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Analysis of GFRG Multistoried Buildings with Irregular Horizontal and Vertical Configurations

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Abstract: ***Glass fiber reinforced Gypsum (GFRG) panel is a new building panel product, where there is a tremendous need for cost effective mass-scale affordable housing. GFRG panel otherwise called Rapidwall, is a vitality effective green building material with gigantic potential for use as load bearing and non-load bearing wall panels. They are load bearing panels with cavities suitable for both external and internal walls. It can likewise be used as intermediate floor slab/roof slab in combination with RCC as a composite material. They are not only eco-friendly, but also resistant to termites, heat, rot, corrosion, water and fire. Concrete infill with vertical reinforcement rods enhances its vertical and lateral load capabilities. Comparative studies of low rise, medium rise and high rise GFRG and RC buildings with horizontal irregularity have been carried out in the present investigation. Rapid wall panel provides speedier construction and leads to environmental protection. Subsequently, it is a perfect option building material to replace bricks or concrete blocks. This paper focuses on equivalent static analysis and response spectrum analysis of high rise, medium rise and low rise GFRG and RC buildings with horizontal irregularity to evaluate the maximum displacement and drift.***

Keywords: GFRG panel, horizontal and vertical irregularity, equivalent static analysis, response spectrum analysis, displacement,drift

1. Introduction

Hybrid Masonry Glass fiber reinforced Gypsum (GFRG) panel also known as Rapid wall is a building panel product, made of calcined gypsum plaster, reinforced with glass fibers, used for building construction, was originally developed and used since 1990 in Australia. GFRG panels are made to a length of 12m, height of 3m and thickness of 124mm. The cavities of panels might be unfilled, somewhat partially filled or fully filled with reinforced concrete according to structural requirement. Test studies and research in various countries have exhibited that GFRG panels, suitably filled with plain reinforced concrete has considerable quality to act as load bearing elements as well as shear wall, capable of resisting lateral loads due to earthquake and wind. GFRG panel can likewise be utilized beneficially as in-fills in combination with RCC framed columns and beams with no limitation on number of stories. Micro-beams and RCC screed can be used as floor/ roof slab. A typical cross section of the panel is shown in the Figure 1.

Figure 1: GFRG Panel

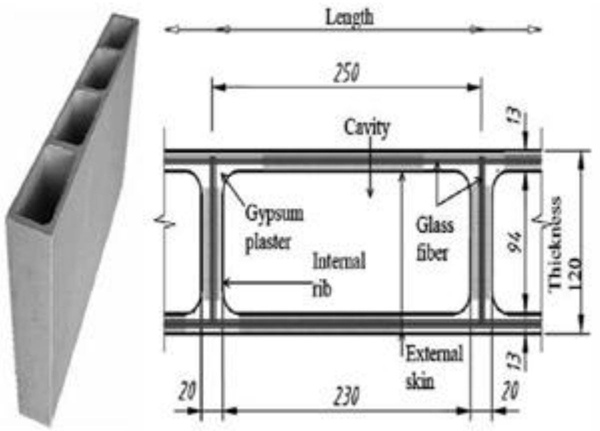

Figure 2: Crossection of GFRG Panel

Use of reprocessed/recycled industrial by product (waste gypsum) to manufacture GFRG panel, helps to abate pollution and protect the environment. It is also suitable for load bearing applications as well as hybrid construction in multi storey buildings. There will be increased speed of construction with less man power, saving of cement, steel, river sand; burnt clay bricks/concrete blocks.

2. Objectives

To compare the performance of GFRG and RC building (high rise, medium rise and low rise) with horizontal and vertical irregularity in Zone III and medium soil conditions.

3. Methodology

The method of analysis used for the present study are
1) Equivalent static analysis
2) Response spectrum method

4. Analysis

4.1 Geometric Modelling of Building

A G+3, G+8 and G+14 storied RC and GFRG building are modeled using ETABS 9.6 software for this study.

