COMPARATIVE STUDY ON VERTICAL AND LATERAL STABILITY OF RCC AND GFRG BUILDING PANEL WITH AND WITHOUT SHEAR WALLS OF G+9 FLOORS.

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Abstract - *During the past fifteen to twenty years, several components of the building made by Fiber Reinforced Polymers are used as basic materials, have been developed. The resistance to corrosion in aggressive environmental conditions, good fatigue strength, high strength to weight ratio and the capability to mould into any shape of fiber reinforced polymer (FRP) composites makes GFRG or Glass Fiber Reinforced Gypsum as an alternative to conventional construction materials. The panels made from Glass Fiber Reinforced Gypsum have high flexural property. So, it is necessary to study the structural behavior of buildings made with GFRG Panels. In this project, a comparative study is made for an RCC structure, GFRG structure and both with and without Shear walls to study the lateral and vertical stability in different seismic Zones. The maximum storey displacement as well as the base shear of these two models are analyzed and compared using dynamic static method of analysis. It has been observed that building with GFRG and Shear walls is better in terms of seismic performance. Analysis was done in ETABS software for both RCC and GFRG structures. Both buildings are of G+9 Floors from this analysis we can say that the displacement is more in the GFRG Building than GFRG with Shear wall building. Regular model with shear wall shows decreased results of maximum displacement and drift in both X and Y direction. Permissible limit of H/400 is less than limit. Model with GFRG panels is suitable only for zone II, for all other zones (H/400) greater than permissible values.*

Key Words: GFRG Glass Fibre Reinforced Gypsum, Etabs, Maximum Displacement, Fibre reinforced polymer

1.INTRODUCTION

As we all know, India is the world's largest country, both in terms of population and size. Increased population growth raises demand for food and shelter cloths, but in India's current economic situation, 35 percent of the population lives in poverty, with the remaining 65 percent divided into the lower middle class and the wealthy. While studying and finding equivalent solutions based on research on this issue is main motive of this GFRG material.

The main aim of this project is to present the dynamic analysis and comparative study of G+9 multistoried building constructed using GFRG panel with and without shear walls and conventional RCC building with and without shear walls. To study the "Response spectrum analysis", "Time History" in Etabs Software. Models are created for analysis of the **Maximum Storey Displacement, Storey Drift, Storey shear and Base reactions for Different Seismic Zones** are perceive and compared in Etabs .

1.1 Typical GFRG Panel Cross Section

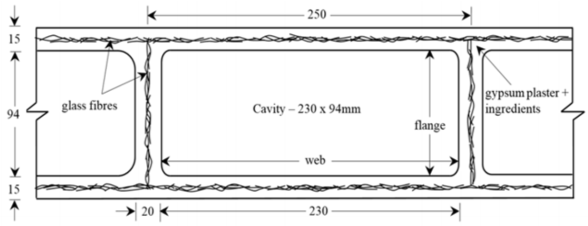

Fig 1 : Typical Cross-Section of GFRG Panel

The GFRG Panel (Glass Fibre Reinforced Gypsum) which is also recognized as Rapid Walls. It is made up of high Strength resistant glass fibres bounded with high density gypsum cement. GFRG Panel is world's largest light weight load-bearing panels manufactured with a size 12m length, 3m height, and 124mm thickness. Each panel has 48 modular holes of size 230 x 94 x 3000 mm dimensions. The weight of one panel is 1440kg.

1.2 OBJECTIVE OF THE PROJECT

The main objective of the thesis is to compare the GFRG building (G+9) with Regular RCC building (G+9) with and without shear walls with following purpose in all the four zones.

1) About GFRG Material and procedure to construction of GFRG Building.
2) Comparative Analysis Of multi-story (G+9) R.C.C Building with and without shear walls and GFRG wall panels with and without shear walls by using ETABS.
3) To analyze the all models in the different seismic Zones i.e., Zone II, Zone III, Zone IV, Zone V for Storey Displacement and Storey Drift etc.,

2. Modelling Details

For analysis and study purpose 16 Models are created with corresponding dimension and analysed for Zone II, III, IV, and V in ETABS.

