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COMPARATIVE STUDY ON G+10 STOREY RCC BULDING WITH AND WITHOUT SHEAR WALL USING 25%, 50% & 75% OPENINGS IN SHEAR WALL UNDER SEISMIC LOADING

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Abstract - ***Shear walls are vertical structural elements designed to withstand lateral loads such as those induced by wind and earthquakes. Shear walls are a type of construction in which they provide all of the horizontal load resistance. Shear walls provide the required lateral strength and stiffness to resist horizontal forces, making them a structurally effective option for stiffening a structure. Shear walls are often built at the foundation level and run the length of the building. The current thesis project's goal is to investigate seismic reactions (storey displacements, storey drift, the fundamental time period and base shear) of a typical G+10 residential complex with and without shear wall and with various percentages of openings (25%, 50% and 75%) in shear wall located in different seismic zones (for Zone II, III, and IV) by Equivalent lateral force analysis and Response Spectrum Method using ETABS.***

Key Words: **Shear wall, storey displacements, storey drift, base shear, ETABS,** etc

1.INTRODUCTION

Shear walls are vertical structural elements designed to withstand lateral loads such as those induced by wind and earthquakes. Shear walls are a type of construction in which they provide all of the horizontal load resistance6. Shear walls provide the required lateral strength and stiffness to resist horizontal forces, making them a structurally effective option for stiffening a structure. Shear walls are often built at the foundation level and run the length of the building. They are frequently supplied along the length and breadth of a structure, and are located on the sides or organized in the shape of a core. Shear walls may have one or more apertures for practical purposes [1].

In terms of size and placement, shear walls are critical. Structures must be symmetrically constructed in plan to reduce the effect of twisting. Buildings with adequately planned and specified shear walls have performed well in prior earthquakes [2]. Strong earthquakes in the past have indicated that shear wall damages and certain failure processes are reliant on a number of factors, including the plan shape, wall and opening dimensions, reinforcement and openings arrangement, site condition, earthquake type, and strain rates. Even if certain failure mechanisms have been thoroughly researched, there are always more to be discovered [3]. In terms of size and placement, shear walls are critical. They must reduce the effect of twisting in buildings.

Shear walls are most commonly found on the sides of buildings or in the form of a core that houses stairwells and elevators. Building shear walls provide the essential lateral strength and stiffness to resist horizontal stresses, making them a structurally viable option for strengthening the structure [4]. They can be seen on both the outside and inside of structures, and they usually run the length and width of the structure. Shear walls are vertical structural components that are used to protect tall structures from lateral loads induced by wind and earthquakes. To protect against earthquakes, the structure has reinforced concrete shear walls. These can be used to improve the seismic response of a structure. The employment of a shear wall in a construction to produce a bending moment.

For practical reasons, shear walls may have one or more apertures, such as doors, windows, and other types of openings. The size and placement of the apertures may differ depending on their function. Shear barriers are critical in terms of size and location. Buildings with adequately planned and specified shear walls have performed well in prior earthquakes [5].

Shear barriers require extra consideration in seismically active areas. Previous earthquakes protected even structures with a sufficient number of walls that were not specially constructed for seismic performance (but had adequate widely dispersed reinforcement). Shear walls are effective in reducing earthquake damage to structural and non-structural elements, both in terms of cost and effectiveness (like glass windows and building contents) [6].

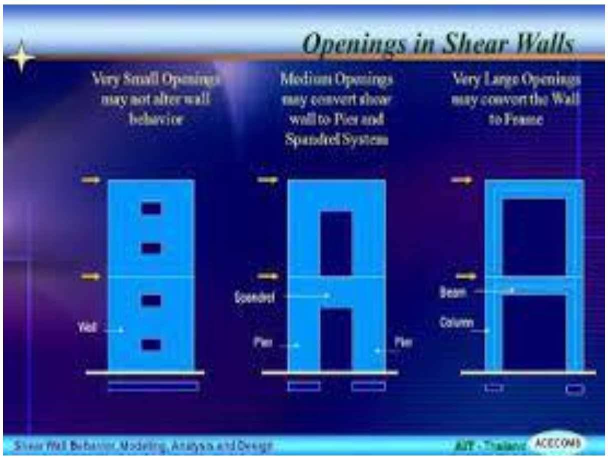

Fig-1 Different type of openings in shear wall

Fig-2 opening in shear wall

1.1 OBJECTIVES OF THE PROJECT

- To Analyze the structure using E TABS.
- The main objective of this study is to compare the regular RCC building with and without shear wall and with 25%, 50%, and 75% opening in shear wall under seismic loading.
- To study the base shear, storey displacement, storey drift, and time period under "Equivalent lateral force" & "Response spectrum analysis".
- To study the base shear, storey displacement, storey drift, and time period of the building with and without shear wall and with 25%, 50% and 75% openings in shear wall for Zone II, III, and IV in ETABS.
- Comparison of effect of openings in regular model, model without opening in shear wall, model with 25% opening, 50% opening & 75% opening in shear wall model.

