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Earthquake Control of Highrise Buildings Using Combination of Shear wall and Concentric Steel Bracing

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***Abstract**:* **Shear wall and steel bracing structural system are the most used in medium to high rise buildings to increase the stiffness, strength and energy dissipation required to resist lateral loads imposed by earthquake and wind. There is an essential need to upgrade the seismic performance of RC buildings to meet the requirements of the new techniques in seismic design.**

In this paper seismic performance of RC building is designed with shear wall, concentric steel bracings, combination of shear wall with bracings and rigid frame structural system [without shear wall and bracings]. A seismic loads is calculated and applied on twenty five stories building which is located in zone II using ETABS 2016. Comparison has been made between stiffness of different types of structural systems of shear wall with bracings and rigid frame structural system [without shear wall and bracings]. The performance of the building is evaluated in *terms of lateral displacement, bending moment and shear force.*

Keywords—Concentric Bracing; Lateral Displacement; Seismic loads;

I. INTRODUCTION

It is no fantasy to say that tall buildings appeal extraordinary determination and endurance from many stakeholders including owners, developers, planners, engineers and architects.

They exert significant demand on infrastructure, in which we are trying to achieve certain objectives such as to minimize cost, minimize deflections, minimize the moments, and maximize the strength and stiffness. In order to achieve optimal structural system which is used in the buildings gravity loads are effectively transferred.

The most common loads resulting from the gravity effects are dead load, live load and snow loads. Buildings are also subjected to lateral loads due to earthquakes and wind loads, which result in high stresses and sway moments. Hence the lateral forces have a major effect in structures. So it is important to have sufficient strength to resist against vertical loads with capable stiffness to resist lateral forces.

To resist lateral forces, reinforced concrete shear walls and bracings have been used as the most effective solution, to give stiffness and resistance to the structure against lateral and vertical loads. [3],[4],[5] The concentric bracings increases the lateral stiffness of the frame which increase the natural frequency by decreases the lateral drift and by increasing the stiffness may bring huge inertia force may occur due to earthquake. While the bracings decreasing the bending moments as well as shear forces in columns, this leads to increase the axial compression in column joints. However the RCC columns are good enough in compression it may not pose a problem to building by the use of concentric steel bracings. [1]

II. SHEAR WALL

A shear wall is a wall that is used to resist the shear, produced due to lateral forces. Many codes made the shear wall design for high rise buildings a mandatory. Shear walls are provided when the center of gravity of building area and loads acted on structure differs by more than 30%. To bring the center of gravity and center of rigidity in range of 30%, concrete walls are provided i.e., lateral forces may not increase much. These shear walls start at foundation level and extend throughout the building height. The thickness of the shear wall may vary from 150mm to 400mm. Shear walls are oriented in vertical direction like wide beams which carry earthquake loads downwards to the foundation and they are usually provided along both the width and length of the buildings. Shear walls in structures located at high seismic regions require special detailing. The construction of shear walls is simple, because reinforcement detailing of walls is relatively straight forward and easy to implement at the site. Shear walls are effective both in construction cost and in minimizing earthquake damage to the structural and non-structural elements also.

III. BRACING SYSTEM

Steel bracing is a highly efficient and economical method of resisting horizontal forces in a frame structure. Bracing has been used to stabilize laterally the majority of the world’s tallest building structures as well as one of the major retrofit measures. 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. 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. A bracing system improves the seismic performance of the frame by increasing its lateral stiffness and capacity. 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. Steel braced frames are efficient structural systems for buildings.

