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Shear wall layout optimization for conceptual building planning

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Abstract – *Most of the high-rise structure is collapse due to the earthquake. Shear wall is the most important component of the high-rise structure which can resists the lateral load. In building planning the location of the shear wall is also important. The effective position of Shear walls in planning the deflection of building due to earthquake is decreases. By providing shear wall we can reduce overall damage of the structure.*

***Key Words*: Shear wall, Displacement, Location, Lateral Load, Analysis.**

1.INTRODUCTION

In past there was no need to construct the high-rise building. Because the population is less and area of land was also available easily. And also that days no more technology and the knowledge about the high-rise structure. In shorter structure, the wind and seismic force is no more affects. Therefore, no need to think about that (wind and seismic) types of Force and their effect on structure. But the time was passing the population is increase and the land for construction is decreases. For fulfilling that situation, the engineer and researchers extended the structure in vertically. Finally, they can have developed the high-rise structure and decrease the land use. An earthquake (also known as a quake, tremor or temblor) is the shaking of the surface of the Earth, resulting from the sudden release of energy in the Earth's lithosphere that creates seismic waves.

A structural member used to resist lateral forces is known as shear wall i.e. parallel to the plane of the wall. Shear wall are vertical elements of the horizontal force resisting system. It gives large strength and stiffness to buildings in the direction of their orientation, which reduces lateral sway of the building and it reduces damage to structure and its contents. Also, shear walls resist large horizontal earthquake forces, wind forces and overturning effects. It is generally used in high-rise buildings subject to lateral wind and seismic forces.

Based on type of material used, shear walls are classified into following types:

1. Reinforced concrete shear wall
2. Concrete block shear wall
3. Steel shear wall
4. Plywood shear wall
5. Mid-ply shear wall

2. LITRATURE RIVEW

Anshul sud [1] studied the five storey RC building located in zone 5 with four shear walls. He could determine the base shear, storey drift, member force and joint displacement. He took the column size 350*500 mm, beam section size 500*500 mm, slab thickness 125 mm, shear wall thickness 300mm for analysis. In X-direction (longer direction) five bays each of 4m width. In z-direction (shorter direction) three bays each of 5m width. Five frame with different shear wall location, frame 1- base frame, frame 2-at core number, frame 3- exterior bay centrally, frame 4 and 5- adjacently placed in exterior of the building. Lived load on each floor is 4KN/$m^2$and 1.5 KN/m^2 on roof.

The shear wall at the exterior side of a frame could reduce the displacement, bending moment, shear force as compared to shear wall at core of structure.

