A Study on 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 structure with and without shear wall core has been studied to depict the advantages of a shear wall core system. The effectiveness of a diagrid structure also depends upon exterior corner column. Hence, it becomes necessary to study the effect exterior corner columns on different analytical parameters. Therefore structures of height 12 storeys with and without exterior corner columns 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 effect of shear wall core in a diagrid system.
3. To study the effect of exterior corner columns in a diagrid 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 with and without shear wall core system. Second part covers the study of effect of exterior corner columns 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

Diagrid with shear wall core and Diagrid without shear wall core

Structure	Diagrid with Shear Wall Core	Diagrid without Shear Wall Core
Beams	250X400, 250x350, 250x300	250X400, 250x350, 250x300
Interior column	600X600	600X600
Diagrid	300X300	300X300
Shear Wall	200 mm thick RCC	--------
Slabs	150 mm thick RCC	150 mm thick RCC

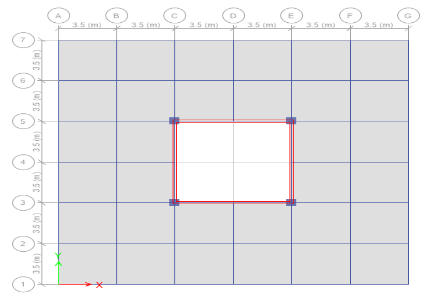

Fig.1 Plan of diagrid with shear wall core structure

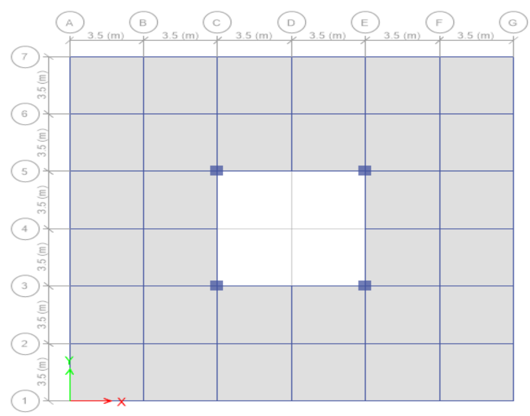

Fig. 2 Plan of diagrid without shear wall core structure

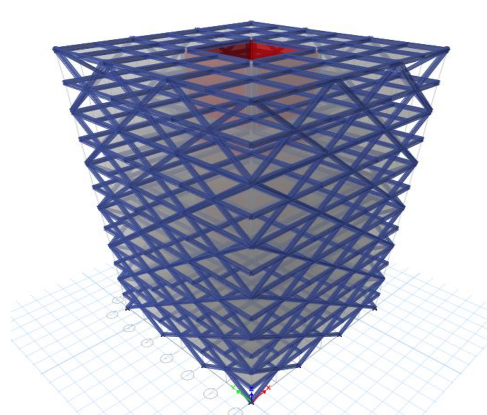

Fig. 3 3D of diagrid with shear wall core structure

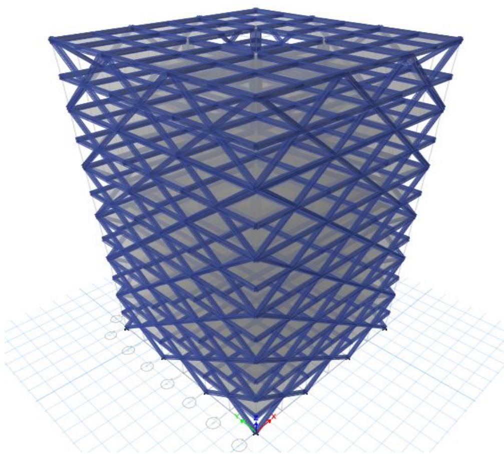

Fig. 4 3D of diagrid without shear wall core structure

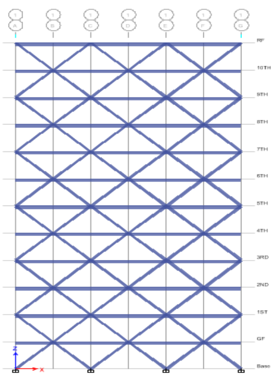

Fig. 5 Elevation of diagrid with shear wall core structure

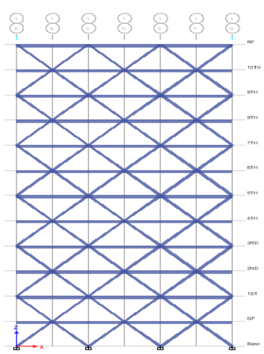

Fig. 6 Elevation of diagrid without shear wall core structure

Diagrid without Exterior Corner Columns and Diagrid with Exterior Corner Columns

Structure	Diagrid without Exterior Corner Columns	Diagrid with Exterior Corner Columns
Beams	250X400, 250x350, 250x300	250X400, 250x350, 250x300
Interior column	600X600	600X600
Exterior Corner Column	---------	400X400
Diagrid	300X300	300X300
Shear Wall	200 mm thick RCC	200 mm thick RCC
Slabs	150 mm thick RCC	150 mm thick RCC

