Analytical Study on Performance of FRP Diagrid Structures Under Seismic Loading

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Abstract- *Structural design of high rise building is mainly governed by lateral forces due to seismic and wind load. Usually braced frame, shear wall and their combination with frames are used to resist the lateral forces. In recent study, diagrid structural system is used to resist lateral forces. The materials generally used as diagrids are steel, concrete and composite materials. In this study four different fibre reinforced polymers are used as diagrids. The shape of diagrid considered is circular with different diameters. A 36 storey building has been analysed for seismic loading condition. Structure is modelled and analysed through ETABS software.*

Keywords- Diagrid structural system, ETABS, Fiber reinforced polymer, Storey drift, Storey displacement, Storey forces

I. INTRODUCTION

Diagonally braced structural system is becoming a hall mark of 21st century modernism. Diagrid is a type of space truss. It is preferred for its structural efficiency. Diagrids look aesthetically good because of its unique geometrical configuration. It consists of a grid around the periphery of the building made up of series of triangular truss system, so that the structure becomes statically determinant.

At this time of increasing global warming and environmental pollution we know that construction industry is contributing a significant part of it, so there is a need for an energy efficient structural material. Fiber reinforced materials requires less energy for the production compared to concrete and steel. As the fiber reinforced material is low density material which makes the structure light weight. Structure being light weight has a lot of advantages in resisting lateral forces. The performance may be in terms of lateral storey displacement, storey drift and base shear etc,.

II. METHODOLOGY

The methodology adopted is as given below:

1. Design and procurement of material properties.
2. Modelling of diagrids.
3. Calculation of loads.
4. Assessment of performance of building using Etabs.

1. DESIGN OF MODEL: The dimensions of the building is 36m X 36m in plan and has 36 storeys. The total height of the building is 129.6m. The beams B1, B2 and B3 are spaced at 3 meters centre to centre. B1 and B3 are ISMB550 and B2 is ISWB600 with top and bottom plate of 220X50mm. The angle of inclination of diagrid is 74.5^0 with the horizontal. Here three floors together make a single triangular diagrid module. There are four built up columns at the centre. The column has two I sections placed at certain distance and a cover plate of 50mm connecting the flanges of the I section. Overall dimension of each column is 1400mm x 1400 mm.

1.2. PROCUREMENT OF MATERIALS: There are four types of materials used in the study:

1. Basalt Fibre Reinforced Polymer (BFRP).
2. Carbon Fibre Reinforced Polymer (CFRP).
3. Hybrid Fibre Reinforced Polymer(HFRP).
4. Glass Fibre Reinforced Polymer (GFRP).

2. MODELLING OF DIAGRID: Diagrid is modelled in Etabs software as per the specifications of building mentioned above.

3. CALCULATION OF LOADS: Loads considered for the analysis of the diagrid building are:

1. Self-Weight Of The Structure.
2. Dead Load And Live Load: The dead load acting on the floor is assumed to be 3.75 kN/m^2 and the imposed load is calculated as per IS 875 part 2.
3. Seismic Load: Seismic load is calculated as per IS:1893-2002 Part1. Its calculated for Bangalore region.

3.1.LOAD COMBINATIONS: The load combinations taken are as shown below:

1. 0.9DL-1.5EX
2. 0.9DL-1.5EY
3. 0.9DL+1.5EX
4. 0.9DL+1.5EY
5. 1.2(DL+LL+EX)
6. 1.2(DL+LL+EY)
7. 1.2(DL+LL-EX)
8. 1.2(DL+LL-EY)
9. 1.5(DL+LL)
10. 1.5(DL+EX)
11. 1.5(DL+EY)
12. 1.5(DL-EX)
13. 1.2(DL-EY)

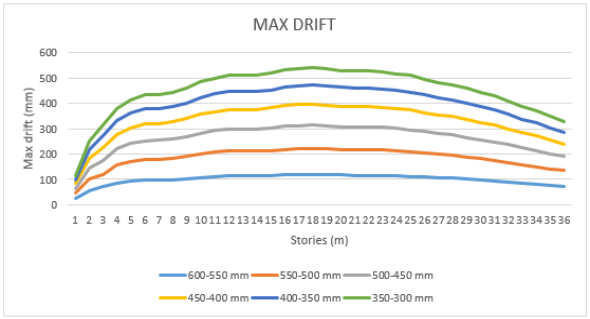
4. ASSESSMENT AND COMPARISON OF BUILDING PERFORMANCE: Performance of the building is compared in terms of storey displacements, storey drifts, storey forces.

III. RESULTS AND DISCUSSION

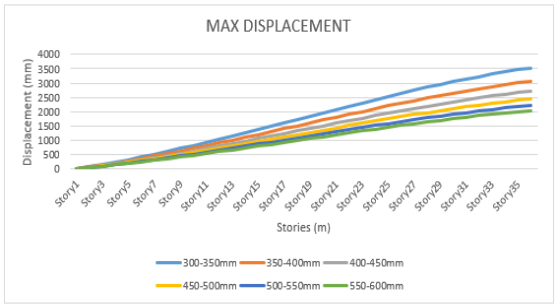
The following results were observed after the complete analysis of the modelled structure. The results of storey drift, storey displacement and storey forces are graphically represented.

