OPTIMUM LOCATION OF RC SHEAR WALL FOR A FIVE STOREY SYMMETRICAL FRAMED STRUCTURE FOR EFFICIENT SEISMIC DESIGN USING PUSHOVER ANALYSIS

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Abstract
Shear walls are effective in resisting lateral loads imposed by wind or earthquakes. They provide substantial strength and stiffness as well as the deformation capacity needed for tall structures to meet seismic demand. It has become increasingly common to combine the moment resisting framed structure for resisting gravity loads and the RC shear walls for resisting lateral loads in tall building structures. The aim of this paper is that finding the optimum location of shear walls for a five storey building by providing shear walls in different locations using the software SAP2000. Pushover analysis for a five story RC wall framed building with 3 different locations of shear wall and one without shear walls are performed to examine the strength of building. Procedure followed for carrying out the analysis and observations are presented in this paper.

Keywords: RC shear wall, SAP 2000, plastic hinge, nonlinear static analysis

I. INTRODUCTION

Reinforced concrete (RC) structural walls, conventionally known as shear walls are effective in resisting lateral loads imposed by wind or earthquakes. They provide substantial strength and stiffness as well as the deformation capacity (capacity to dissipate energy) needed for tall structures to meet seismic demand. It has become increasingly common to combine the moment resisting framed structure for resisting gravity loads and the RC shear walls for resisting lateral loads in tall building structures. Generally few shear walls are located symmetrically in the building plan as per the architectural requirements of the buildings or concentrated centrally as core wall to provide the lateral load resistance and lateral stiffness required to limit the lateral deformations to acceptable levels. Nonlinear static Pushover analysis is performed for RC frame building with shear walls have been reviewed and studied.

II. SHEAR WALLS

Shear walls are like vertically-oriented wide beams that carry earthquake or wind loads and transfer them downwards to the foundation. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm or as high as 400mm in high rise buildings. Shear walls are usually provided along both length and width of buildings. Most RC buildings with shear walls also have columns. These columns primarily carry gravity loads and shear walls are designed to carry lateral loads. Shear walls provide large strength and stiffness to buildings in the direction of their orientation, which significantly reduces lateral sway of the building and thereby reduces damage to structure and its contents. In this paper, five frames with different placement of shear walls are analyzed for their performance in terms of base shear, storey drift, member forces and joint displacements. Figure 1 shows typical arrangement of shear wall in a building.

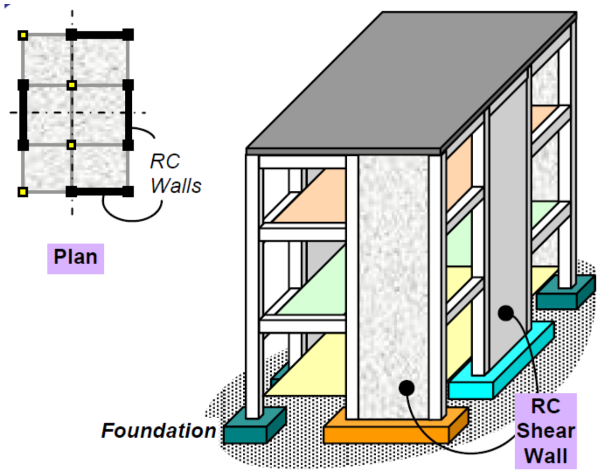


Figure 1: Reinforced concrete shear walls in buildings

The shear walls are modeled using a set of frame elements. The most common modeling technique is to use a composition of mid-pier frame to represent the shear wall stiffness and a horizontal frame (rigid arm) to allow proper connections with intersecting beams and slab components (Figure 2). This model is used widely in practice to model planar shear walls in building structures for linear and nonlinear analyses. This model might have no reliable results for very long, interacting or complex shear walls with openings. Shear walls can also modelled using multilayer shell element method & shell element model.

