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Seismic Analysis and Cost Estimation of GFRP and RCC Auditorium Building using ETABS

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Abstract: ***Fibre-reinforced plastic or polymer (FRP) is a composite material made of a polymer matrix reinforced with fibres. Fibre reinforced polymer (FRP) is corrosion resistant, lightweight, high in strength, has good thermal conductive and anti-fire performance and not only has a long lifespan, but it's production can greatly reduce CO2 emissions both through its method of manufacture, plus it's effective thermal insulation qualities. As a consequence, FRP building elements could prove to be one of the newer types of material being used in the construction industry in the near future. Glass Fiber Reinforced Polymer (GFRP) has become a staple in the construction field. It is a recently developed technique used for roofs, facades, panels etc. In this paper the GFRP panel is used for facades and ceilings. In this paper involves comparative study of GFRP and Reinforced concrete building, cost estimation of RCC and GFRP. Equivalent static and response spectrum analysis was carried out using ETABS 2015 Software to evaluate base shear, maximum storey drift, maximum storey displacement, storey stiffness.***

Keyword: ETABS 2015, Equivalent static analysis, facades, GFRP panels, Response spectrum analysis

1. Introduction

Fibre-reinforced plastic or polymer (FRP) is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually carbon, glass, aramid, or basalt. The polymer is usually an vinylester, epoxy or polyester thermosetting plastic and phenol formaldehyde resins are still in use. FRP's are commonly used in automotive, marine, aerospace and construction industries.

Fibre reinforced polymer (FRP) is corrosion resistant, lightweight, high in strength, has good thermal conductive and anti-fire performance and not only has a long lifespan, but it's production can greatly reduce CO2 emissions both through its method of manufacture, plus it's effective thermal insulation qualities. As a consequence, FRP building elements could prove to be one of the newer types of material being used in the construction industry in the near future. GFRP and GFRG are the mostly commonly used composite materials in the construction industry.

At the present study, linear static and response spectrum analysis of a RCC structure is compared with the structure with GFRP Panel.

Figure 1: Pultruded GFRP panel

2. Objective

To study the comparison of GFRP and Reinforced Concrete building by static and dynamic method.

3. Methodology

Equivalent static and response spectrum analysis is adopted.

4. Analysis

4.1 Modelling of Buildings

A Multistoried structure is to be modelled which is irregular and unsymmetrical. Modelling of the structure includes drawing of grid plan in ETABS software. It also includes defining material properties and defining section properties such as beam, column and slab.

4.2 Building Plan and Dimensional Details

An auditorium building is considered with cellar. The dimensional detail of building is given in table 1.

Table 1: Dimensional details of the building model

Zone	III
Soil type	III
Number of floors	G +1
Typical storey height	4.2m
Ground floor height	3.6m
Grade of concrete	M25
Grade of steel	Fe415
Thickness of brick wall	230mm
GFRP wall thickness	300mm
Density of concrete	25 kN/m^3
Density of brick wall	20 kN/m^3
Poisson ratio for concrete	0.2
Poisson ratio for GFRP	0.24

Density of GFRP	17.2597 kN/m^3
Poisson ratio for brick wall	0.15
Response reduction factor	3
Importance factor	1.5
Longer beam	230mm × 450mm
Shorter beam	230mm × 300mm
Circular column	300mm Diameter
Square column	300mm × 300mm

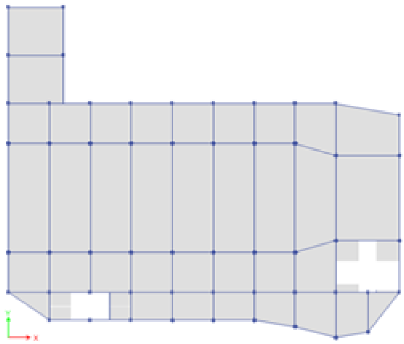

Figure 2: Plan view of the model

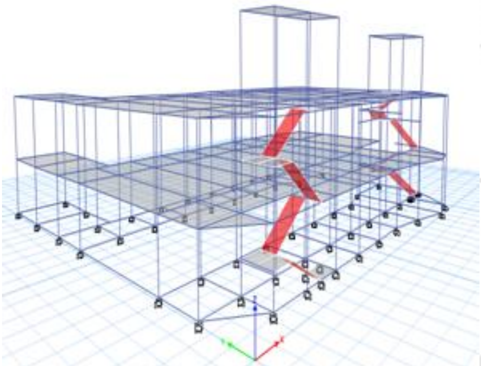

Figure 3: Three dimensional view of the RCC model

Figure 4: Rendered view of the RCC model

Load combination is given as per IS 1893 (Part 1)2002

1)1.5(DL+LL)
2)1.2(DL+LL±EL)
3)1.5(DL±EL)
4)0.9DL±1.5EL

4.3 Analysis

Equivalent static analysis is carried out to investigate base shear, maximum storey drift, maximum storey displacement, storey stiffness.

