Sesimic Analysis of a GFRG Building & Regular RC Building by using ETABS (Static & Dynamic)

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Abstract— The effective design and the construction of earthquake resistant structures have much greater importance in all over the world. The behavior of GFRG building and regular RC building of G+5 multi stories building under earth quake is complex and it varies of wind loads are assumed to act simultaneously with earth quake loads. In this paper the seismic analysis by the response spectrum method will be done to the GFRG building and regular RC building of calculating various responses in different zones by using ETABS software, so that the both results be compared. The Glass fibre reinforced gypsum (GFRG) walls are gypsum panels with hallow cores or cavities which can be filled with concrete. GFRG walls are in residential, commercial and industrial buildings. GFRG panels are a composite material consisting of gypsum plaster and glass fibers. The gypsum is industrial by product waste the product is not only ecofriendly, but also resistant to water and fire. IIT madras has been involved, since 2003 with the development of building system especially earthquake resistant design for use in India. Our India is still developing country fighting with huge shortage of houses for every year. To meet this challenge, India requires innovative, energy efficient, strong and durable in fast method of construction at economical cost. The main aim of this paper is to find out the different responses like Storey drift, Storey displacements, Base shear and Storey shear and Modal periods and Frequencies of both the GFRG and regular RC buildings. It is found that the GFRG are economical in design and construction in sub urban and low rise building constructions. But Displacements will be increasing with increase in number of storeys.

Key words: GFRG Panels, Wind Load, Earthquake, Story Displacement, Story Shear, Story Drift, Modal Periods and Frequencies, Base Shear and Response Spectrum Analysis

I. INTRODUCTION

GFRG buildings are a new type of construction to which conventional structural theories and design codes are not applicable. Glass fibre reinforced gypsum binder composites were produced by using E-type glass fibre and newly developed water-resistant gypsum binder [5]. The water resistant gypsum binder was produced by blending ground granulated slag, ordinary port land cement and an organic retarder with claimed phosphogypsum in a ball mill to obtain a uniform product. The binder possesses good water resistance as it does not show leaching in water up to 28 days of immersion , while plain plaster shows leaching after 3 days of immersion, in water. For the reinforcing material in this programme, chopped uncoated E-type glass fibre was used [14]. Rapid wall panel is world’s largest load bearing light light weight panels. Each panel has 48 modular cavities of 12mx3mxx124m dimension. Reinforced concrete is one of the most widely used modern building materials. Concrete is an “artificial stone” obtained by mixing cement, sand and aggregates with water. Presently reinforced concrete buildings in many earthquake prone areas of the world are built to design codes and yet many still suffer failure during earthquakes. This may mean that they are deficiencies in design. This event cannot be avoided but, by proper planning and design we can prevent it to a notable extent and hence structural engineer’s needs to design the structure taking into account all necessary factors including infill walls which plays a important role during earthquakes. We observed the main comparison of different responses like story drift, story shear, story displacements, base shear and modal periods and frequencies of both the modal periods and frequencies of both the GFRG and regular RC buildings in the entire four zones ZONE II, ZONE III, ZONE IV, and ZONE V.

The rapid growth of population, large-scale industrialization and very high land cost has resulted in a vast expansion in building construction industry. Our India is still a developing country fighting with a huge shortage of housing every year. So we need a very fast construction technology which can increase our development rate. Glass fibre reinforced gypsum walls are gypsum panels with hallow cores developed in Australia 1990 [5]. It is a load bearing prefabricated walling system with broad construction applications from industrial dwelling units to multi storey residential buildings, formwork, industrial paneling and compound walling [1].Construction of RC buildings formation of huge amount of co2(about 40% is developed due to construction industry) increases the chances of global warming [3]. Fertilizer industries are facing problems regarding disposal of industrial waste gypsum (2000 tons per day). Rapid wall is a large load bearing panel with modular cavities suitable for both external and internal walls .It can also be used as intermediate floor slab/roof in combination with RCC as composite material. The Light weight rapid wall has high compressive strength, shearing strength, flexural strength and ductility. It has very high level of resistance to fire, heat, water, termites, rot and corrosion [6&9]. Concrete infill with vertical reinforcement rods enhances its vertical and lateral load capabilities. Rapid wall buildings are resistant to earthquakes, cyclones and fire.

