width. However, if they are provided along only one direction, a proper grid of beams and columns in the vertical plane (called a moment-resistant frame) must be provided along the other direction to resist strong earthquake effects[13][14].

1.3Strengthening of RCC building with Steel Bracing

Steel bracing is a highly efficient and economical method of resisting horizontal forces in a frame structure [6]. Bracing has been used to stabilize laterally for the majority of the world's tallest building structures as well as one of the major retrofit measures [1]. Bracing is efficient because the diagonals work in axial stress and therefore call for minimum member sizes in providing stiffness and strength against horizontal shear [42]. A number of researchers have investigated various techniques such as infilling walls, adding walls to existing columns, encasing columns, and adding steel bracing to improve the strength and/or ductility of existing buildings[27][28]. A bracing system improves the seismic performance of the frame by increasing its lateral stiffness and capacity [26]. Through the addition of the bracing system, load could be transferred out of the frame and into the braces, bypassing the weak columns while increasing strength [29]. Steel braced frames are efficient structural systems for buildings subjected to seismic or wind lateral loadings. Therefore, the use of steel bracing systems for retrofitting reinforced concrete is a frame with inadequate lateral resistance is attractive. Existing RC framed buildings designed without seismic criteria and ductile detailing can represent a considerable hazard during earthquake ground motions [7]. The non-ductile behaviour of these frames derives from the inadequate transverse reinforcement in columns, beams and joints, from bond slip of beam bottom reinforcement at the joint, from the poor confinement of the columns [5].

In the presence of these deficiencies the upgrading of seismic performance may be realized with the introduction of new structural members such as steel bracing systems or RC shear walls. The introduction of steel braces in steel structures and of RC shear walls in RC structures. However, the use of steel bracing systems for RC buildings may have both practical and economical advantages [1]. In particular, this system offers advantages such as the ability to accommodate openings and the minimal added weight of the structure. Furthermore, if it is realized with external steel systems (External Bracing) the minimum disruption to the full operationally of the building is obtained [18]. There are two types of bracing systems, Concentric Bracing System and Eccentric Bracing System [2]. The steel braces are usually placed in vertically aligned spans. This system allows obtaining a great increase of stiffness with a minimal added weight, and so it is very effective for existing structure for which the poor lateral stiffness is the main problem [9]. The concentric bracings increase the lateral stiffness of the frame, thus increasing the natural frequency and also usually decreasing the lateral drift. However, increase in the stiffness may attract a larger inertia force due to earthquake. Further, while the bracings decrease the bending moments and shear forces in columns, they increase the axial compression in the columns to which they are connected. Since reinforced concrete columns are strong in compression, it may not pose a problem to retrofit in RC frame using concentric steel bracings [43].

Eccentric Bracings reduce the lateral stiffness of the system and improve the energy dissipation capacity [9]. Due to eccentric connection of the braces to beams, the lateral stiffness of the system depends upon the flexural stiffness of the beams and columns, thus reducing the lateral stiffness of the frame. The vertical component of the bracing forces due to earthquake cause lateral concentrated load on the beams at the point of connection of the eccentric bracings.[18]

II. Modelling

The E-TABS software is used to develop 3D model and to carry out the analysis. The lateral loads to be applied on the buildings are based on the Indian standards. The study is performed for seismic zone III as per IS 456 (Dead load, Live Load) IS 1893:2002 (Earthquake load), IS875: 1987(Wind Load). The building consists of reinforced concrete and brick masonry elements.

G+12 storied building analyzed for seismic and gravity forces.
G+12 storied building analyzed with different types Shear wall system
G+12 storied building analyzed with different types of bracing systems.
The different type Bracings placed for peripheral columns only.

To find out effectiveness of steel bracing and shear wall to RCC building there is need o study parameters as Lateral displacement, Story shear, Story drift, Pushover curve, capacity and demand of structure for that there is need to do linear and nonlinear analysis of structure.