2. MODELING DETAILS

For analysis and study purpose 15 Models are created with corresponding dimension and analyzed for Zone II, III, and IV in ETABS.

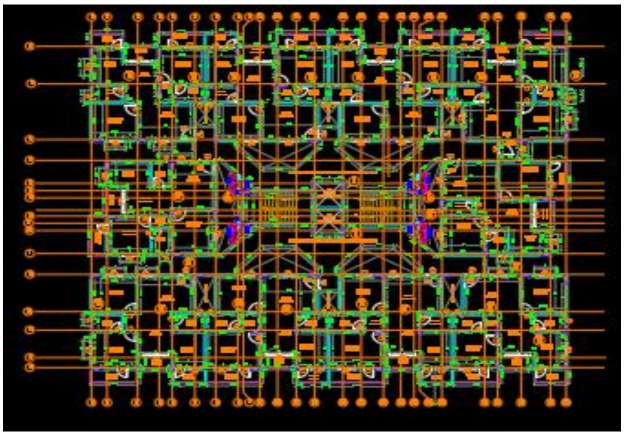

Fig- 3 Architecture plan of Regular MODEL

SL.NO	Properties	Dimension
1	Building Plan	33.7m x 26.47m
2	Column C1	300mm x 900mm
3	Column C2	300mm x 750mm
4	Beam B1	300mm x 750mm
5	Beam B2	300mm x 600mm
6	Shear wall thickness	200mm
7	Storey Height	3.2m
8	Width of shear wall	3.2m
9	Soil type	II Type
10	25% openings	1.2mx2m
11	50% openings	1.8mx2.8m
12	75% openings	2.5mx2.9m

Table 1 : Details about RCC Building

2.1 MATERIALS

Grade of concrete- M25

Grade of steel -Fe500

Density of concrete-25KN/m^3

Density of brick – 11KN/m^3

Modulus of elasticity of concrete – 28.5KN/mm^2

Modulus of elasticity of Steel – 210,00N/mm^2

Design loads : The loads which have been used for the modelling are as follows:

- Self-weight of the structure
- Floor finish
- Wall load
- Typical live load
- Roof live load
- Seismic load

1. Dead load as per IS: 875 (Part I)-1987
2. From masonry walls – 4.3 kN/m ^{3}
3. Live load as per IS: 875 (Part-II)-1987
   i) Live load on floor – 3.00 kN/m^2
   ii) Live load on roof - 1.50 kN/m^2
3. Earthquake load. IS: 1893-2016
   i) Zone factor - 0.1
   ii) Zone factor - 0.16
   iii) Zone factor - 0.24