II. OBJECTIVE OF THE PROJECT

The main objective of the thesis is to compare the GFRG building (G+5) with regular RC building (G+5) with regular RC building (G+5) with following purposes in all the entire four zones .here we will be discussing the main comparison in zone II.

1) About the GFRG Material and procedure to construction of GFRG Building Systems

2) Comparative Analysis Of multi-story (G+5) R.C.C Building with conventional brick masonary and GFRG wall panels by using ETABS
3) Compression of the material usage with conventional brick masonry and GFRG wall panel in R.C.C Building

III. PROCEDURE TO CONSTRUCTION OF GFRG BUILDING

Structure-OMRF
No of storey-G+5
Floor to floor height-3.00 m
Type of building-Residential
Foundation type-Isolated footing
Soil strata-Medium

A. Materials

Grade of concrete-M25
Grade of steel-Fe415
Density of concrete-25KN/m^3
Density of brick-20 KN/m^3
Modulus of elasticity of concrete-25KN/mm^2
Modulus of elasticity of steel-2x10^5N/mm^2
Modulus of elasticity of masonry-36x10^5N/mm^2
Modulus of elasticity of GFRG panel-7500N/mm^2
Load Intensities
Floor finish-1.0KN/m^2
Live load-2KN/m^2

B. Seismic Zone Intensities: zones-II,III,IV,V

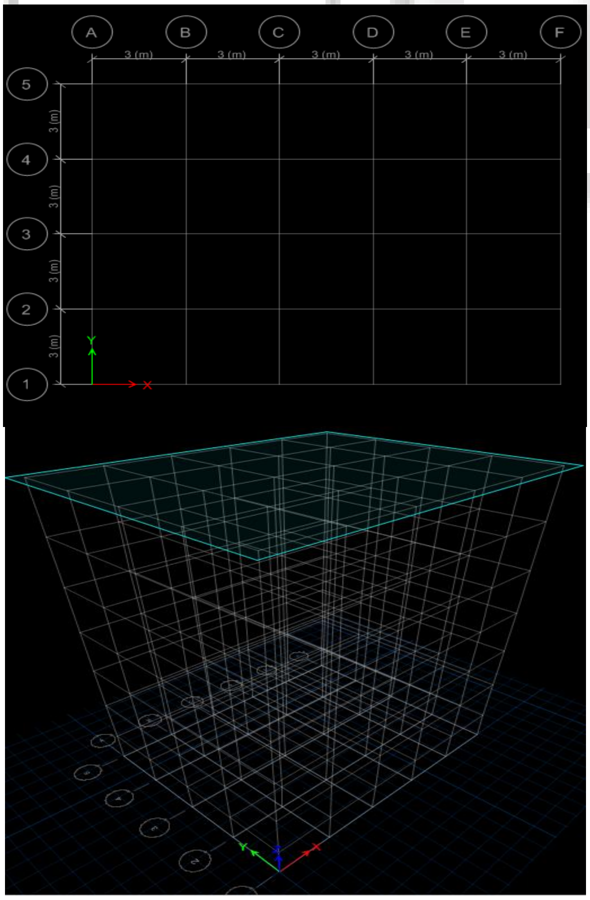

Fig. 1: Typical Plan and Elevation of Structure

IV. RESULTS & DISCUSSION

Here we are comparing the results obtained from response spectrum analysis of GFRG and regular RC building. This paper presents the main analysis of zone II specifically at 'top' location.