Table 1: Dimensional Details of RC Building

Properties	*Details*
Floor Height	3m
Beam Sizes	450 × 450 mm
Column sizes	650 × 650 mm
Concrete Grade	M30
Slab Thickness	125 mm
Grade of Steel	Fe415

Table 2: Dimensional Details of GFRG Building

Properties	*Details*
Floor Height	3m
Tie Beams	200 × 94 mm
Concrete Grade	M30
Slab Thickness	125 mm
Grade of Steel	Fe415
Wall Panel Thickness	124mm

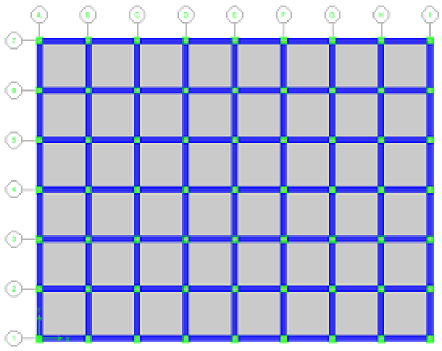

Figure 3: Plan of Rectangular Shaped RC and GFRG Building

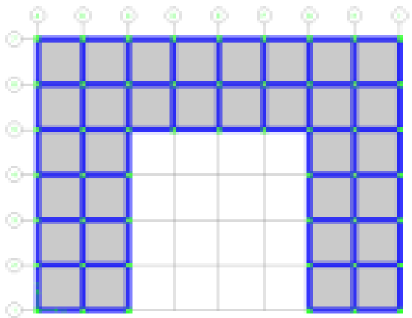

Figure 4: Plan of C Shaped RC and GFRG Building

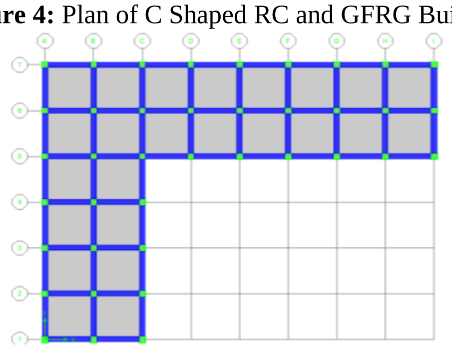

Figure 5: Plan of L Shaped RC and GFRG Building

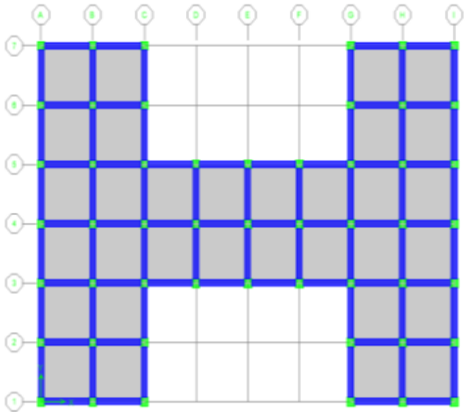

Figure 6: Plan of H Shaped RC and GFRG Building

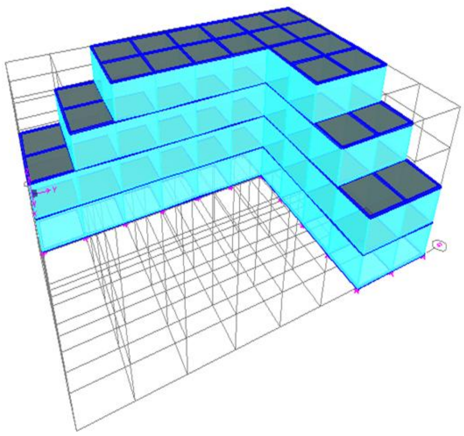

Figure 7: 3D View of GFRG Building

Table 3: Loading Details of RC Building

Loads	*Values*
Wall load	13.8 kN/m
Floor load	4 kN/m^2
Roof load	2 kN/m^2

Table 4: Loading Details of GFRG Building

Loads	*Values*
Floor load	4 kN/m^2
Roof load	2 kN/m^2

Table 5: Earthquake Load Data

Property	*Value*
Seismic zone	III
Soil Type	Medium (Type -2)
Zone Factor ,Z	0.16
Importance factor ,I	1
Response reduction factor, R	5
Damping Ratio	0.05

4.2 Analysis

Equivalent static and response spectrum analysis were carried out in low rise, medium rise and high rise RC and GFRG building with horizontal and vertical irregularities. Maximum displacements and drift in X and Y directions are obtained from the analysis. Displacement and drifts of low rise, medium rise and high rise RC and GFRG building is given table 6 to 11.