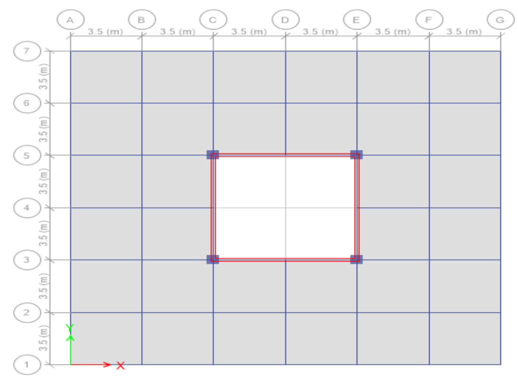

Fig.7 Plan of diagrid without exterior corner columns structure

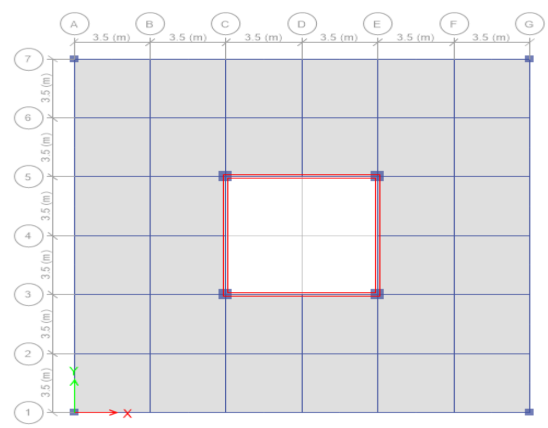

Fig. 8 Plan of diagrid with exterior corner columns structure

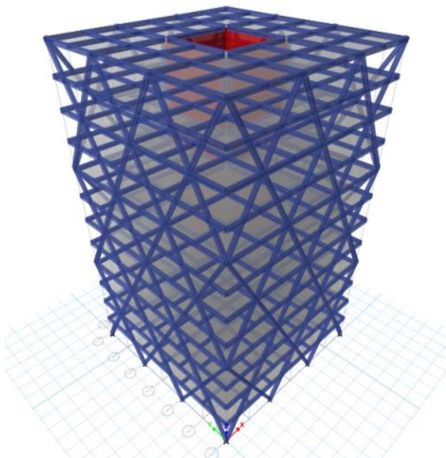

Fig. 9 3D of diagrid without exterior corner columns structure

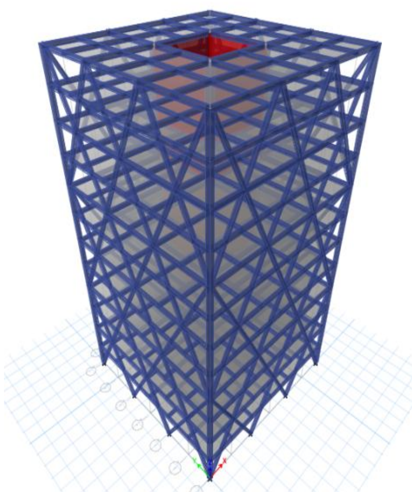

Fig. 10 3D of diagrid with exterior corner columns structure

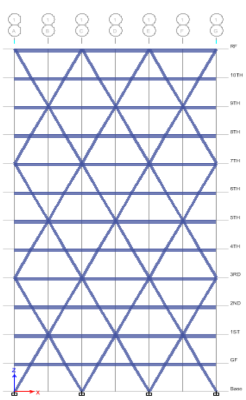

Fig. 11 Elevation of diagrid without exterior corner columns structure

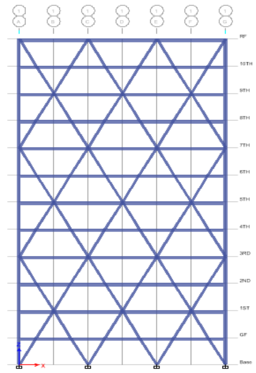

Fig. 12 Elevation of diagrid with exterior corner columns structure

IV. RESULT AND DISCUSSION

Effect of Shear Wall Core on Diagrid System

Parameters	Without shear wall core	With shear wall core
Maximum top storey displacement (mm)	9.5	6.3
Maximum Inter-Storey Drift ratio	0.000304	0.000206
Base Shear V_b (kN)	1279.16	2080.65
Maximum Time Period (s)	0.753	0.503

