Assessment of location and optimum percentage of shear wall for typical plans

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***Abstract* - In the seismic design of buildings, reinforced concrete structural walls, or shear walls, act as major earthquake resisting members. Structural walls provide an efficient bracing system and offer great potential for lateral load resistance. The properties of these seismic shear walls dominate the response of the buildings, and therefore, it is important to evaluate the seismic response of the walls appropriately. In this paper, RCC buildings of different heights and different typical plan shapes but same plan area placed in Solapur subjected to earthquake loading in zone-III are considered. An earthquake load is calculated by seismic coefficient method using IS 1893 (PART–I):2002& Detailed as per IS 13920:1993. These analyses were performed using ETABS 2013. A study has been carried out to determine the effect of RC shear wall on earthquake resistance of a multistoried building by changing shear wall location. Different cases of shear wall positions for buildings of different heights and different plans have been analyzed. Also optimum percentage of shear wall is determined with respect to perimeter of the buildings. The results are compared with help of dimensionless charts.**

***Index Terms* - Shear Wall, Seismic analysis, Rectangular shaped building, C Shaped Building, Top Storey Displacements, Base Shear.**

I. INTRODUCTION

Shear wall are one of the excellent means of providing earthquake resistance to multistoried reinforced concrete building. The structure is still damaged due to some or the other reason during earthquakes. Behavior of structure during earthquake motion depends on distribution of weight, stiffness and strength in both horizontal and planes of building.

In modern tall buildings, shear walls are commonly used as a vertical structural element for resisting the lateral loads that may be induced by the effect of wind and earthquakes which cause the failure of structure. Shear walls of varying cross sections i.e. rectangular shapes to more irregular cores such as channel, T, L, barbell shape, box etc. can be used. Provision of walls helps to divide an enclose space, whereas of cores to contain and convey services such as elevator. Shear walls are usually provided between columns, stairwells, lift wells, toilets, and utility shafts. Wall openings are inevitably required for windows in external walls and for doors or corridors in inner walls or in lift cores. The size and location of openings may vary from architectural and functional point of view .The use of shear wall structure has gained popularity in high rise building structure, especially in the construction of service apartment or office/ commercial tower. When shear wall are situated in advantageous positions in the building, they can form an efficient lateral force resisting system. It has been proven that this system provides efficient structural system for multi storey building in the range of 30-35 storey's (MARSONO & SUBEDI, 2000). In the past 30 years of the record service history of tall building containing shear wall element, none has collapsed during strong winds and earthquakes (FINTEL, 1995). **Abolhassan Astaneh-Asl[1] (2001)** presented information on cyclic behavior and seismic design of composite shear walls made of steel plate and reinforced concrete encasement walls connected to each other to act as a composite element. **Kevin B.D.White & Gupta[2] (2009)** conducted monotonic earthquake loadings fully and partially restrained wood frame shear walls. It was found that partially anchored subduction zone earthquake tests caused wall failure modes consistent with monotonic and cyclic tests. Fully anchored subduction zone tests caused wall failure modes consistent with cyclic tests. Fully anchored monotonic tests did not cause screw fracture or nail withdrawal and therefore did not have failure modes consistent with subduction zone earthquake tests. Energy dissipation was most similar to cyclic tests rather than monotonic tests. **P.P.Chandurkar[3]** presented a paper in determining the shear wall location of four different types of models varying with earthquake load with zones II, III, IV, V as per IS: 1893: 2002. It was found that shear wall in short span at corner in model 4 was economical and effective in high rise buildings. **P.V.Sumanth Choudhary and Pandian[4]** made research on different positions of shear wall in a rectangular building. It was found that, In zone V and IV like high earthquake intensity areas providing shear walls on all four corners and centroid of the building to reduces deflection in X and Y direction. **Varsha R. Harne[5]** analyzed the stability of multistoried building with shear walls at different locations. Also compared these models considering different load combinations. It was found that among all the load combination, the load combination of (1.5DL+1.5EQX) is found to be more critical combination for all the models. **Venkata Sai Ram Kumar & Maruthi Krishna[6]** analyzed behavior of reinforced concrete shear walls by considering increase of height of buildings from ground level to G+7 of height of each floor as 3.5m. The analysis involved in developing of capacity curves which relates wind drift, shear wall length, wind drift, wind shear, wind moment, seismic drift, seismic shear, seismic moment, base moment and base shear with increase in height the base shear of medium and soft soils have no change and varied

linearly, but for rocky soils there is a slight decrease in base shear after 20mts of building height. **Ugale Ashish B. and Raut Harshalata R.**[7] consider a building frame with(G+6) storey situated in seismic zone III as per Indian code 1893:2002, steel plate shear wall behavior was analyzed using STAAD PRO software, with shear wall and without shear wall. As Compared to without Steel Plate Shear Wall (SPSW) building, building with SPSW has very less deflection, bending moment, shear force, deflection and also quantity of steel is also reduced. SPSW occupies less space compared to RC shear wall which have economical and architectural aspect.