1 .BASALT FRP DIAGRID

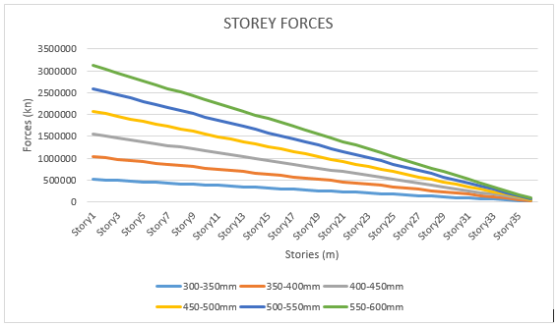
STOREY DRIFT



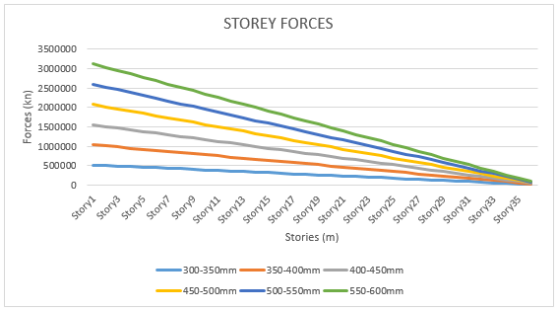
STOREY DISPLACEMENT



STOREY FORCES
TOP STOREY

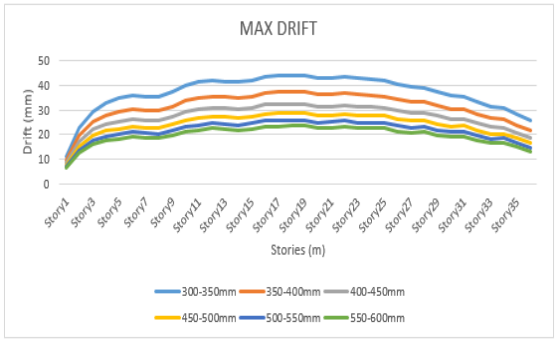


BOTTOM STOREY

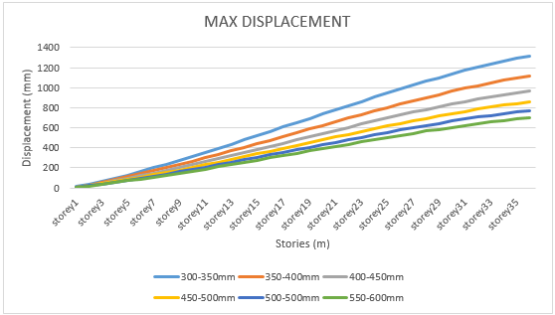


2. CARBON FRP DIAGRID

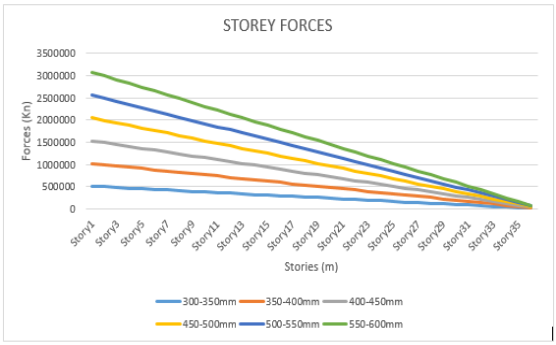
STOREY DRIFT



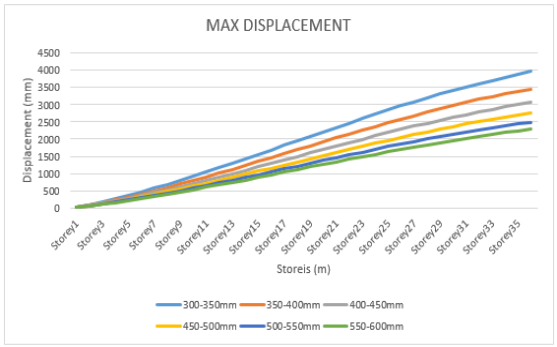
STOREY DISPLACEMENT



STOREY FORCES
TOP STOREY



STOREY FORCES
TOP STOREY



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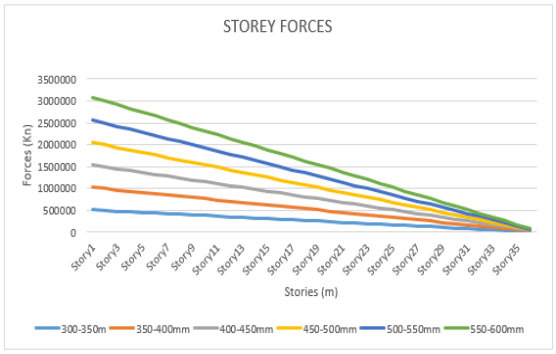

