International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 07 | July-2018 www.irjet.net p-ISSN: 2395-0072

NONLINEAR DYNAMIC ANALYSIS OF INFLUENCE OF PLACEMENT AND OPENING OF SHEAR WALL IN MULTI STOREY RC BUILDING

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Abstract –*Shear wall is the widely accepted structural member for the lateral load resisting system in high seismic zone areas. Strength and stiffness are the main structural requirements for the shear wall and it will be extensively affected by its positioning. Also when the openings are provided on these members for the cause of architectural and functional use, its behavior may vary from its initial condition that will cause the bad influence on the performance of shear wall. In the present study, a nonlinear dynamic analysis is carried out on the multi storey plan irregular RC structures consisting of shear walls with openings of different pattern configurations and at the end of the study, to predict the better configuration of opening for the shear walls. For the purpose of the study, two plan irregular models of G+24 storeys were considered. Analysis will be done through nonlinear time history analysis by adopting bhuj earthquake acceleration data using software tool ETABS v 16.0. Comparative study is carried out between the bare frame model, model with shear wall and model with shear wall consisting of different opening configurations. Opening configuration will be regular opening and staggered opening. Parameters considered for the extractions of results are maximum storey displacement, maximum storey drift, base shear and Time period*

Key Words: *Shear Wall, Nonlinear Dynamic Analysis, RC Structures, Bare Frame Model, Openings, ETABS v 16.0, Maximum Storey Displacement.*

1. INTRODUCTION

Lateral load resistant system is the major topic in the construction of high rise building, where wind and seismic loads acts horizontally to the structure. Buildings were usually constructed to resist vertical loads that are implemented on it, but when the multi storey structures are constructed in high seismic zone regions, structural engineers face the big challenge to design the buildings that are having better lateral stiffness. Many lateral load resisting systems are available whereas shear wall is the most general one because of its high stiffness and simple design. Also in addition to resist the lateral load, it will helps to with stand the gravity loads that are implemented on it. Effective Location of shear wall in the structure is another important task so that it will be most efficient and profitable one. From the study, it reveals that core type shear wall has better efficiency but it should be torsional resistant. Shear walls are constructed from the level of foundation to the top most storeys. In regular plan building, Symmetrical placement of shear wall can be preferred. For the sake of architectural purpose, plan of the building may be irregular one. For that plan, location of shear wall should be effective.

Solid shear walls will acts as a deep beam, but when the openings are introduced to those shear wall members for some functional reasons, it will no more behaves as a deep beam and its resulting behavior on the effect of lateral load will be varies from the solid shear wall. Openings of shear wall may adversely affect the performance of shear wall by increasing the displacement and reducing the stiffness. Therefore effective configuration of opening should be made while designing the shear wall. In the present study, effect of placement of shear wall in two irregular plan buildings are going to be observed and comparative study between the impact of two patterns of openings such as regular openings and staggered openings in the shear walls are considered. Building models for the current studies are assumed to be located at zone III. At the end of the analysis, results corresponding to storey displacement, storey drift, base shear and time periods are extracted and the comparative study of bare frame model, model with shear wall and model with shear wall having two patterns of openings are carried out.

2. OBJECTIVES

- Modeling and analysis of two plan irregular bare frame RC structures with the help of ETABS software to understand its performance exposed to seismic loads
- To understand the influence of placement of shear wall in same plan irregular reinforced concrete structures and considering those locations for the further study.
- To analyse the openings effect on shear walls consists of two patterns that is regular and staggered opening in plan irregular multi storey RC structure.
- To understand the mutual effect of position and opening in shear walls on behaviour of RC structures.
- To predict the better opening configuration pattern for the efficient performance of shear wall.

3. METHODOLOGY

Two irregular plans of G+24 storey buildings located in seismic zone 3 are considered. Shape of the building and location of shear walls are shown in Fig -1 to Fig -8. Opening percentage of 16.67% will be considered for the shear wall. Bhuj earthquake acceleration data will be considered for the time history analysis.