II. MODELING OF BUILDING

A typical Rectangular shaped plan & C Shaped plan of apartment are considered for analysis. Initially requirements for each unit are considered and plans are designed in accordance with fulfillment of all requirements. The designed plan of Rectangular shaped plan is about 386.35sq.m and that of C shaped plan is 379.15sq.m which is approximately same.

By working out the actual requirement of shear wall in projected rectangular shaped plan for a normal building, it is found that minimum 5% length of perimeter of plan is used as shear wall for the purpose of Vertical Circulation such as Lifts etc.

Therefore, additional 5% shear wall is provided as the base of project and its percentage is increased in steps of consecutive 5% as 10% shear wall, 15% shear wall and 20% shear wall with respect to periphery of the plan.

Structural Properties considered for both the plans:

SR. NO.	Data Summary for Building Frame	
1	Structural steel	TOR Steel
2	Concrete	M-30
3	Main Steel Reinforcement	Fe415, Fe500
4	Number of Storeys	30,35,40
5	Height of storey	3m
6	Density of concrete	30KN/m^3
7	Poisson Ratio	0.2
8	Damping	0.05
9	Seismic Zone	III
10	Importance Factor	1
11	Response Reduction Factor	5
12	Foundation	Hard soil
13	Beam sizes (in mm)	(450 x 750),(600 x 800)
14	Column sizes (in mm)	(450 x 750),(600 x 800)
15	Slab Thickness	200 mm
16	Shear Wall Thickness	250 mm

Table 1:- Detailed features of both building

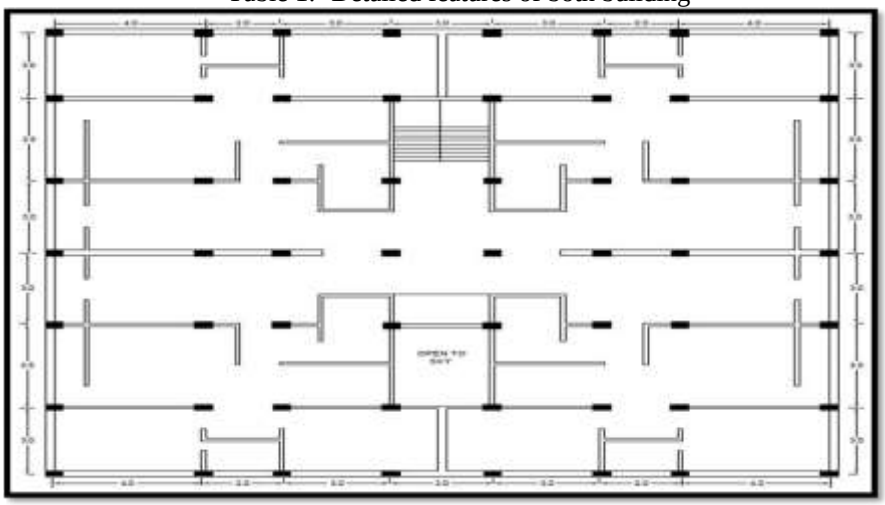
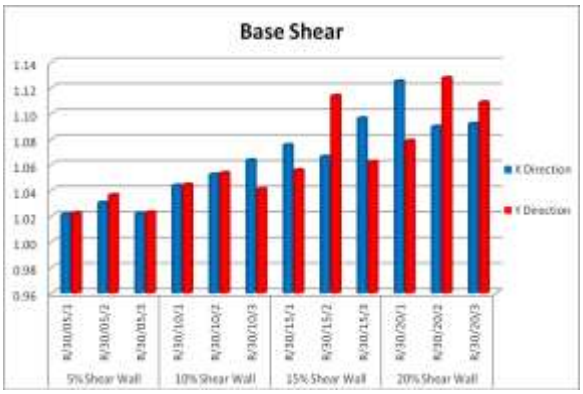


Fig 1: Plan Of Rectangular Shaped Building

30 Storey Rectangular shaped Building:

Considering Value of Top Storey Displacement & Base shear of building without shear wall as Unit (i.e. 1), Graphs are plotted for various locations and percentages of shear wall.

