Effect of Module Variation In Diagrid Structural System For High Rise Concrete Building

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Abstract- *Advancement in construction techniques, increasing population density and limited availability of land has shifted the focus of Civil Engineers towards the construction of tall structures. Structural design of high rise building is governed by lateral loads due to wind or earthquake. Lateral load resistance of structure is provided by interior structural system or exterior structural system. Usually shear wall core, braced frame and their combination with frames are interior system, where lateral load resisted by centrally located elements. While framed tube, braced tube structural system resist lateral loads by elements provided on periphery of structure. It is very important that the selected structural system is such that the structural elements are utilized effectively while satisfying the design requirements. Recently diagrid structural system is being adopted in tall buildings due to its structural efficiency and flexibility in architectural planning. Compared to closely space vertical columns in framed tube, diagrid structures consist of inclined columns on the exterior surface of building.*

The present study is aimed to understand the different structural aspects related to this system. Linear dynamic analysis of different structures has been performed in ETABS using response spectrum method. Analysis results in terms of top storey displacement, inter-storey drift, base shear and time period have been compared to understand the variations. Firstly, a comparison between diagrid and conventional system has been studied to depict the advantages of a diagrid system. The effectiveness of a diagrid structure mainly depends upon its module size. Hence, it becomes necessary to study the effect of module variation on different analytical parameters. Therefore structure of height 12 storeys with variation in module as 2-storey, 4-storey and 6-storey have been studied.

Keywords- Diagrid system, Conventional structure, ETABS, Module size, Response spectrum analysis, Story displacement, Inter storey drift, Base shear.

I. INTRODUCTION

The rapid increase in population and scarcity of land has increased the demand of taller building. Expanding the building vertically seems to be an efficient option considering all the factors. As the building height increases role of lateral load (Wind and Seismic) resisting systems become more prominent as compare to gravity load resisting system. Basically there are three main types of buildings: steel building, reinforced concrete building, and composite building. Innovative framing systems and modern design method, improved fire protection, corrosion resistance, fabrication, and erection techniques combined with the advanced analytical techniques made possible by computers, have also permitted the use of steel in just any rational structural system for tall buildings.

Besides this, when compared to steel, reinforced concrete tall buildings have better damping ratios contributing to minimize motion perception and heavier concrete structures offer improved stability against wind loads. A classification of structural system for the tall buildings as;

- Rigid frame systems
- Braced and shear Walled Frame systems
- Outrigger system
- Tube systems:
  - a) Framed-Tube systems
  - b) Braced-Tube systems
  - c) Bundled-Tube systems
- Diagrid structural systems

II. OBJECTIVES OF THE WORK

The objectives of present work are:-

1. To review the existing literature related to diagrid structural system.
2. To study the effectiveness of Diagrid structural system over conventional system.
3. To study the effect of module variation vertically on different parameters of Diagrid Structural system.

III. MODELLING AND ANALYSIS

This part has been divided into two parts. In the first part a comparison has been shown between a diagrid structural system and a conventional system. Second part covers the study of effect of module variation vertically in a diagrid structural system.

Building Configuration

- Plan Dimension :- 21 m X 21 m
- Story Height :- 3.2 m
- Shear Wall Core Dimensions :-7 m X 7 m
- External to Core Distance :- 7 m
- Number of stories :- 12 Stories

Load Definitions

- Dead load: - Self weight of the structure.
- Superimposed load due to finishing etc.:- 1 kN/m^2
- Live Load:- 3 kN/m^2
- Earthquake in X-direction:- As per IS 1893:2002
- Earthquake in Y-direction:- As per IS 1893:2002
- Wind load:- As per IS 875 (Part 3)

Earthquake force data:

- Response reduction factor, R:- 5
- Seismic zone:- IV
- Seismic zone factor, Z:- 0.24
- Soil type:- II
- Importance factor:- 1
- Time period:- Program calculated

Etab Models

Conventional and Diagrid Structure

Structure	Conventional	Diagrid
Beams	250X400, 250x350, 250x300	250X400, 250x350, 250x300
Exterior Columns	400X400	300X300
Interior Columns	600X600	600X600
Shear Wall	200 mm thick RCC	200 mm thick RCC
Slabs	150 mm thick RCC	150 mm thick RCC