Table -1: Building Details

Number of storeys	G+24
Height of each storey	3m
Number of grids	10
Spacing of each grid	5m
Size of beam	300 x 450 mm
Size of column	450 x 600 mm
Thickness of slab	200mm
Thickness of shear wall	200mm
Percentage of opening	16.67%
Grade of concrete	30 N/mm^2
Grade of steel	500 N/mm^2
Main wall load	12 KN/m
Parapet wall load	6 KN/m
Partition wall load	1 KN/m^2
Floor finish	1 KN/m^2
Live Load	3 KN/m^2
Seismic zone	III
Zone factor, Z	0.16
Importance factor, I	1.5
Response reduction factor, R	5
Type of soil	Medium
Time period, T	1.8922 sec

Table -2: Description of models

Plans	Models	Description
Plan 1	M1	Bare frame model
	M2	Model with solid shear wall
	M3	Model with shear wall having regular openings
	M4	Model with shear wall having staggered openings
Plan 2	M5	Bare frame model
	M6	Model with solid shear wall
	M7	Model with shear wall having regular openings
	M8	Model with shear wall having staggered openings

4. MODELLING AND ANALYSIS

4.1 Plan 1

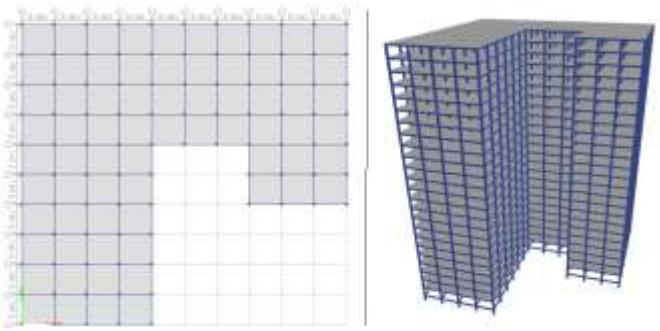

Fig -1: Plan and 3D view of Model 1

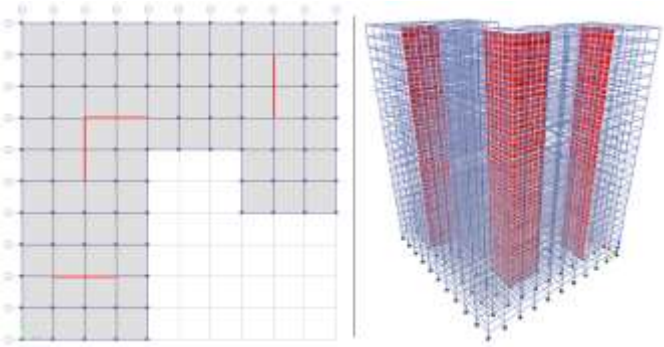

Fig -2: Plan and 3D view of Model 2

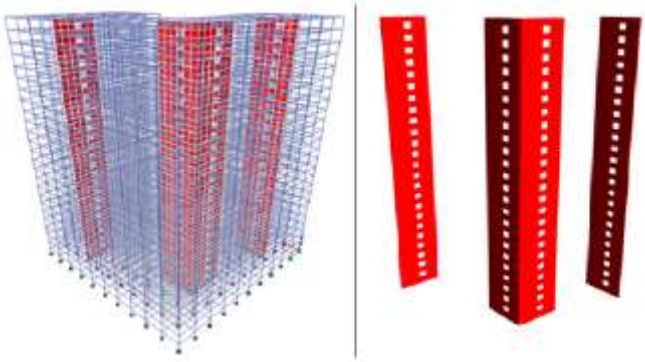

Fig -3: 3D view of Model 3

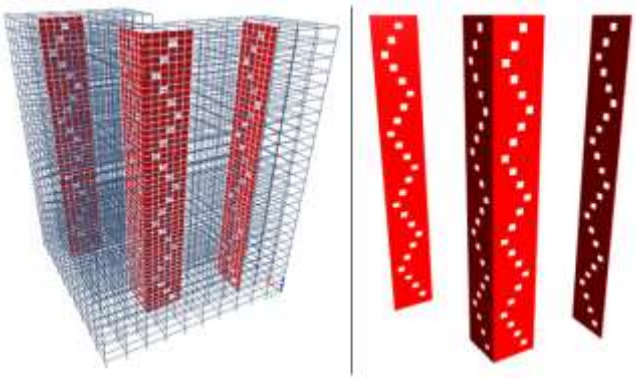

Fig -4: 3D view of Model 4.

