Comparison of GFRG Building with Regular RC Building by Using ETABS

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Abstract— The behaviour of GFRG and regular RC 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 a comparison of GFRG building with regular RC building of G+5 multi story building is studied for earth quake and wind load using ETABS. The Glass fibre reinforced gypsum (GFRG) walls are gypsum panels with hallow cores or cavities which can filled with concrete .GFRG walls are used in residential, commercial and industrial buildings. GRFG panels are a composite material consisting of gypsum plaster and glass fibres. The gypsum is industrial by product waste the product is not only eco-friendly, but also resistant to water and fire. GFRG panels can be used as various structural elements such as walls and slabs. GFRG walls find more and more applications and interests in the building industry in Australia as well as in other countries including china and India. GFRG panels are presently manufactured to a thickness of 124mm, a length of 12m and a height of 3m. 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. In India fertilizer industries are facing problem in disposal of industrial waste gypsum (2000 tons per day). 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 Story drift, Story Displacements, Story Shear, Base shear and Modal periods and frequencies of both the GFRG and regular RC buildings in the entire four zones ZONE I, ZONE II, ZONE III, ZONE IV and ZONE V.

Key words: GFRG Panels, Loadings, Wind, Earthquake, Story Displacement, Story Shear, Story Drift, Modal Periods and Frequencies and Base Shear

I. Introduction

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 hollow cores developed in Australia 1990. It is a load bearing pre-fabricated walling system with broad construction applications from industrial dwelling units to multi storey residential buildings, formwork, industrial panelling and compound huge amount of co2 (about 40% is developed due to construction industry) increases the chances of global warming. 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 be also used as intermediate floor slab/roof in combination with RCC as composite material. It has been used for buildings ranging from single storey to medium-high rise buildings. 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 .Concrete infill with vertical reinforcement rods enhances its vertical and lateral load capabilities. Rapid wall buildings are resistant to earthquakes, cyclones and fire.

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 .The water –resistant gypsum binder was produced by blending ground granulated slag , ordinary Portland 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. Rapid wall panel is world’s largest load bearing light weight panels. Each panel has 48 modular cavities of 12mx3mx124m dimension. Reinforced concrete is walling. Construction of RC buildings formation of 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.

II. Procedure to construction of GFRG building

- A conventional foundation like spread footing, RCC column footing, raft or pile foundation is used as per the soil condition and load factors.
- All around the building RCC plinth beam is provided at basement plinth level.
- For erection of panel as wall, 12 mm diameter vertical reinforcement called “starter bars” of 0.75m length of

which 0.45m protrudes up and remaining portion with 0.15m angle is placed into the RCC plinth beams before casting.

– These bars are kept at a distance of 1m centre to centre to match the cavities of the panel.

A. *Super Structure:*

– Pre-cut panels are brought to the construction site.
– Panels are kept over the starter bars on the plinth beam using cranes.
– Grooves are cut into the panels at every joint to facilitate integral bonding.
– Appropriate reinforcement bars are inserted as per design into the cavities.
– These reinforcements are then tied to the starter bars.
– Verticality of panels are checked and then cavities having reinforcements are filled with concrete.
– It is mandatory to reinforce and fill all the joints with concrete.
– Other cavities can be filled with any inert materials (e.g. quarry dust mixed with 5% cement and water)
– After completing the walls, doors and windows are fixed in position at their respective locations where panels are cut and that is fixed by filling the cavities with concrete.
– Then shuttering for sunshades are kept in position and concreting is done.

Staircase is constructed by using panel as waist and landing slabs with reinforcement in all the cavities

B. *Roof Slab:*

– Formworks are erected.
– Tie beams are constructed all along the walls to provide bond between roof slab and walls.
– Panels are then placed in position.
– Every third cavity is then cut open from the top and reinforcement cages are inserted for concrete micro beams.
– Electrical conduits are then placed in position.
– Welded wire mesh is then kept all over the panel.
– Then concreting is done with thickness 50mm.
– Subsequently waterproofing of roof is done.

III. 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 following purposes in all the entire four zones.

1) About the GFRG material and Procedure to construction of GFRG building systems,
2) Determination of story displacement in both GFRG and regular RC buildings in all the four zones,
3) Determination of story drift in both GFRG building and regular RC building in all the four zones,
4) Determination of story shear in both GFRG building and regular RC building in all the four zones,
5) Determination of modal periods and frequencies in both GFRG building and regular RC building in all the four zones,
6) Determination of base shear in both GFRG building and regular RC building in all the four zones,
7) Determination of Shear Force, Bending moment, axial force and Torsion for beams and columns of one floor in both the buildings.
8) The main objective of the present study is to know the details of GFRG panels and procedure to construction of GFRG building systems and comparison of GFRG building with regular RC building in different responses in all the entire four zones like ZONE II, ZONE III, ZONE IV and ZONE V.

IV. STRUCTURAL MODELLING AND ANALYSIS

A. *Description of the Building*

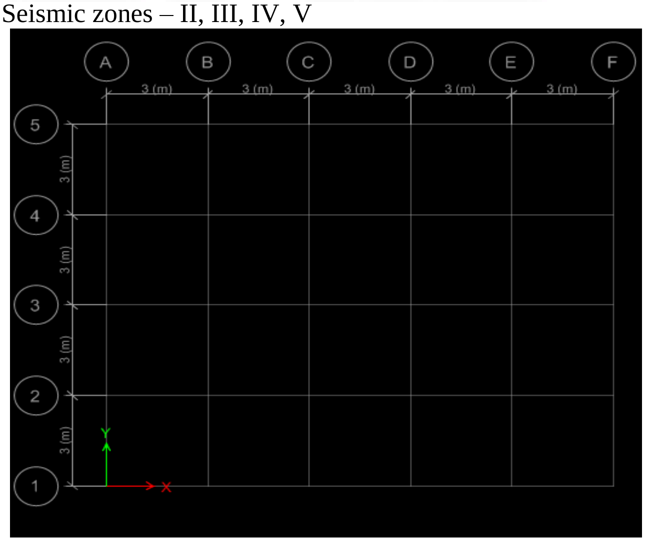
The data of modelled buildings is given below
Plan dimension – 16mx 12 m
Structure - OMRF
No. of storey - G + 5
Floor to floor height - 3.00 m
Type of building - Residential
Foundation type - Isolated footing
Soil strata - Medium