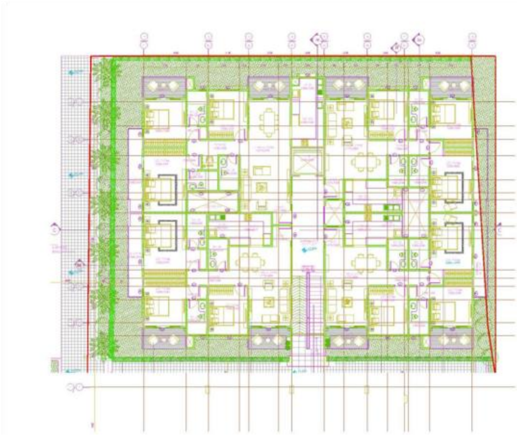

Fig 2 : Plan for RCC and GFRG

Serial Number	Properties	Dimension
1	Building Plan	25.9m x 21m
2	Column C1	300mm x 1050mm
3	Column C2	200mm x 600mm
4	Column C3	200mm x 450mm
5	Beam	200mm x 600mm
6	Shear wall thickness	150mm
7	Storey Height	3.5m
8	Soil type	II Type

Table 1 : Details about RCC Building

Serial Number	Properties	Dimension
1	Building plan	25.9m x 21m
2	GFRG Panel thickness	124mm
3	Storey height	3m
4	Unit weight of GFRG panel	0.40 N/m³
5	No. of Storey	10
6	Shear wall Thickness	150mm

Table -2: Details about GFRG building

2.1 Materials

Grade of concrete – M25
Grade of steel – HYSD Fe500
Density of concrete – $25KN/m^3$
Density of brick – $20KN/m^3$
Modulus of elasticity of concrete – $28.5KN/mm^2$
Modulus of elasticity of Steel – $210,00N/mm^2$
Modulus of elasticity of GFRG Panel – $7500N/mm^2$

2.2 Design Loads

Floor Finishes – 1.5KN/m2
Live load – 3KN/m2
Dead load
Wind load
Earthquake loads IS 1893-2016
i) Zone factor – 0.1
ii) Zone factor – 0.16
iii) Zone factor – 0.24
iv) Zone factor – 0.36
Imporatance Factor – 1
Time period in X direction – 0.39
Time period in Y direction – 0.41

Seismic Zones -Zone II, III, IV, V

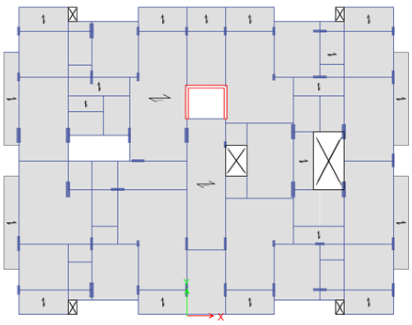

Fig 3a : RCC Typical plan layout from ETABS.

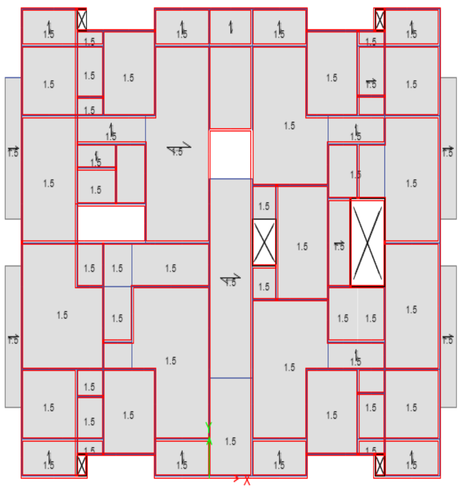

Fig 3b : GFRG Typical plan layout from ETABS.