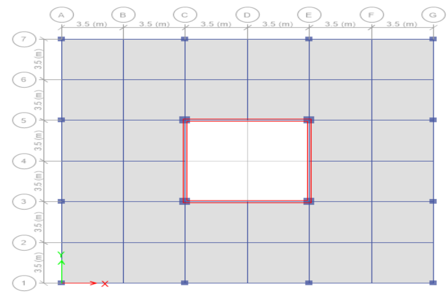

Fig.1 Plan of Conventional Structure

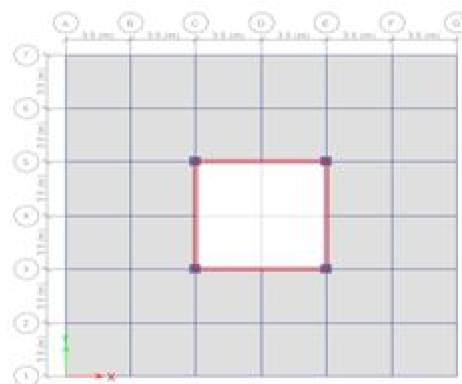

Fig. 2 Plan of Diagrid Structure

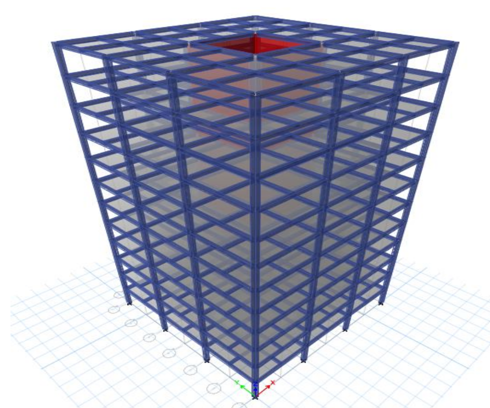

Fig. 3 3D of Conventional Structure

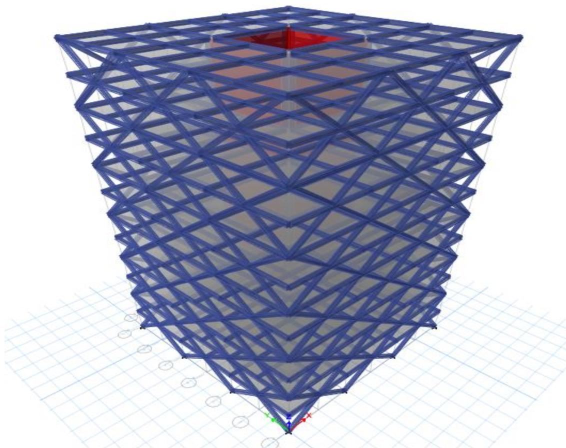

Fig. 4 3D of Diagrid Structure

Diagrid Structure with different story module

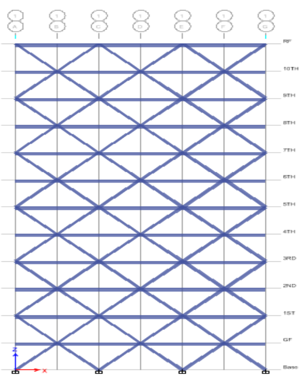

Fig. 5 Elevation of 2-Storey Module

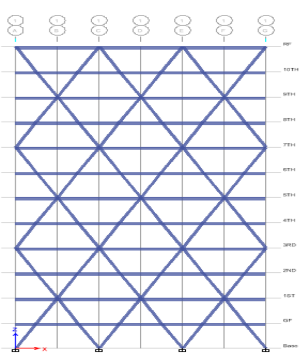

Fig. 6 Elevation of 4-Storey Module

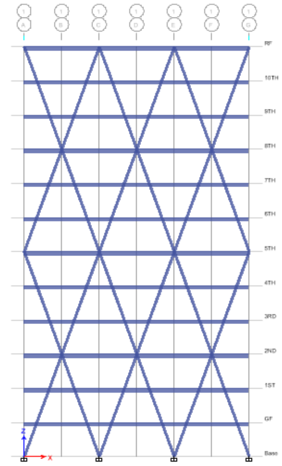

Fig. 7 Elevation of 6-Storey Module

IV. RESULT AND DISCUSSION

Comparative study between a diagrid and a conventional frame system

Parameters	Conventional Frame	Diagrid System
Maximum top storey displacement (mm)	8.1	6.3
Maximum Inter-Storey Drift ratio	0.000269	0.000206
Base Shear V_b (kN)	1849.97	2080.65
Maximum Time Period (s)	0.604	0.503

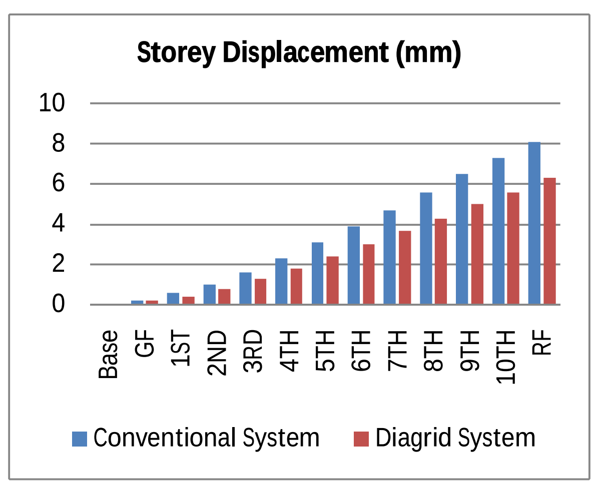

Fig. 8 Storey Displacement (mm)