2.1 Model Data:-

Structure	SMRF
No. Of stories	G+12
Storey Height	3.00 m
Material property	
Grade of concrete	M25
Grade of Steel	Fe 415
Member Properties	
Thickness of slab	0.125 m
Beam Size	0.30 x 0.45 m
Column Size	0.30 x 0.60 m
Load Intensities	
Seismic Zone	III

Table 2.1

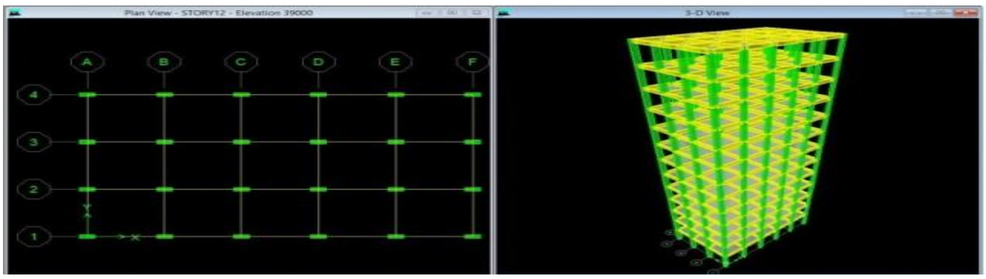

Fig.2.1 Bare Frame Model

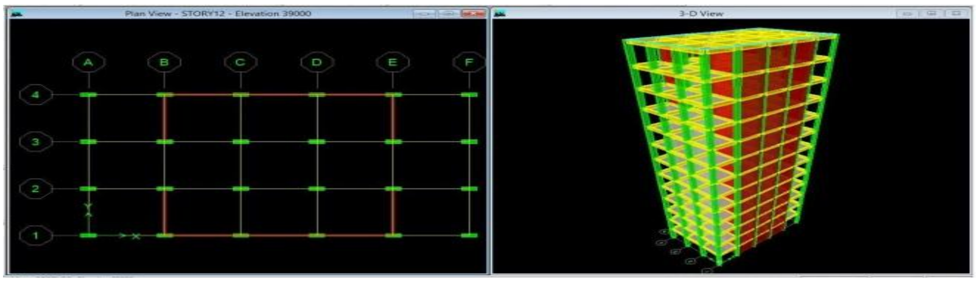

Fig. 2.2 SW Type-III

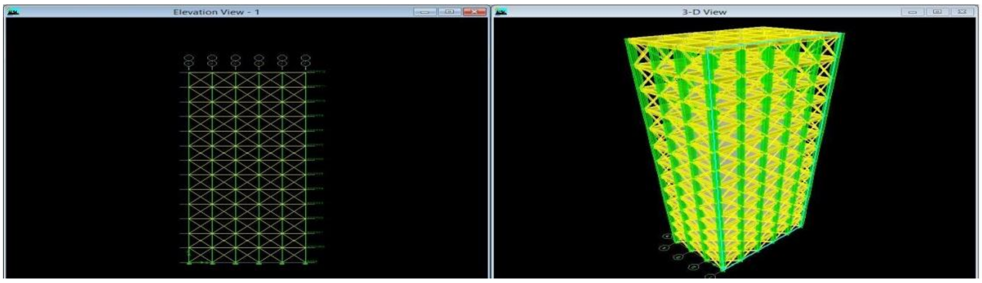

Fig.2.3 SB Type-I

III. Result and Discussion

Analysis of G+12 storied bare frame model, Shear wall model and steel bracing model is done using standard software, from the analysis results obtained, bare frame model ,SW Type-III and G+12 SB Type-I are compared. The comparison of these results to find effective lateral load resisting system is as below.