Steel bracing is highly efficient and economic method to increase the resistance of existing structure against later forces. Bracing improves the performance of frame structure by increasing its lateral stiffness, ductility and capacity. Through braces, load can be transferred out of frame to braces bypassing the weak columns while increasing strength. Poor confinement of columns, week column beam joint, and inappropriate detailing of steel reinforcements are major factors for non-ductile behavior of frame structure. In the presence of these deficiencies, addition of steel bracing has been proved a viable and economic solution to enhance the seismic performance of the system. Moreover this technique of strengthening accommodates more openings and offer minimal self-weight to the structure

IV RIGID FRAME STRUCTURE

Rigid frame structures consist of girders and columns joined by moment resisting connections. For a rigid frame building the lateral stiffness depends on the bending stiffness of the columns, girders, and connections in the plane of the bent. The main advantage of the rigid fame structure is its open rectangular arrangement, which allows the choice of planning and simple fitting of doors and windows. The rigid frame is characterized by flexure of beams and columns and rotation at the joints. Interior rigid frames for office buildings are usually inefficient because: (1) the number of columns in any given frame is restricted due to leasing considerations and (2) the beam depths are often limited by the floor-to-floor height. However, frames located at the building exterior do not inevitably have these limitations. An efficient frame action can thus be developed by providing closely spaced columns and deep spandrels at the building exterior. Above 25 stories the quite high lateral flexibility of the frame calls for inefficiently large members in order to control the drifts. If the rigid frame is used as the only structure to resist the lateral loads in its typical 6m to 9m by size, it is economical only for buildings up to about 25 stories.

DESIGN PERAMETERS

1. Height of typical storey 3M
2 .Height of Ground and podium 3.5m
3. Length of the building -29.12M
4. Width of the building -45.65M
5. Height of the building -76M
6. Number of stores -25
7. Wall thickness -230 mm
8. Slab Thickness -150mm
9. Grade of the concrete- M40
10. Grade of the steel -Fe415 and Fe500
11. Thickness of shear wall- 200, 300 & 350
12. Support -fixed
13. Column sizes-300mmX900mm and 375mmX900mm.
14. Beam sizes 230mmX450mm, 230mmX600mm

V CASES OF STUDY

- Case 1 Shear wall with Bracings Model
- Case 2 Shear wall Model
- Case 3 Concentric Bracings Model
- Case 4 Rigid Frame Structure Model