B. *Material Properties*

Grade of concrete - M25
Grade of steel - Fe 415
Density of concrete – 25 KN/m^3
Density of brick - 20 KN/m^3
Modulus of elasticity of concrete –25KN/mm^2
Modulus of elasticity of steel - 2×10^5 N/mm^2
Modulus of elasticity of masonry-36x10^5N/mm^2
Modulus of elasticity of GFRG panel -7500 N/mm^2

C. *Load Intensities*

Floor finish – 1.0KN/m2
Live load – 2KN/m2
Seismic Zone Intensities
Seismic zones – II, III, IV, V



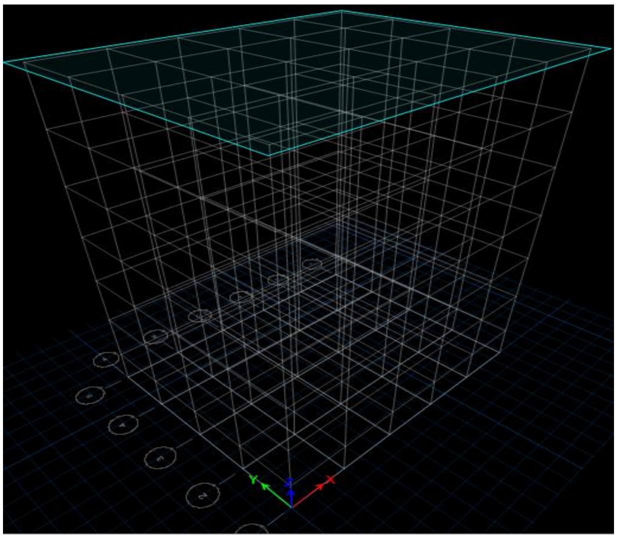


Fig. 1: Typical Plan and Elevation of Structure

V. RESULTS & DISCUSSION

A. Comparison GFRG building with regular RC building from zone 2 to zone 5

1) Story Displacement for EQ-X Direction:

The following graph shows the variation of Story Height Vs Story Displacement of GFRG and regular RC buildings for a load combination of 1.5(DL+EQ-X) in all the four zones.

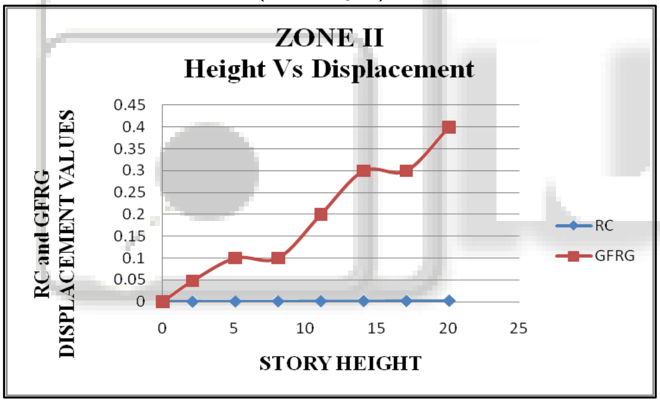


Fig. 2: Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for ZONE II

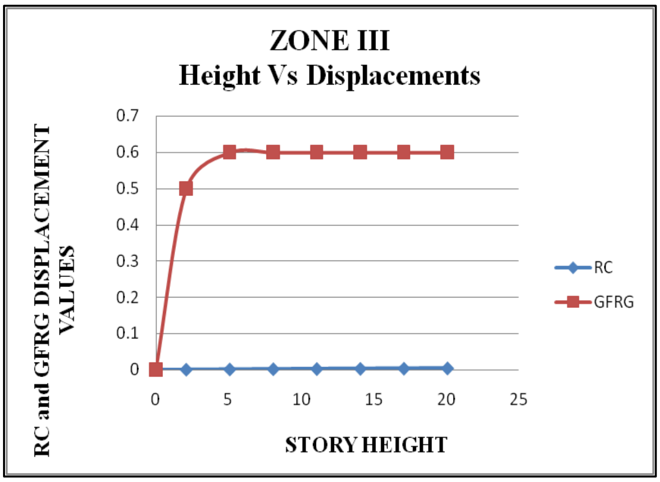


Fig. 3: AGraph Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for ZONE III

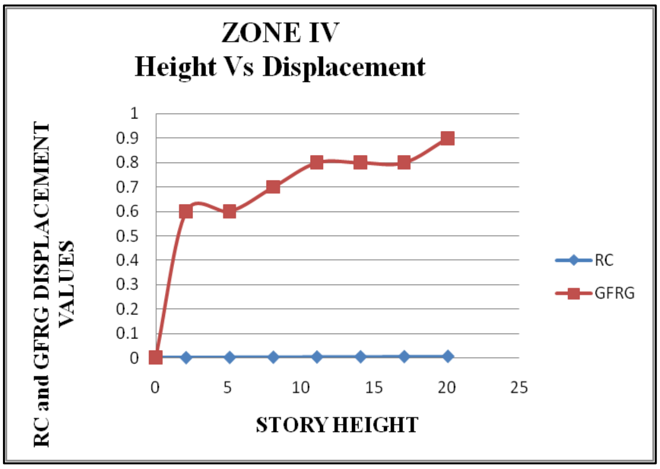


Fig.4. A Graph Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for ZONE IV.

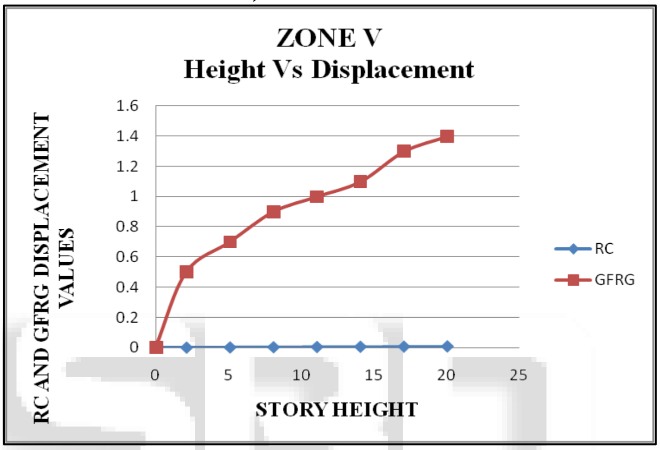


Fig. 5: A Graph with Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for ZONE V.5

2) Story Displacement for EQ-Y Direction:

The following graph shows the variation of Story Height Vs Story Displacement of GFRG and regular RC buildings for a load combination of 1.5(DL+EQ-Y) in all the four zones.