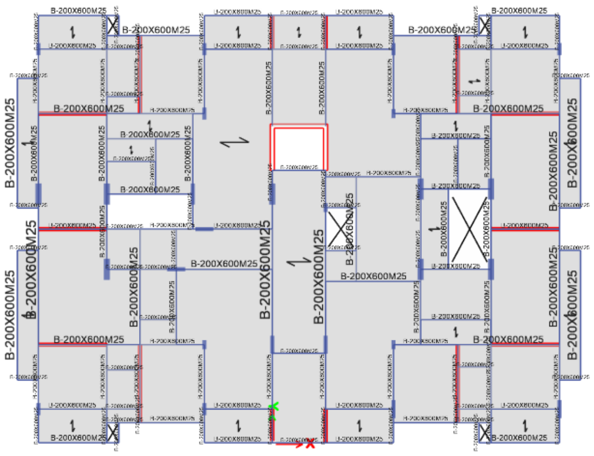

Fig 3c:RCC With Shear Walls Typical plan layout from ETABS.

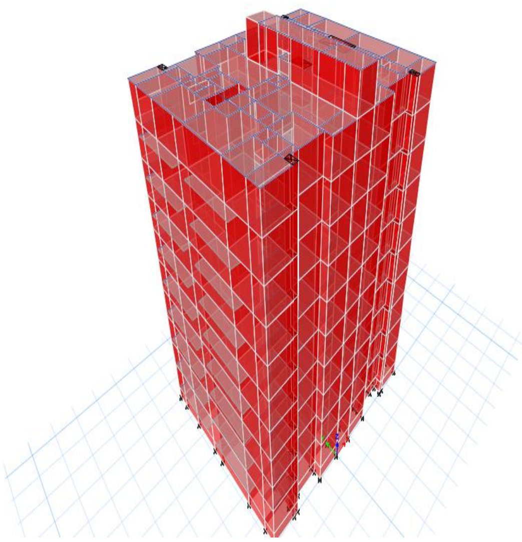

Fig -4 : GFRG Elevation from Etabs

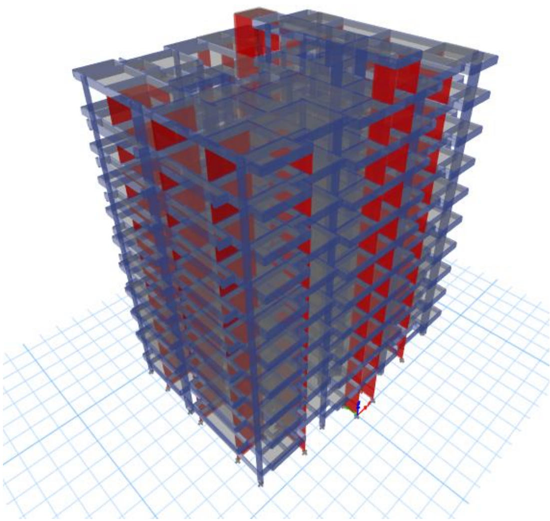

Fig -4a : RCC with shear walls Elevation from Etabs

3. RESULTS AND DISCUSSION

The maximum values of displacements are tabulated by comparing X and Y directions. The values of displacement of different models are obtained by subjecting the models to response spectrum analysis and time history analysis (linear) shows max displacement. Further the tabulated results are plotted in a graph and can be seen below:

ZONES	MAX DISPLACEMENT FOR REGULAR MODEL (mm) SPECX	MAX DISPLACEMENT FOR GFRG MODEL (mm) SPECX	MAX DISPLACEMENT FOR REGULAR MODEL WITH SHEAR WALL in mm SPECX	MAX DISPLACEMENT FOR GFRG MODEL WITH SHEAR WALL in mm SPECX
ZONE II	58.50	66.51	22.14	19.11
ZONE III	93.60	106.42	35.43	30.58
ZONE IV	140.41	159.63	53.15	45.87
ZONE V	210.62	239.44	79.73	68.81

Table 3: Max Displacement values for different Zones (Response spectrum in X direction)

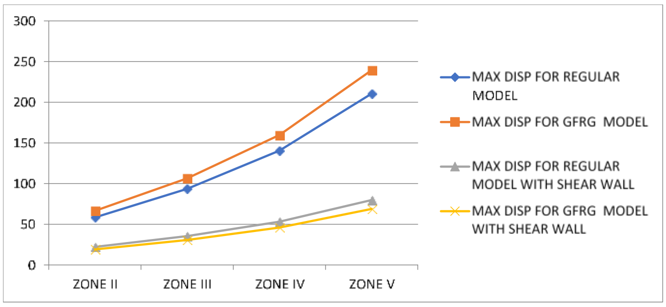

Fig -5 : Graph of displacement variation in X direction.