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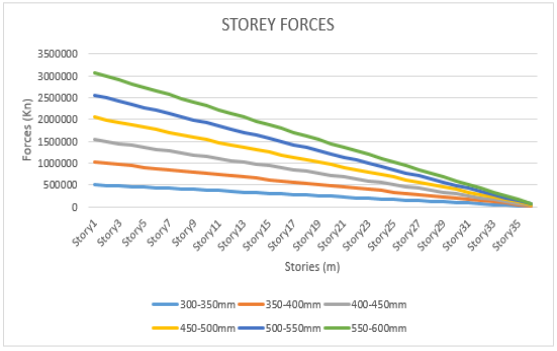
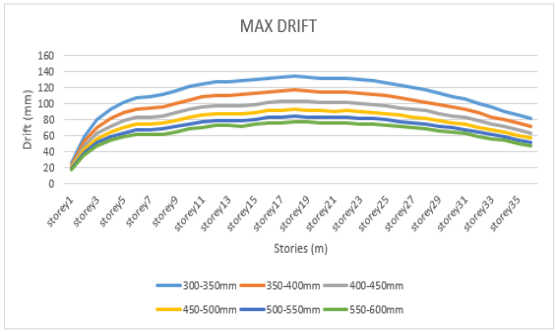
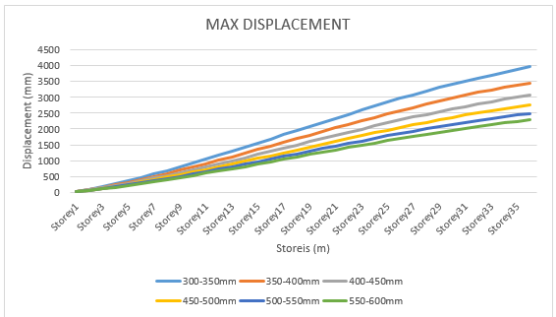


3. GLASS FRP DIAGRID

STOREY DRIFT

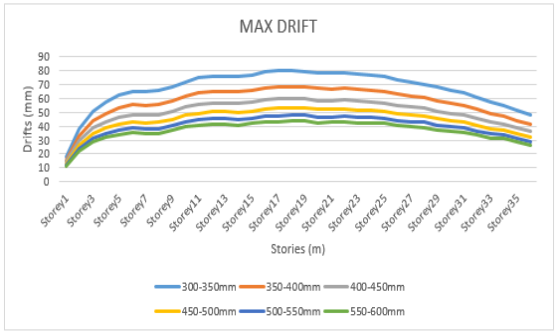


STOREY DISPLACEMENT

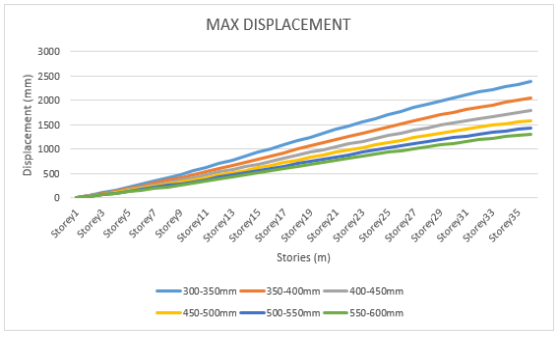


4. HYBRID FRP DIAGRID

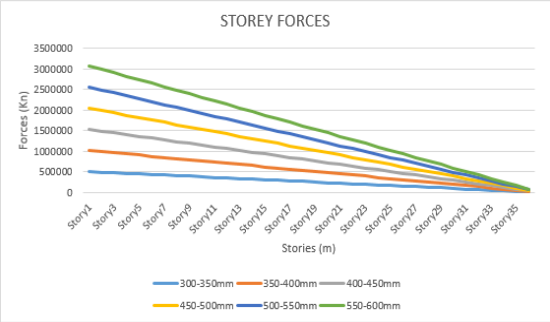
STOREY DRIFT



STOREY DISPLACEMENT



STOREY FORCES
TOP STOREY



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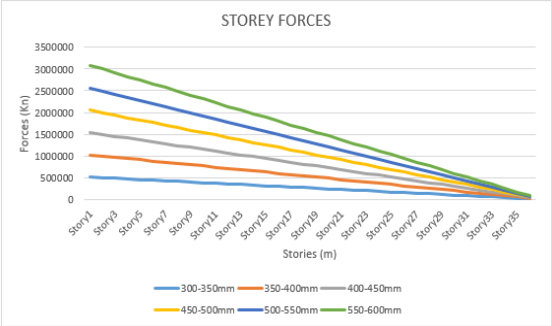

IV. CONCLUSION

The study is concentrated on suggesting best material for diagrid members. The following conclusions are drawn on the basis of analysis conducted on the diagrid building.

1. Diagrid with CFRP material as the bracing element shows minimum displacement and GFRP material shows maximum, this may be due to high value of elastic modulus of CFRP material.
2. Maximum storey drift is minimum for CFRP diagrid and maximum for BFRP building. Diagrids with circular cross section of diameter 400-450mm and 450-500mm shows optimum deflection compared to other diameter.
3. Storey forces increases with increase in diameter.

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