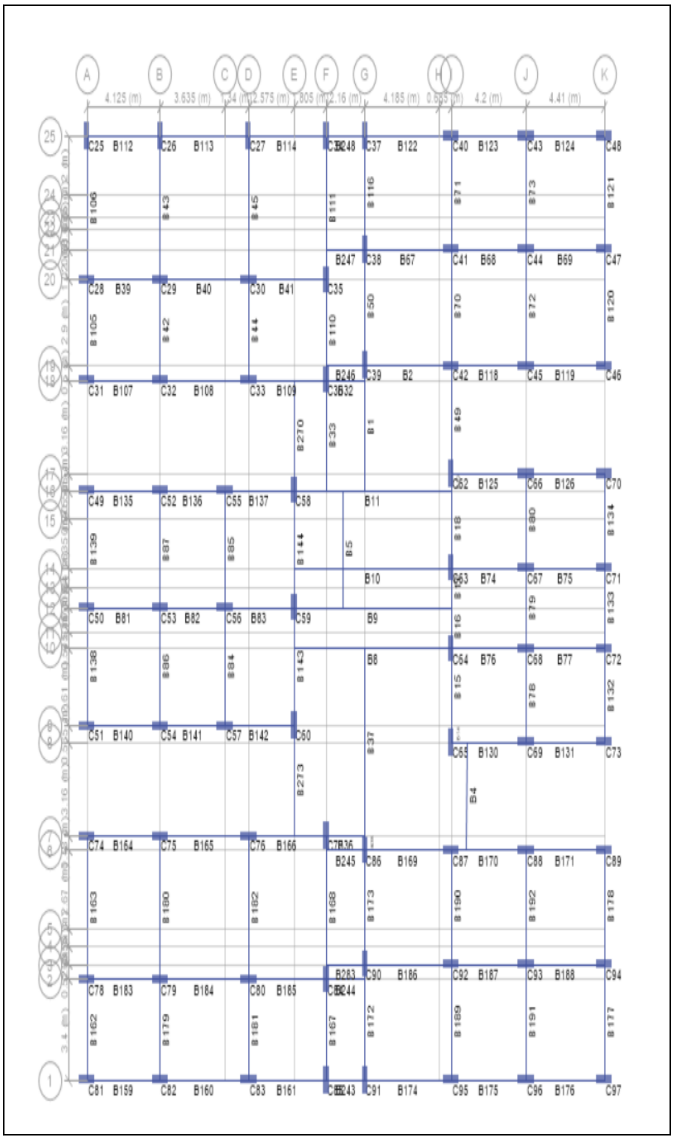


Fig1: plan of Building

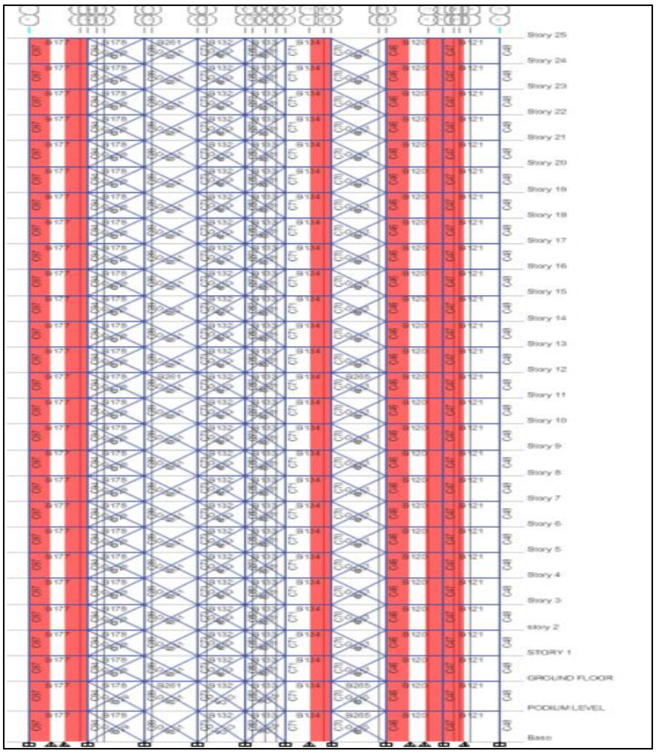


Fig2: Elevation of Shear wall with Bracings Model (Case1)
Bracings are provided at peripherals only.

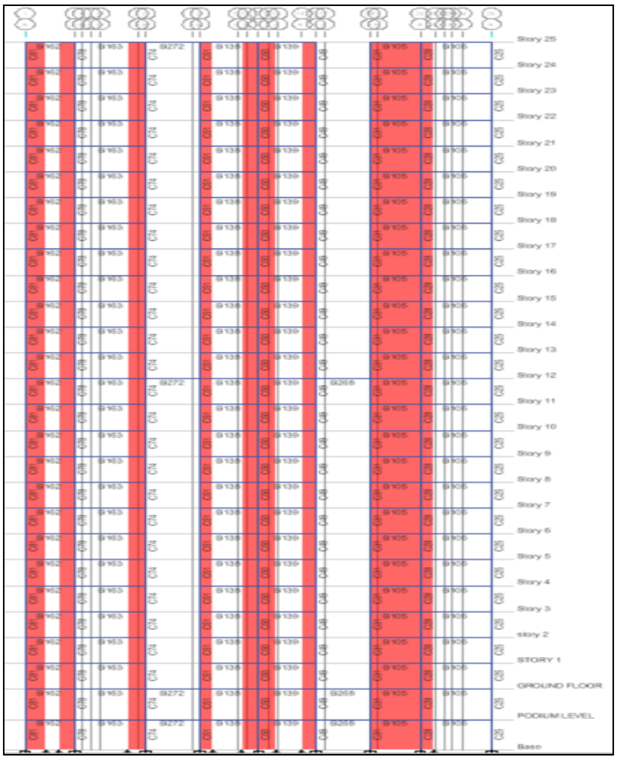


Fig4: Elevation view of Shear wall Model (Case2)

