Analysis of Diagrid Structures under Seismic Loading

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Abstract - Diagrids are one of the innovative methods to design tall buildings due to lack of land, development in finance, advancement in frame works etc. Diagrids are helpful especially in extreme seismic zones which are governed by lateral loads, to resist such loads, the peripheral columns are replaced with diagonal columns. The current paper analysed the behaviour of diagrid structure with angles of 55˚, 65˚ and 75˚ under seismic zone 3 consisting of G+13 storey building in comparison with conventional building, using ETABS software under response spectrum analysis. With reference to IS 456 and IS 1893 part 1.

Key Words - Diagrid, Response Spectrum Analysis, ETABS, Displacement, Base Shear.

I. INTRODUCTION

Recent financial developments have led to a tendency toward structures with mechanical development, improvements in fundamental structures, urban settlements, and the human impulse to build higher. As a structure get taller, lateral factors like earthquake forces and wind load affect the building during its service life affecting the design criteria. The use of a diagrid structural system comprising of angled columns on the exterior, is one of the most efficient ways minimise lateral stresses. The structure allows them to resist lateral forces acting as axial members. A diagrid is a framework used for construction of beams and a roof that consists of diagonally positioned metal, concrete, or timber beams. A structural system that is unique in thickness and obtains its structural integrity through triangulation is referred to as a "Diagrid," a combination of the words "diagonal" and "grid." They frequently use crystalline shapes or curvature to boost their stiffness, and they can be planar, crystalline, or take on various curvatures. The diagonal members are diffusely spread resulting in closely spaced diagonal elements and permitting the complete elimination of the conventional vertical columns, while the perimeter configuration still holds for maintaining the maximum bending resistance and rigidity, the diagrids serves as both inclined columns and bracing components, carrying gravity loads as well as lateral forces. Below Figure.1 is one of the examples of diagrid structure.

Fig.1 I-Building, Hyderabad

II. METHODOLOGY

1. Description of Model

The model consists of G+13 storey conventional RCC structure and the diagrids of 55˚, 65˚, and 75˚of 36mx36m regular plan. The analysis is carried using ETABS software under response spectrum analysis for zone 3 of zone factor 0.16 in accordance with IS 1893 part 1. Then the obtained results from the response spectrum analysis are compared for diagrids of 55˚, 65˚, and 75˚ with respect to conventional RCC structure for storey displacement, storey drift and base shear.

2. Properties of Structural Members

Model Data

Area of plan - 36mx36m
Height of the building - 43.5m
Height of intermediate floors - 3m
Inclination of diagrid structures – 55˚, 65˚ and 75˚

Material Properties

Grade of Concrete - M30
Grade of Reinforcing Steel - HYSD500

Structural Members Dimensions

Beams - 400mm x 600mm
Columns - 750mm x 750mm
Diagrids - 500mm x 500mm

Loads Assigned
Typical live load -2 kN/m^2
Roof live - 1.5 kN/m^2
Floor finish - 1.5 kN/m^2
Seismic Parameters
Seismic zone - V
Seismic zone factor – 0.36
Soil type - Medium (II)
Response reduction factor - 5
Importance factor - 1
Time period - Program calculated
3. Models Considered for Analysis in ETABS Software