4.2 Plan 2

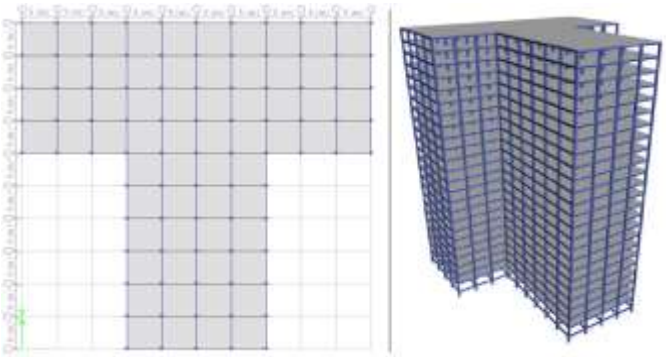

Fig -5: Plan and 3D view of Model 5

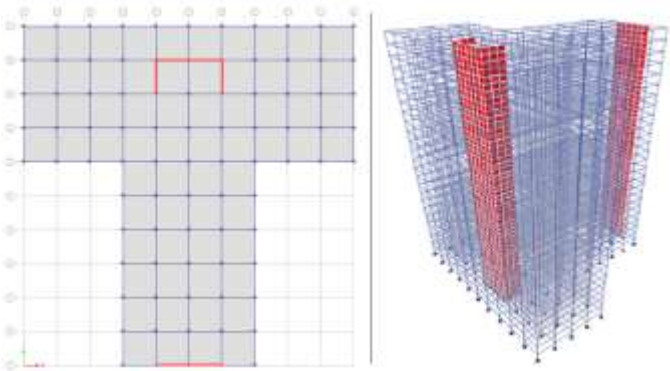

Fig -6: Plan and 3D view of Model 6

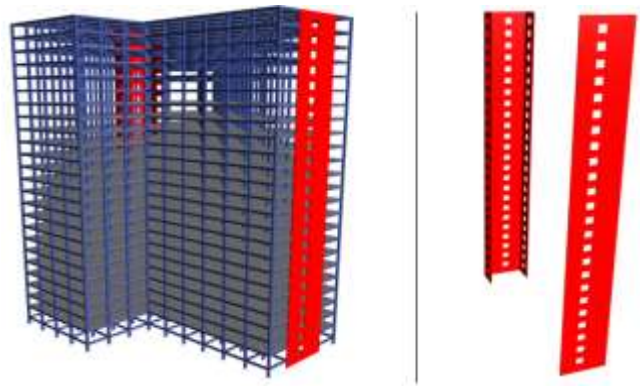

Fig -7: 3D view of Model 7

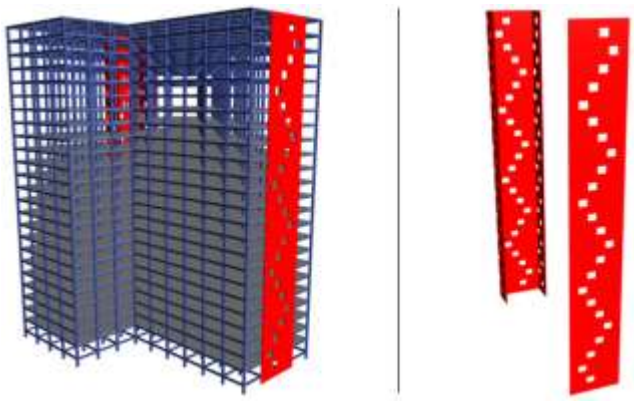

Fig -8: 3D view of Model 8

5. RESULTS AND DISCUSSION

Results such as storey displacement, storey drift, base shear and Time periods are extracted from the software analysis and the comparison between each model in both x and y directions are represented in below tables and figures.