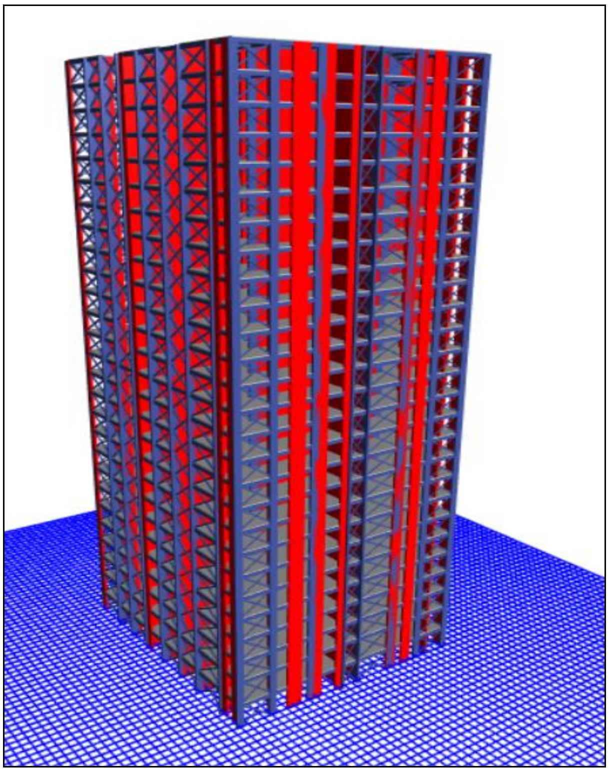


Fig3: Isometric view of Shear wall with Bracings Model

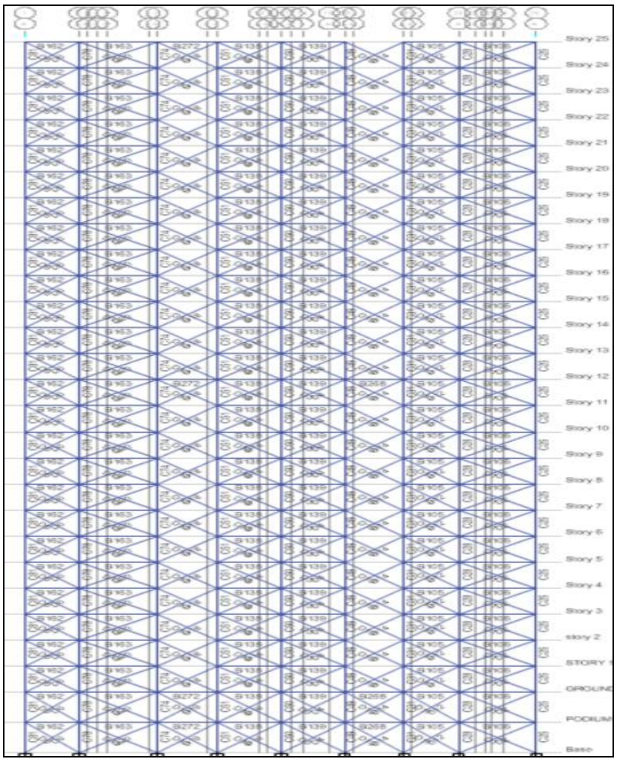


Fig5: Elevation view of Bracings Model (Case3)

Note: Bracings are provided for peripherals of model only.