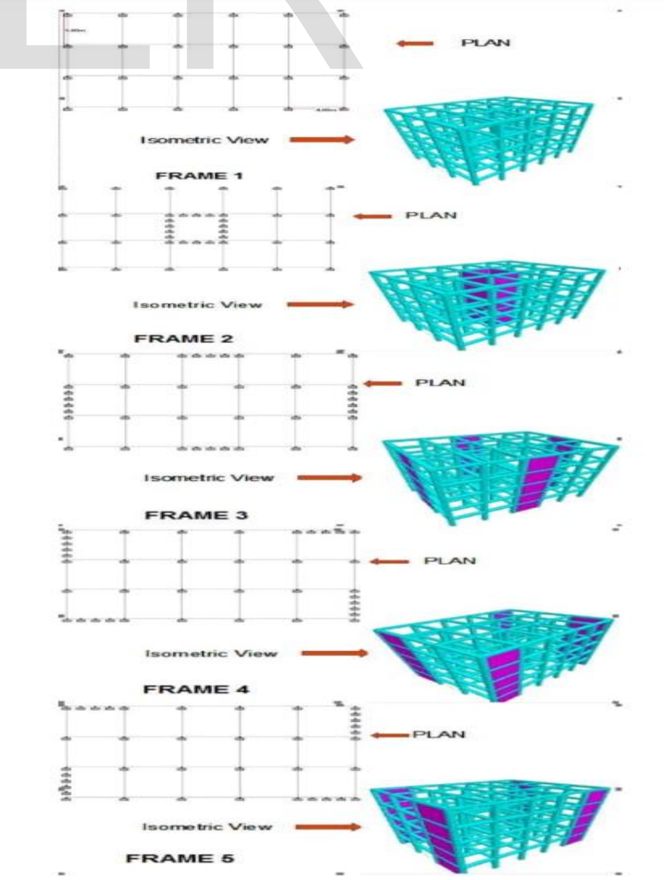

Fig1 : five frame showing plan and isometric view

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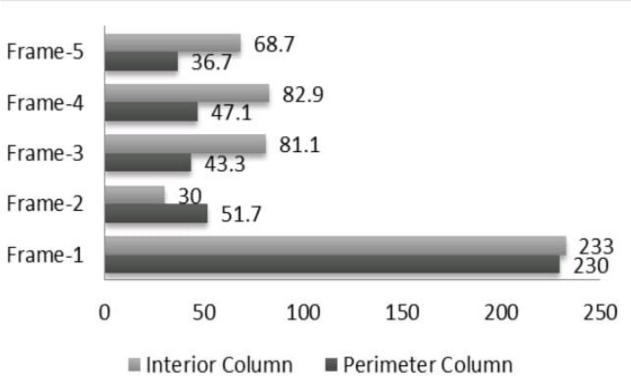

Fig 2: Bending moment in ground storey columns

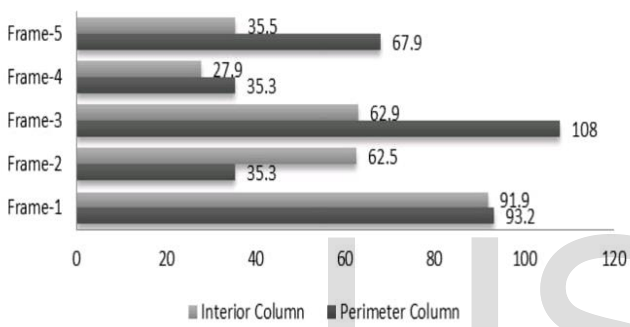

Fig 3: Bending moment in top storey columns

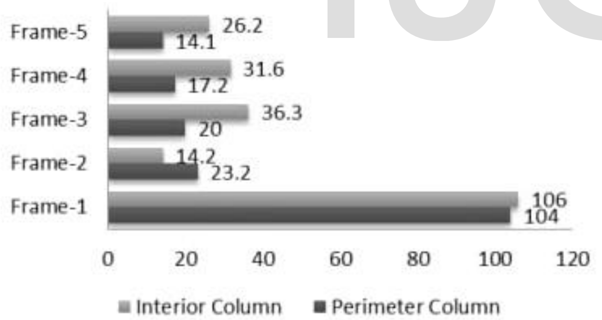

Fig 4 : shear force in ground storey building

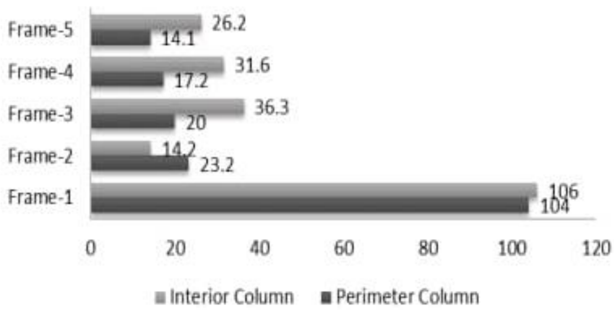

Fig 5 : shear force in top storey building

Table 1: storey drift in X-direction

	Displacements (mm) in *x*-direction				
Storey	**Frame-1**	**Frame-2**	**Frame-3**	**Frame-4**	**Frame-5**
Fifth	34.813	9.964	12.403	14.998	12.248
Fourth	30.940	8.586	9.494	11.95	9.301
Third	24.122	6.290	6.343	8.192	6.297
Second	15.317	3.728	3.455	4.594	3.558
First	6.040	1.406	1.182	1.507	1.344

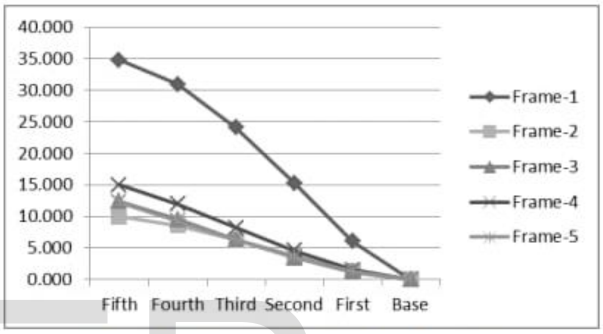

Fig 8: storey drift (mm) in X-direction

Table 2: storey drift in Z-direction

	Displacement(mm) in *z*-direction				
Storey	**Frame-1**	**Frame-2**	**Frame-3**	**Frame-4**	**Frame-5**
Fifth	60.911	13.444	10.135	12.917	11.691
Fourth	53.123	11.569	7.689	9.84	8.982
Third	40.622	8.477	5.107	6.729	5.942
Second	24.849	4.922	2.773	3.832	3.183
First	8.944	1.129	0.961	1.621	1.039