ZONES	MAX DISPLACEMENT FOR REGULAR MODEL (mm) SPECY	MAX DISPLACEMENT FOR GFRG MODEL (mm) SPECY	MAX DISPLACEMENT FOR REGULAR MODEL WITH SHEAR WALL (mm) SPECY	MAX DISPLACEMENT FOR GFRG MODEL WITH SHEAR WALL (mm) SPECY
ZONE II	24.38	55.24	20.52	19.54
ZONE III	39.01	88.38	27.06	31.27
ZONE IV	58.52	132.58	40.59	46.91
ZONE V	87.78	198.87	61.18	70.37

Table 4: Max Displacement values for different Zones (Response spectrum in Y direction)

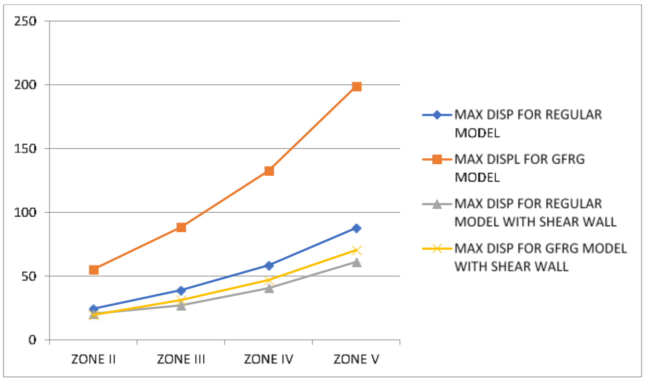

Fig -6 : Graph of displacement variation in Y direction.

ZONES	REGULAR MODEL in mm	GFRG MODEL in mm	REGULAR MODEL WITH SHEAR WALL in mm	GFRG MODEL WITH SHEAR WALL in mm
ZONE II	58.77	83.77	22.97	21.76
ZONE III	91.18	134.04	38.29	34.41
ZONE IV	141.64	201.061	58.74	53.42
ZONE V	212.767	301.591	82.71	80.96

Table 5: Max Displacement values for different Zones (Time History in X direction)

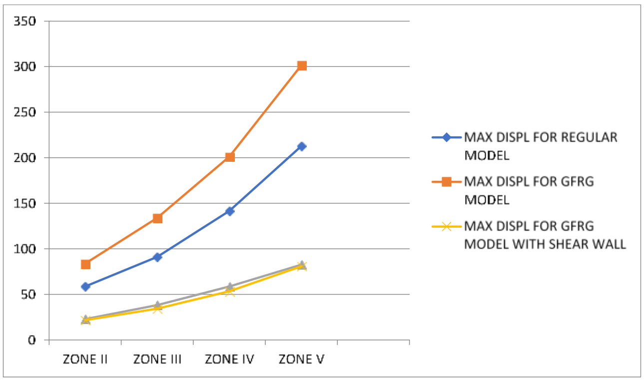

Fig7 : Graph of displacement variation in X direction.

ZONES	REGULAR MODEL in mm	GFRG MODEL in mm	REGULAR MODEL WITH SHEAR WALL in mm	GFRG MODEL WITH SHEAR WALL in mm

ZONE II	19.60	48.17	18.05	21.86
ZONE III	30.36	77.92	28.75	33.03
ZONE IV	47.05	117.37	43.33	51.95
ZONE V	70.57	176.06	62.11	78.72

Table 6: Max Displacement values for different Zones (Time History in Y direction)

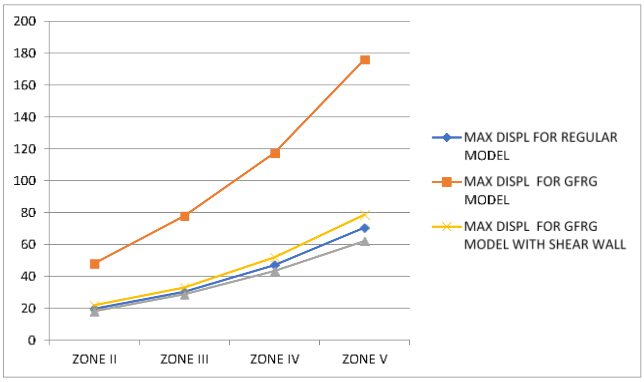

Fig 8 : Graph of displacement variation in Y direction.