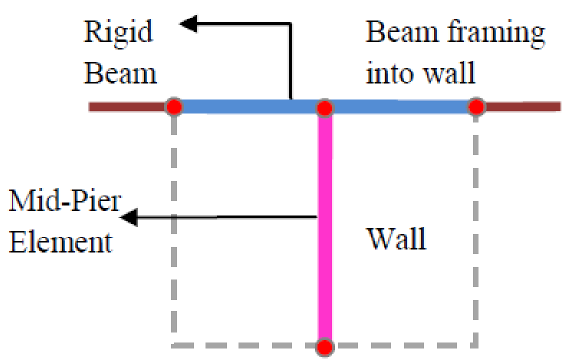


Figure 2: Mid-pier frame element model

III. ANALYSED STRUCTURE

A five storied moment resisting RC framed building having the plan dimensions of 20mx 20m with bay length of 4m in both directions and a typical floor height of 3 m is considered in the study. Four such models are considered with shear walls provided as described in table 1. The total length of shear walls is 16m for each model except model 1.

Properties of the concrete: Modulus of elasticity = 22360MPa, Poisson's ratio = 0.15, thickness of slab = 0.15m. Properties of steel: Modulus of elasticity = 200000MPa, Poisson's ratio = 0.3.

Properties of masonry: Modulus of elasticity = 3850MPa, Poisson's ratio = 0.15, thickness of wall = 0.25m. Column size = 0.45m x 0.50m. Beam size = 0.3m x 0.4m. Shear wall thickness = 0.20m. Shear walls are provided on a concept of mid-pier frame structure.

Arrangements of shear walls are as shown in figure 3. The nonlinear properties for columns and beams are assumed to be a plastic PMM hinge and one component plastic moment hinge, respectively. Nonlinear properties for shear walls are assumed to be a plastic PMM hinge.

Table 1: Structural configuration of shear walls

~~**MODEL NUMBER**~~	~~**DESCRIPTION**~~
~~**1**~~	~~**RC moment resisting frame with full masonry infill without shear walls**~~
~~**2**~~	~~**RC moment resisting frame with replacement of masonry infill by shear walls symmetrically placed centre of outermost walls.**~~
~~**3**~~	~~**RC moment resisting frame with replacement of masonry infill by shear walls symmetrically placed centre of walls just inside bays of outer walls.**~~
~~**4**~~	~~**RC moment resisting frame with replacement of masonry infill by shear walls symmetrically placed in the central core.**~~

Structural configurations of shear walls are described in table 1. In which Model 1 doesn't contain shear walls and all other models contain 16m length shear walls.

Proper understanding of optimum location for shear walls is very important in earthquake resistant buildings using shear walls. Large amount of shear wall can increase lateral resistance of the building. But it should be cost effective as well as sufficient. So proper allocation of shear wall is necessary.

Pushover analysis is a static, nonlinear procedure using simplified nonlinear technique to estimate seismic structural deformations. It is an incremental static analysis used to determine the force-displacement relationship, or the capacity curve, for a structure or structural element.