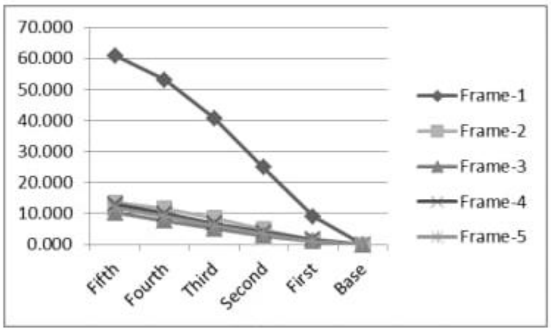

Fig 9: storey drift (mm) in Z-direction

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Vikas Mehta[2] studied the principal reasons of failure of building are lake of stiffness, faulty construction parctices,mass irregularity and floating column etc. In his work shear wall is provided at different locations symmetrically and the building frame considered is also symmetrical. He studied the 3 models. Model-1 having no shear wall. Model-2 having shear wall at the edges. Model-3 having shear wall at the centre of sides.

TABLE 1: VARIOUS INPUT PARAMETER

Number of storeys	G+5
Plan size	12m x 12m (Each grid of size 3m x 3m)
Size of columns	500mm x 500mm
Size of beams	500mm x 500mm
Shear wall thickness	200mm
Total height	18m
Floor to floor height	3.0m
Grade of concrete and steel	M25 and Fe415
Ductility design	IS: 13920-1993
Support condition	Fixed