Soil type - II

Importance factor - 1

Time period in X direction – 0.6 second

Time period in Y direction – 0.67 second

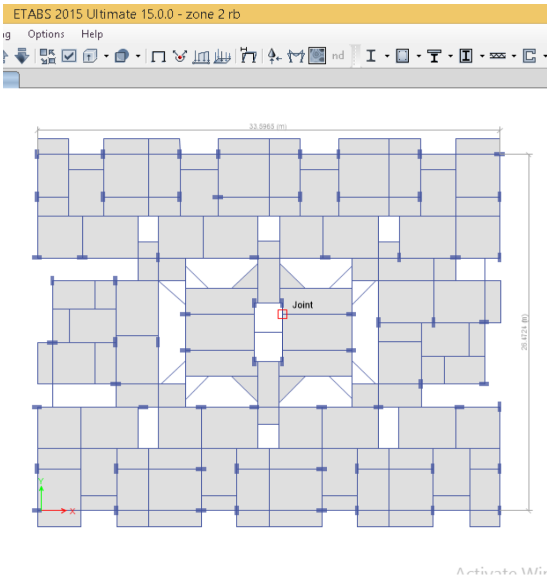

Fig-4 Etabs plan of Regular MODEL

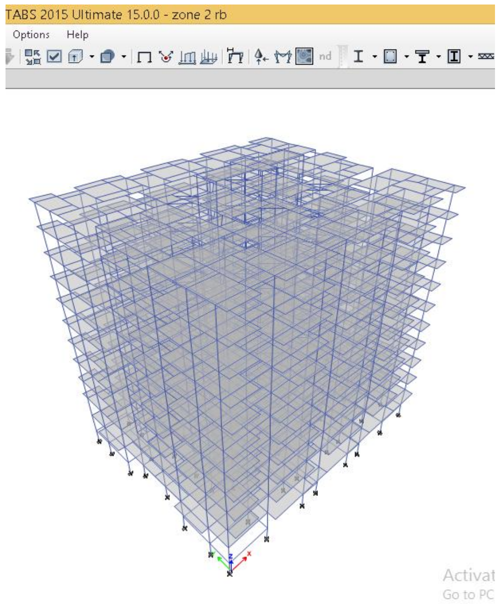

Fig-5 Etabs Regular 3D MODEL

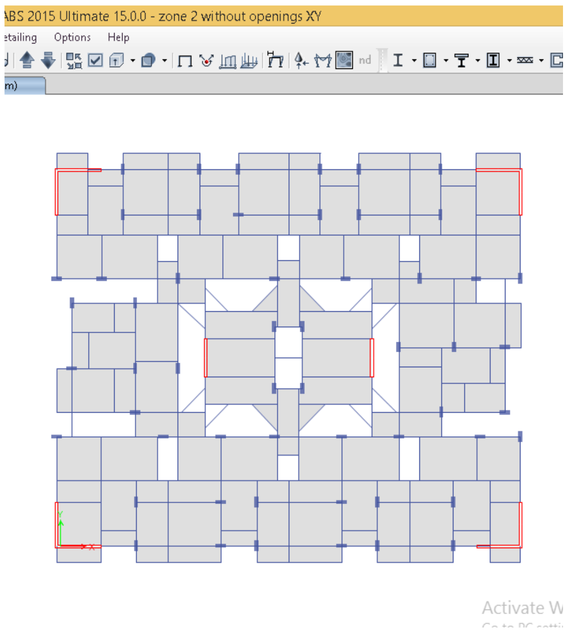

Fig-6 Etabs plan of regular model with shear wall

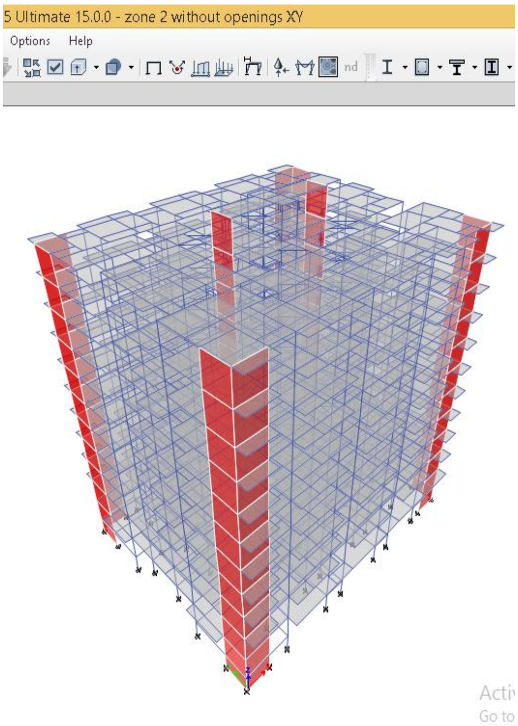

Fig-7 Etabs 3D model of regular model with shear wall

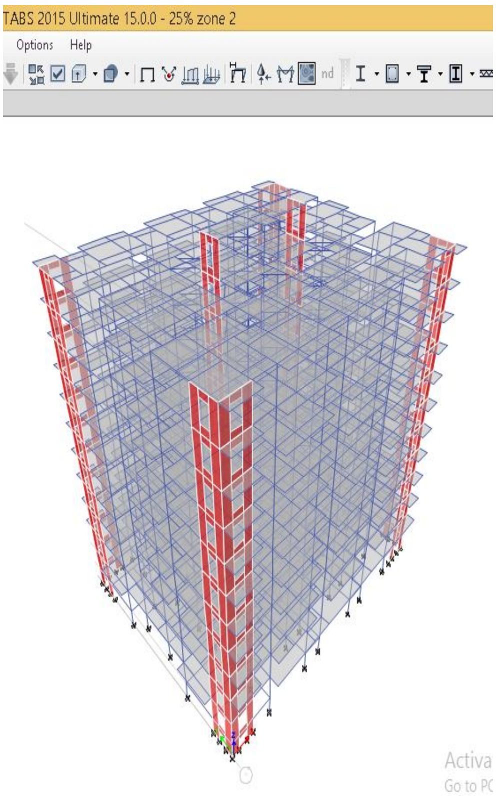

Fig-8 Etabs 3D model with 25% opening in shear wall

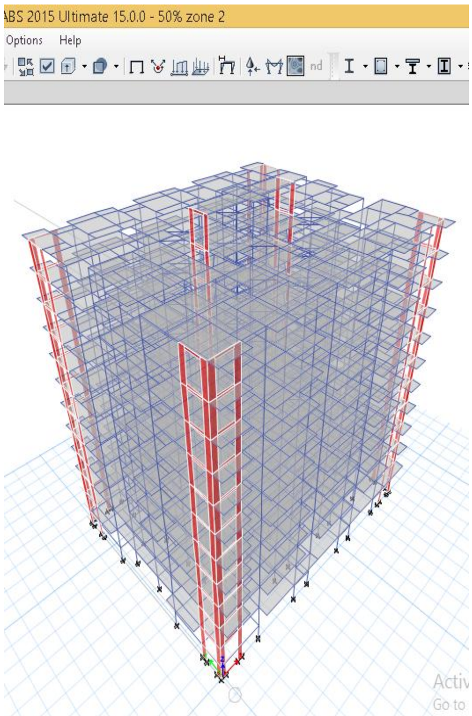

Fig-9 Etabs 3D model with 50% opening in shear wall

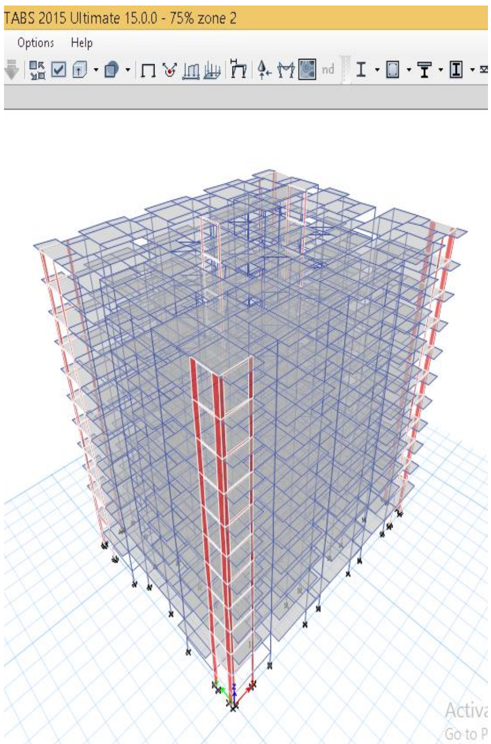

Fig-10 Etabs 3D model with 75% opening in shear wall

3. RESULTS AND DISCUSSION

This chapter gives the seismic analysis results for all of the models that were evaluated in the model study presented in Chapter 3. With the help of relevant tables and figures, the results and comments are thoroughly examined.

3.1 Results

3.1.1 Displacement

By comparing the X and Y directions, the maximum values of displacements are recorded. The displacement values of various models are acquired by exposing them to Equivalent lateral force analysis and response spectrum analysis, which reveals the maximum displacement. The tabulated results are also shown in a graph, as seen in Fig.11 .