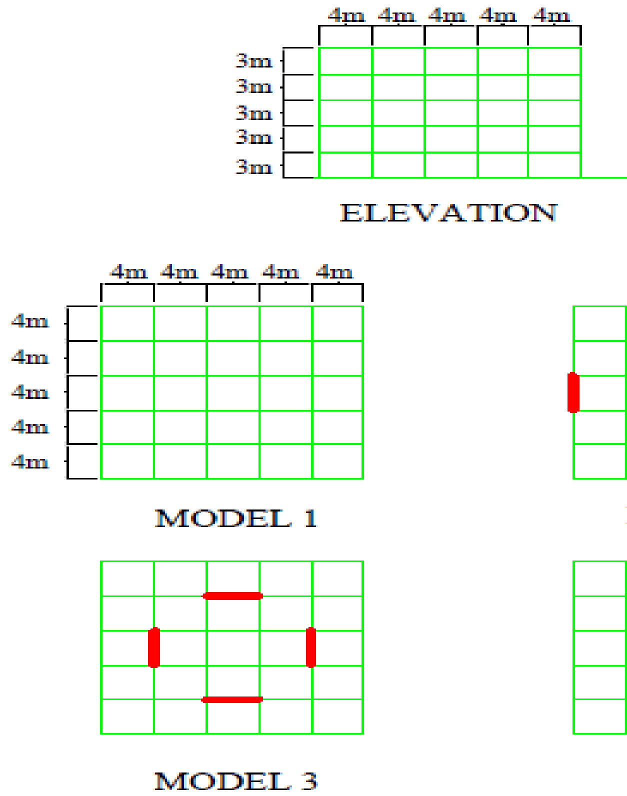
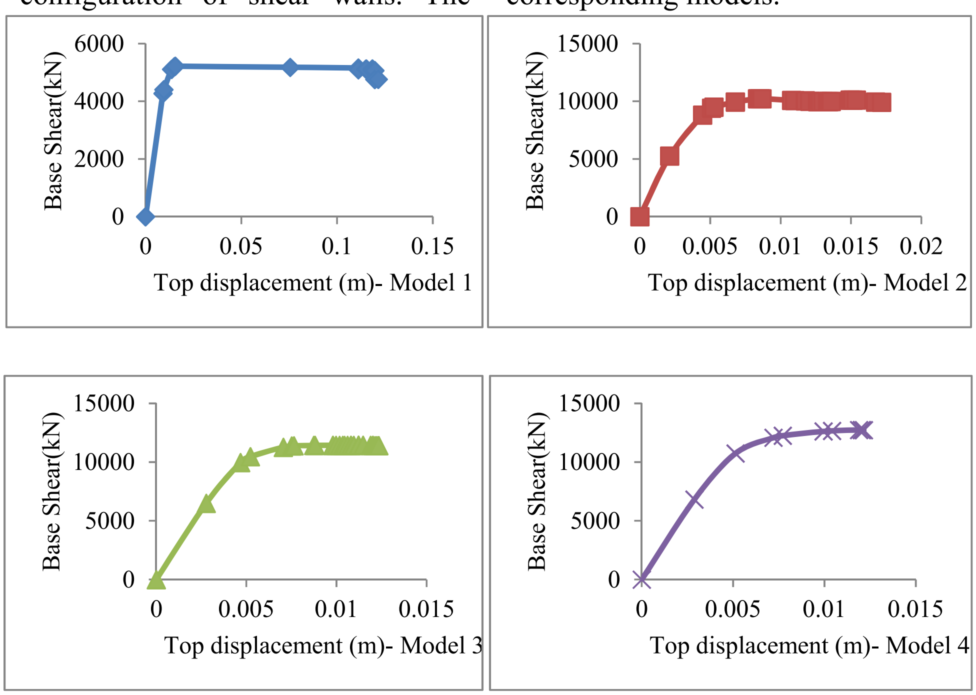


Figure 3: Structural configuration of the RC frame with shear walls (Red)

IV. DISCUSSION

Pushover analysis was applied to the four models described in Figure 3 with different structural configuration of shear walls. The results obtained after pushover analysis are shown in figure 4, which represents top displacement versus base shear for the corresponding models.