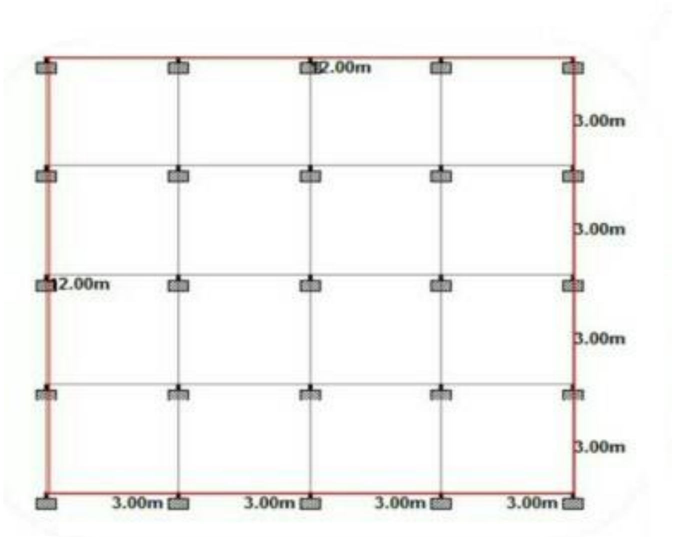

Fig 10: plan of building

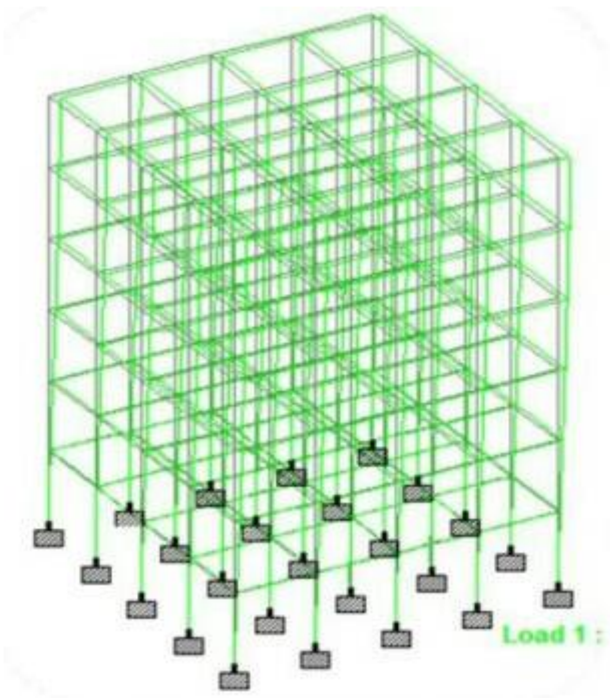

Fig 11: model-1 having no shear wall

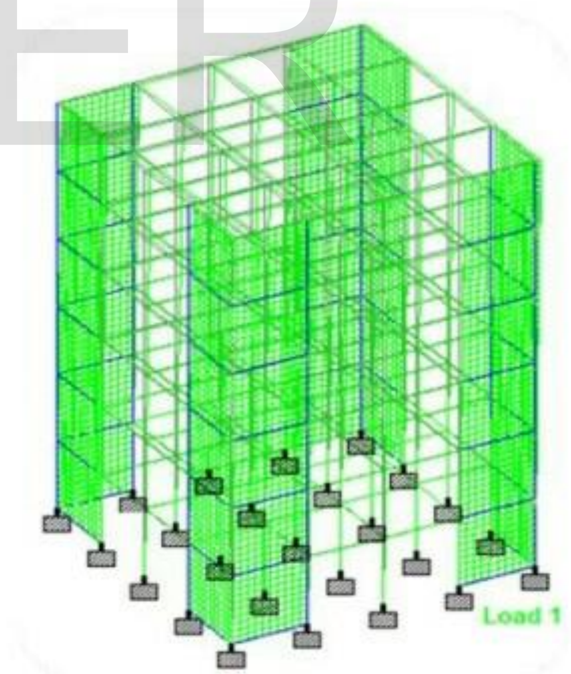

Fig 12: model-2 having shear wall at edges

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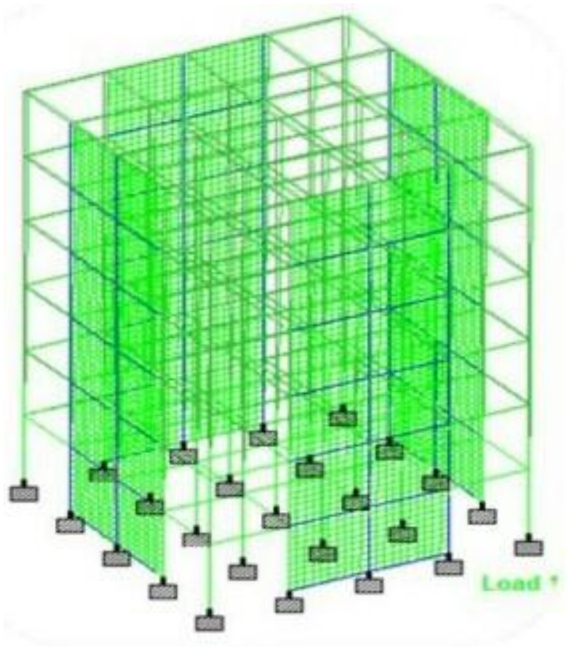

Fig 13: model-3 having shear wall at centre of side

Result and graphs

1. Storey drift along X- direction :

Table 2. variation of storey drift with storey number

STOREY DRIFT (mm)			
Storey Number	Model-1	Model-2	Model-3
6	21.725	22.856	16.065
5	36.375	24.952	18.028
4	49.275	25.733	18.718
3	58.925	24.719	18.195
2	63.450	21.280	16.146
1	46.482	15.772	12.969
Base	0.000	0.000	0.000

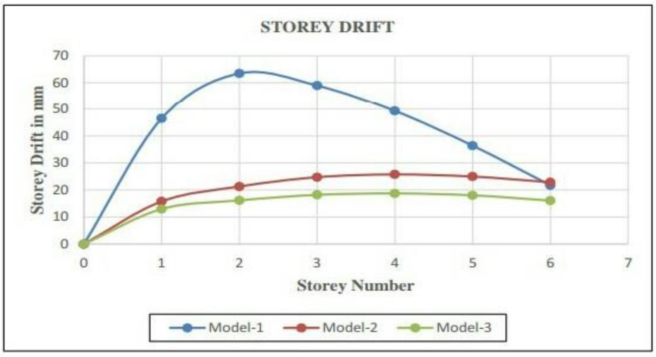

Fig.14

2. Storey drift along Z-direction

Table 2. variation of storey drift with storey number

STOREY DRIFT (mm)			
Storey Number	Model-1	Model-2	Model-3
6	21.722	19.117	12.232
5	36.375	25.212	18.795
4	49.278	28.361	21.770
3	58.924	28.909	22.913
2	63.447	27.613	22.951
1	46.484	19.244	17.194
Base	0.000	0.000	0.000

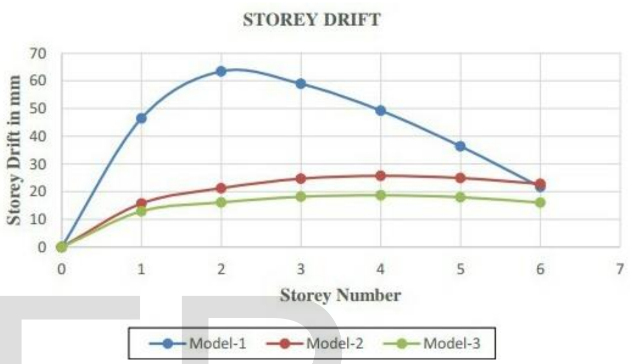

Fig 15.