B. Maximum Storey Drift

ZONES	MAX DRIFT FOR REGULAR MODEL (mm) SPECX	MAX DRIFT FOR GFRG MODEL (mm) SPECX	MAX DRIFT FOR REGULAR MODEL WITH SHEAR WALL (mm) SPECX	MAX DRIFT FOR GFRG MODEL WITH SHEAR WALL (mm) SPECX
ZONE II	0.002337	0.002438	0.000829	0.000710
ZONE III	0.003739	0.003901	0.001326	0.001136
ZONE IV	0.005609	0.005852	0.001989	0.001703
ZONE V	0.008413	0.008778	0.002983	0.002570

Table 7: Max storey Drift for different Zones (Response spectrum in X direction)

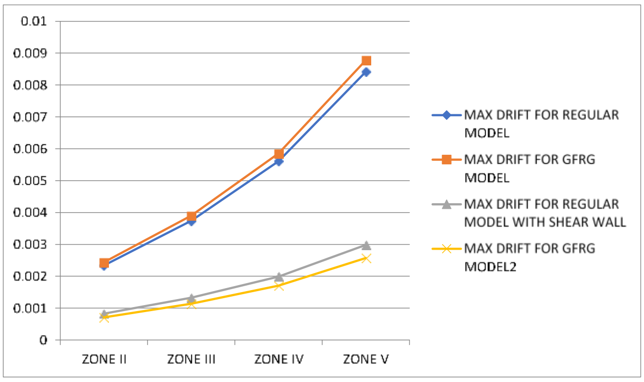

Fig 9 : Graph of drift variation in X direction.

ZONES	MAX DRIFT FOR REGULAR MODEL (mm) SPECY	MAX DRIFT FOR GFRG MODEL (mm) SPECY	MAX DRIFT FOR REGULAR MODEL WITH SHEAR WALL (mm) SPECY	MAX DRIFT FOR GFRG MODEL WITH SHEAR WALL (mm) SPECY
ZONE II	0.000931	0.002055	0.000775	0.000731
ZONE III	0.001489	0.003288	0.001022	0.001169
ZONE IV	0.002233	0.004931	0.001533	0.001754
ZONE V	0.003347	0.007397	0.002314	0.002630

Table 8: Max storey Drift for different Zones (Response spectrum in Y direction)

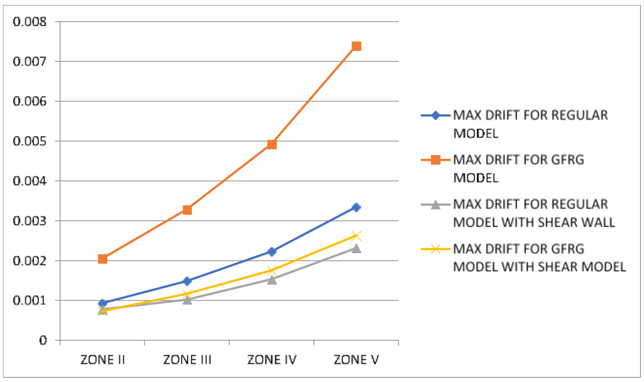

Fig 8 : Graph of drift variation in Y direction.

ZONES	MAX DRIFT FOR REGULAR MODEL (mm) THX	MAX DRIFT FOR GFRG MODEL (mm) THX	MAX DRIFT FOR REGULAR MODEL WITH SHEAR WALL (mm) THX	MAX DRIFT FOR GFRG MODEL WITH SHEAR WALL (mm) THX
ZONE II	0.002305	0.003161	0.000863	0.000801
ZONE III	0.003688	0.005057	0.001438	0.001275
ZONE IV	0.005555	0.007586	0.002071	0.001903
ZONE V	0.008344	0.011379	0.003106	0.002883