A. Story Displacements

Storey	Height	RC	RC	GFRG	GFRG
	m	x-dir(mm)	y-dir(mm)	x-dir(mm)	y-dir(mm)
Base	0	0	0	0	0
Storey 1	2.1	0.0005	0.00050	0.04684	0.03319
Storey 2	5.1	0.0009	0.00097	0.1	0.1
Storey 3	8.1	0.0013	0.00139	0.1	0.1
Storey 4	11.1	0.0016	0.00183	0.2	0.1
Storey 5	14.1	0.0019	0.00226	0.3	0.2
Storey 6	17.1	0.0022	0.00026	0.3	0.2
Storey 7	20.1	0.0027	0.003714	0.4	0.2

Table 2: Maximum Displacements of RC and GFRG Building at Zone 2 for Earthquake Load 1.5(DL+EQ+X), 1.5(DL+EQ+Y)

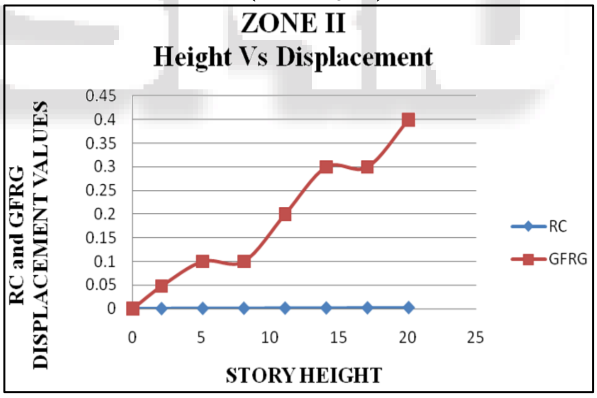

Fig. 2: Story height Vs Story Displacements of RC and GFRG building for Load Combination 1.5(DL+EQ+X)

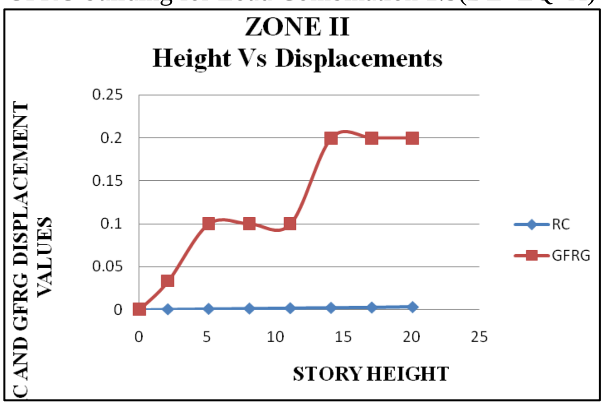

Figure3: Story Height Vs Story Displacements of RC and GFRG building for load combination 1.5(DL+EQ+Y)

Storey	Height	RC	RC	GFRG	GFRG
	m	x-dir(mm)	y-dir(mm)	x-dir(mm)	y-dir(mm)
Base	0	0	0	0	0
Storey 1	2.1	0.00045	0.00045	0.04067	0.04449
Storey 2	5.1	0.00071	0.00073	0.1	0.1
Storey 3	8.1	0.00083	0.00089	0.1	0.1
Storey 4	11.1	0.00089	0.00101	0.1	0.1
Storey 5	14.1	0.00091	0.00111	0.1	0.2
Storey 6	17.1	0.00086	0.00114	0.1	0.2
Storey 7	20.1	0.00099	0.00132	0.1	0.2

Table 3: Maximum Displacements of RC and GFRG building at zone 2 for Wind Load 1.5(DL+WL+x),1.5(DL+WL+y)

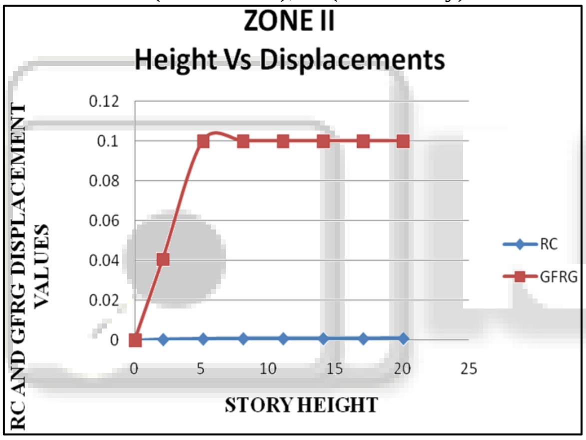

Fig. 4: Story height Vs Story Displacements of RC and GFRG Building for Load Combination 1.5(DL+WL+X)