3.1 Linear Analysis

3.1.1 Lateral Displacement

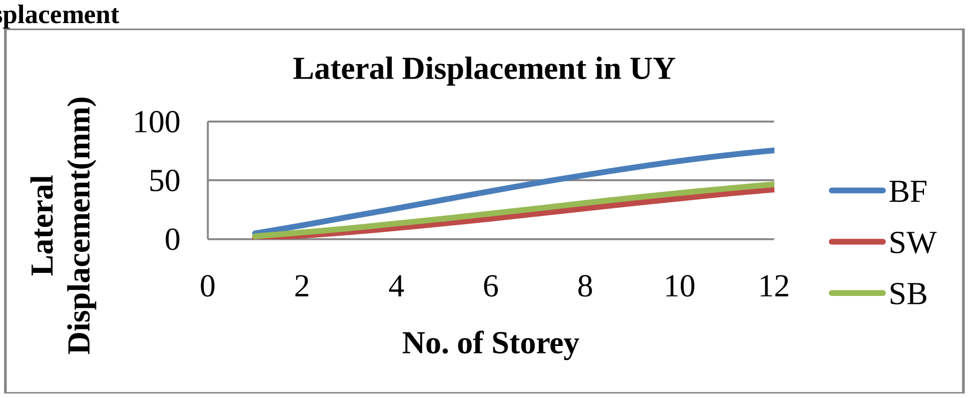

Fig.3.1

Lateral displacement of bare frame model is controlled by Shear wall and steel bracing as a lateral load resisting system. The lateral displacement of the bare frame model is 56.38 mm in X direction and 78.28 mm, in Y direction. The lateral displacement of bare frame models is reduced by 70 to 80 % in X Direction and 50 to 55 % in Y direction as compare with shear wall model. The lateral displacement of bare frame models is reduced by 40 to 50 % in X & Y direction as compare with Steel bracing model.

3.1.2 Storey Drift

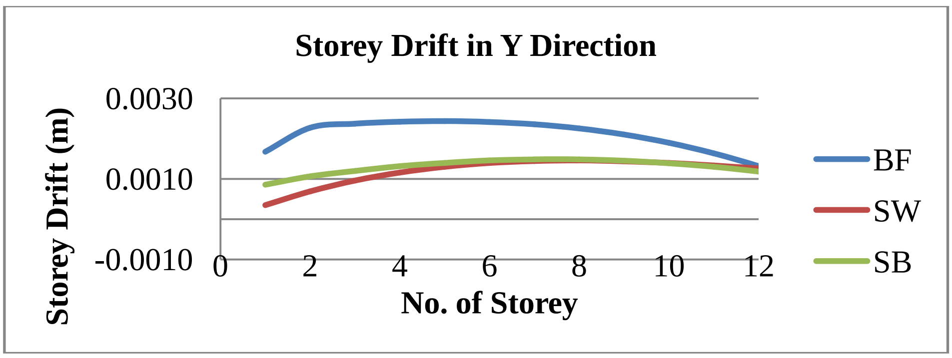

Fig.3.2

Shear wall and steel bracing significantly decrease in the story drift compared with bare frame model which is within limitas per clause no 7.11.1 of IS-1893 (Part-1):2002.

3.1.3 Storey Shear

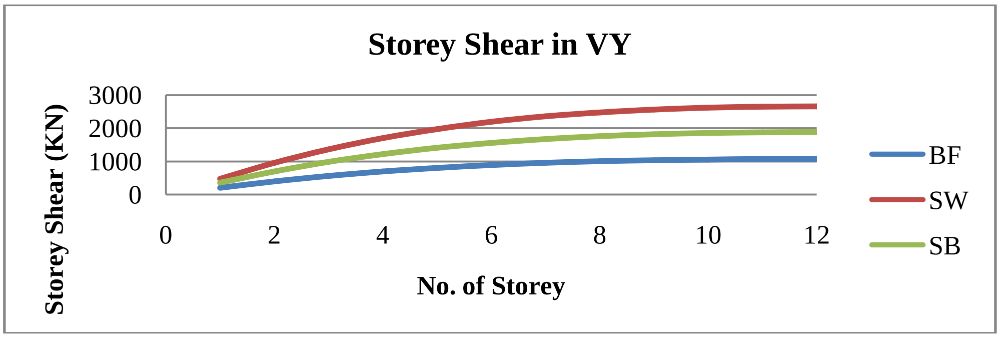

Fig.3.3

The maximum storey shear of the bare frame model is 1505.24 KN in X direction and 1078.16 KN in Y direction. The Storey shear of shear wall model is 80 to 100 % more than bare frame. The storey shear steel braced model in X direction is 60 to 70 % and 50 to 60 % in Y direction more than bare frame model.