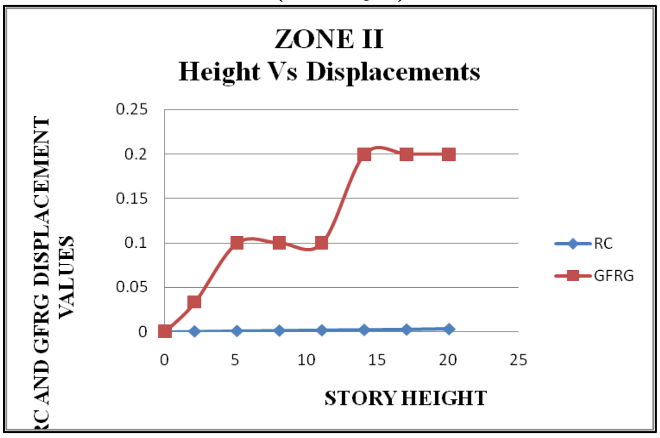


Fig. 6: A Graph Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for ZONE II.

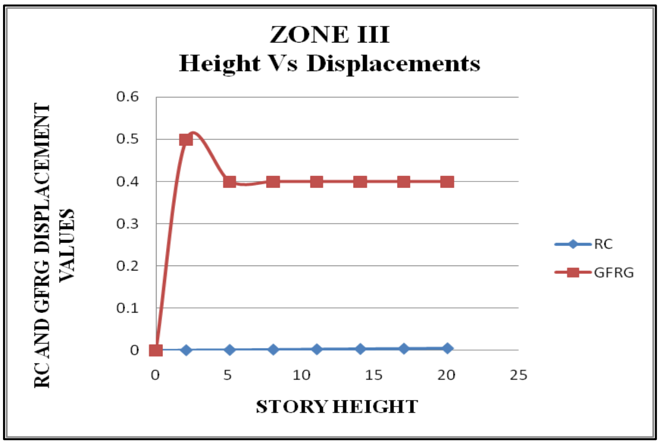


Fig. 7: A Graph Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for ZONE III.

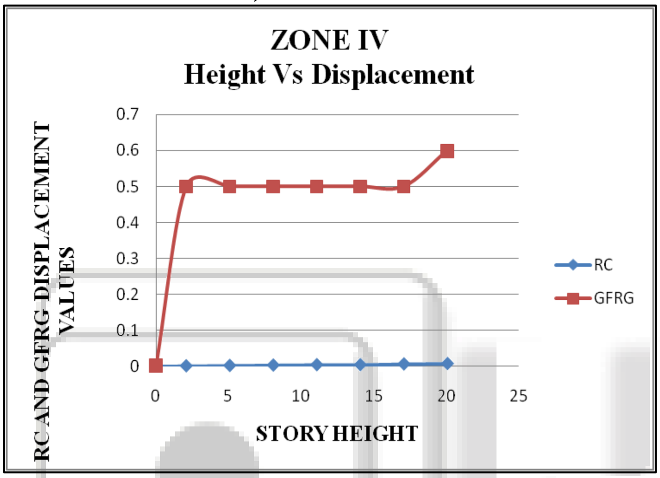


Fig. 8: A Graph Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for ZONE IV.

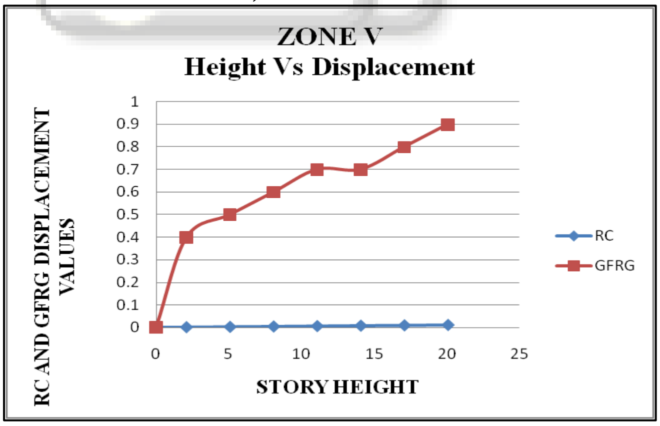


Fig. 9: A Graph Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for ZONE V.

3) Story Displacement for WL-X Direction:

The following graph shows the variation of Story Height Vs Story Displacement of GFRG and regular RC buildings for a load combination of 1.5(DL+WL-X) in all the four zones.

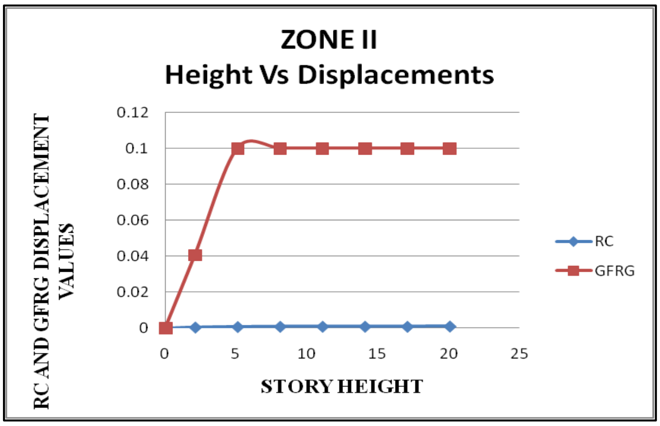


Fig. 10: A Graph with Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+WL-X) for ZONE II.

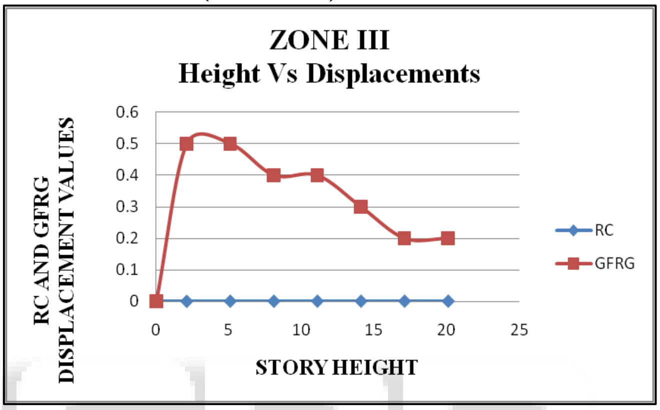


Fig. 11: A Graph with Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+WL-X) for ZONE III.