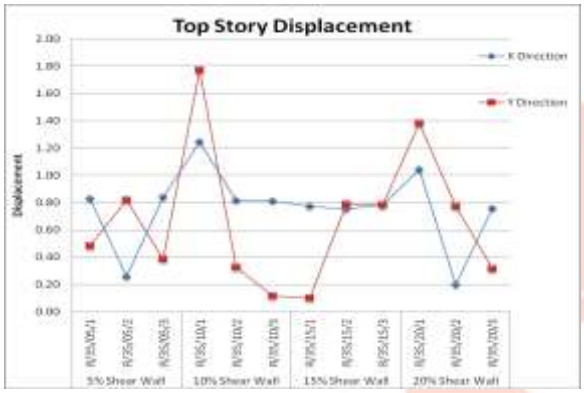


Graph 1 : Top Storey displacements for (G+30) rectangular shaped building

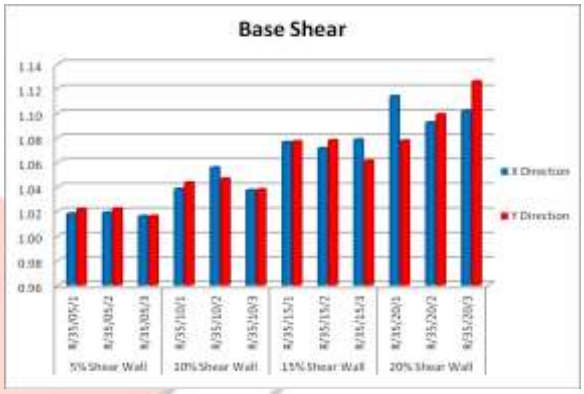
Graph 2 : Base shear for (G+30) rectangular shaped building

35 Storey Rectangular Shaped Building

Considering Value of Top Storey Displacement & Base shear of building without shear wall as Unit (i.e. 1), Graphs are plotted for various locations and percentages of shear wall.



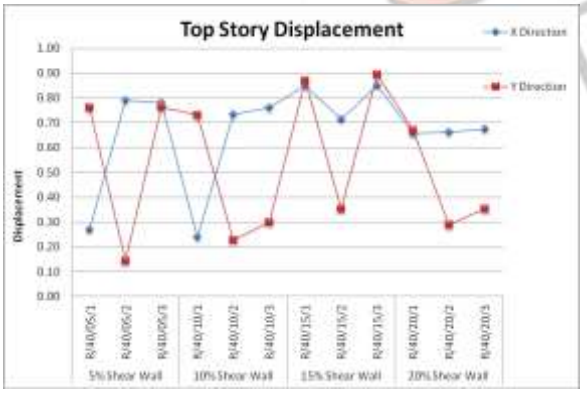
Graph 3: Top Storey displacements for (G+35) rectangular shaped building



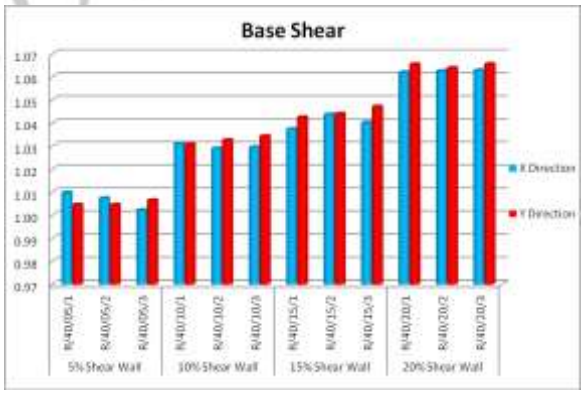
Graph 4: Base shear for (G+35) rectangular shaped building

40 Storey Rectangular Shaped Building

Considering Value of Top Storey Displacement & Base shear of building without shear wall as Unit (i.e. 1), Graphs are plotted for various locations and percentages of shear wall.



Graph 5: Top Storey displacements for (G+40) rectangular shaped building



Graph 6: Base shear for (G+40) rectangular shaped building

III. RESULTS & DISCUSSION

1. In case of (G+30) rectangular shaped building, shear wall location R/30/10/2 gives optimum results considering Top storey displacement & base shear as compared with building without shear wall.