Table 4: Displacement and Drift Values of Low Rise RC and GFRG Building by Static Method

Parameters	*Maximum Displacement (mm)*				*Maximum Storey Drift × 10^{-5}*			
	RC		GFRG		RC		GFRG	
	X	Y	X	Y	X	Y	X	Y
C Shape	0.75	0.81	0.02	0.02	7.68	8.55	0.2	0.2
H Shape	0.65	0.63	0.02	0.01	7.78	6.28	0.2	0.1
L Shape	0.77	0.73	0.02	0.02	7.88	7.68	0.2	0.2
Rectangular Shape	0.63	0.60	0.02	0.01	6.27	6.07	0.1	0.1

Table 5: Displacement and Drift Values of Low Rise RC and GFRG Building by Response Spectrum Method

Parameters	*Maximum Displacement (mm)*				*Maximum Storey Drift × 10^{-5}*			
	RC		GFRG		RC		GFRG	
	X	Y	X	Y	X	Y	X	Y
C Shape	0.97	1.10	0.02	0.02	10.47	12.13	0.2	0.2
H Shape	0.87	0.73	0.02	0.01	18.15	10.55	0.1	0.1
L Shape	1.08	0.98	0.02	0.02	19.07	10.67	0.2	0.2
Rectangular Shape	0.74	0.71	0.01	0.01	7.18	6.96	0.1	0.1

Table 6: Displacement and Drift Values of Medium Rise RC and GFRG Building by Static Method

Parameters	*Maximum Displacement (mm)*				*Maximum Storey Drift × 10^{-5}*			
	RC		GFRG		RC		GFRG	
	X	Y	X	Y	X	Y	X	Y
C Shape	6.41	7.30	0.16	0.20	29.82	32.41	0.90	0.6
H Shape	6.44	6.95	0.15	0.13	31.01	26.71	0.99	0.4
L Shape	6.63	7.06	0.20	0.18	31.22	32.32	1.0	0.5
Rectangular Shape	6.18	6.90	0.13	0.10	30.31	32.31	0.8	0.5

Table 7: Displacement and Drift Values of Medium Rise RC and GFRG Building by Response Spectrum Method

Parameters	Maximum Displacement (mm)				Maximum Storey Drift × 10^{-5}			
	RC		GFRG		RC		GFRG	
	X	Y	X	Y	X	Y	X	Y
C Shape	5.82	6.24	0.16	0.17	28.62	32.92	0.7	0.79
H Shape	5.83	5.55	0.13	0.08	28.92	26.73	0.9	0.40
L Shape	6.10	6.03	0.25	0.15	30.52	30.52	1.20	0.79
Rectangular Shape	5.81	5.54	0.10	0.07	28.74	27.53	0.6	0.40

Table 8: Displacement and Drift Values of High Rise RC and GFRG Building by Static Method

Parameters	Maximum Displacement (mm)				Maximum Storey Drift x 10^{-5}			
	RC		GFRG		RC		GFRG	
	X	Y	X	Y	X	Y	X	Y
C Shape	14.0	9.17	0.93	1.03	41.59	43.76	3.49	2.99
H Shape	14.0	8.13	0.67	0.34	45.70	37.30	2.69	1.09
L Shape	16.3	8.39	0.96	0.97	46.07	39.89	2.88	2.89
Rectangular Shape	13.9	8.02	0.64	0.33	47.17	39.38	2.59	1.30

Table 9: Displacement and Drift Values of High Rise RC and GFRG Building by Response Spectrum Method

Parameters	Maximum Displacement (mm)				Maximum Storey Drift × 10^{-5}			
	RC		GFRG		RC		GFRG	
	X	Y	X	Y	X	Y	X	Y
C Shape	8.60	9.17	0.69	0.68	25.63	29.5	2.09	2.09
H Shape	8.72	8.13	0.59	0.33	28.92	25.1	2.49	1.00
L Shape	9.44	8.39	1.01	0.56	29.12	25.6	2.99	1.7
Rectangular Shape	8.60	8.02	0.52	0.32	31.41	25.5	2.19	1.09

5. Results and Discussion

The results obtained after equivalent static and response spectrum analysis of RC and GFRG buildings are compared and plotted in Fig 8 to 13.