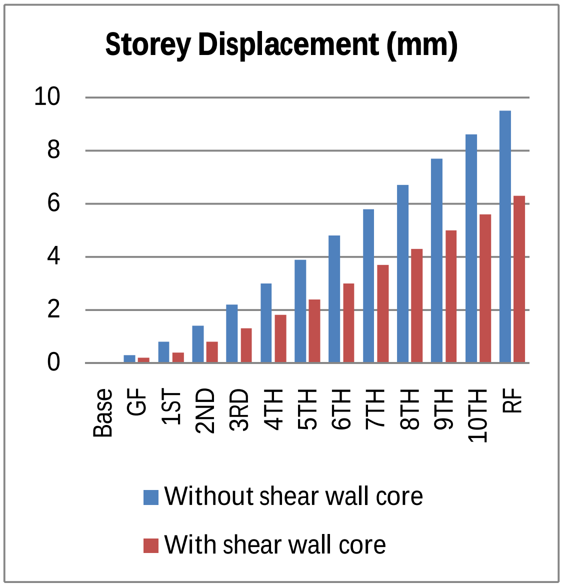

Fig. 13 Storey Displacement (mm)

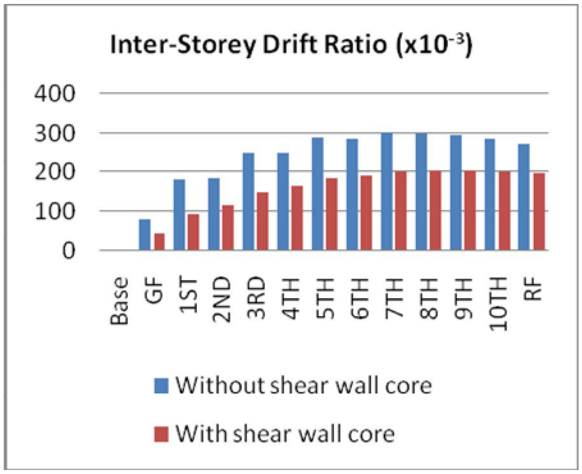

Fig. 14 Inter-Storey Drift Ratio (x10^{-3})

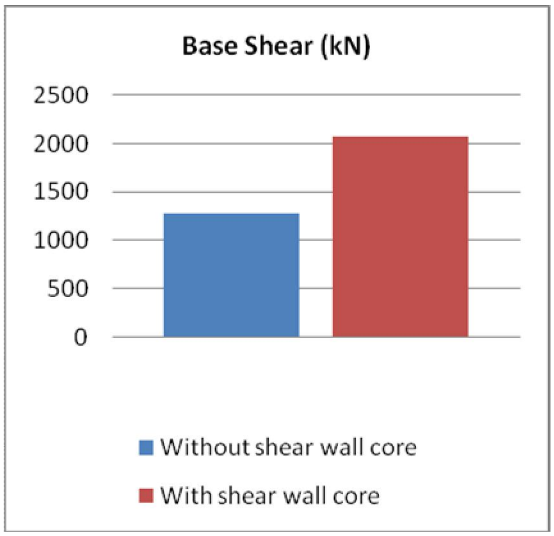

Fig. 15 Base Shear (kN)

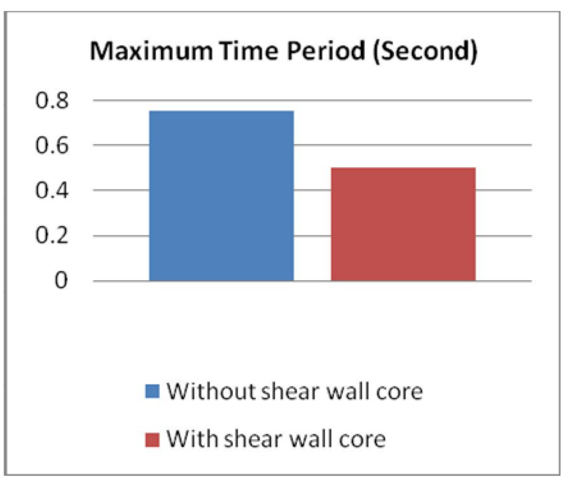

Fig. 16 Maximum Time period (Second)

Effect of exterior corner columns in a diagrid system

Parameters	Without Corner Column	With Corner Column
Maximum top storey displacement (mm)	5.3	4.7
Maximum Inter-Storey Drift ratio	0.000171	0.000149
Base Shear V_b (kN)	2039.86	2072.30
Maximum Time Period (s)	0.470	0.445