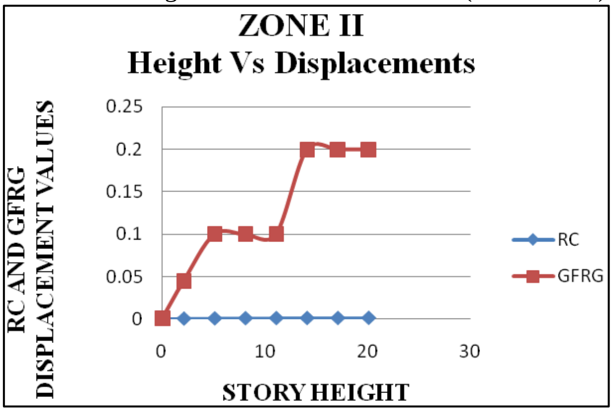

Fig. 4: Story height Vs Story Displacements of RC and GFRG Building for Load Combination 1.5(DL+WL+Y)

B. *Story Drifts*

We analysed the variation of story height and story drifts of regular RC and GFRG buildings for earthquake and wind load combinations.

Storey	Height	RC	RC	GFRG	GFRG
	m	x-dir(mm)	y-dir(mm)	x-dir(mm)	y-dir(mm)
Base	0	0	0	0	0
Storey 1	2.1	2.462E	2.4E-07	0.00002	1.6E-05
Storey 2	5.1	1.514E	1.6E-07	0.00001	1.1E-05
Storey 3	8.1	1.429E	1.7E-07	0.00002	1.2E-05
Storey 4	11.1	1.635E	1.9E-07	0.00022	1.4E-05
Storey 5	14.1	1.698E	1.9E-07	0.00022	1.4E-05
Storey 6	17.1	1.709E	1.9E-07	0.00002	1.3E-05
Storey 7	20.1	2.003E	2.2E-07	0.00018	1.2E-05

Table 4: Story Drift of regular RC and GFRG Building at Zone 2 for Earthquake Load 1.5(DL+EQ+x), 1.5(DL+EQ+y)

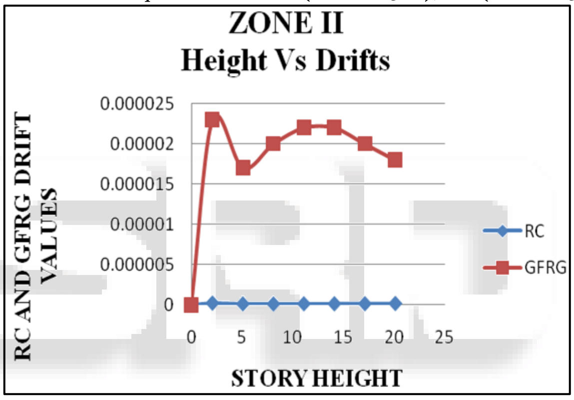

Fig. 4: Story height Vs Story Drifts of RC and GFRG Building for Load Combination 1.5(DL+EQ+X)

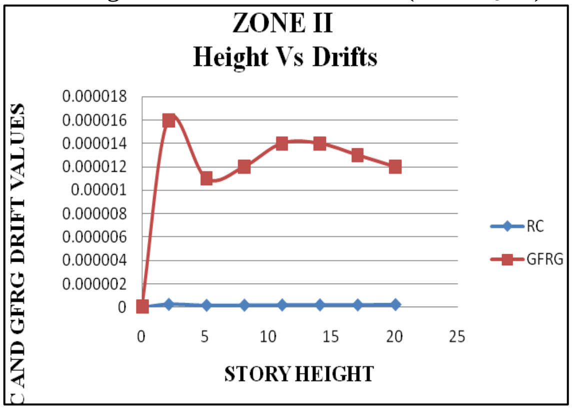

Fig. 4: Story Height Vs Story Drifts of RC and GFRG Building for Load Combination 1.5(DL+EQ+X)