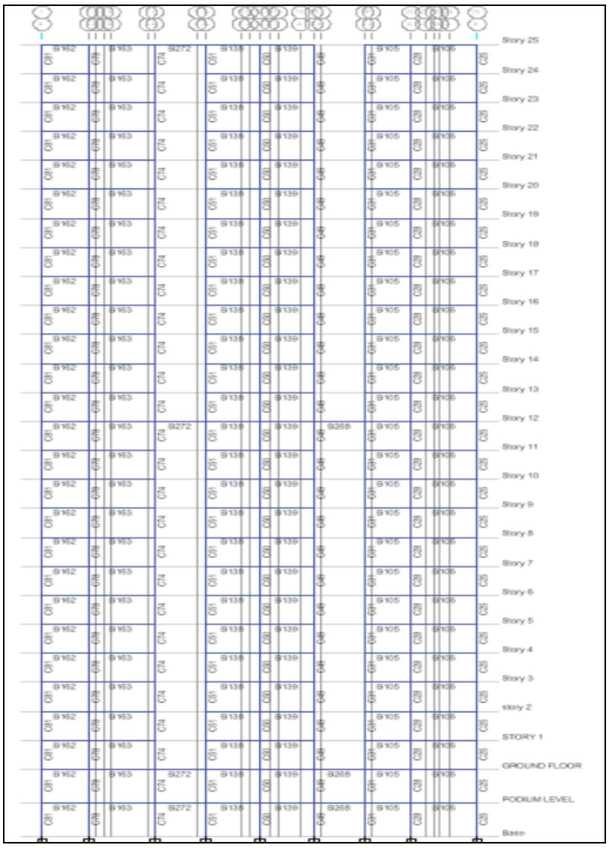
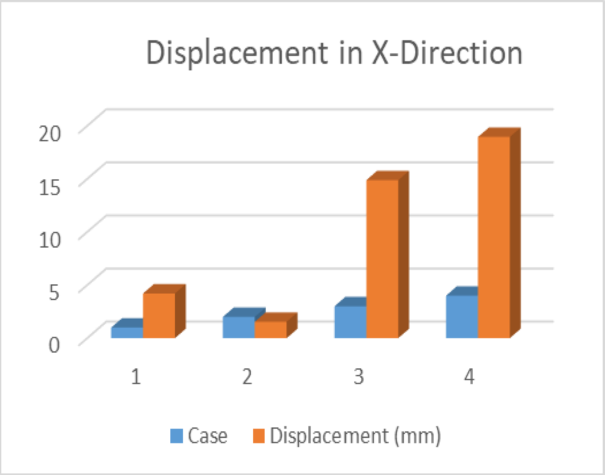


Fig6: Elevation view of Rigid Frame Structure (Case4)

