Optimum Location of Shear Wall in RC Building

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Abstract: Lateral loads play the governing role in analysis and design of tall RCC buildings. As height of the building increases, the stiffness become important than strength due to lateral load carrying responsibility. Shear wall is an effective structural system with higher in-plan stiffness and strength. It carries the seismic and wind loads by combine axial-shear-bending action and attracts most of the lateral loads which in turn causes to reduce the moment and shear demands of various structural elements. The location and positioning of shear walls in building structure is a major issue which plays an important role in seismic performance of such system against lateral loads. Improper positioning of shear wall generates eccentricity in building which is the main cause for torsion system. In this paper attempt has been made to find out the optimum location of shear walls in RC building by modeling and analyzing of building with different shear wall positions. A G+9 storey RC building has modeled in ETABS software with different locations of shear walls (i.e. shear wall around core, shear walls in inner bays of the building, shear walls at building periphery and the final case is the building corners). The analytical result of each model has compared with that of Bare Frame in terms of Base Shear, Top Storey Displacement, Storey Drift and Time Period.

***Keys Words* –Shear Wall, Moment resisting System, Lateral Loads, ETABS etc.**

I. Introduction

Getting up the cost of land, development of urban areas, availability of quality construction materials and development of modern structural systems are the governing factors of tall structures development. By increasing the height of building it becomes susceptible to lateral loads such as earthquake and wind. The stiffness is important than strength in design of tall buildings subjected to lateral loads. To carry the lateral loads and control the excessive lateral deflection of tall buildings, provision of an efficient structural system is a good solution for such issue. Shear wall is an efficient lateral load resisting system in RC building of low to mid-rise buildings. Shear wall has higher in-plan strength and stiffness which carries the lateral loads by combine bending-shear-axial action and attracts most of the lateral loads when employed in the building. In addition of providing lateral stiffness, shear wall system also provides torsional resistance in tall building of irregular plan. Positioning of the structural walls in building plays a vital role in overall performance of this system. Improper positioning of structural walls create eccentricity which causes the building to twist about its vertical axis. Torsion of the building is a big issue in structural design of which causes the distress of various structural elements and brittle shear failure. The main aim of the current paper is to find out the optimum location and positioning of structural walls in RC buildings subjected to earthquake load. A G+9 RC building is modeled and analyzed in ETABS software with different location of shear walls (i.e. shear wall around core, shear walls in inner bays of **the** building, shear walls at building periphery and the final case is the building corners). The Response Spectrum analysis of each building model has conducted to find the base shear, lateral displacement, inter-storey drift and time period. The analytical result of each model has compared with that of Bare frame system to assess and select the most efficient one.

II. MODELLING AND ANALYSIS OF BUILDINGS

The analysis of G+9 storey building was carried out by using the ETABS software for buildings with shear walls and bare frame system of situated in seismic zone V. Various seismic parameters such as base shear, top storey displacement, storey drift and time period were obtained. The below mentioned table 1 shows the various details of the building models.

Table 1 – Data for problem formulation

Various details	No of stories
	G+9
Plan	Square Building
Typical floor height	3.5m for ground level and 3m for all above floors
Plan dimensions	25m*25m
Typical Column size	500mm*500
Beam size	300mm x 500mm
Slab thickness	130mm
Shear wall thickness	250mm
Seismic zone	V
Soil type	Medium(II)

Response reduction factor (R)	4 for dual systems (SMRF + shear walls) 5 for SMRF
Imp. factor (I)	1.5
Damping	5% for RCC, 2% for steel
Grade of concrete	M 25
Grade of steel	Fe 415
Live load	3 kN/ sq.m.
Floor finish	1.5 kN/ sq.m.

Table 2 – Structural models detail

Model No	Model Code	Detail
1	M-1	Moment Resisting System
2	M-2	Shear Wall (Core)
3	M-3	Shear Wall (Inner Bays)
4	M-4	Shear Wall (periphery)
5	M-5	Shear Wall (Corners)