Storey	Height	RC	RC	GFRG	GFRG
	m	x-dir(mm)	y-dir(mm)	x-dir(mm)	y-dir(mm)
Base	0	0	0	0	0

Storey 1	2.1	2.15E	2.1E	0.00019	2.1E
Storey 2	5.1	8.84E	9.4E	0.00009	1.2E
Storey 3	8.1	5.49E	7.7E	0.00008	1.2E
Storey 4	11.1	6.58E	8.2E	0.00008	1.2E
Storey 5	14.1	6.98E	8.1E	0.00008	1.1E
Storey 6	17.1	7.79E	8.4E	0.00007	1.1E
Storey 7	20.1	1.19E	1.3E	0.00007	0.0001

Table 5: Story Drift of Regular RC and GFRG Building at Zone 2 for Wind Load 1.5(DL+WL+x), 1.5(DL+WL+y)

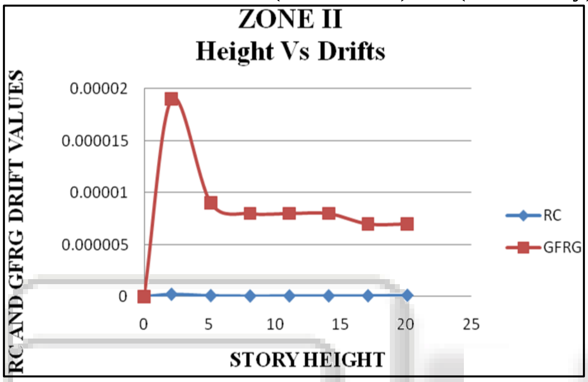

Fig. 5: Story height Vs Story Drifts of RC and GFRG Building for Load Combination 1.5(DL+WL+X)

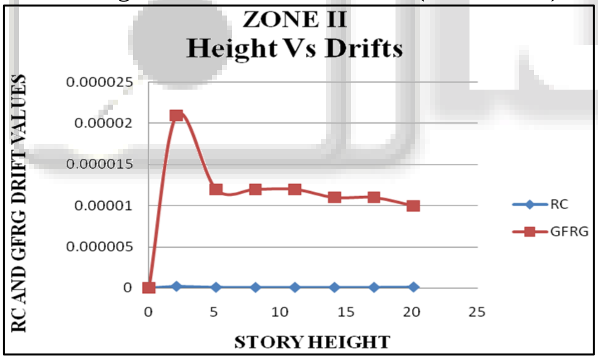

Fig. 6: Story height Vs Story Drifts of RC and GFRG Building for Load Combination 1.5(DL+WL+Y)

C. *Story Shear*

We analysed the variation of story height and story shear of regular RC and GFRG buildings for earthquake and wind load combinations.

Storey	Height	RC	RC	GFRG	GFRG
	m	x-dir(KN)	y-dir(KN)	x-dir(KN)	y-dir(KN)
Base	0	0	0	0	0
Storey 1	2.1	1164.98	1164.98	908.819	454.4097
Storey 2	5.1	1161.60	1161.60	906.237	453.1189
Storey 3	8.1	1130.75	1130.75	882.369	441.1846
Storey 4	11.1	1052.93	1052.93	822.160	411.0803
Storey 5	14.1	906.802	906.802	709.094	354.5471
Storey 6	17.1	671.001	671.001	526.651	263.325
Storey 7	20.1	324.183	324.183	258.316	129.157

Table 6: Story Shear of regular RC and GFRG Building at Zone 2 for Wind Load 1.5 (DL+EQ+x), 1.5(DL+EQ+y)

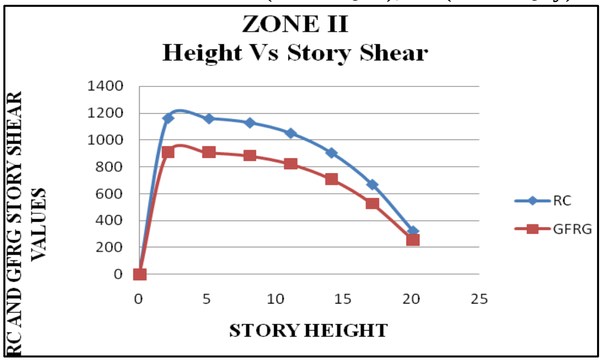

Fig. 7: Story height Vs Story Shear of RC and GFRG Building for Load Combination 1.5(DL+EQ+X)