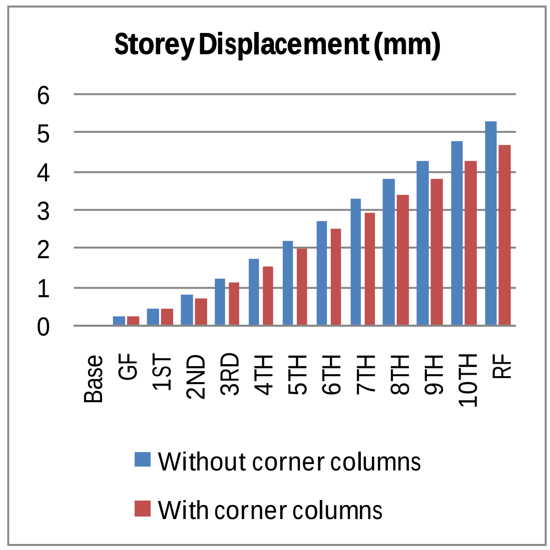

Fig. 17 Storey Displacement (mm)

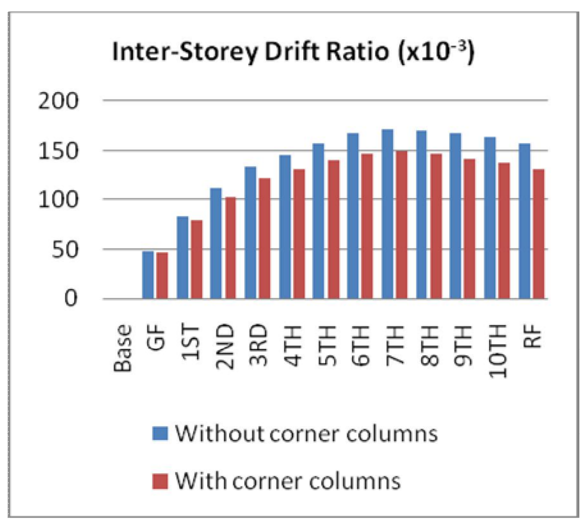

Fig. 18 Inter-Storey Drift Ratio (x10^{-3})

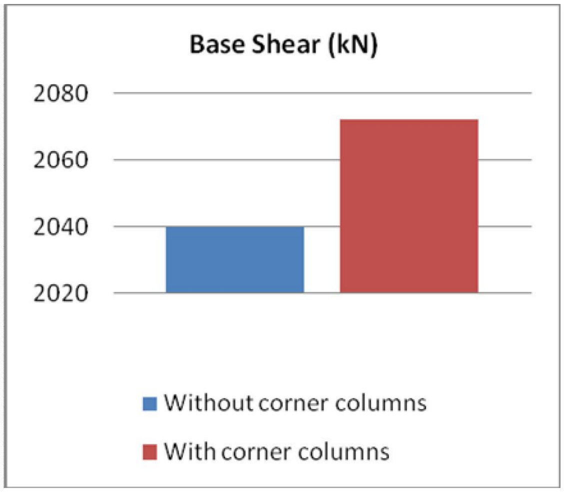

Fig. 19 Base Shear (kN)

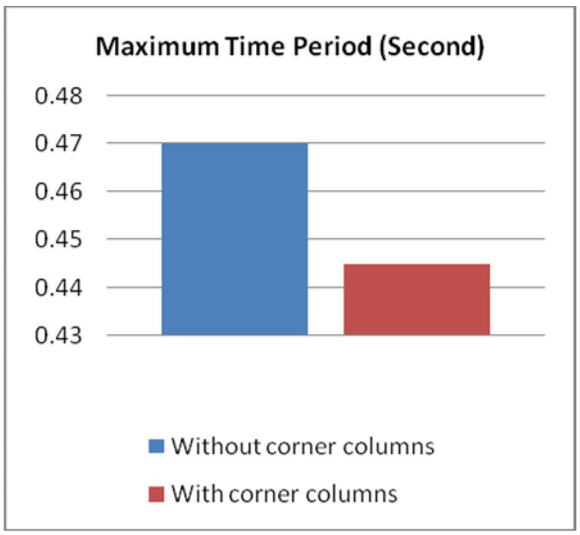

Fig. 20 Maximum Time Period (Second)

V. CONCLUSION

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

From the result of effect of shear wall in a diagrid system, it is seen that shear wall core enhances the performance of diagrid structure. The lateral top storey displacement decreases from 9.5 mm to 6.3 mm thus reducing by around 33.68%. In case of maximum inter storey drift ratio the value decreases by 32.23% while in case maximum modal period the percentage reduction is around 33.20%. Thus, it is desirable to use a shear wall core in diagrid system as the same can be utilized as a lift core.

Result to effect of corner columns in a diagrid system showed decrease in the value of lateral top storey displacement by around 11.32% and that in inter storey drift by 12.86%. The corner columns are effective in increasing the stiffness of the system and thus reducing the lateral load parameters. However diagrid structure without corner columns create valuable column less corner spaces, which provide better views and aesthetical appearance.

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