3. Peak storey shear:

Table 4. variation of peak storey shear with storey number

PEAK STOREY SHEAR (KN)			
Storey Number	Model-1	Model-2	Model-3
6	8937.79	10681.15	10366.75
5	16994.80	21102.78	20768.82
4	23565.79	29174.97	29013.63
3	28707.94	35088.61	35158.78
2	32301.68	39003.57	39284.46
1	34044.48	40848.72	41275.75
Base	34044.48	40907.95	41351.70

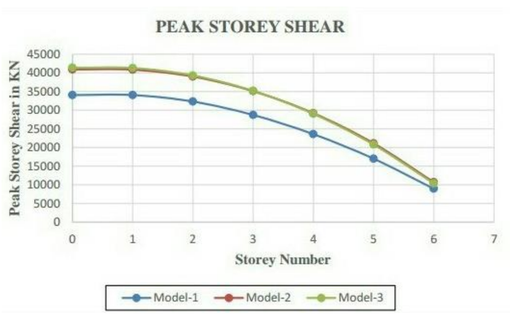

Fig 16.

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Dr. S. B. Shinde[3] He carried out the study of G+25 story building in zone III Aurangabad region is presented with some investigation which is analyzed by changing the thickness of shear wall at interval of five story in same building for determining the parameters like story drift, story shear and deflection is done by using ETAB software. He take thickness of shear wall are 100mm, 150mm, 200mm, 250mm and 300mm and height of shear wall are up to G+4,G+9,G+14,G+19 and G+25.

Table: Dimension of beam and column

Story	No of Bay X direction	No of Bay Y direction	X direction bay in M	Y direction bay in M	Column size	Beam size
G+24	6	03	4.50	3.00	800 x 800 mm	230 x 600 mm

Model No	Story Height	Shear wall thickness	Deflection in X Dir.	Deflection in Y Dir.	Stiffness (X-dir) KN/M	Stiffness (Y-dir) KN/M	Drifts (X-dir)	Drifts (Y-dir)	Story Shears X-dir.	Story Shears Y- dir.
III	G+14	100	12.1	30.2	211595.35	83764.76	0.000149	0.000382	94.76	95.98
		150	12.1	30.2	211595.35	83764.16	0.000149	0.000382	94.76	95.98
		200	11.8	29	214513.84	87296.17	0.000151	0.000374	96.89	98.04
		250	11.6	28.1	217448.89	90403.58	0.000152	0.000369	98.89	100.01
		300	11.4	27.4	220323.86	93183.00	0.000153	0.000365	100.81	101.92

Fig: 17. G+14 Analysis Result

Model No	Story Height	Shear wall thickness	Deflection in X Dir.	Deflection in Y Dir.	Stiffness (X-dir) KN/M	Stiffness (Y-dir) KN/M	Drifts (X-dir)	Drifts (Y-dir)	Story Shears X-dir.	Story Shears Y- dir.
V	G+25	100	12.8	32.2	207915.79	78237.06	0.00015	0.000405	93.60	95.14
		150	12.4	31	211920	83098.33	0.000153	0.000394	96.97	98.16
		200	12.3	30.1	215411.17	87415.87	0.000155	0.000385	100.12	101.06
		250	12.2	29.5	218511.50	91296.01	0.000157	0.000379	103.16	103.91
		300	12.2	29	221336.97	94811.98	0.00016	0.000375	106.16	106.75

Fig: 18. G+25 Analysis Result

Amita baghel [4] investigated on best position of R.C shear wall due to seismic load, In that work, a G+2 storey R.C building frame has been considered and analyzed for seismic zone-III (jabalpur) using staad.prove8i (series4) package, special moment resisting frame (SMRF) and hard rock type used in work. Parameter which compared and analyzed for the result was node displacement and reactions for different arrangement.

Loads acting on the structure are:

Dead load (DL) and live load (LL) : As per IS 875 (part 1)(1987) and IS 875(part 2)(1987) , respectively. Seismic load (SL): as per IS 1893(part 1)(2002) approch.

DL: Dead load: Self weight of the structure,Floor load and Wall loads

LL: live load 3 KN/sq.m is considered for floor load, 1 KN/sq.m considered for floor finish.