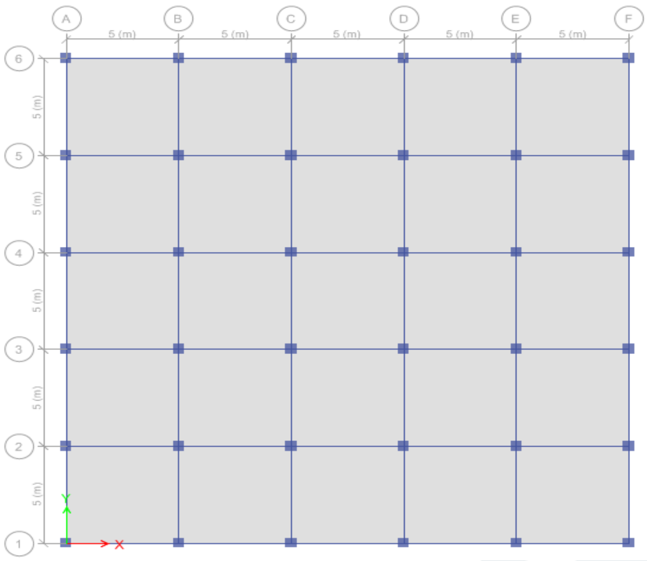

Fig 1. Plan of building

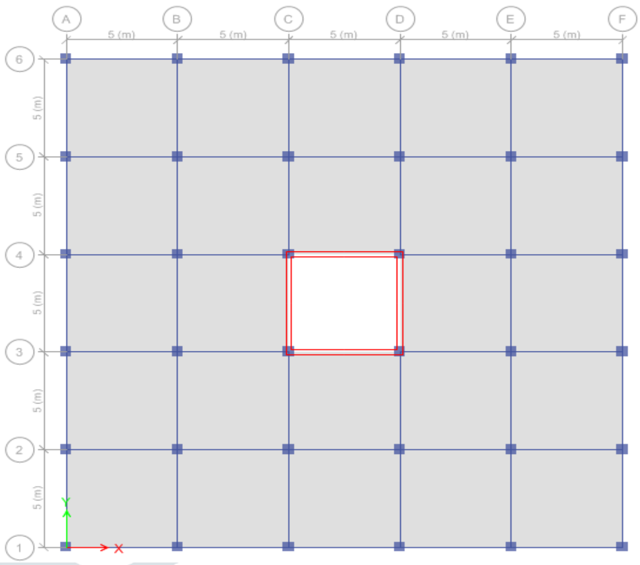

Fig 2. Shear Wall at Core

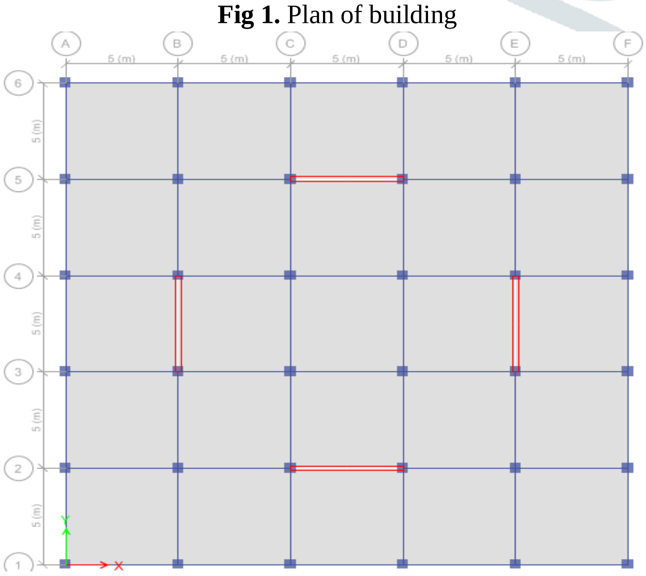

Fig 3. Shear Wall at inner bays

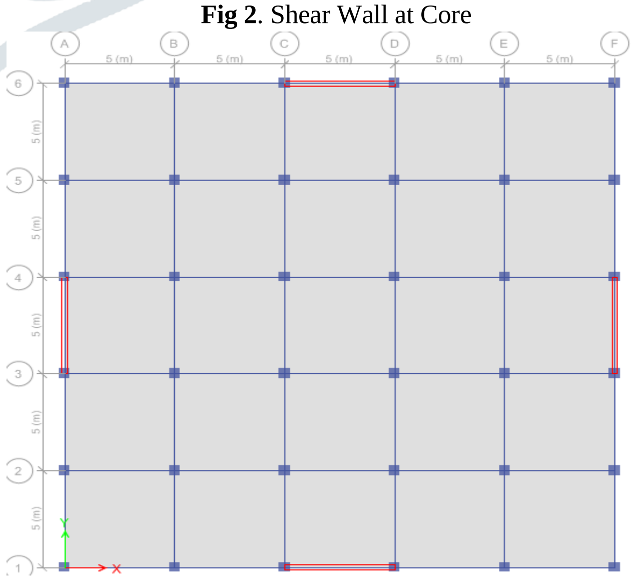

Fig 4. Shear wall at periphery

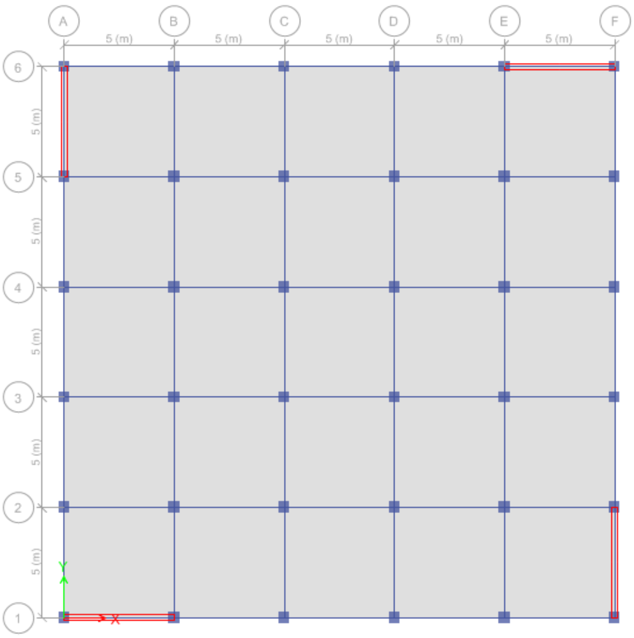

Fig 5. Shear walls at corners

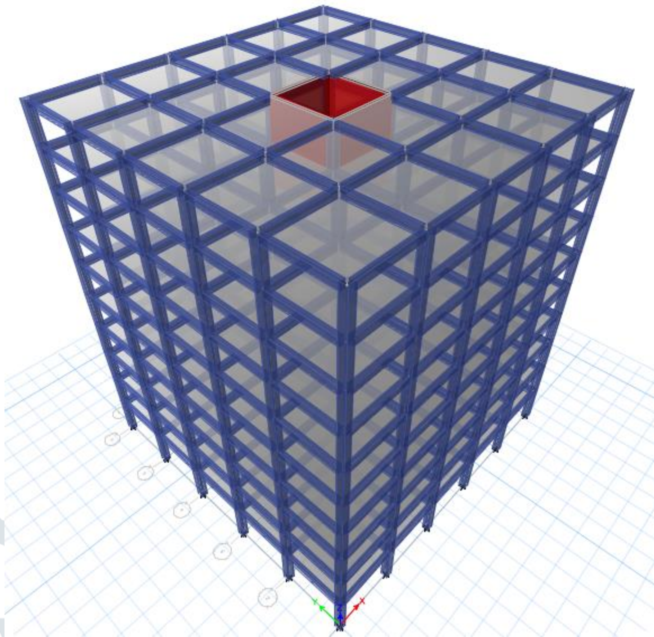

Fig 6. 3-D model for shear walls at core

III. RESULTS

Below tables and graphs show the analytical results for all building models considered.

- **<u>For Base Shear capacity</u>**

Table 3 – Base Shear(kN) Comparison of all Models considered

Model	Base Shear(kN)	Difference(%)
M-1	4779.21	
M-2	11701.09	144
M-3	10002.27	109
M-4	9980.76	108.8
M-5	9717.57	103