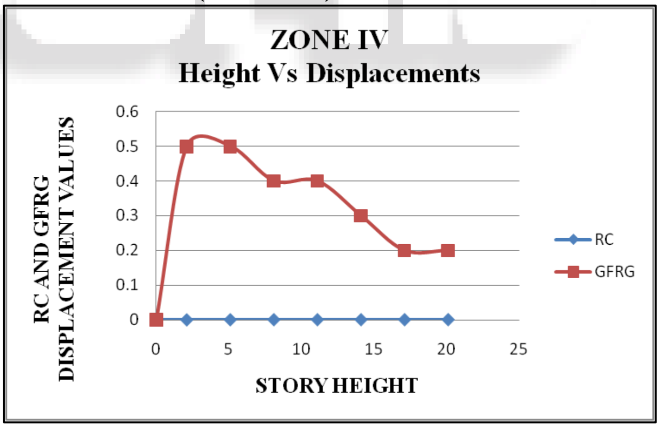


Fig. 12: A Graph with Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+WL-X) for ZONE IV.

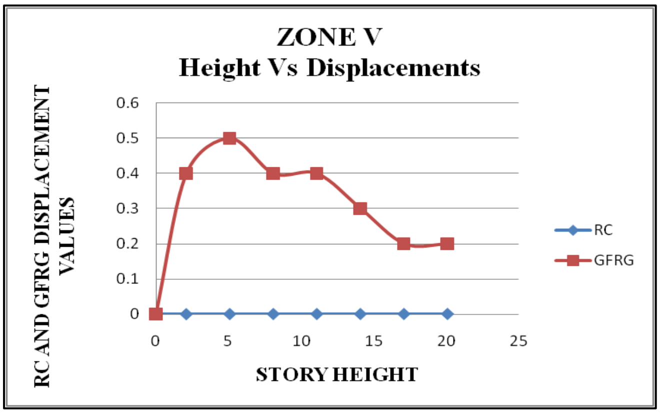


Fig. 13: A Graph with Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+WL-X) for ZONE V.

4) Story Displacement for WL-Y Direction:

The following graph shows the variation of Story Height Vs Story Displacement of GFRG and regular RC buildings for a load combination of 1.5(DL+WL-Y) in all the four zones.

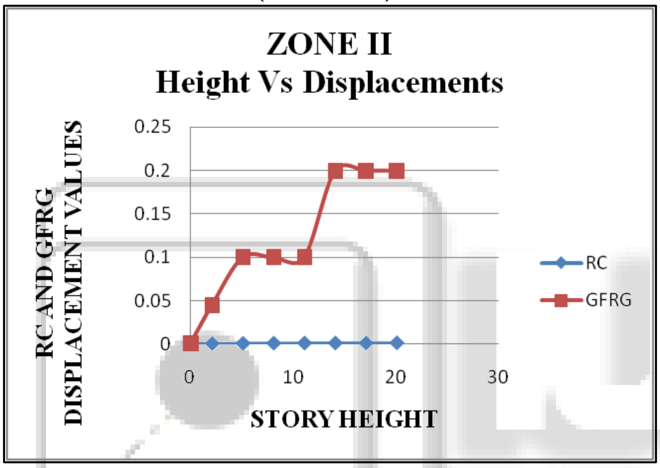


Fig. 14: A Graph with Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+WL-Y) for ZONE II.

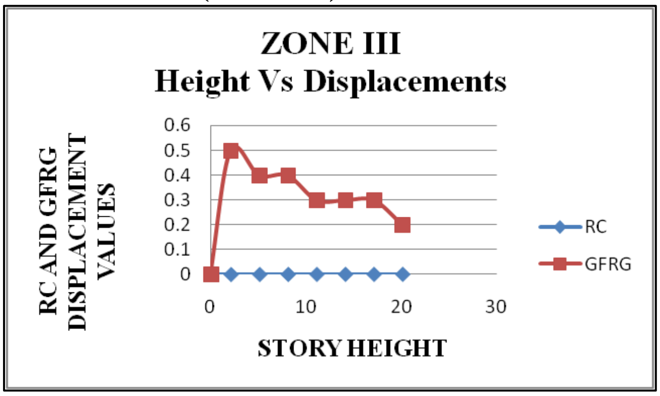


Fig. 15: A Graph with Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+WL-Y) for ZONE III.

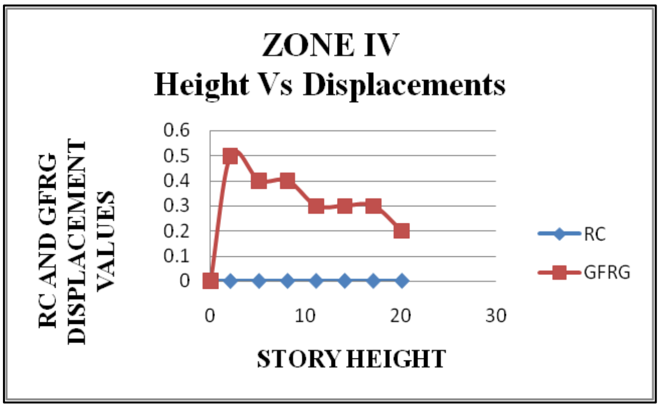


Fig. 16: A Graph with Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+WL-Y) for ZONE IV.

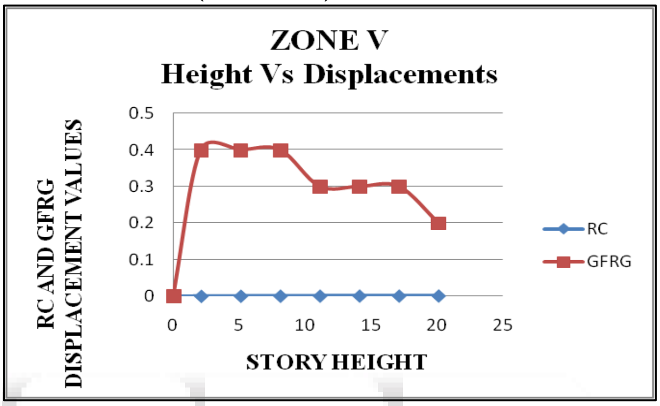


Fig. 17: A Graph with Story Height Vs Story Displacements of RC and GFRG buildings for a load combination of 1.5(DL+WL-Y) for ZONE V.

5) Story Drift for EQ-X Direction:

The following graph shows the variation of Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for all the four zones.