Zone: III (Z=0.16),Rock/soil type : hard, Rock and soil site factor : 1, Response reduction factor : 5,Importance factor : 1,Damping : 5 %

The preliminary data as is taken up for this study.

Table: Preliminary Data

G+3	Number of storeys
12m x 12m (Each grid size 3m x 3m)	Plan size
300mm x 300mm	Size of ground floor- 3rd floor columns
300mm x 300mm	Size of beams
230mm	Wall thickness
120mm	Depth of slab
150mm	Shear wall thickness
3.0m	Ground storey height from foundation
12m	Total height
3m	Floor to floor height
Fixed	Support type

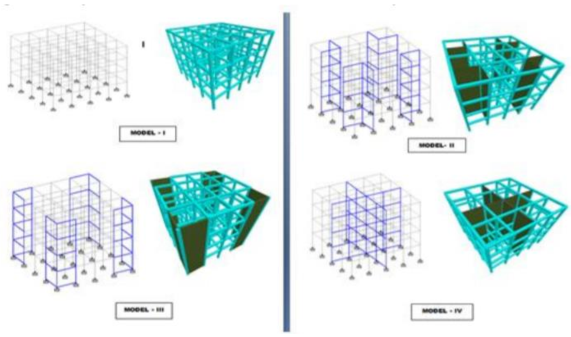

Fig: 19 Different model Consideration

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Results and graphs

DIRECTIONS		Models
Z(23)	X (71)	
2.222	2.222	Model I
0.406	0.406	Model II
0.882	0.882	Model III
0.119	0.119	Model IV

Table : maximum node displacement

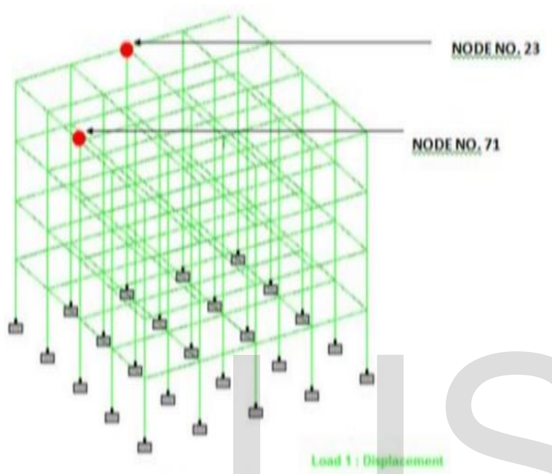
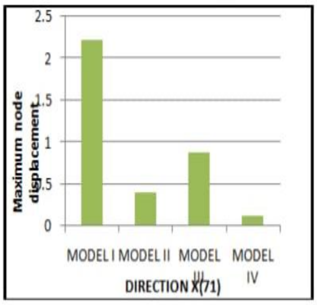


Fig 20: fig shows node no 71 & 23



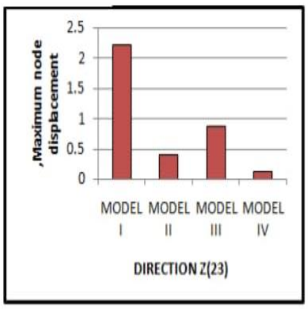


FIG 21 FIG 22

Fig 21 max node displacement in X-direction
Fig 22 max node displacement in Z-direction

Table : maximum reaction

Directions		Models
Z(3)	X(51)	
2.668	2.668	Model I
1.560	1.560	Model II
2.629	2.629	Model III
68.234	68.234	Model IV