Table 9: Max storey Drift for different Zones (Time History in X direction)

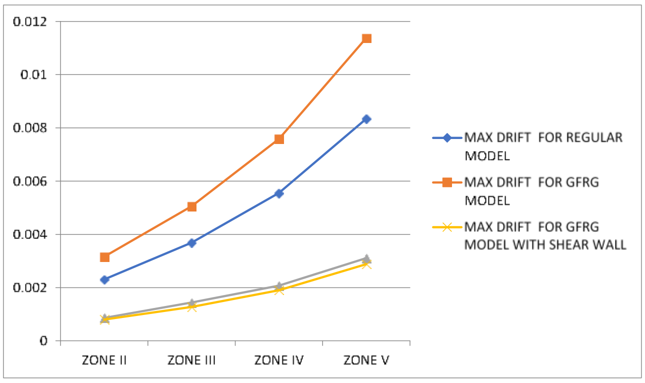

Fig 10 : Graph of drift variation in X direction.

ZONES	MAX DRIFT FOR REGULAR MODEL (mm) THY	MAX DRIFT FOR GFRG MODEL (mm) THY	MAX DRIFT FOR REGULAR MODEL WITH SHEAR WALL (mm) THY	MAX DRIFT FOR GFRG MODEL WITH SHEAR WALL (mm) THY
ZONE II	0.000797	0.001811	0.000648	0.000786
ZONE III	0.001275	0.002898	0.001079	0.001223
ZONE IV	0.001913	0.004366	0.001554	0.001867
ZONE V	0.002869	0.006548	0.002332	0.002766

Table 10: Max storey Drift for different Zones (Time History in Y direction)

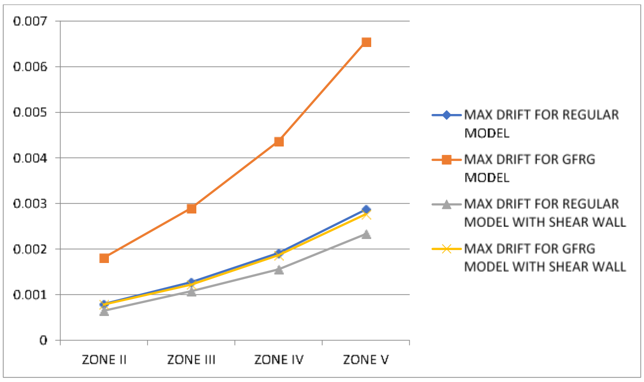

Fig 11 : Graph of drift variation in Y direction.

Time period

ZONES	TIME PERIOD FOR REGULAR MODEL (SEC)	TIME PERIOD FOR GFRG MODEL (SEC)	TIME PERIOD FOR REGULAR WITH SHEAR WALL MODEL (SEC)	TIME PERIOD FOR GFRG MODEL WITH SHEAR WALL (SEC)
ZONE II	2.230	2.810	1.437	1.349
ZONE III	2.230	2.810	1.437	1.349
ZONE IV	2.230	2.810	1.437	1.349
ZONE V	2.230	2.810	1.437	1.349

Table 11: Time period values for Models different zones

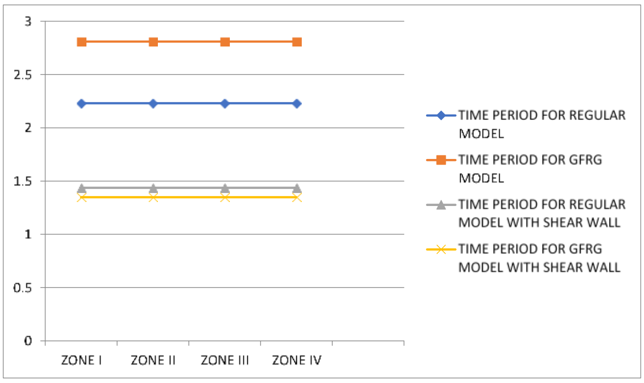

Fig 12 : Graph of variation in Time Period.

Base shear

Base shear is a measure of the maximum expected lateral force that will happen due to the seismic ground motion at the base of the structure. Since base shear value directly proportional to weight of the building, the regular model is having fewer loads compared to other models. Calculation of base shear rely on upon, soil conditions at the site, concurrence to potential sources of seismic activities. The base shear values are obtained as shown below table.