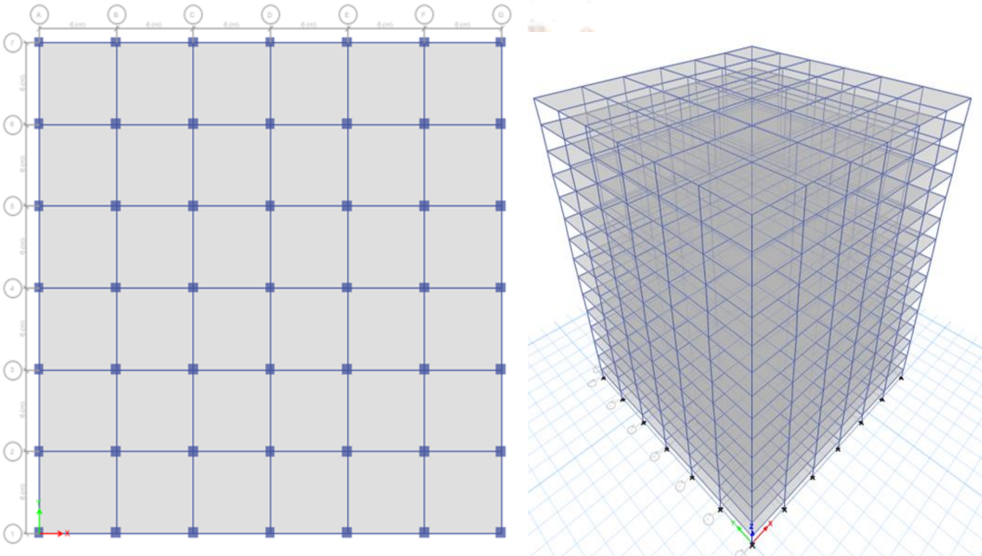

Fig.2 Plan and 3D view of conventional RCC structure

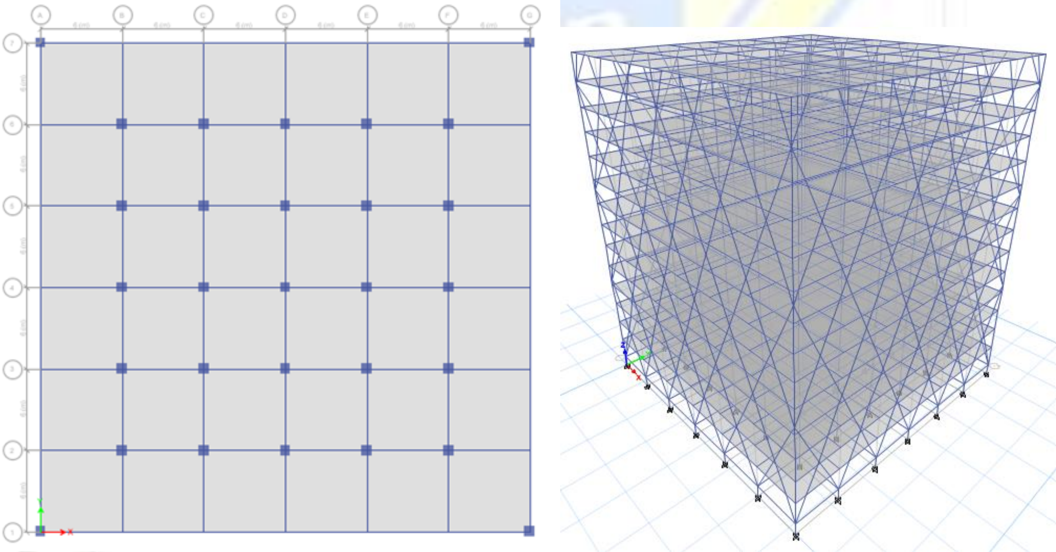

Fig.3 Plan and 3D view of diagrid structure

III. RESULTS AND DISCUSSIONS

1. Storey Displacement

The displacement results for all the models are plotted as shown in the [Figure 4] the results for the models with varying angles are extracted and the outcomes are compared with each other to know the most efficient model under seismic zone 3. The maximum displacement is found to be 20.66mm for conventional RCC structure and minimum of 8.094mm for diagrid structure for angle 55º The percentage reductions is found to be 60.82% when compared with conventional RCC structure.

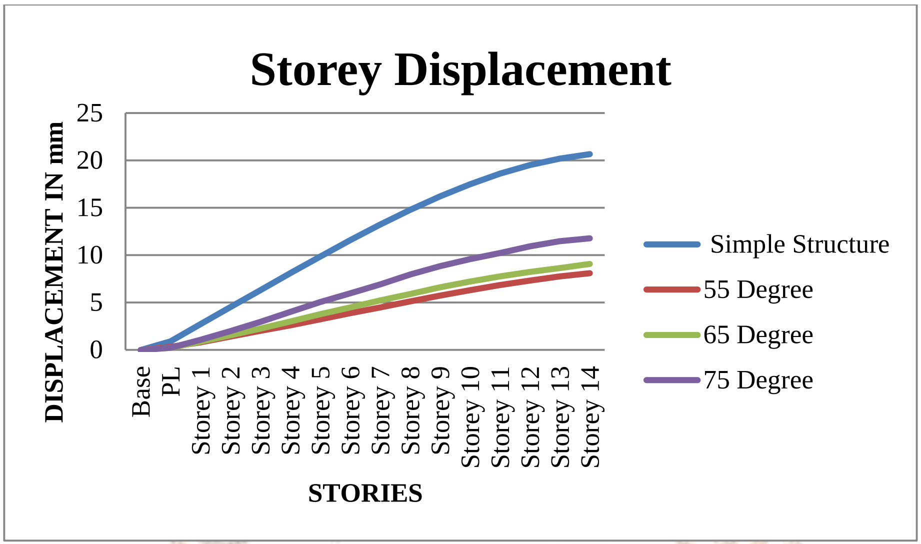

Fig.4 Storey Displacement in Zone 3

2. Storey Drift

The storey drift results are plotted as shown in [Figure 5] for seismic zone 3. The storey drift values for diagrid structure shows complete different pattern mainly due to change in structural arrangement and the angle of exterior columns. It is observed that storey drift values are more in conventional RCC structure than diagrid structures. The percentage reduction for storey drift was found to be 64.62%.