3.2 Non Linear Analysis

3.2.2 Demand Spectrum

It can be observed that demand spectrum of bare frame model intersect away from D which means that the structure will behave poorly during imposed seismic excitation and need remedial measures. The demand spectrum of model with shear wall intersect near even point B and IO, which means that an elastic response and good security. It can observe demand of model with steel bracing intersect the capacity curve near the even point between B and IO, which means that an elastic response and good security margin.

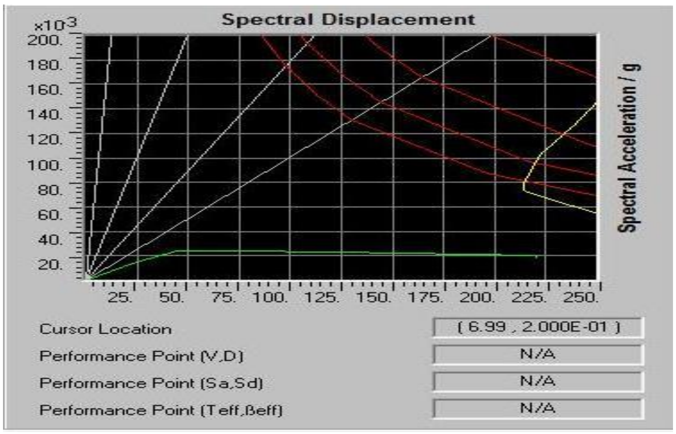

Figure.3.4 Performance Point of Bare frame model (Push Y)

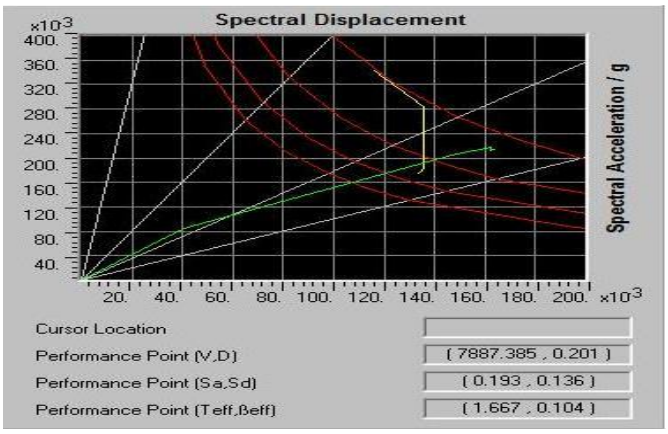

Figure.3.5 Performance Point of shear wall (Push Y)

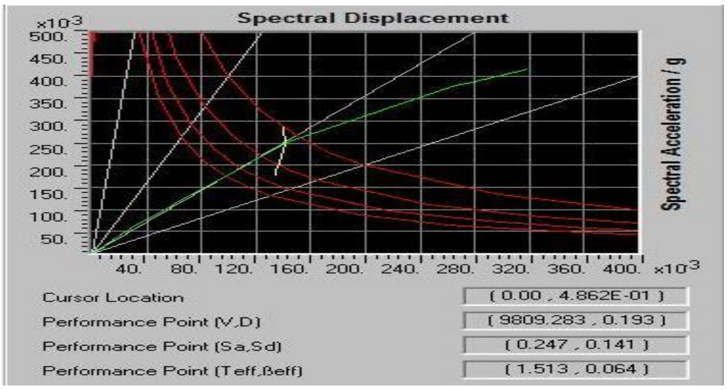

Figure.3.6 Performance Point of Steel Bracing (Push Y)

3.2.3 Plastic Hinge Mechanism

Model with shear wall shows better performance than bare frame model. The yielding of model with shear wall occurs at events C-D at step-2 and D-E at step 5-10. Model with steel bracing shows better performance. The yielding of the model with steel bracing occurs at event B-IO and IO-LS and LS-CP the amount of damage in this structure will be limited.