ZONES	MAX BASE SHEAR FOR REGULAR MODEL kN	MAX BASE SHEAR FOR GFRG MODEL kN	MAX BASE SHEAR FOR REGULAR MODEL WITH SHEAR WALL kN	MAX BASE SHEAR FOR GFRG MODEL WITH SHEAR WALL kN
ZONE II	1894.138	1213.230	1920.469	1296.69
ZONE III	2958.621	1914.178	3072.751	2074.700
ZONE IV	4437.932	2911.767	4609.127	3112.057
ZONE V	6656.898	4367.650	6913.690	4668.086

Table 12 : Base shear values for Zone II, III, IV, V

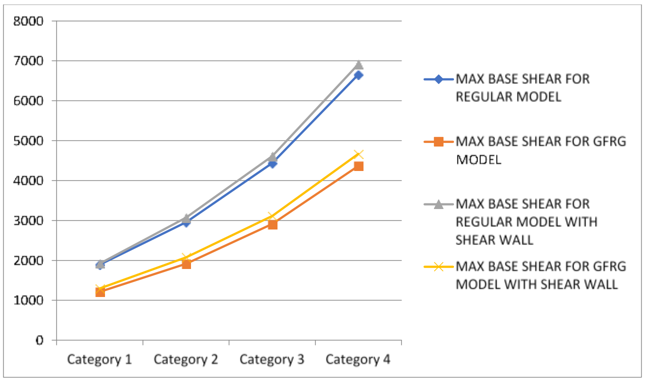

Fig 8 : Graph of variation in Base Shear.

3.1 DISCUSSION

A. Displacement

Regular model:

- From the results of displacement it is noted that the increase in lateral displacement for response spectrum and time history analysis from zone II to zone V.
- For zone II the maximum displacement in X and Y direction for both analysis less than the (H/400). For all other zones expect zone II displacement is more than maximum permissible displacement in building (H/400).

GFRG model:

- In response spectrum analysis GFRG model displacement increased compared to regular model by 13.69% in X direction and 126.57% in Y direction for all zones.
- In time history analysis GFRG model displacement increased compared to regular model by 42.53% in zone II, 47.00% in zone III, 41.95% in zone IV and zone V along X direction and 145.76% in zone II, 156.65% in zone III, 149.45% in zone IV and zone V along Y direction for all zones.
- Except for zone II, all other zone GFRG model will not satisfy for maximum permissible displacement (H/400).

Regular model with shear wall:

- Regular model with shear wall maximum displacement decreases when compared to regular model by 62.15% in X direction and 15.83% in zone II, 30.63% in all other zones along Y direction for response spectrum analysis.
- Regular model with shear wall maximum displacement decreases when compared to regular model by 60.91% in zone II, 58.00% in zone III, 58.5% in zone IV and 61.12% in zone V along X direction and by 7.90% in zone II, 5.30% in zone III, 7.90% in zone IV and 11.90% in zone V along Y direction for time history analysis.
- For all zone, regular model with shear wall model satisfy for maximum permissible

B. Time period

GFRG model:

From the graphs and tables of time period in the results section it is clearly observed that the Model with GFRG (for all zones) has increased compared to regular model. It is noted that in Model with GFRG the time period of the building was increased by about 20.64%.

Regular model with shear wall:

For regular model with shear wall time period of the building decreased 35.56% compared to regular model.

GFRG model with shear wall:

For GFRG model with shear wall time period of the building decreased 51.99% compared to GFRG model.

For GFRG model with shear wall time period of the building decreased 6.12% compared to regular model with shear wall.

GFRG model with shear wall:

- Compared to model with GFRG maximum displacement decreased by 71.26% and 64.12 % along X and Y direction for all zones in responses spectrum analysis.
- Compared to regular model with shear wall in response spectrum analysis GFRG model with shear

wall decreased by 13.68% in X direction and 4.77% in zone II and 15.55% for all zones in Y direction.