Table 1: Max Displacement for different Earthquake Zones in X direction Equivalent lateral force (EQX in mm)

ZONES	REGULAR MODEL	WITHOUT OPENING IN SHAER WALL	25% OPENING IN SHEAR WALL	50% OPENING IN SHEAR WALL	75% OPENING IN SHEAR WALL
ZONE II	32.8	18.5	19.9	26.1	28.1
ZONE III	52.5	29.3	31.8	41.7	45.4
ZONE IV	78.7	44.4	47.7	62.5	67.4

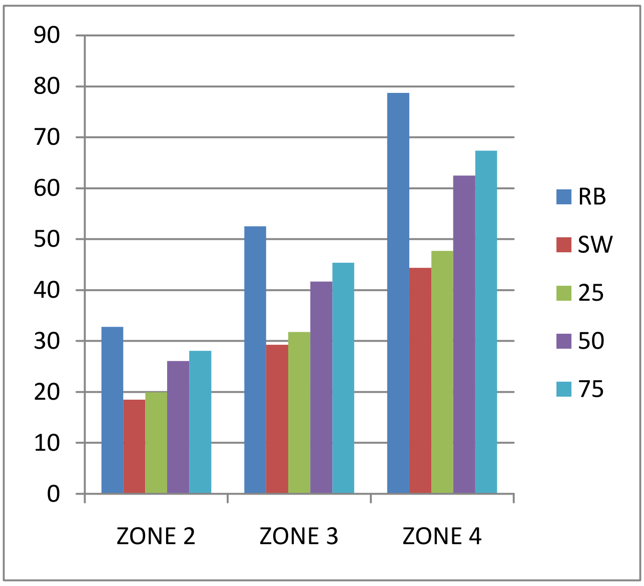

Fig- 11 Displacement variation graph

The biggest reduction in lateral displacement is shown in the model without opening in the shear wall model along X direction, according to the displacement data.

Table 2: Max Displacement for different Earthquake Zones in Y direction Equivalent lateral force (EQY in mm)

ZONES	REGULAR MODEL	WITHOUT OPENING IN SHAER WALL	25% OPENING IN SHEAR WALL	50% OPENING IN SHEAR WALL	75% OPENING IN SHEAR WALL
ZONE II	28.90	18.5	19.2	23.6	25.1
ZONE III	46.2	29.8	30.7	37.8	40.6
ZONE IV	69.3	44.3	46	56.7	60.2

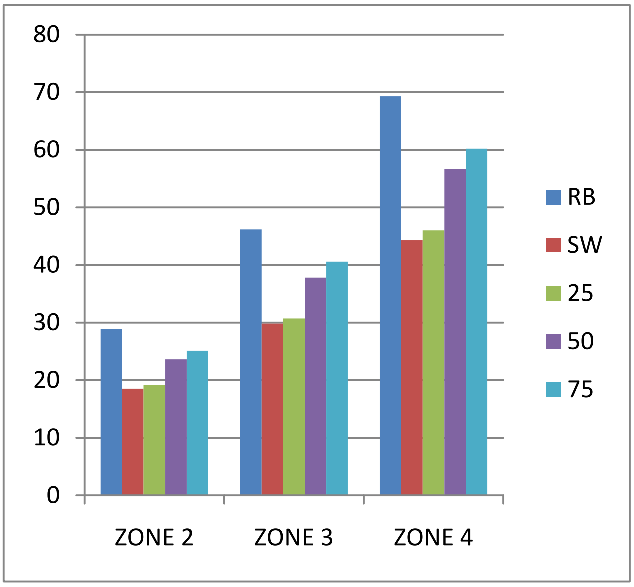

Fig -12 Displacement variation graph

The biggest reduction in lateral displacement is shown in the model without opening in the shear wall model along Y direction, according to the displacement data.