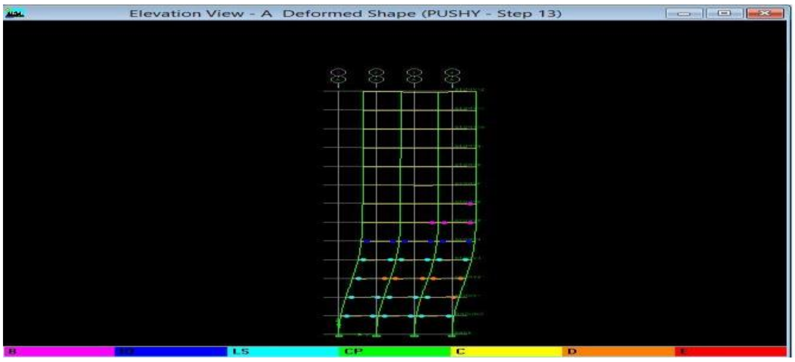

Figure.3.7 Plastic Hinge Mechanism of Bare frame model in (Push Y)

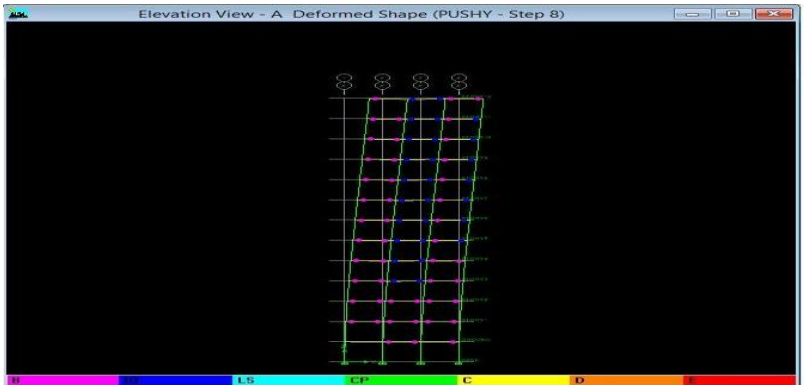

Figure.3.8 Plastic Hinge Mechanism of SW (Push Y)

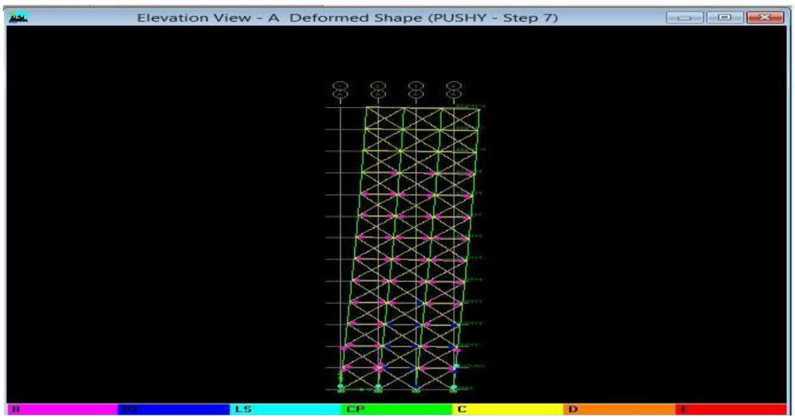

Figure.3.9 Plastic Hinge Mechanism of SB (Push Y)

IV. Conclusion

G+ 12 bare frame model, shear wall model and Steel bracing model is analyzed using standard software. The following conclusions are drawn based on present study.

1) The concept of using steel bracing is one of the advantageous concepts which can be used to strengthen structure
2) Steel bracings reduce flexure and shear demands on beams and columns and transfer the lateral load through axial load mechanism.
3) The lateral displacement of the building is reduced by 40 to 60 % by the use of shear wall Type-III and X Type steel bracing system.
4) Storey drift of the Shear wall and steel braced model is within the limit as clause no 7.11.1 of IS-1893 (Part-1):2002.
5) Steel bracings can be used as an alternative to the other strengthening techniques available as the total weight of structure changes significantly.
6) Shear wall has more storey shear as compare to steel bracing but there is 10 to15% difference in lateral displacement between shear wall and steel bracing.
7) Shear wall and steel bracing increases the level of safety since the demand curve intersect near the elastic domain.
8) Capacity of the steel braced structure is more as compare to the shear wall structure.
9) Steel bracing has more margin of safety against collapse as compare with shear wall.

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