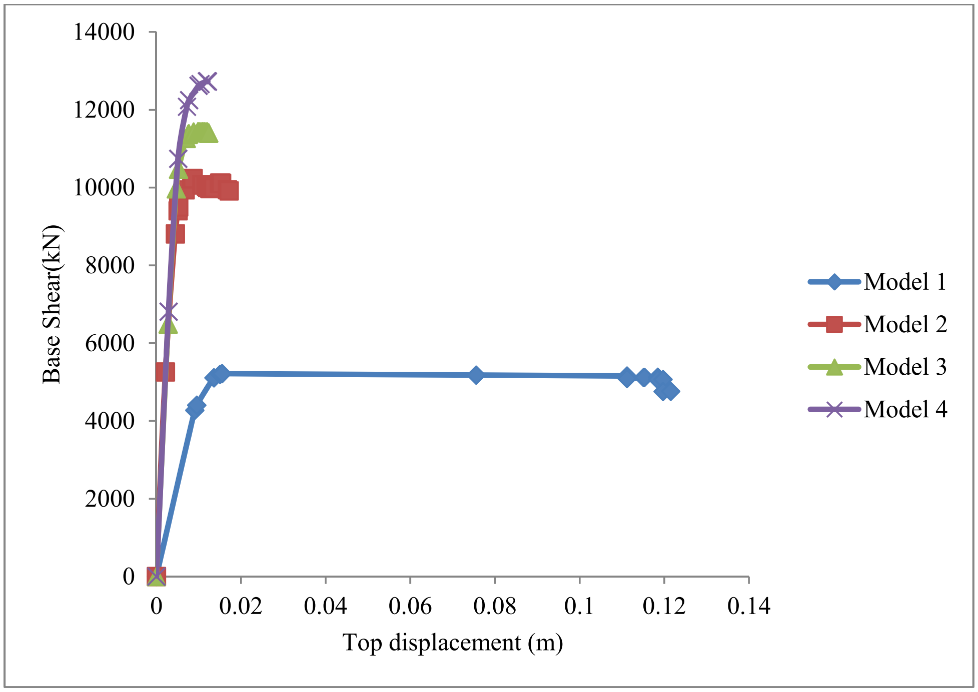
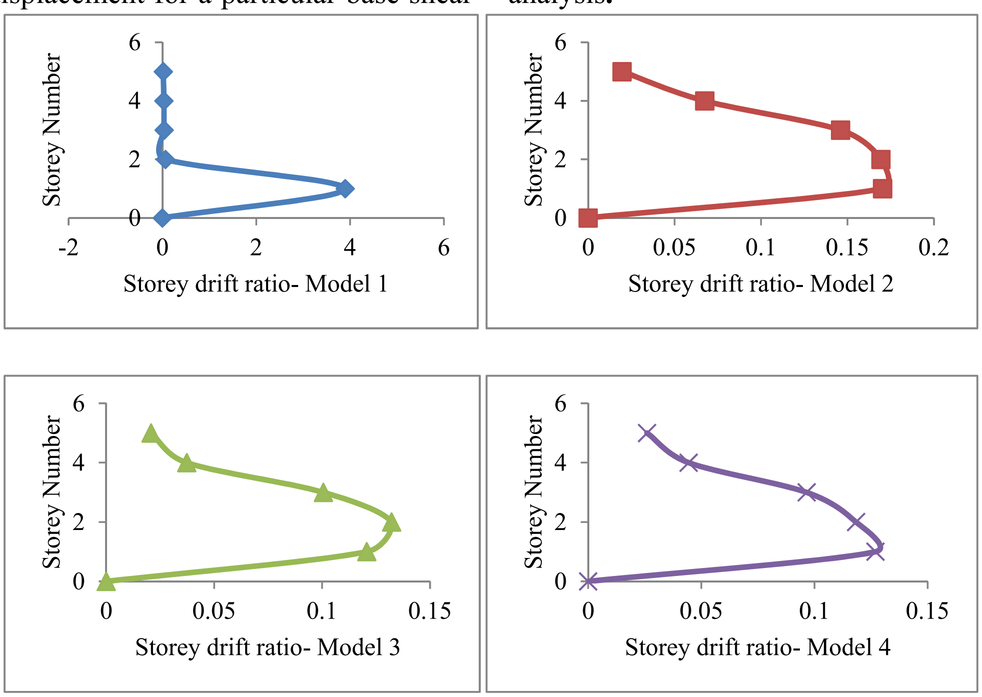


Figure 4: Displacement versus Base shear for various shear wall locations

From the curves obtained model four, i.e., shear walls provided at the inner core gives smaller displacement for a particular base shear rather than other three models. Figure 5 shows storey drift ratio of same models after pushover analysis**.**