5.1 Maximum storey displacement

The results of maximum storey displacement for both the two plans in x and y directions are showed in below table 3 and Fig-9 and Fig-10.

Table -3: Maximum storey displacement

Plans	Models	U_x in mm	U_y in mm
Plan 1	M1	134.74	142.01
	M2	87.64	98.60
	M3	92.70	105.23
	M4	89.93	102.72
Plan 2	M5	133.35	142.45
	M6	80.40	111.30
	M7	88.73	118.60
	M8	85.50	114.76

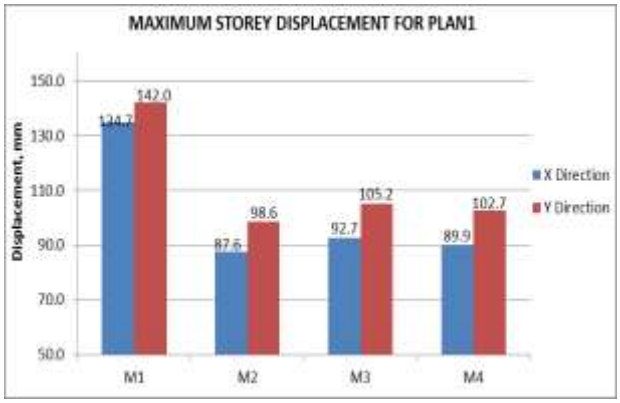

Fig -9: Maximum storey displacement for plan 1

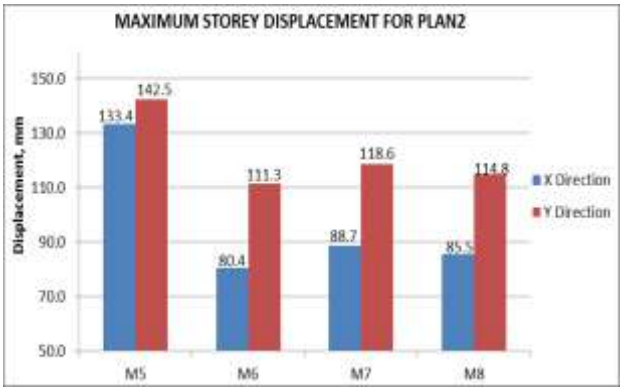

Fig -10: Maximum storey displacement for plan 2

From the results of storey displacement, it can be observed that after the introduction of shear wall to the bare frame

model, drastic reduction in displacement was occurred and when the openings are provided, small rise in displacement can be observed. From the observation, it can be noted that shear wall with staggered openings has lesser displacement than the regular opening.

5.2 Maximum storey drifts

The results of maximum storey drift for both the two plans in x and y directions are showed in below table 4 and Fig-11 and Fig-12.

Table -4: Maximum storey drifts

Plans	Models	Drift X	Drift Y
Plan 1	M1	0.001950	0.002370
	M2	0.001532	0.001676
	M3	0.001589	0.001732
	M4	0.001537	0.001726
Plan 2	M5	0.003832	0.004286
	M6	0.001583	0.002223
	M7	0.001590	0.002569
	M8	0.001586	0.002446