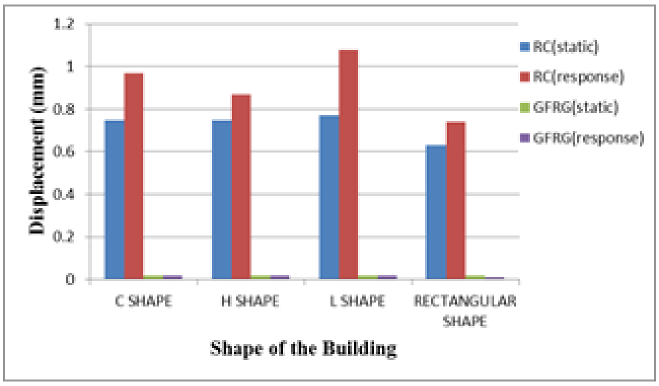

Figure 8: Comparison of Displacement of Low Rise RC and GFRG Building

From Fig 8, it can be seen that the value of maximum displacement for low rise RC building is higher than low rise GFRG building with vertical irregularity. When we considering horizontal and vertical irregularity, H shaped RC building has least displacement value as compared to other shapes. In the case of GFRG building, C, L and H shape has almost same value. And the higher value of displacement is obtained in L shaped RC building

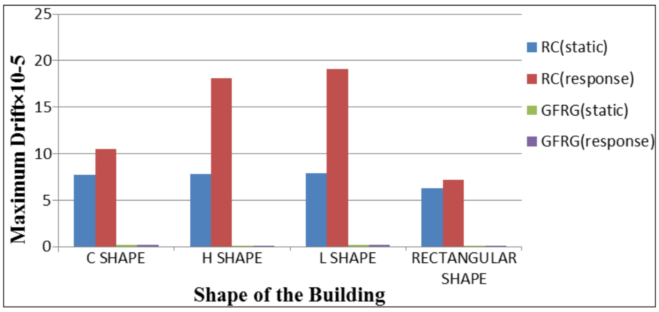

Figure 9: Comparison of Drift of Low Rise RC and GFRG Building

From Fig 9, it can be seen that the value of maximum drift for low rise RC building is higher than low rise GFRG building with vertical irregularity. When we considering horizontal and vertical irregularity, C shaped RC building has least drift value as compared to other shapes. In the case of GFRG building, H shape has least drift value as compared to other shapes. And the higher value of drift is obtained in L shaped building.