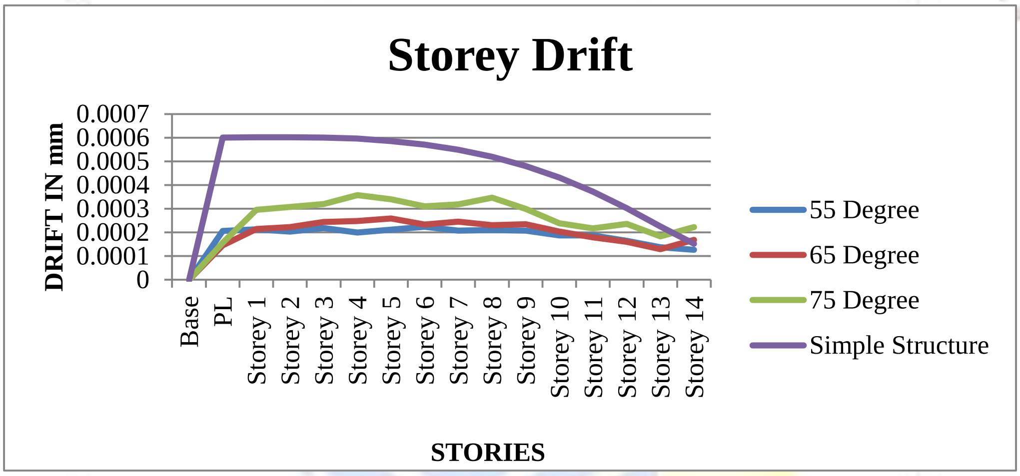

Fig.5 Storey Drift in Zone 3

3. Base Shear

Base shear is measurement of the expected lateral impact load caused by seismic waves on the base of the structure. The base shear results are plotted as shown below in [Figure 6] for seismic zone 3.The base shear value in conventional RCC structure is less than diagrid structure. The maximum base shear is found to be 7649.1785kN for diagrid structure for angle 55º and minimum of 2808.8366kN for conventional RCC structure. The maximum base shear value implies that the structure is more rigid, thus having better seismic performance.

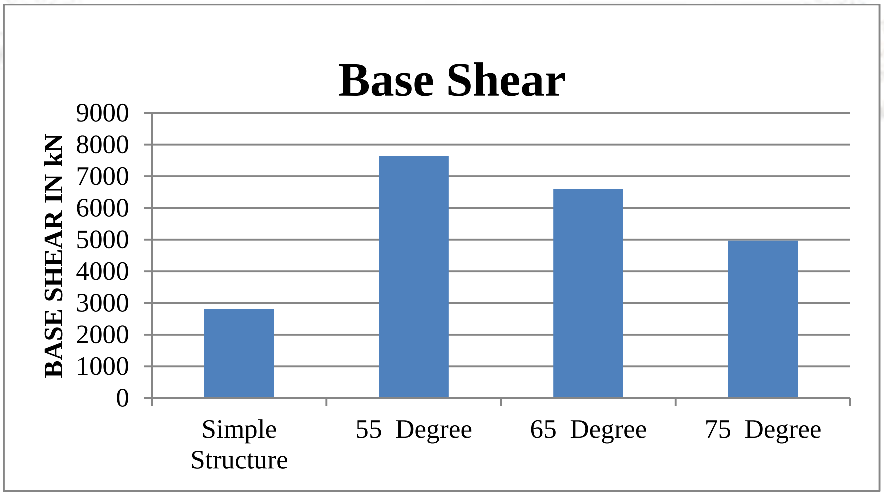

Fig.6 Base Shear in Zone 3

IV. CONCLUSIONS

We can observe that the storey displacement and storey drift is found to be minimum in diagrid structure which indicates that the diagrids can resist the lateral forces acting on the structure better than conventional RCC structure, whereas the base shear is found to be maximum for diagrid structure which indicates that the stricture is more rigid. The optimal angle is found to be 65º. As an outcome we may conclude that by using lateral force resisting system such as diagrids with optimal grid angle, improves the overall structural stability, safety and efficiency against lateral forces which are caused by earthquake.

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