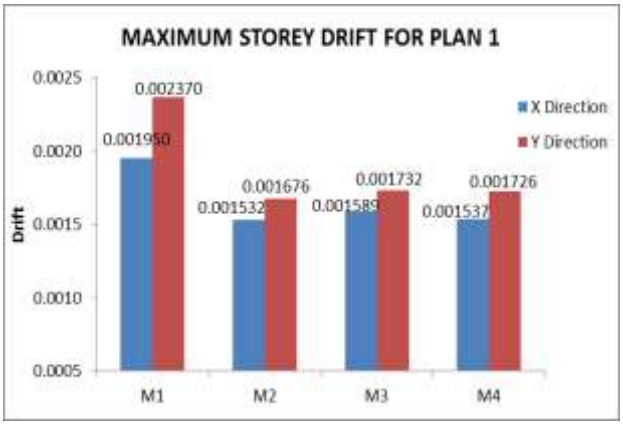

Fig -11: Maximum storey drifts for plan 1

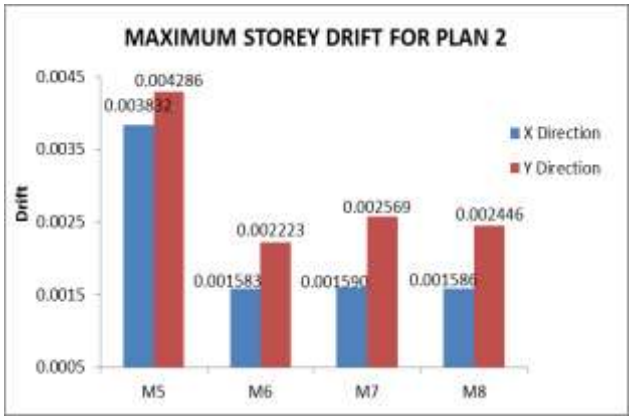

Fig -12: Maximum storey drifts for plan 2

The obtained result of maximum storey drifts in both the plans clearly shows that the drift ratio for the model with solid shear wall has very much lesser value than the bare frame model. When openings are provided, slight rise in drift value can be observed and also when the comparison is made between two patterns opening, staggered opening has lesser drift value than the regular one.

5.3 Base shear

The results of Base shear for both the two plans in x and y directions are showed in below Fig-13 and Fig-14.

Fig -13: Base shear for plan 1

Fig -14: Base shear for plan 2

Base shear for the model with shear wall has higher value than the bare frame model; this is due to the increasing in seismic weight of the building. When the openings are provided, small reduction in base shear can be observed, but the value of base shear for both the opening patterns remains same due to the equal seismic weight

5.4 Time period

The results of Time period for both the two plans in x and y directions are showed in below table 5 and Fig-15 and Fig-16.

Table -5: Time period

Plans	Models	Time period, s
Plan 1	M1	4.6315
	M2	3.5320
	M3	3.5641
	M4	3.5526
Plan 2	M5	4.6455
	M6	4.0245
	M7	4.0678
	M8	4.0675

Fig -15: Time Period for Plan 1

Fig -16: Time Period for Plan 2

Very high value of time period can be observed for the bare frame model compared to the model with shear wall, on the introduction of openings, its value get increased to smaller extent, but the value of time period for both the opening patterns will almost remain same

6. CONCLUSIONS

- Value of maximum storey displacement and drift ratios are higher in bare frame building model in both the two plans considered.
- After the placement of shear wall, maximum displacement will be reduced to 35% for plan 1 and it will be reduced to 40% for plan 2.
- Regular openings will cause the raise in displacement of 5% to 6% for plan1 and 6% to 10% for plan2, whereas staggered openings will cause only 2% to 4% of increase in displacement for plan 1 and 3% to 6% for plan 2 from the solid shear wall.
- Maximum storey drifts in bare frame model will be 0.001950 and 0.002370 in x and y direction respectively for plan 1, which will get reduced to 0.001532 in x direction and 0.001676 in y direction after the placing of shear wall, when the value of drifts are compared between two opening patterns, staggered openings has 3% to 5% lesser drift ratio than regular opening.
- Similarly in plan 2, bare frame model has the drift value of 0.003832, and that will reduced to 0.001583 for solid shear wall model. And staggered openings has 8% to 10% lesser drift ratio than the regular opening.
- The obtained base shear value for plan 1 will be 13440 KN and 12245 KN for plan 2, then it will be raise up to 13580 KN for plan 1 and 12303 KN for plan2. But the base shear for two types of openings in both the plans are remains same.
- Huge variation in time period between the bare frame model and model with shear wall can be observed but the difference in time period between two types of openings are almost negligible
- Results obtained from all the parameter conclude that the location of shear wall will effects on the behavior of building efficiently and enhancement of performance can be observed.
- Staggered opening has less adverse effect on performance of shear wall than the regular one and hence staggered pattern of opening can be preferred for the shear wall.

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