Table 3: Max Displacement for different Earthquake Zones (Response spectrum in X direction) (SPECX in mm)

ZONES	REGULAR MODEL	WITHOUT OPENING IN SHAER WALL	25% OPENING IN SHEAR WALL	50% OPENING IN SHEAR WALL	75% OPENING IN SHEAR WALL
ZONE II	30.1	15.7	16.5	21	23
ZONE III	48.1	24.9	26.5	33.7	37.1
ZONE IV	72.3	37.6	39.7	50.5	55.3

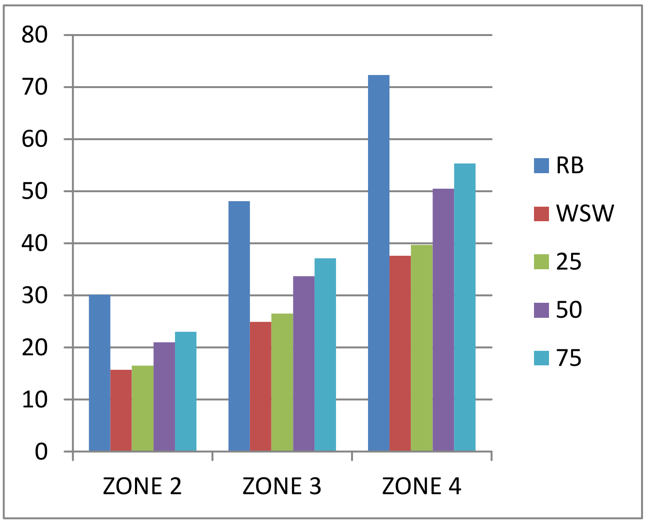

Fig -13 Displacement variation graph

The biggest reduction in lateral displacement is shown in the model without opening in the shear wall model along X direction, according to the displacement data.

Table 4: Max Displacement for different Earthquake Zones (Response spectrum in Y direction) (SPECY in mm)

ZONES	REGULAR MODEL	WITHOUT OPENING IN SHAER WALL	25% OPENING IN SHAER WALL	50% OPENING IN SHEAR WALL	75% OPENING IN SHEAR WALL
ZONE II	22.8	15.1	15.6	18.9	**20**
ZONE III	36.5	24.7	24.9	30.3	32.4
ZONE IV	54.8	36.2	37.3	45.4	48.1

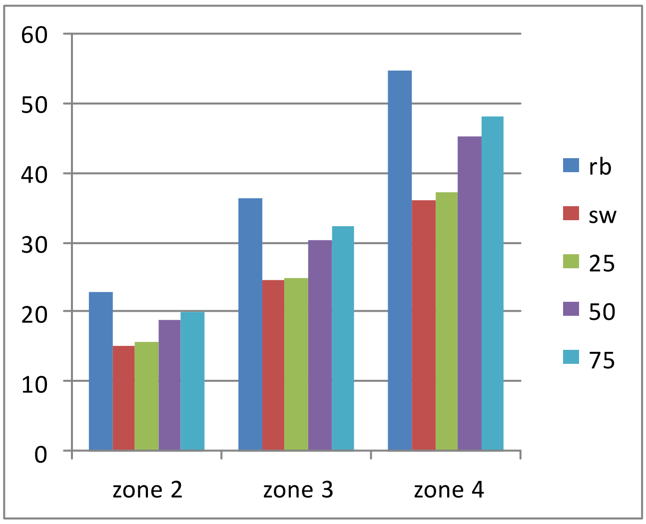

Fig-14 Displacement variation graph

The biggest reduction in lateral displacement is shown in the model without opening in the shear wall model along Y direction, according to the displacement data.