5. Results and Discussions

The results obtained after linear static and response spectrum analysis of an auditorium building is represented in tables and plotted in graphs.

Table 2: Maximum storey displacement (mm)

Model	Linear static	Response spectrum
RCC	46.10	46.11
GFRP	38.68	37.42

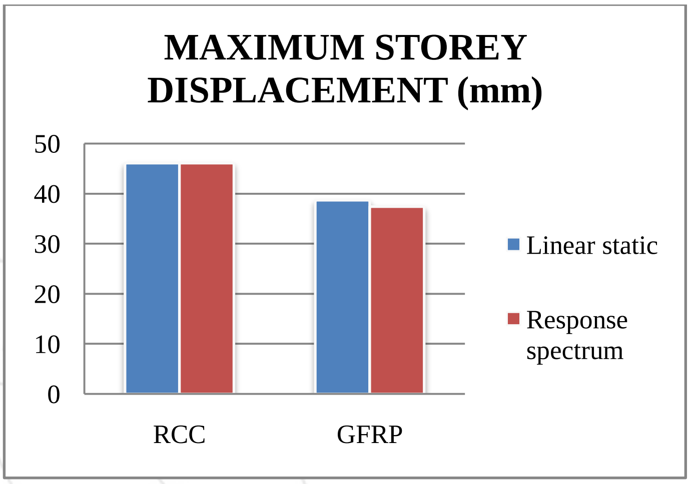

Figure 5: Comparison of maximum storey displacement in RCC and GFRP

Table 3: Storey stiffness (kn/m)

Model	Linear static	Response spectrum
RCC	144309	144461
GFRP	149781	149970

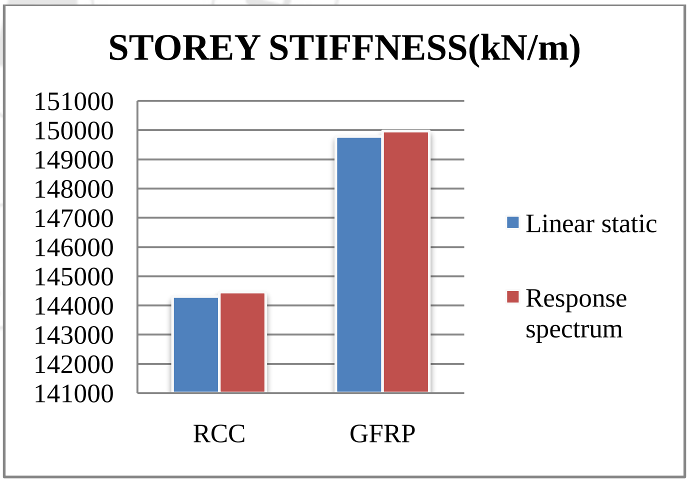

Figure 6: Comparison of storey stiffness in RCC and GFRP

Table 4: Maximum storey drift

Model	Linear static	Response spectrum
RCC	0.005029	0.005029
GFRP	0.0045	0.0048

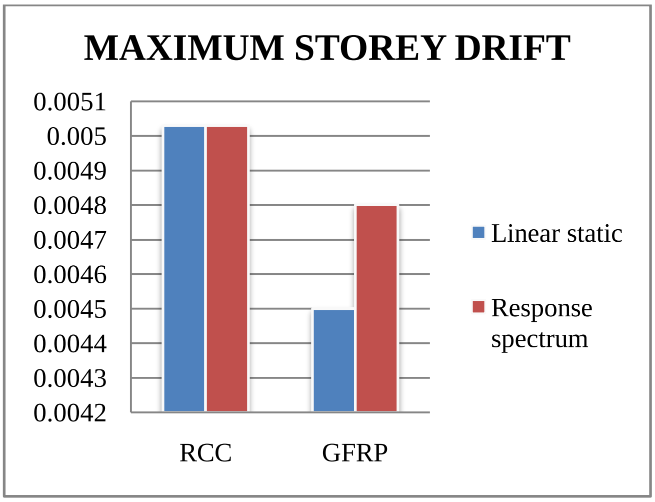

Figure 7: Comparison of maximum storey drift in RCC and GFRP

Table 5: Base shear in linear static analysis (kn)