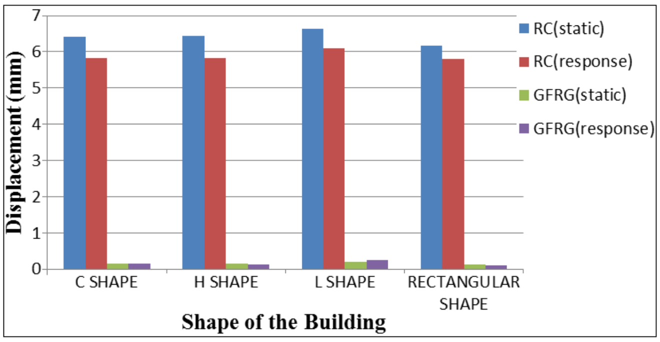

Figure 10: Comparison of Displacement of Medium Rise RC and GFRG Building

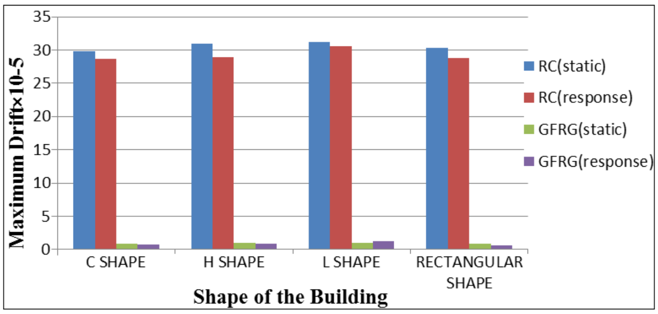

Figure 11: Comparison of Drift of Medium Rise RC and GFRG Building

From Fig10 and Fig 11, it can be seen that the value of maximum displacement and drift for medium rise RC building is higher than medium rise GFRG building with horizontal and vertical irregularity. When we considering horizontal and vertical irregularity, C shaped RC and GFRG building has least drift value as compared to other shapes. And the higher value of drift is obtained in L shaped building.

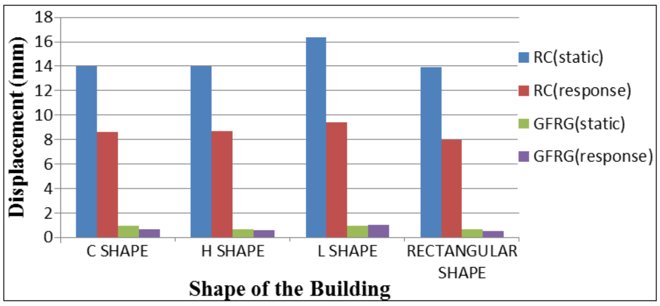

Figure 12: Comparison of Displacement of High Rise RC and GFRG Building

From Figure 12, it can be seen that the value of maximum displacement for high rise RC building is higher than high rise GFRG building with different types of horizontal irregularity. With increasing the height of building, it can be seen that the maximum value of storey displacement occur at the top stories compared to bottom storey. When we considering horizontal and vertical irregularity, C shaped RC building has least displacement value as compared to other shapes. In the case of GFRG building, H shape has least displacement value as compared to other shapes. And the higher value of displacement is obtained in L shaped building.

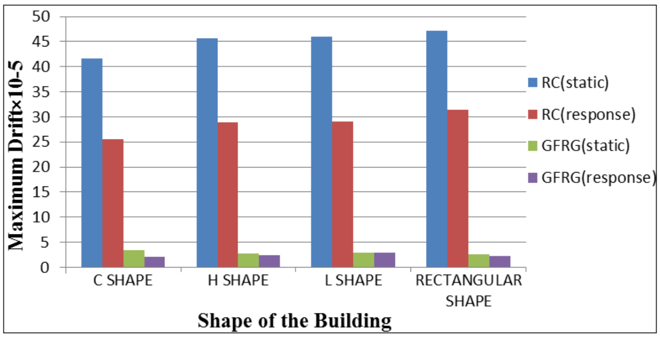

Figure 13: Comparison of Drift of High Rise RC and GFRG Building

From Fig 13, it can be seen that the value of maximum drift for high rise RC building is higher than high rise GFRG building with different types of horizontal irregularity. When we considering horizontal and vertical irregularity, H shaped RC and GFRG building has least drift value as compared to other shapes. And the higher value of drift is obtained in L shaped building

6. Conclusions

The low rise, medium rise and high rise RC and GFRG buildings with horizontal and vertical irregularities were studied. From the above study, following conclusions were drawn.

- Low rise, medium rise and high rise GFRG buildings performs better in terms of least displacement and drift when compared to low rise, medium rise and high rise RC buildings
- Low rise GFRG building performs better with 95% reduction in displacement and drift when compared to low rise RC building.
- Medium rise GFRG building performs with 95% reduction in displacement and drift when compared to medium rise RC building.
- High rise GFRG building performs better with 90% reduction in displacement and drift when compared to high rise RC building.
- Maximum displacement and drift values are higher in response spectrum method as compared to static method for low rise buildings.
- Maximum displacement and drift values are almost same for both static and response spectrum method for medium rise buildings.
- Maximum displacement and drift values are higher in static method as compared to response spectrum method for high rise buildings.
- Results of response spectrum method are more accurate. Response spectrum is based on known seismic activity and static analysis is base shear analysis

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