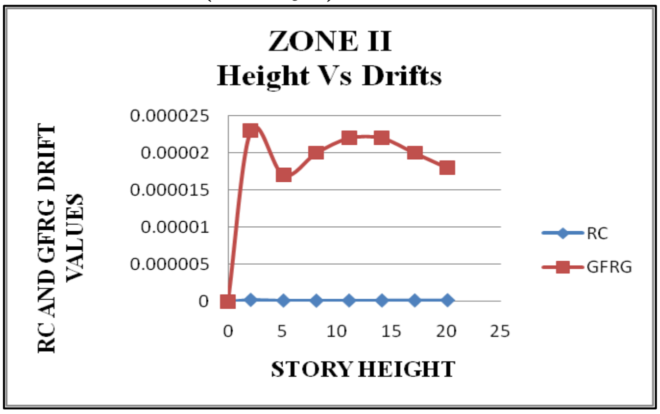


Fig. 18: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for ZONE II.

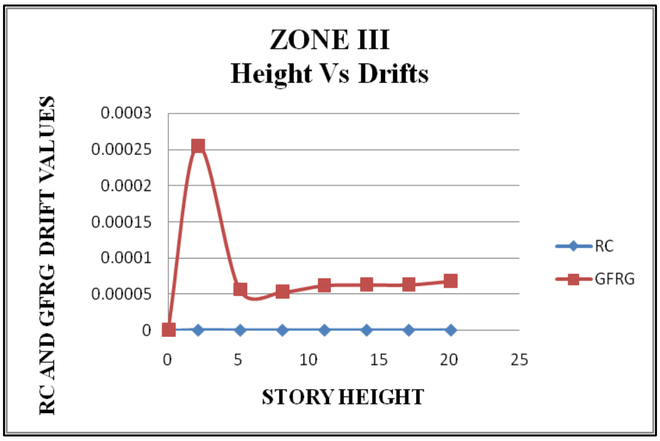


Fig. 19: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for ZONE III.

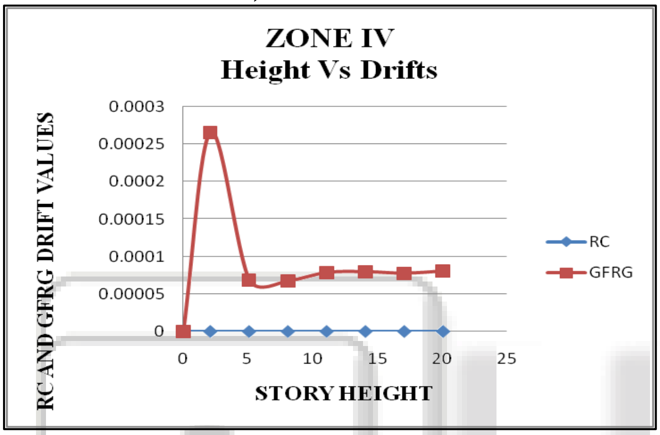


Fig. 20: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for ZONE IV.

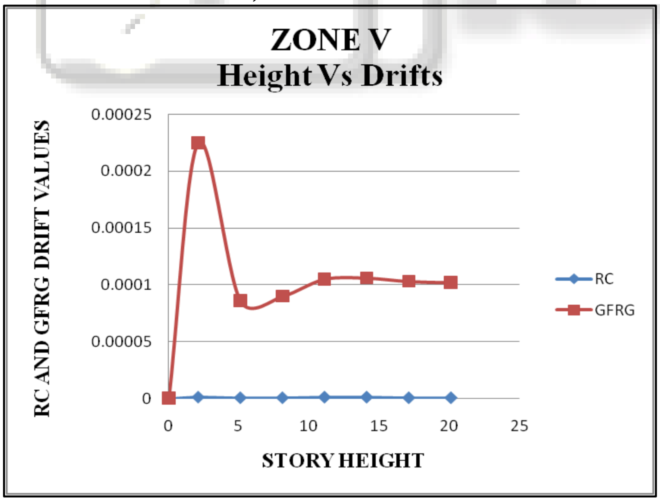


Fig. 21: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for ZONE V.

6) Story Drift for EQ-Y Direction:

The following graph shows the variation of Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for all the four zones.

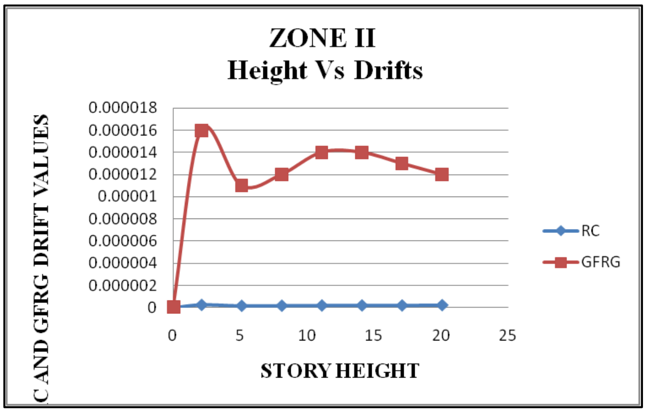


Fig. 22: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for ZONE II.

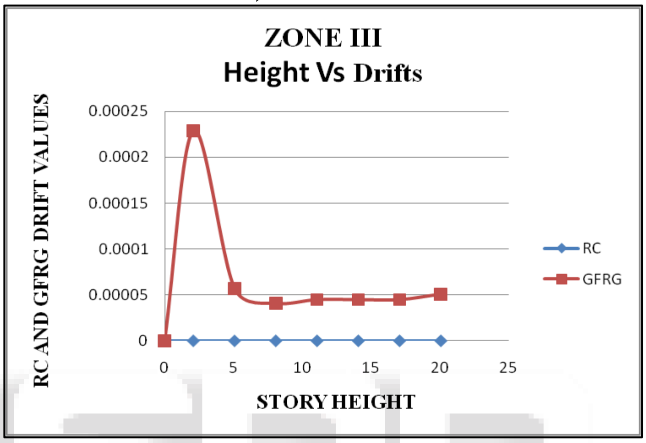


Fig. 23: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for ZONE III.

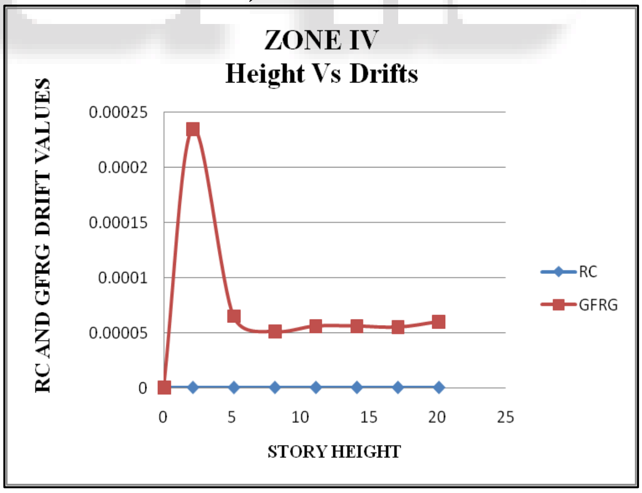


Fig. 24: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for ZONE IV.