3.1.2 Storey drift

Table 5: Max Storey Drift values for different Zones in X direction Equivalent lateral force (EQX in mm)

ZONES	REGULAR MODEL	WITHOUT OPENING IN SHAER WALL	25% OPENING IN SHAER WALL	50% OPENING IN SHEAR WALL	75% OPENING IN SHEAR WALL
ZONE II	0.00125	0.00064	0.00067	0.00088	0.00096
ZONE III	0.00199	0.00101	0.00107	0.00140	0.00154
ZONE IV	0.00299	0.00153	0.00160	0.00210	0.00231

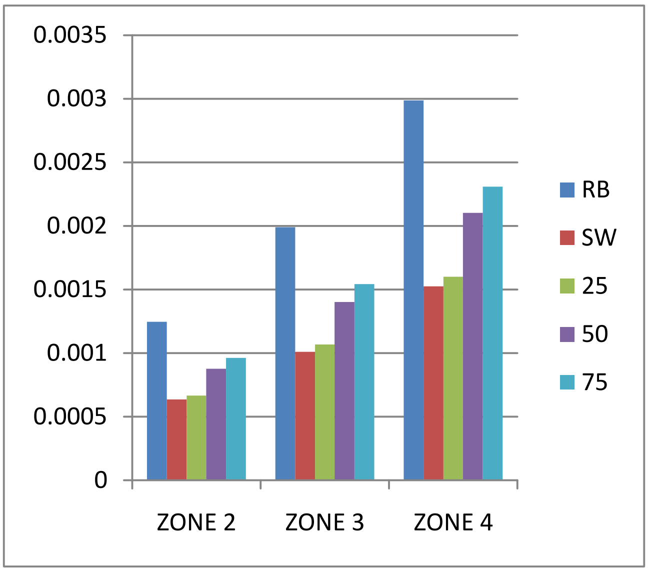

Fig- 15 Storey drift variation graph

According to the storey drift data, the model without opening in the shear wall along the X direction has the greatest reduction in storey drift.

Table 6: Max Storey Drift values for different Zones in Y direction Equivalent lateral force (EQY in mm)

ZONES	REGULAR MODEL	WITHOUT OPENING IN SHAER WALL	25% OPENING IN SHAER WALL	50% OPENING IN SHEAR WALL	75% OPENING IN SHEAR WALL
ZONE II	0.00099	0.00062	0.00064	0.0008	0.00086
ZONE III	0.00158	0.00099	0.00103	0.00128	0.00138
ZONE IV	0.00238	0.00149	0.00154	0.00192	0.00206

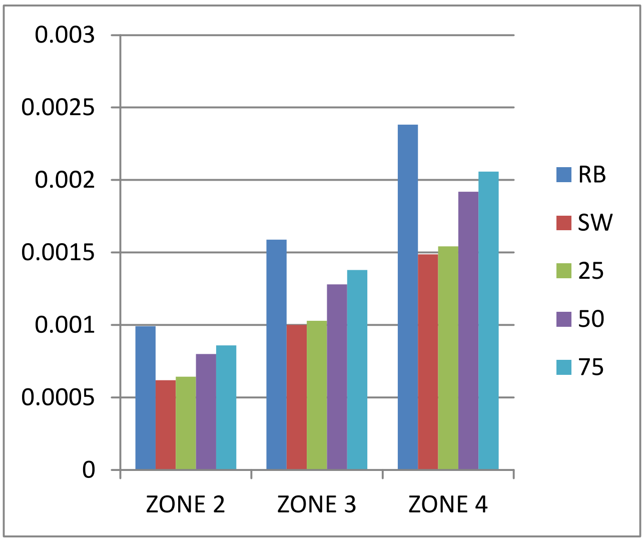

Fig- 16 Storey drift variation graph

According to the storey drift data, the model without opening in the shear wall along the Y direction has the greatest reduction in storey drift.

Table 7: Max Storey Drift values for different Zones (Response spectrum in X direction) (SPECX in mm)

ZONES	REGULAR MODEL	WITHOUT OPENING IN SHAER WALL	25% OPENING IN SHAER WALL	50% OPENING IN SHEAR WALL	75% OPENING IN SHEAR WALL
ZONE II	0.00125	0.00056	0.00059	0.00076	0.00087
ZONE III	0.00199	0.00089	0.00095	0.00122	0.00138
ZONE IV	0.003	0.00136	0.00143	0.00182	0.00209

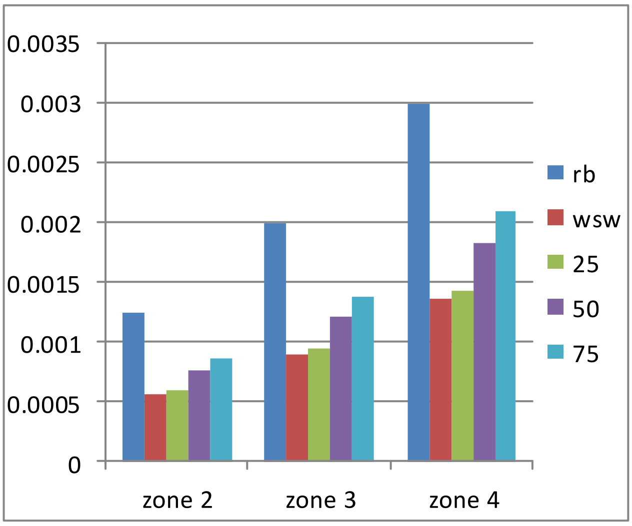

Fig-17 Storey drifts variation graph

According to the storey drift data, the model without opening in the shear wall along the X direction has the greatest reduction in storey drift.