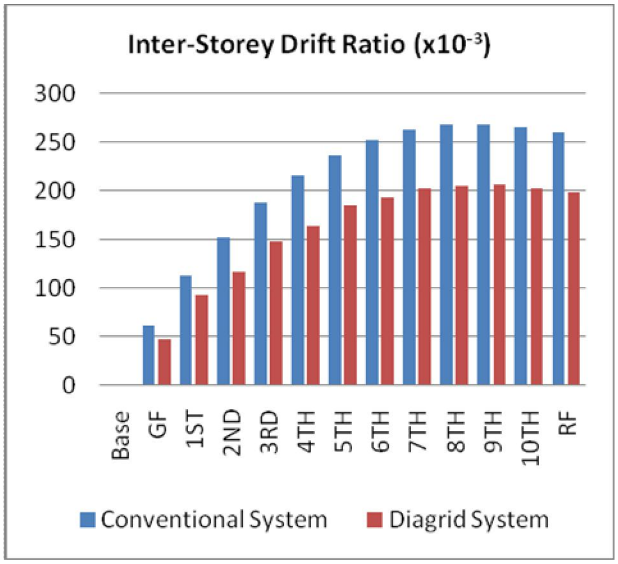

Fig. 9 Inter-Storey Drift Ratio (x10^{-3})

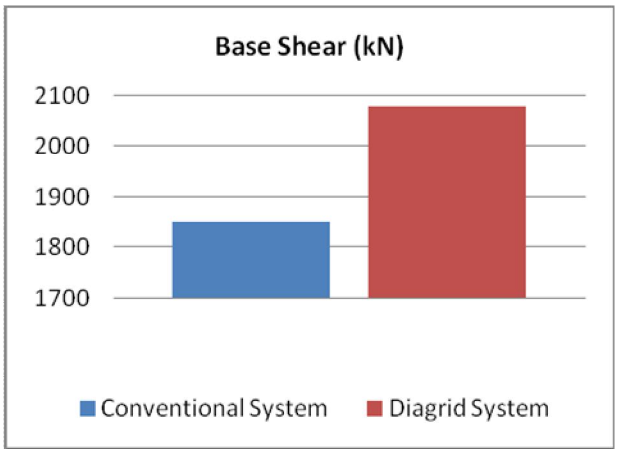

Fig. 10 Base Shear (kN)

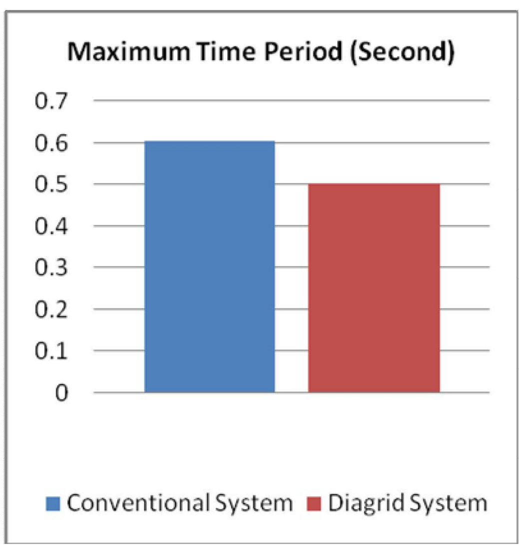

Fig. 11 Maximum Time period (Second)

Effect of Module Variation in a Diagrid System

Parameters	2-Storey Module	4-Storey Module	6-Storey Module
Maximum top storey displacement (mm)	6.3	5.3	6.2
Maximum Inter-Storey Drift ratio	0.000206	0.000171	0.000205
Base Shear V_b (kN)	2080.65	2039.86	2030.87
Maximum Time Period (s)	0.503	0.470	0.498

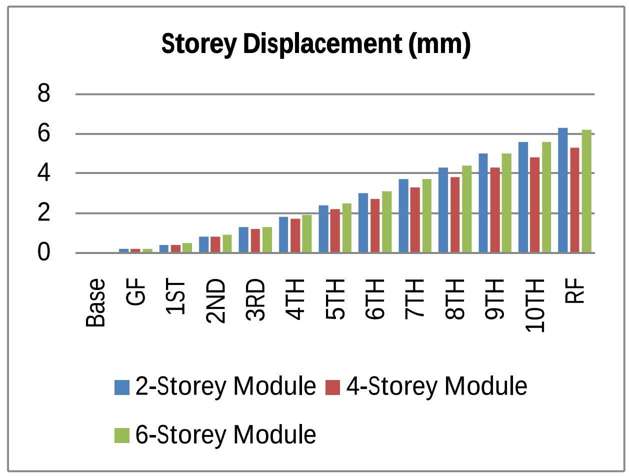

Fig. 12 Storey Displacement (mm)