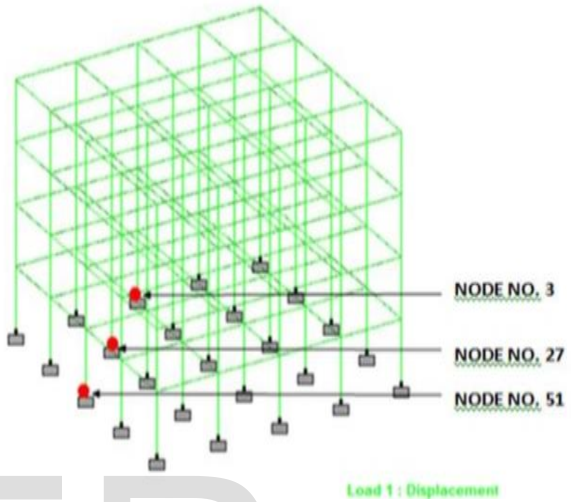


Fig 21 fig shows node no 3, 27, &51

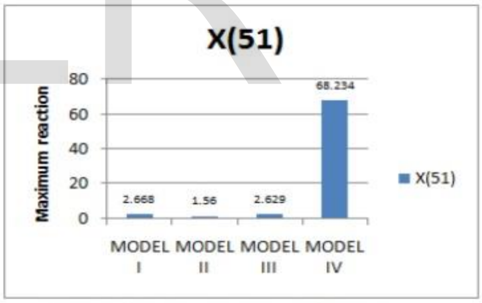


Fig 22 max reaction in x- direction

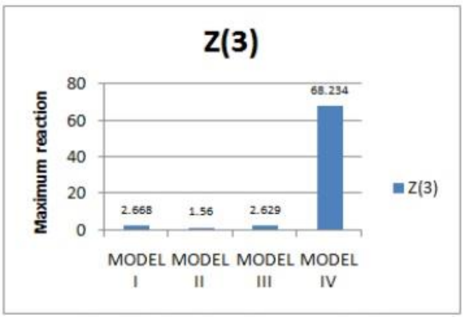


Fig 23 max reaction in z- direction

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Kasliwal N. A.[5] Studied on effect of numbers and positions of shear wall on seismic behavior of multistoried structure. He investigated about dynamic linear response spectra method on multi Storey shear wall building with variation in number and position of shear wall. Parameter which analyzed was deformations, natural frequencies, time period and floor response displacement.

Following data is used in the analysis of the RC frame building models

Type of frame: special RC moment resisting frame fixed at the base

Seismic zone: v

Number of Storey : G+9

Floor height: 3 m

Size of beam: (230*450) mm

Size of column :(600*600) mm

Spacing between frames:

5 m along X direction

4 m along Y direction

Floor finish: 2 KN/sq.m

Terrance water proofing: 2 KN/ sq.m

Materials: M25 concrete, Fe 415 steel

Density of concrete: 25 KN/ cubic meter

Density of brick infill: 20 KN/cubic meter

Poison ratio of concrete: 0.2

Compressive strength of concrete 5000

√25 = 250000 Mpa

Live load on floor: 3 KN / cubic meter

Type of soil: Hard, medium, soft

Response spectra: As per IS 1893(part 1):2002

Damping of structure: 5 percent

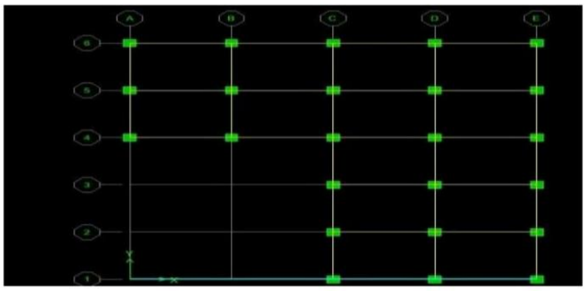


Fig 24: plan for base frame model(M1)

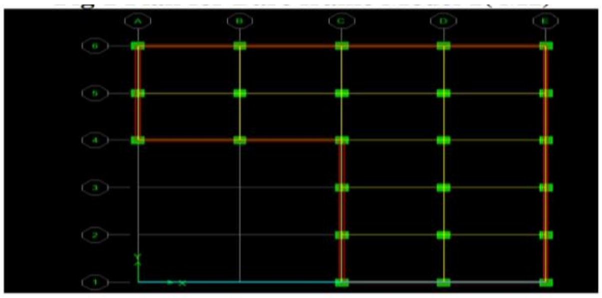
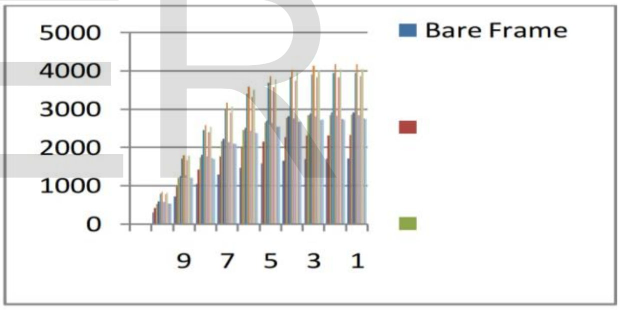
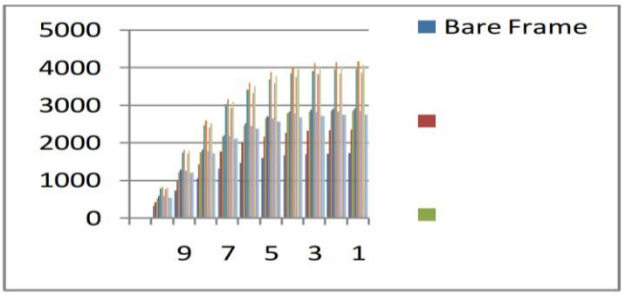