Table 8: Max Storey Drift values for different Zones (Response spectrum in Y direction) (SPECY in mm)

ZONES	REGULAR MODEL	WITHOUT OPENING IN SHAER WALL	25% OPENING IN SHAER WALL	50% OPENING IN SHEAR WALL	75% OPENING IN SHEAR WALL
ZONE II	0.00084	0.00052	0.00054	0.00066	0.00072
ZONE III	0.00134	0.00085	0.00086	0.00106	0.00115
ZONE IV	0.00201	0.00125	0.00129	0.00159	0.00173

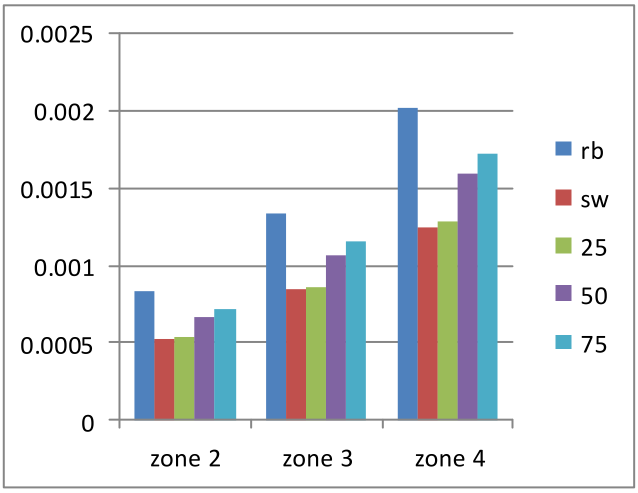

Fig-18 Storey drifts variation graph

According to the storey drift data, the model without opening in the shear wall along the Y direction has the greatest reduction in storey drift.

3.1.3 Time period

Table 9 : Time period values for Models different zones (in seconds)

ZONES	REGULAR MODEL	WITHOUT OPENING IN SHEAR WALL	25% OPENING IN SHEAR WALL	50% OPENING IN SHEAR WALL	75% OPENING IN SHEAR WALL
ZONE II	1.736	1.29	1.321	1.484	1.548
ZONE III	1.736	1.295	1.321	1.484	1.553
ZONE IV	1.736	1.29	1.321	1.484	1.548

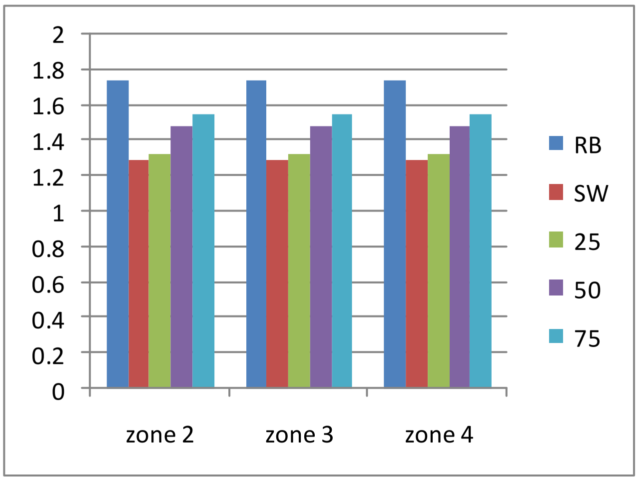

Fig-19 variation in time period.

According to the natural time period data, the model without opening in the shear wall has the greatest reduction in time period for one oscillation.

3.1.4 Base shear

Base shear is a measurement of the highest predicted lateral force caused by seismic ground motion at the structure's base. The regular model has fewer loads than the other models since the base shear value is exactly related to the weight of the building. The soil conditions at the site, as well as the proximity to probable seismic sources, are used to calculate base shear. The base shear values for the best model are shown in the table below.

Table 10: Base shear values for Zone II, III, IV along X direction (EQX in KN)

ZONES	REGULAR MODEL	WITH OUT OPENING IN SHEAR WALL	25% OPENING IN SHEAR WALL	50% OPENING IN SHEAR WALL	75% OPENING IN SHEAR WALL
ZONE II	2886.47	3109.93	3046.35	2843.78	2822.89
ZONE III	4618.17	4922.84	4883.9	4549.48	4530.75
ZONE IV	6932.79	7463.82	7325.85	6824.04	6787.84

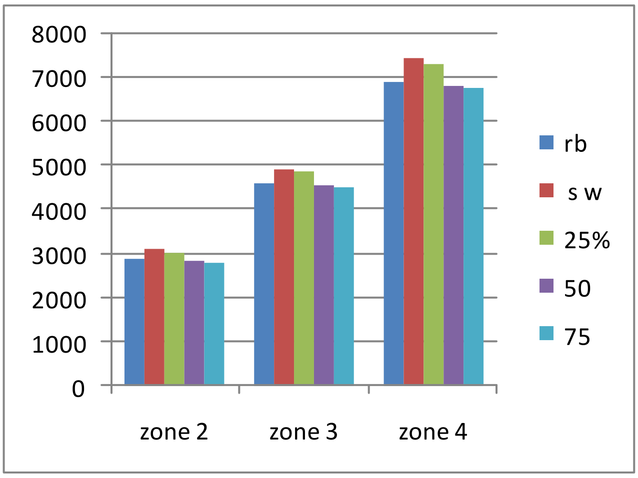

Fig-20 Graph of variation in base shear.