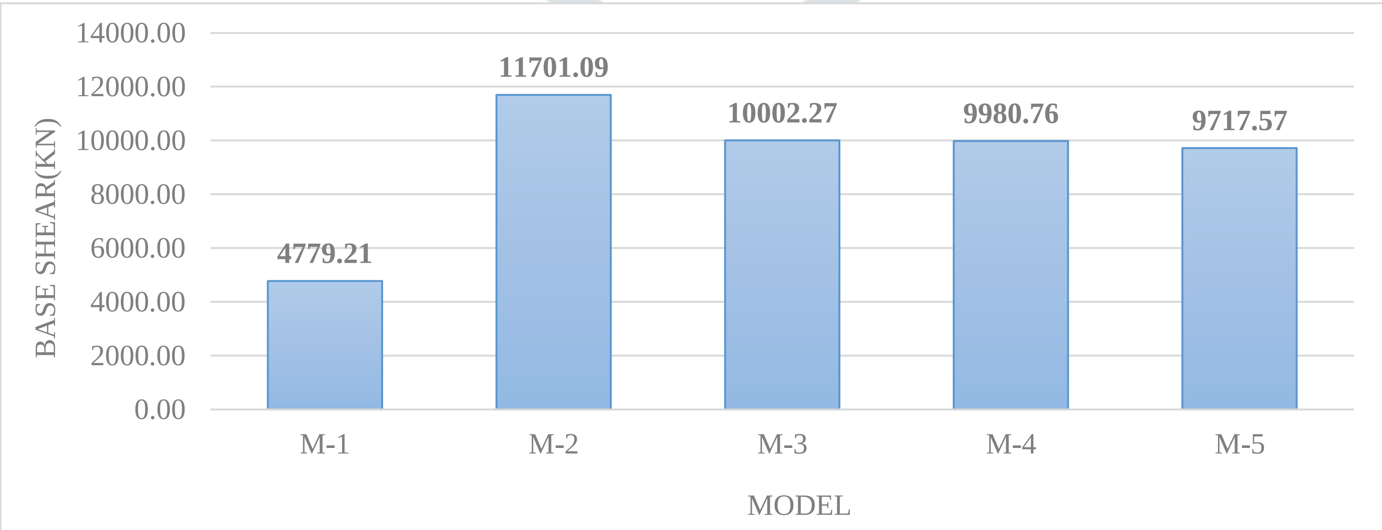

Chart 1. Base shear (kN) Comparison of various Models

- **For Lateral Displacement**

Table 4 – Lateral Displacement(mm) Comparison of all Models considered

Model	Displacement(mm)	Difference(%)
M-1	68.05	
M-2	48.51	28.72
M-3	57.53	15.45
M-4	58.30	14.33
M-5	60.22	11.50

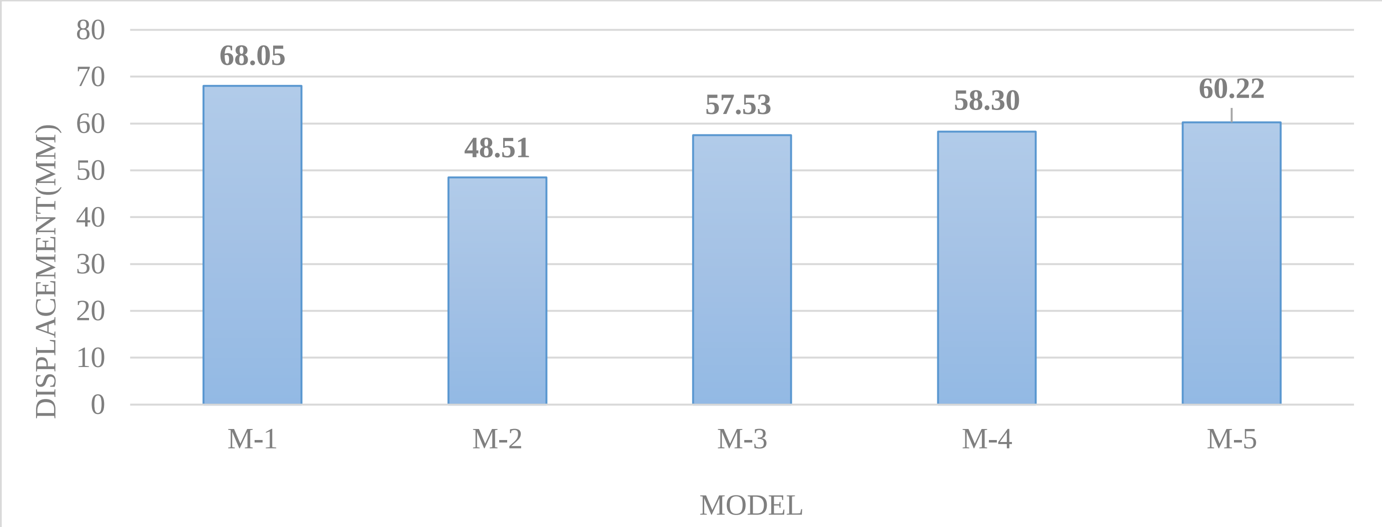

Chart 2. Displacement (mm) Comparison of All models considered

- **For Time Period**

Table 4 – Time Period(sec) Comparison of all Models considered

Model	Time Period(Sec)	Difference(%)
M-1	1.54	
M-2	0.82	46.82
M-3	0.96	37.55
M-4	0.98	36.77
M-5	1.05	31.91