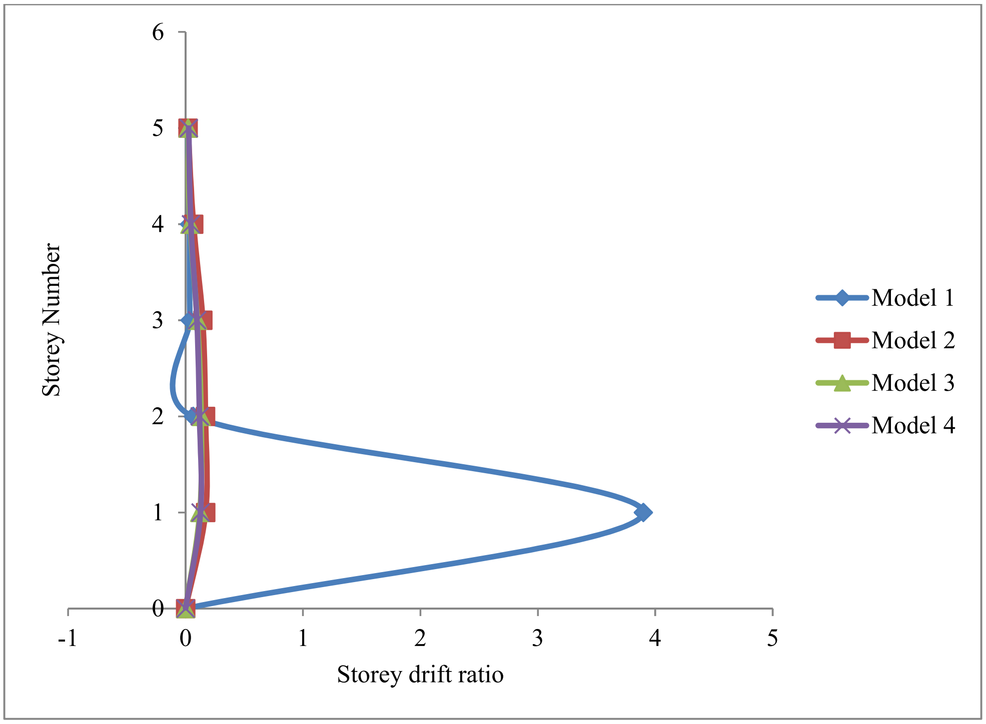


Figure 5: Storey drift ratio

From the results obtained after pushover analysis, in which also model four gives better characteristics than other three models. Figure 6 shows ductility versus storey number for a five storey five bay building after pushover analysis for all the four models. Ductility value between 3 and 6 is the best structure.

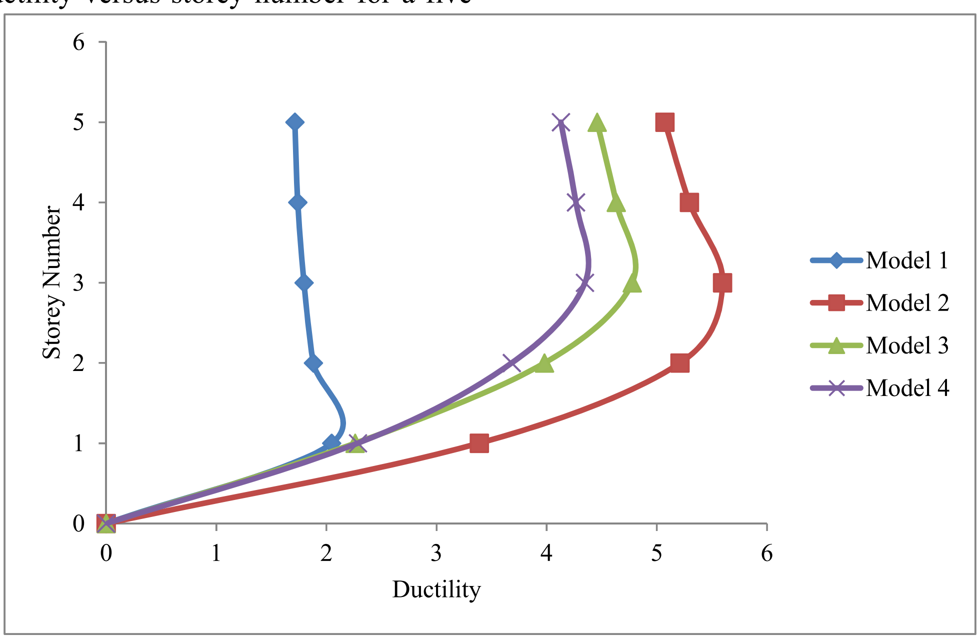


Figure 6: Ductility

In this case all models except model one, i.e., without shear walls, gives a ductility value between 3 and 6. This indicates that provision of shear walls provides ductility in between three to six, which is necessary for a good structure. Table 2 shows top displacement values of models 1 and 4 obtained for the five storey building for a base shear of 5000kN.

Table 2: Shear wall percentage & top displacement

Top displacement (m) Model 1	Top displacement (m) Model 4	Percentage of shear wall provided (%)	Percentage reduction in top displacement (%)
0.1197	0.00486	20	95.93

V. CONCLUSIONS

In general, the provision of shear walls has significant influence on lateral strength. The structural configuration of model 4 has exhibited superior structural performance. Since all the 3 models are provided with same length of shear walls, cost of construction is same. In which shear wall provided at the central core (model 4) gives maximum performance. For a particular base shear model 4 gives smaller displacement. Model with shear wall at the central core gives good ductile character than other three models considered. It is clear that by providing shear walls about 20% of the side length, we can decrease the top displacement by 95% than the structures without shear walls. This type of allocation is possible in case of symmetrical structures. In case of unsymmetrical structures torsion may takes place due to asymmetry. It's another type of situation and detailed study required.

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