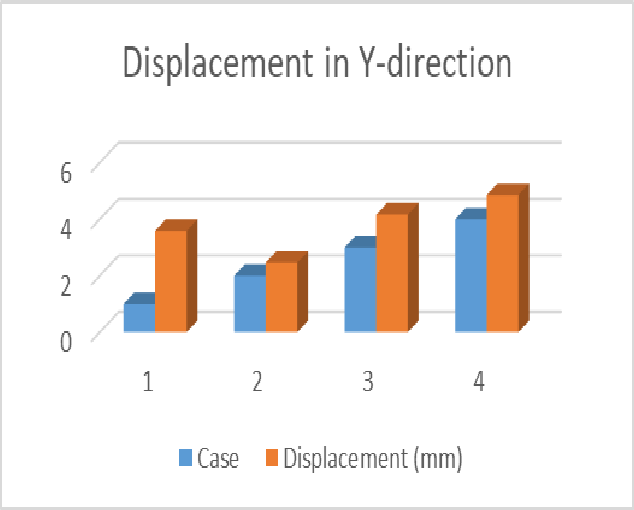
VI RESULTS

Table 1: Values of Displacement in X-direction

Case	Displacement (mm)
1	4.206
2	1.54
3	14.88
4	18.956



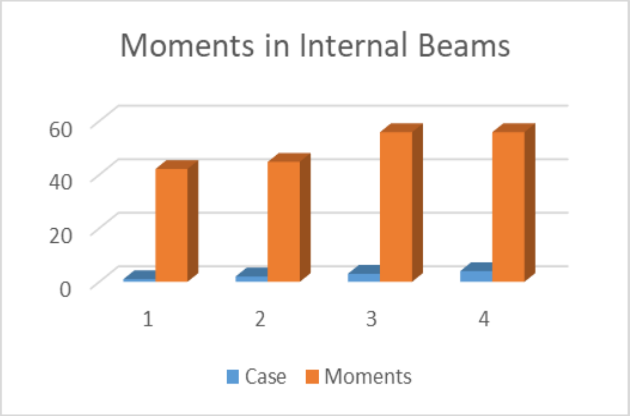
At Story 25 Maximum Displacement



At Story 25 Maximum Displacement

Table 2: Values of Moment in Internal Beams

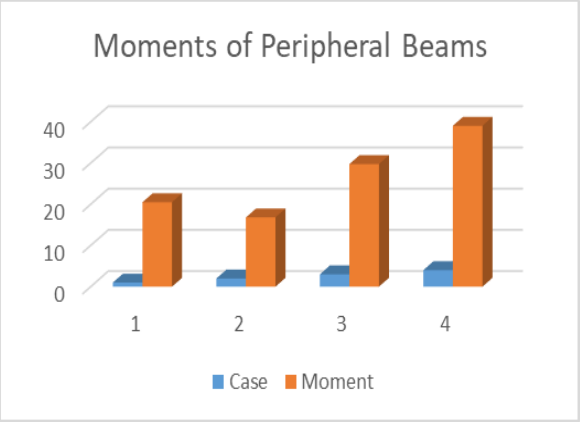
Case	Moments (KN)
1	42.14
2	44.81
3	55.9
4	55.9



At Story 25 Elevation D 25th grid.

Table 3: Values of Moment in peripheral Beams

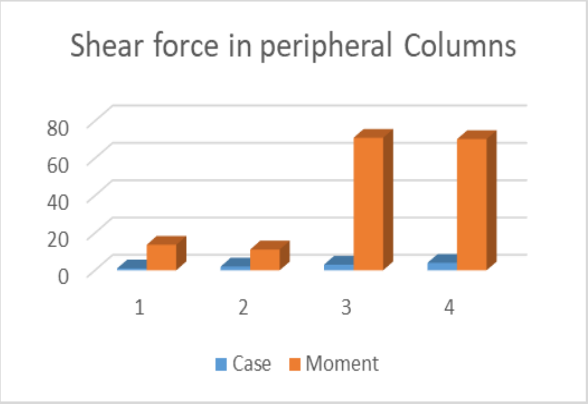
Case	Moment (KN)
1	20.49
2	16.82
3	29.75
4	39.05



At Story 25 Elevation A 25th grid.

Table 4: Values of Shear Force in peripheral Columns

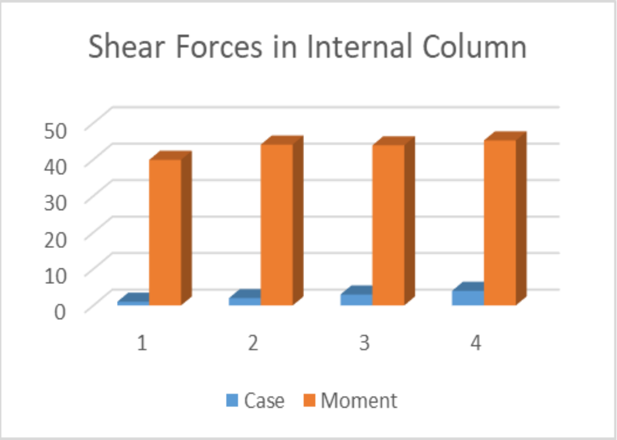
Case	Moment
1	13.66
2	11.14
3	71
4	70.29



At Story 25 Elevation A 25th grid.

Table 5: Values of Shear Force in Internal Columns

Case	Moment
1	39.91
2	44.1
3	43.9
4	45.25



At Story 25 Elevation D 25th grid.

Load Combination

1.2DL+1.2LL.+1.2EQX   IS456-2000

(clauses 18.2.3.1, 36.4.1 and B-4.3).

VII CONCLUSIONS

- From the above results it is clear that Case 1 (Shear wall with Bracings) Reduces larger displacements Shear Forces and moments compared to other two cases (Bracings Model and Rigid Frame structure Model)
- Case 2 gives the lowest displacement values followed by Case 1(Shear wall with Bracings).
- Case 1 has the minimum shear force and moments compared to other cases because the Shear wall and bracings are included in the Case 1.
- Minimum Displacement is given by Case 2, overall Case 2 performs better than Case 1 because of the continuity of Shear wall being maintained by Case 2.
- Minimum Moment is given by Case 1, overall Case 1 performs better than Case 2 because of the combination of Shear wall with bracings being maintained by Case 1.
- Minimum Shear force is given by Case 1, overall Case 1 performs better than Case 2 because of the combination of Shear wall with bracings being maintained by Case 1.

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