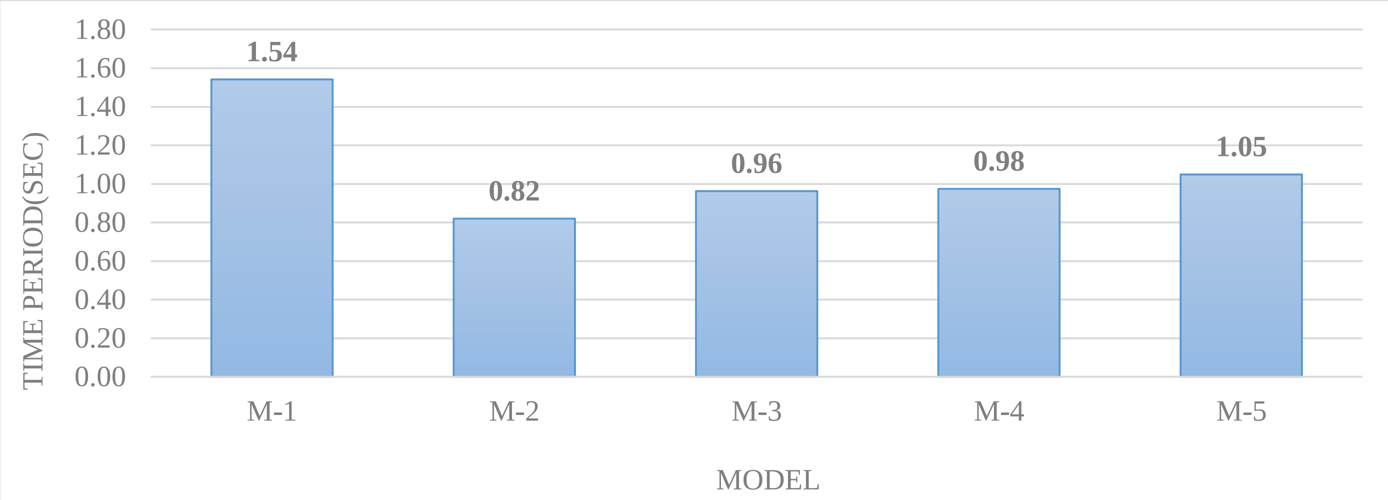

Chart 3. Fundamental Natural Period (sec) Comparison of All models considered

- **For Storey Drift**

Table 5 – Storey Drift Comparison of all Models considered

No.Storey	Model/Storey Drift				
	M-1	M-2	M-3	M-4	M-5
10	0.00085	0.00184	0.00220	0.00217	0.00219
9	0.00138	0.00200	0.00237	0.00232	0.00234
8	0.00185	0.00209	0.00248	0.00243	0.00244
7	0.00222	0.00214	0.00256	0.00250	0.00250
6	0.00250	0.00213	0.00257	0.00250	0.00250
5	0.00270	0.00205	0.00249	0.00241	0.00240
4	0.00283	0.00189	0.00229	0.00221	0.00220
3	0.00288	0.00165	0.00197	0.00189	0.00188
2	0.00279	0.00132	0.00149	0.00143	0.00141
1	0.00193	0.00079	0.00076	0.00072	0.00071
0	0	0	0	0	0