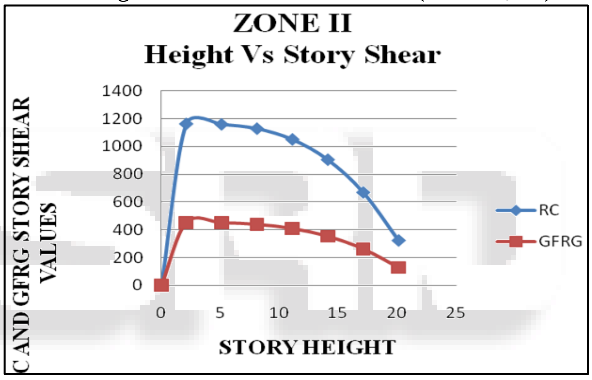

Fig. 8: Story height Vs Story Shear of RC and GFRG Building for Load Combination 1.5(DL+EQ+Y)

Storey	Height	RC	RC	GFRG	GFRG
	m	x-dir(mm)	y-dir(mm)	x-dir(mm)	y-dir(mm)
Base	0	0	0	0	0
Storey 1	2.1	-515.05	643.81	-515.05	643.81
Storey 2	5.1	-448.92	561.16	-448.92	561.16
Storey 3	8.1	-371.13	463.92	-371.13	463.92
Storey 4	11.1	-293.34	366.67	-293.34	366.67
Storey 5	14.1	-214.14	267.68	-214.14	267.68
Storey 6	17.1	-131.06	163.82	-131.06	163.82
Storey 7	20.1	-44.693	55.867	-44.693	55.867

Table 7: Story Shear of Regular RC and GFRG Building at Zone 2 for wind load 1.5(DL+WL+x), 1.5(DL+WL+y).

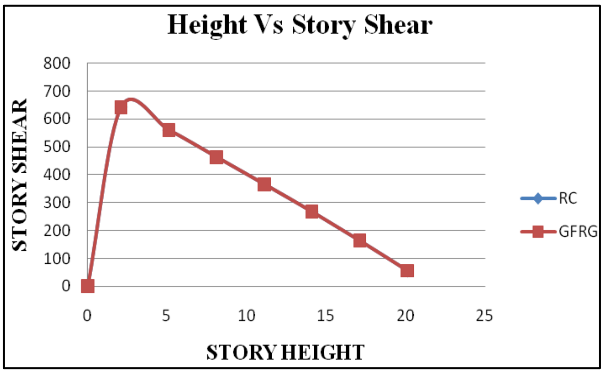

Fig. 9: Story height Vs Story Shear of RC and GFRG Building for Load Combination 1.5(DL+WL+X)

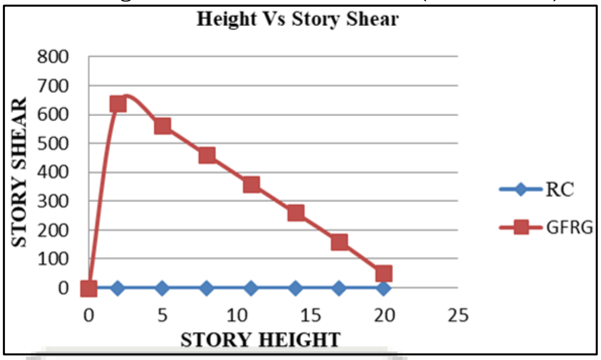

Fig. 10: Story height Vs Story Shear of RC and GFRG Building for Load Combination 1.5(DL+WL+Y)

D. The Different Analysis Procedure Are

1) Linear Static Analysis
2) Nonlinear Static Analysis
3) Linear Dynamic Analysis
4) Nonlinear Dynamic Analysis

- Also known as Equivalent Static method.
- Based on formulas given in the code of practice.