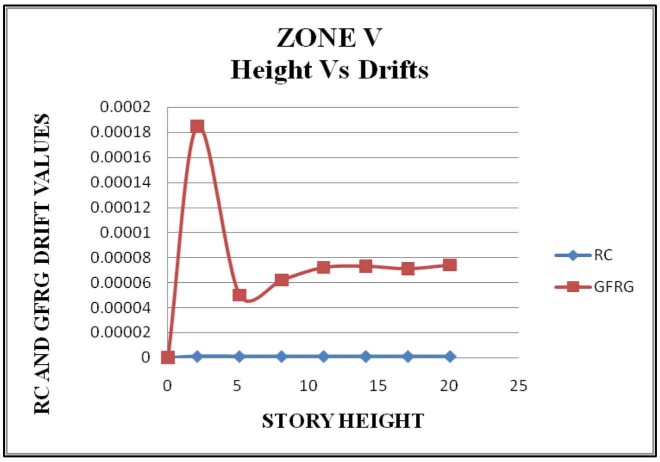


Fig. 25: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for ZONE V.

7) Story Drift for WL-X Direction:

The following graph shows the variation of Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+WL-X) for all the four zones.

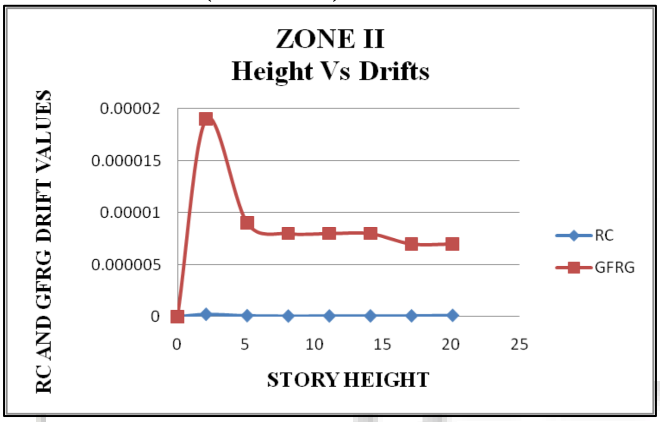


Fig. 26: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+WL-X) for ZONE II.

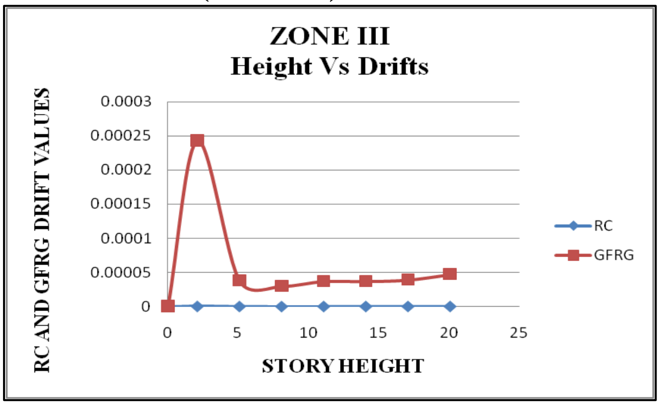


Fig. 27: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+WL-X) for ZONE III.

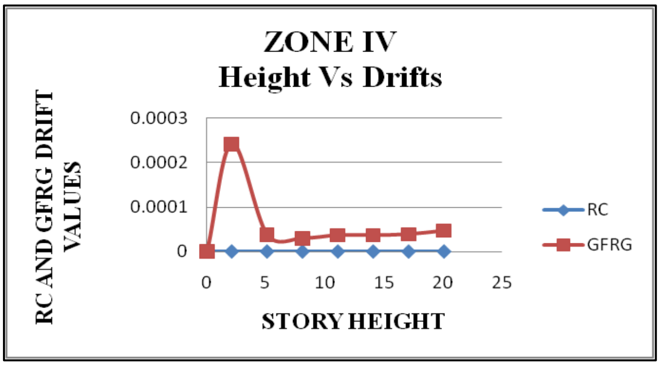


Fig. 28: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+WL-X) for ZONE IV.

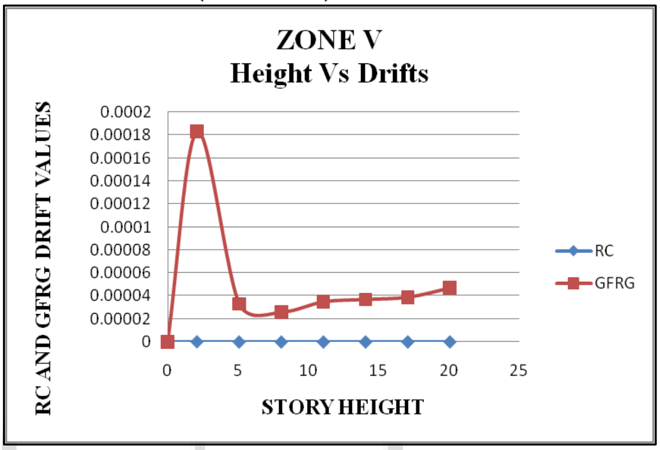


Fig. 29: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+WL-X) for ZONE V.

8) Story Drift for WL-Y Direction:

The following graph shows the variation of Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+WL-Y) for all the four zones.

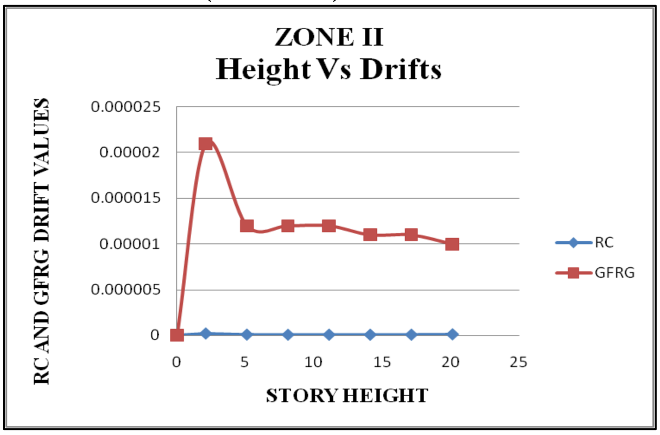


Fig. 30: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+WL-Y) for ZONE II.