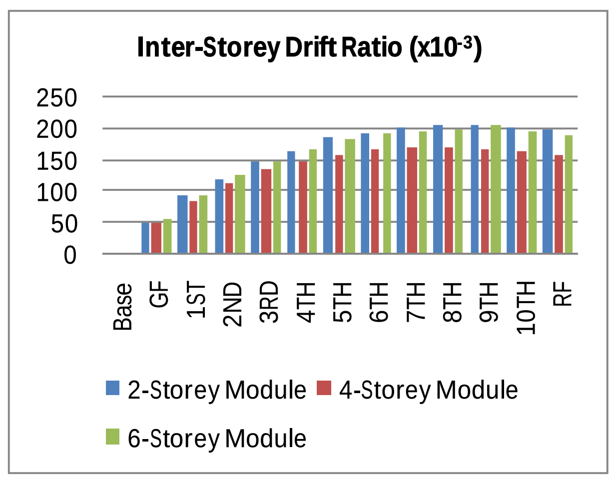

Fig. 13 Inter-Storey Drift Ratio (x10^{-3})

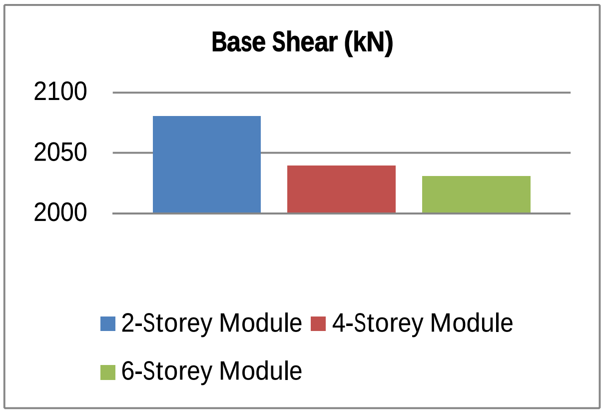

Fig. 14 Base Shear (kN)

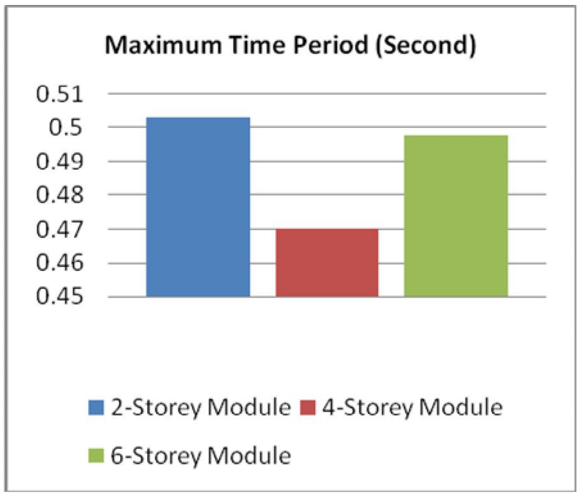

Fig. 15 Maximum Time Period (Second)

V. CONCLUSION

From the analysis of various types of diagrid structures it is concluded:

Comparison of Diagrid Structure with a Conventional Frame Structure depicted the importance of diagrid system in the reduction of various lateral load parameters such as top storey displacement, inter-storey drift ratio, and modal periods. Value of top storey displacement in case of conventional frame was found to be 28.57% higher compared to diagrid system. For maximum inter storey drift, value was around 30.58% higher for conventional system. Value of modal period for the first mode was 20.07% higher in case of conventional frame building. This is all due to the fact that diagrid system has an external lateral load resisting system which can serve the purpose of resisting gravity loads as well. Whereas in case of conventional system there isn't any lateral load resisting system and the loads are resisted through flexural action. Thus for the tall structure where lateral loads govern the design, diagrid is a better option.

Result of effect of module variation showed that module size significantly influences the structural parameters of Diagrid. Optimal size of module is thus critical for the design of diagrid. In case of 12-storey, optimal size came to be 4-storey module. Thus the optimal angle came out to be in the range of 60 degrees to 62 degrees.

Also the vertically varied module showed optimum results in every case. Thus it can be concluded that as the height of building is increasing optimal size also increases. It is also to be noted that smaller size of module would result in more number of nodes which is not desirable as nodes are complex to design as well as fabricate. But on the other hand they provide smaller unsupported length which is desirable from design point of view. Hence Vertically Varied Module can be the suitable option in those cases.

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