STEPS

- First, the design base shear is computed for the whole building
- It is then distributed along the height of the building.
- The lateral forces at each floor levels thus obtained Are distribute to individual lateral load resisting Elements

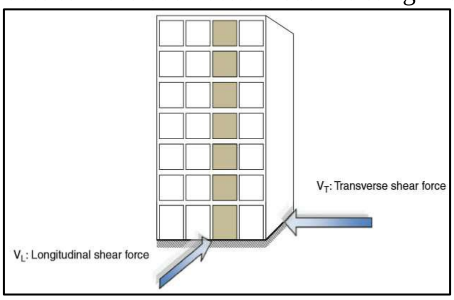

Fig. 11: Equivalent Lateral Shear Force along Two Orthogonal Axis

E. Drift Story

- It is a measure of how much one floor or roof level displaces under the lateral force relative to the floor level immediately below.
- It is the ratio of the difference in deflection between two adjacent floors divided by the height of the story that separates the floors.

F. Linear Dynamic Analysis

- Response spectrum method is a linear dynamic analysis method.
- In this approach multiple mode shapes of the building are taken into account.
- For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass.
- They are then combined to provide an estimate of the total response of the structure using modal combination methods.
- Combination methods include the following:
- Absolute Sum method
- Square Root Sum of Squares (SRSS)
- Complete Quadratic Combination (CQC)
- The design base shear calculated using the dynamic analysis procedure is compared with a base shear *Vb*, calculated using static analysis.
- If *Vb* is less than, all the response quantities, eg. member forces, displacements, storey forces, storey shears, and base reactions, should be multiplied by *Vb*

V. CONCLUSION

The following conclusions are drawn based on the present study.

1) Considering displacements in the combination of 1.5(DL+EQ±X) and 1.5(DL+EQ±Y) for all the four zones, the displacements increases from ground floor to top floor in both the cases i.e., RC building and GFRG building.
2) GFRG building produce greater displacements when compare with RC building.
3) When displacements are considered under wind load combination of 1.5(DL+WL±X) and 1.5(DL+WL±Y), the maximum displacements produced at 1st story than it gradually decreases for GFRG buildings. For RC building displacement values are very low when compared with GFRG building.
4) While considering Story Drift for a load combination of 1.5(DL+EQ±X) and 1.5(DL+EQ±Y), the maximum Drift observed at 1st story in both RC and GFRG buildings.
5) Drift values for RC building are very low when compared to GFRG building in a load combination of 1.5(DL+EQ±X) and 1.5(DL+EQ±Y).
6) Similarly story drift for both RC and GFRG buildings with wind load combination of 1.5(DL+WL±X) and 1.5(DL+WL±Y) gives the same results as under seismic loads.
7) Story shear for both RC and GFRG buildings under 1.5(DL+EQ±X) shows gradual decrease of shear from bottom story to top story. GFRG buildings have lower story shear when compared to RC building.
8) Considering story shear in the combination of 1.5(DL+EQ±Y). The difference between RC and GFRG

building very high when compared to the difference of story shear in the combination of 1.5(DL+EQ±X).

9) Story shear in the combination 1.5(DL+WL±X) and 1.5(DL+EQ±Y) shows no difference in RC and GFRG buildings. This implies wind load as no effect on story drift in both the buildings.
10) For RC buildings the time periods in all the earthquake zones are same. Similarly for GFRG building the time period are the same in all the four zones.
11) The time period for GFRG buildings is much greater than RC buildings. For smaller structures, response spectrum analysis static analysis can be used with little effort.
12) Depending upon the accuracy of results needed and the importance of the building that should be analysed various seismic analysis of the building that should be analysed various seismic analysis
13) Of the building that should be analysed various seismic analysis
    Static Analysis, Linear Dynamic Analysis and Nonlinear Dynamic Analysis

From the above parameters we can conclude that GFRG buildings act similar to RC buildings. But as displacements keep on increasing with increase in number of storeys. It is suitable to use are GFRG buildings for small sub-urban areas and also suitable for low rise buildings.

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