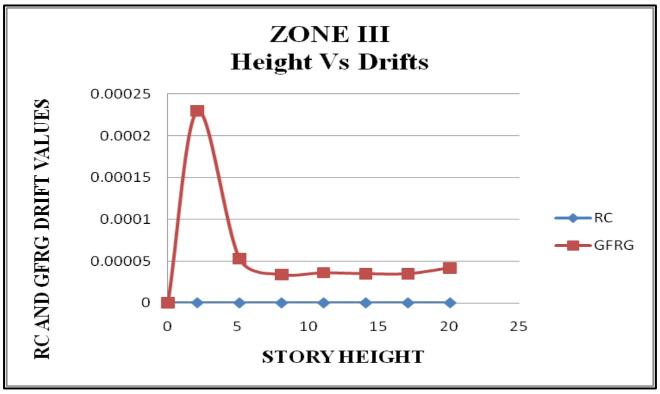


Fig. 31: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+WL-Y) for ZONE III.

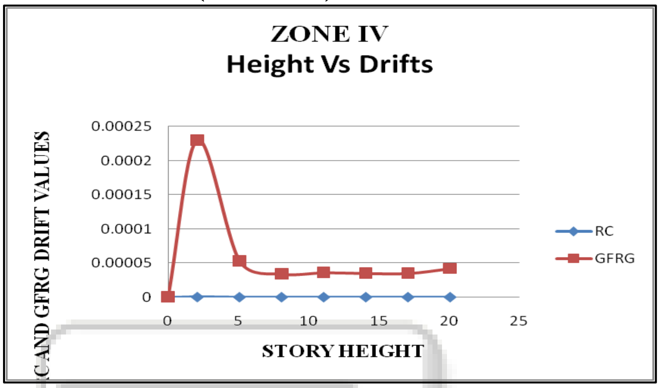


Fig. 32: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+WL-Y) for ZONE IV.

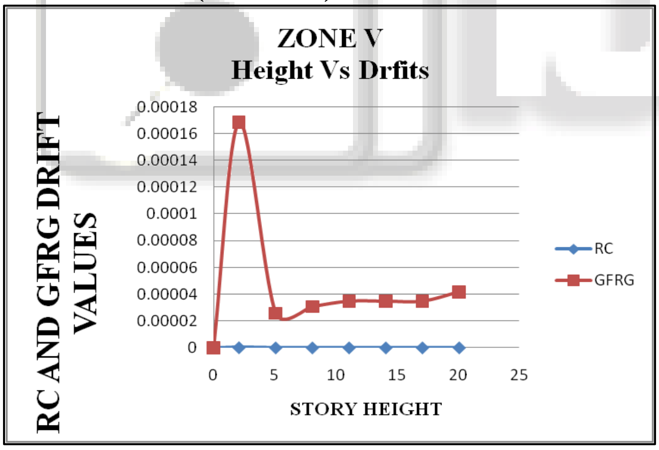


Fig. 33: A Graph with Story Height Vs Story Drifts of RC and GFRG buildings for a load combination of 1.5(DL+WL-Y) for ZONE V.

9) *Story Shear for EQ-X Direction:*

The following graph shows the variation of Story Height Vs Story Shear of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for all the four zones.

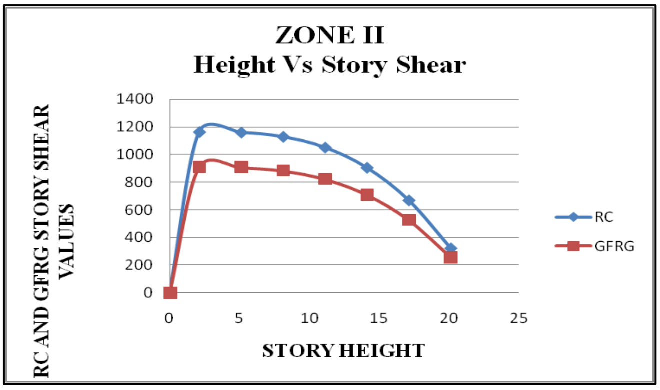


Fig. 34: A Graph with Story Height Vs Story Shear of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for ZONE II.

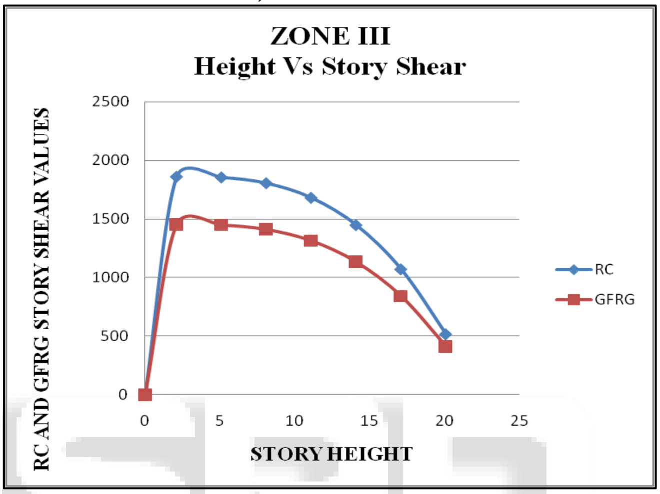


Fig. 35: A Graph with Story Height Vs Story Shear of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for ZONE III.

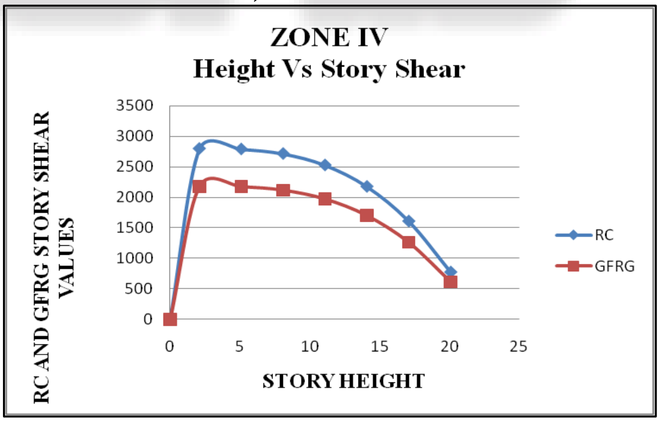


Fig. 36: A Graph with Story Height Vs Story Shear of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for ZONE IV.