The highest reduction in base shear is shown in the model with a 75 percent opening in the shear wall along the X direction, according to the results of base shear.

Table 11: Base shear values for Zone II, III, IV along Y direction (EQY in KN)

ZONES	REGULAR MODEL	WITH OUT OPENING IN SHEAR WALL	25% OPENING IN SHEAR WALL	50% OPENING IN SHEAR WALL	75% OPENING IN SHEAR WALL
ZONE II	2585.35	2784.51	2734.10	2547.02	2528.76
ZONE III	4136.56	4480.10	4374.56	4074.07	4070.96
ZONE IV	6209.82	6682.83	6561.84	6112.83	6077.81

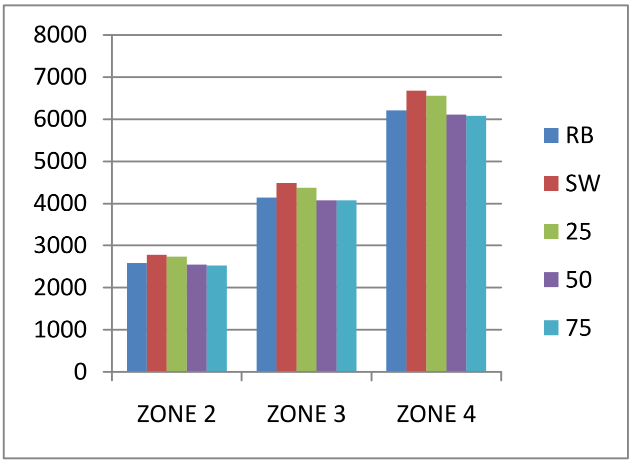

Fig-21 variation graph for base shear.

The highest reduction in base shear is shown in the model with a 75 percent opening in the shear wall along the X direction, according to the results of base shear.

3.2 Discussion of Result

In this study, a G+10 storey structure with regular and shear wall openings was examined for different zones (zone II, zone III, and zone IV) for Equivalent lateral force analysis and Response Spectrum Method

- For zones II, III, and IV, a regular model with dead load, live load, and earthquake loading is used.
- For zones II, III, and IV, a shear wall model with dead load, live load, and earthquake loading is used.
- For zones II, III, and IV, a model with a 25% aperture in the shear wall includes dead load, live load, and earthquake loading.
- For zones II, III, and IV, a model with a 50% aperture in the shear wall includes dead load, live load, and earthquake loading.
- For zones II, III, and IV, a model with a 75 percent aperture in the shear wall includes dead load, live load, earthquake loading.

For displacement, storey drift, time period, and base shear, all of the above models with three zones were examined for Equivalent lateral force analysis and Response Spectrum Method. The following results were obtained after a comparison was made between them.

3.2.1 Displacement (for both Equivalent lateral force analysis and Response Spectrum Method)

- As the percentage of opening in shear wall increases the displacement of the building will also increases.
- The maximum displacement is less for the model without opening in the shear wall in X and Y directions compared to the other openings.
- The maximum displacement obtained for the model without opening in the shear wall in X direction is 18.5mm and for model with 25% opening in shear wall is 19.9mm.
- The displacement of the building increases with increase in zone factors.

3.2.2 Time period

The construction with shear wall without opening has a shorter time period, as shown in the graphs and tables of time periods in the findings section. It is worth noting that in a building with the shear wall model, the time period of the building is around 25.69% shorter than in a regular model for zone II.

3.2.3 Storey drift (for both Equivalent lateral force analysis and Response Spectrum Method)

- The highest reduction in lateral drift is shown in the model with shear wall without opening in shear wall model along X and Y directions, according to the drift data.
- The drift value is more for zone IV compared to zone II and zone III.
- As zone factor increases drift value also increases.
- It also increases with increase in percentage of opening in shear wall.

3.2.4 Base Shear

- The base shear value along X and Y direction for 25% opening in the shear wall is less compared to without opening in the shear wall.
- Base shear values decreases with increase in the percentage of opening in shear wall for different earthquake zones.
- We can observed that the model without opening shows higher base shear values compared to the model with varying percentage of openings.

4. CONCLUSIONS

By studying the behavior of models with distinct zones in dynamic earthquake loading. The model with shear wall without openings shown to produce the best results. When compared to a regular model, it tends to shorten the time period, lateral displacement, and storey drift in both the X and Y directions by a significant margin.

- In all zones, the model without openings in the shear wall results in less displacement, drift, and time period than the other models.
- Models with a higher percentage of openings have less base shear than models with a lower percentage of openings.
- The building's displacement, drift, and time period are directly related to the opening in the shear wall.

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Also, authored more than 8 books to his credit.