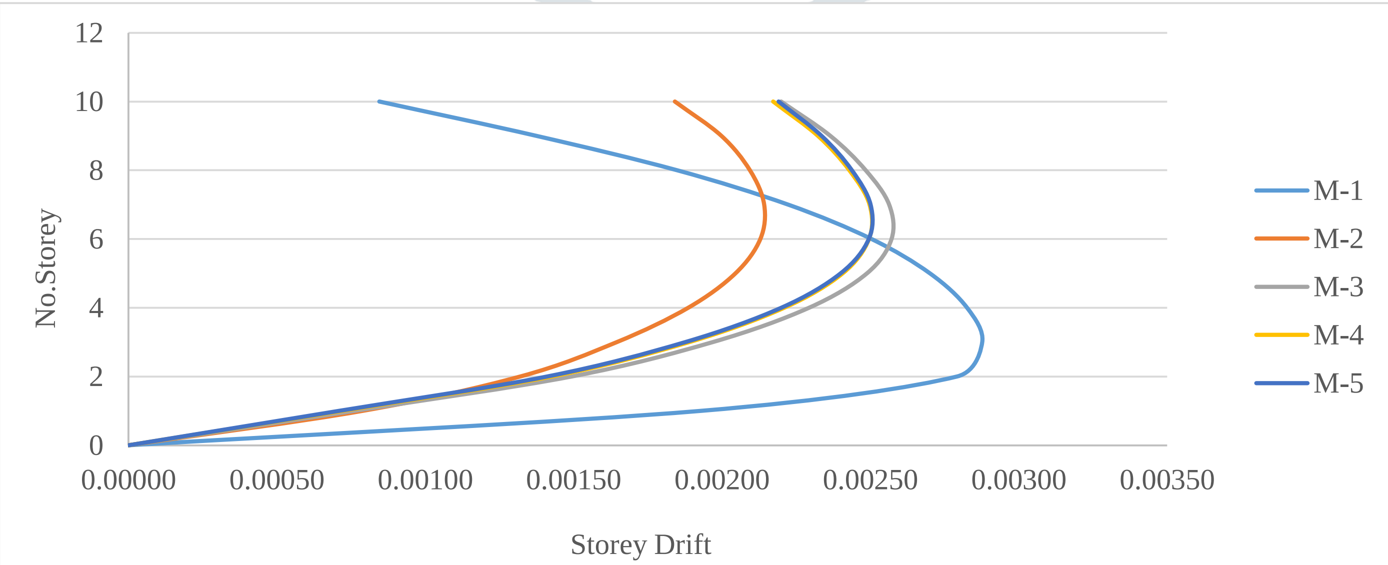

Chart 4. Inter-storey Drift Comparison of All models considered

- **Modal Shape**

Table 6 – First Three mode shape of all models

Model	1st mode Shape	2nd mode Shape	3rd mode Shape
M-1	Diagonal	Diagonal	Torsion(Y)
M-2	Torsion(Z)	Translation(X)	Translation(Y)
M-3	Translation(X)	Translation(Y)	Torsion(Z)
M-4	Translation(X)	Translation(Y)	Torsion(Z)
M-4	Translation(X)	Translation(Y)	Torsion(Z)

IV. Result Discussion

Building model M-2(shear wall at building core) has higher base shear capacity among all building models. The percentage increase in base shear of M-2 model is about 150% compared to conventional moment resisting frame. From analytical results it can be concluded that as location of shear walls become apart from geometric centre of mass of the building, the base shear capacity of building reduces.

Lateral displacement of bare frame system is more than permissible limit prescribed in the code(h/500). The permissible limit for lateral displacement of current building models with 30500 mm height is 61mm. the lateral displacement of M-2 building model is less compared to other building models. The percentage decrease of lateral displacement in model M-2 is 28.72% compared to bare frame system.

Time period of building model M-2 is less compared to other models but torsion is governing the first mode of vibration in this system.

Like other parameters, storey drift of model M-2 is less among all building models. Storey drift of bare frame system is higher compared to remaining models but is less than permissible limit (0.004).

From table-6 it can be seen that the torsion is governing the first mode of vibration in building model M-2 and Diagonal translation in model M-1 which are not desirable. The primary purpose of of providing shear wall in building is to avoid the torsion. Both torsion and diagonal translation cause distress of structural elements (especially columns) which cause brittle shear failure.

V. CONCLUSSION

[1] Shear wall positioned at building core has good seismic response compared to other options due to higher tendency of attraction of lateral loads. As shear wall gets apart from centre of the building, its seismic response getting reduced.

[2] For provision of torsional resistance in buildings provided with shear wall, place as much of the shear walls as possible apart from centre of mass of the building.

[3] The first mode of vibration in building models M-3, M-4 and M-5 are translation which are effective from stress in structural members point of view.

[4] From the analytical results it can be concluded that the optimum position of shear walls is at the inner bays of the building.

Above results may vary by changing size and location of shear wall.

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