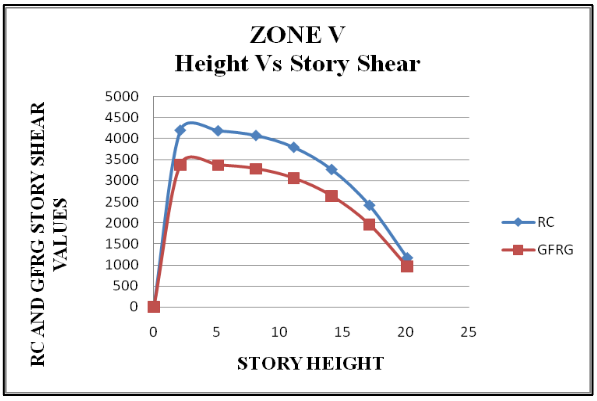


Fig. 37: A Graph with Story Height Vs Story Shear of RC and GFRG buildings for a load combination of 1.5(DL+EQ-X) for ZONE V.

10) Story Shear for EQ-Y Direction:

The following graph shows the variation of Story Height Vs Story Shear of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for all the four zones.

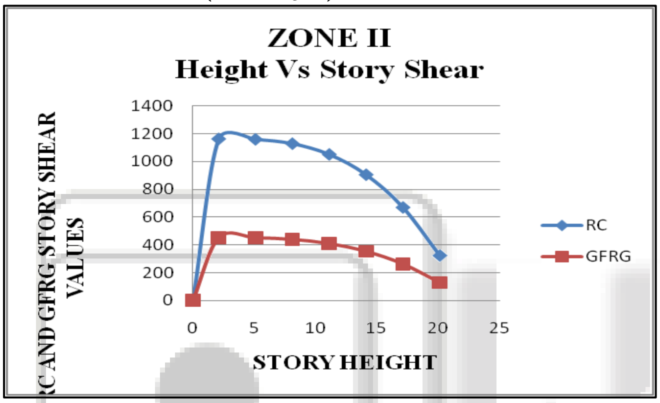


Fig. 38: A Graph with Story Height Vs Story Shear of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for ZONE II.

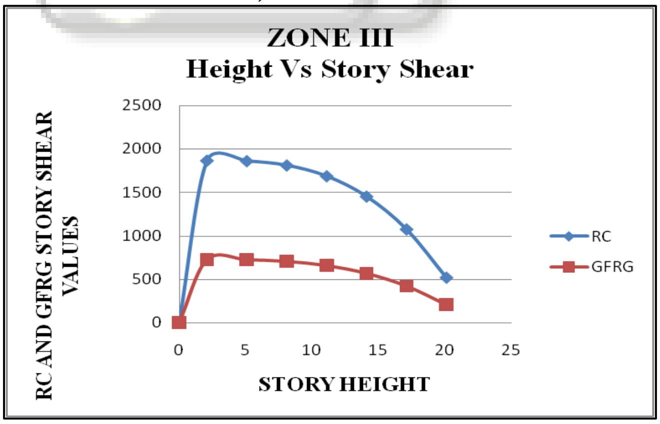


Fig. 39: A Graph with Story Height Vs Story Shear of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for ZONE III.

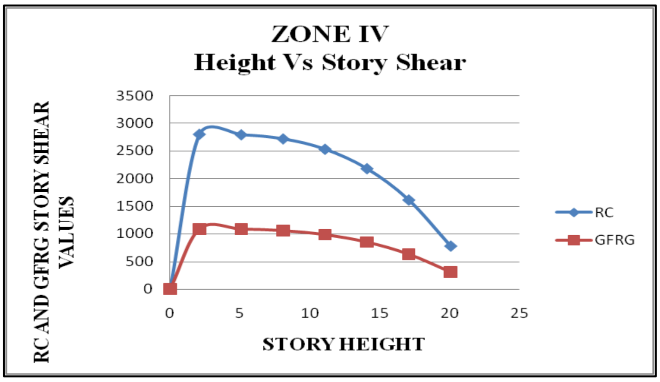


Fig. 40: A Graph with Story Height Vs Story Shear of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for ZONE IV.

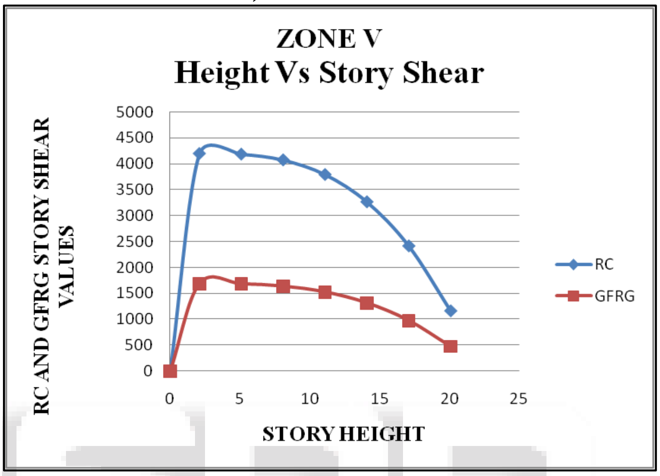
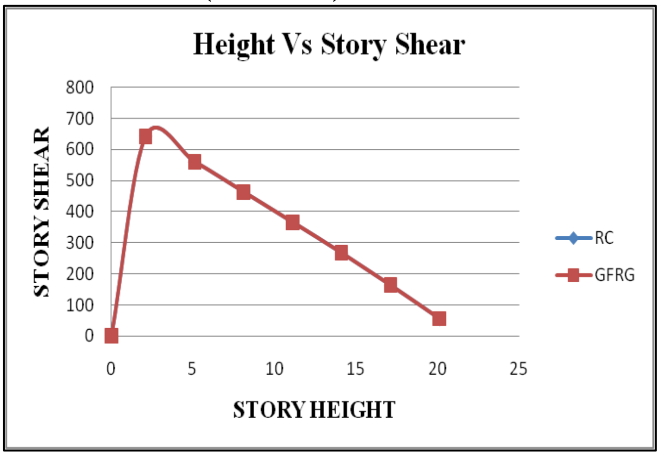


Fig. 41: A Graph with Story Height Vs Story Shear of RC and GFRG buildings for a load combination of 1.5(DL+EQ-Y) for ZONE V.

11) Story Shear for WL-X Direction:

The following graph shows the variation of Story Height Vs Story Shear of RC and GFRG buildings for a load combination of 1.5(DL+WL-X) for all the four zones.



VI. 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.

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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