- Compared to model with GFRG maximum displacement decreased by 74.02% in zone II, 74.32% in zone III, 73.43% in zone IV and 73.15% in zone V along X direction and 54.61% in zone II, 57.61% in zone III, 55.73% in zone IV and 55.28% in zone V along Y direction for all zones in time history analysis.
- Compared to regular model with shear wall in time history analysis GFRG model with shear wall decreased by 5.26% in zone II, 10.13% in zone III, 9.05% in zone IV and 2.11% in zone V along X direction and 21.10% in zone II, 14.88% in zone III, 19.89% in zone IV and 26.79% in zone V along Y direction.
- For all zone GFRG model will satisfy for maximum permissible displacement (H/400).

C. Base shear

GFRG model:

Since base shear value directly proportional to weight of the building, the regular model is having heavier loads compared to the GFRG model. It is observed from the graphs and tables that the results of analysis shows that for model with GFRG ,base shear reduced by 35.94%, 35.30%, 34.38%, 34.38 % for zone II, zone III, zone IV, zone V.

Regular model with shear wall:

For regular model with shear wall base shear increased by 1.39%, 3.71%, 3.71%, 3.85 % for zone II, zone III, zone IV, zone V compared to regular model.

GFRG model with shear wall:

For GFRG model with shear wall base shear increased by 6.87%, 8.38%, 6.87%, 6.87 % for zone II, zone III, zone IV, zone V compared to GFRG model.

For regular model with shear wall base shear decreased by 32.48% for all zones compared to regular model with shear wall.

D. Storey drift

Regular model:

- From the results of storey drift it is noted that the increase in lateral drift for response spectrum and time history analysis from zone II to zone V.

GFRG model:

- For response spectrum analysis GFRG model drift increased compared to regular model by 4.32% in X direction and 120.73% in Y direction for all zones.
- For time history analysis GFRG model drift increased compared to regular model by 37.13% in zone II, 27.07% in zone III, 36.56% in zone IV and 36.37% in zone V along X direction and 127.22% in zone II, 56.18% in zone III, zone IV and zone V along Y direction for all zones.

Regular model with shear wall:

- Regular model with shear wall maximum drift decreases when compared to regular model by 64.52% in X direction and 16.75% in zone II, 31.36% in all other zones along Y direction for response spectrum analysis.
- Regular model with shear wall maximum drift decreases when compared to regular model by 62.55% in zone II, 61.00% in zone III, 62.73% in zone IV and 62.77% in zone V along X direction and by 18.69% in zone II, 15.37% in zone III, 18.76% in zone IV and 18.71% in zone V along Y direction for time history analysis.

GFRG model with shear wall:

- Compared to model with GFRG maximum drift decreased by 70.87% and 64.42 % along X and Y direction for all zones in responses spectrum analysis.
- Compared to regular model with shear wall in response spectrum analysis GFRG model with shear wall decreased by 74.65% in X direction and 56.59% in zone II and 57.57% for all zones in Y direction.
- Compared to model with GFRG maximum drift decreased by 14.32% in all zones along X direction and 12.57% in all zones along Y direction for all zones in time history analysis.
- Compared to regular model with shear wall in time history analysis GFRG model with shear wall increased by 7.18% in zone II, 11.33% in zone III, 8.11% in zone IV and 7.17% in zone V along X direction and 21.29% in zone II, 13.34% in zone III, 20.14% in zone IV and 18.61% in zone V along Y direction.

4. CONCLUSIONS

By considering the models with different zones and their behaviour in dynamic earthquake loading. It is concluded that Model with GFRG (except for zone II) will not give the most suitable results. As it tends to increase the time period, increase the lateral displacement and storey drift in both X and Y direction by a good margin compared to regular model.

- Model with GFRG panels is suitable only for zone II, for all other zones (H/400) greater than permissible values.
- Regular model with shear wall shows decreased results of maximum displacement and drift in both X and Y direction. Permissible limit of H/400 is less than limit.
- GFRG model with shear wall shows less displacement and storey drift in both X and Y direction in comparison to regular model with shear

wall in zone II, for all other in x direction displacement and drift decreases and in Y direction it is increasing as the structure has more walls in x direction.

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BIOGRAPHIES

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