Fig 25: plan for complete shear wall model 2(M2)



Graph 1 comparative study of base shear of static x direction



Graph 2 comparative study of base shear of static y direction

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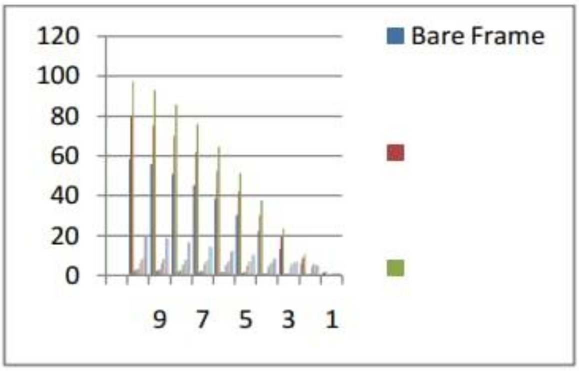
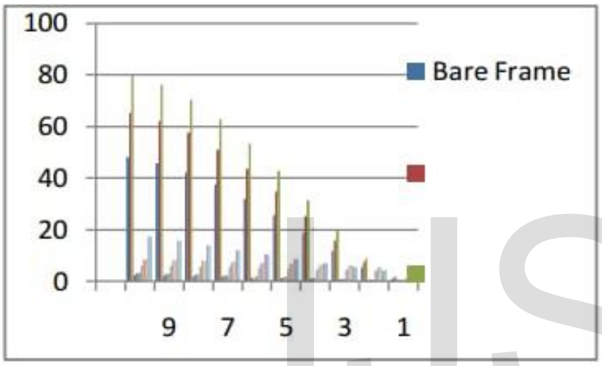
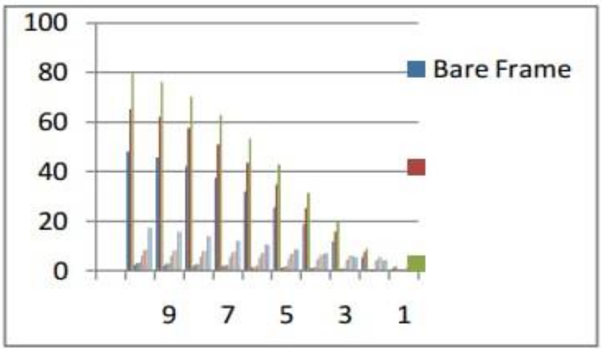


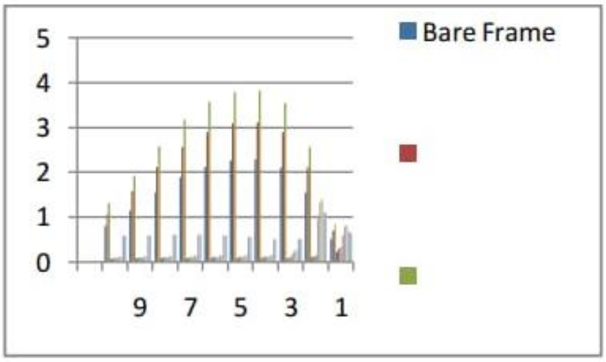
Graph 3 comparative study of displacement shear of static x direction



Graph 4 comparative study of displacement of static y direction



Graph 5 comparative study of storey drift of static x direction



Graph 6 comparative study of storey drift of static y direction

3.CONCLUSION

1. By constructing shear walls, it may minimize the damage of structure due to effect of lateral forces due to earthquake.
2. By providing shear wall at suitable location can reduce displacement due to earthquake.
3. From study, provided shear wall at corner and centrally show better performance.
4. Shear wall at mid span of wall is seen to perform better in major number of cases.
5. From seismic analysis the value of bending moment and shear force decrease by providing shear wall.
6. Shear wall provided perpendicular to each other in plan gives efficient effect.
7. From above research papers we conclude that, the torsion effect is reduced by shear wall.
8. Shear walls in buildings must be symmetrically located in plan to reduce ill effects of twist in building.
9. Shear walls are more effective when located along exterior perimeter of the building.
10. Shear wall are efficient, both in terms of construction cost and effectives in minimizing earthquake damage in structural and non-structural elements. (like glass windows and building contents).

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