Force	RCC	GFRP
FX	2215.6462	1752.66
FY	2274.4427	1802.55

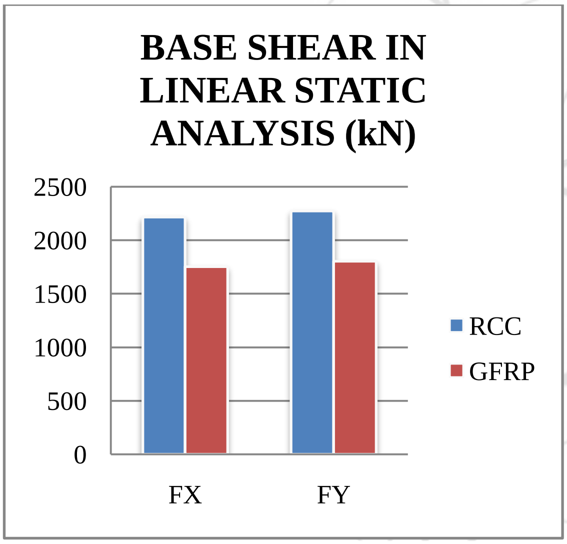

Figure 8: Comparison of maximum base shear in RCC and GFRP by linear static analysis

As we know that the base shear is the maximum lateral force that will occur due to seismic ground motion at the base of the structure. From the tables and graphs it is clear that the base shear for RCC is greater than GFRP model by 26.41% in x axis and 26.17% in y axis respectively in linear static and 29.57% in x axis and 26.73% in y axis respectively in response spectrum analysis. From other parameters like maximum storey displacement, maximum storey drift RCC is greater than GFRP. In storey stiffness RCC is least when compared to GFRP.

Estimation costs of the models i.e. RCC, and GFRP are ₹ 91, 21, 896.99, ₹74, 94202.71, shows that there is significant difference in the total costs of the these models though the actual structure is same. Cost comparison reveals that RCC structure is more costly than GFRP structures and the cheapest structure is the GFRP structure. The total cost of RCC structure greater than GFRP structure by 21.71%.

Table 6: Base shear in response spectrum analysis (kn)

Force	RCC	GFRP
FX	2953.9668	2279.68
FY	2978.6912	2350.28

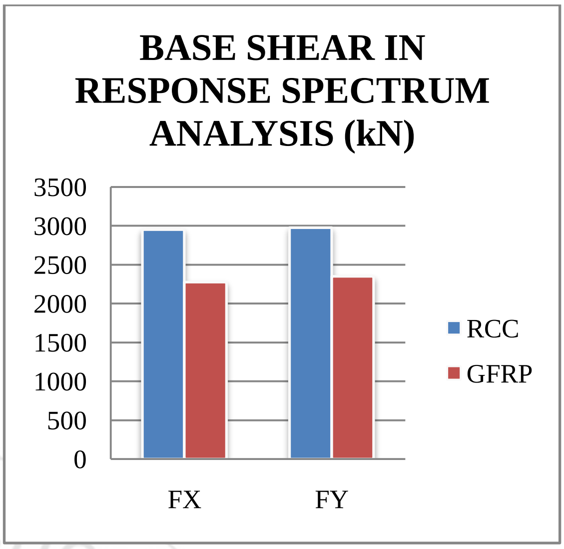

Figure 9: Comparison of maximum base shear in RCC and GFRP by response spectrum analysis

6. Conclusion

The present work deals with the study of GFRP and RCC building and their behavior towards the lateral loads. From the analysis results for GFRP and RCC building indicates that:

- GFRP is a good material when compared to RCC with respect to easy to use, economic, fire resistance, corrosion etc
- According to maximum storey drift, displacement, base shear, storey stiffness GFRP is better than RCC
- Hence while considering both the structural and economic point of view, GFRP structure is more satisfactory and performance wise better than RCC structure.

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