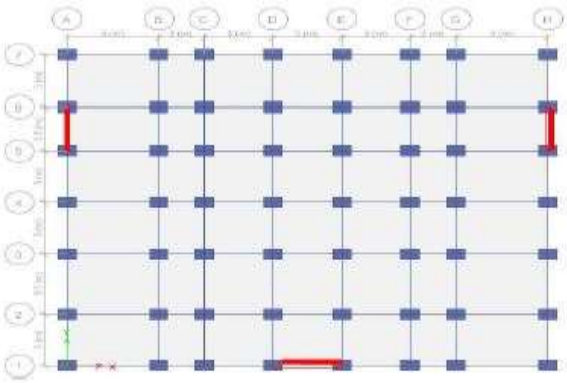


Fig 2: Shear Wall condition R/30/10/2

2. Considering different variations in location & percentage of shear wall for (G+35) rectangular shaped building, condition R/35/15/1 gives most feasible results for top storey displacement and base shear as compared to building without shear wall.

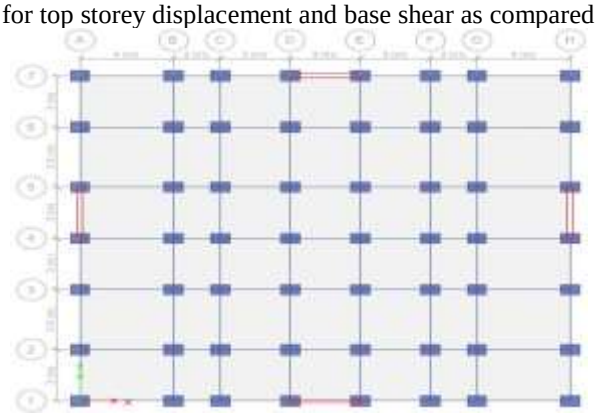


Fig 3: Shear Wall condition R/35/15/1

3. In parametric study of (G+40) rectangular shaped building, variation R/40/20/2 gives optimum results for top storey displacement and base shear when compares with building without shear wall.

Fig 4: Shear wall condition R/40/20/2

4. Similarly, different locations and percentages of shear wall for C shaped plan (Fig 5) for [(G+30), (G+35) & (G+40)] having same plan area are analyzed and results are obtained using ETABS 2013.

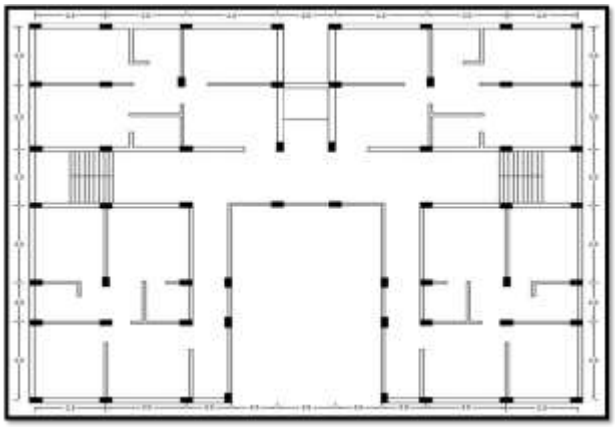


Fig 5: Plan of C Shaped Building

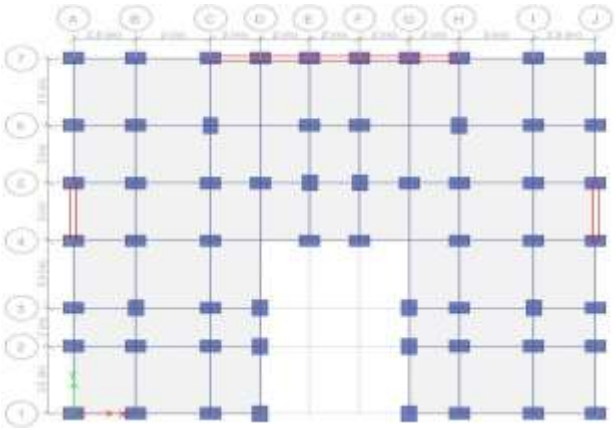


Fig 6: Shear wall condition C/40/20/2

IV. CONCLUSION

1) All Rectangular shaped buildings (i.e. (G+30), (G+35) & (G+40)) are considered, it is observed that R/40/20/2 combination gives the more stable results to the structure along with optimum results.
2) In case of All C-shaped buildings (i.e. (G+30), (G+35) & (G+40)) considered, it is found that C/40/20/2 gives the most stable results in top storey displacement as well as base shear.
3) It is observed from results obtained, as the height of structure increases, confined shapes of plan for moderate percentage of shear wall gives better results than any other shape of plan.
4) A confined shape in plans gives high stability against top storey displacement. However, it doesn't cause any noticeable change in Base shear.

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