Performance Analysis of Tall Structures with Hexagrid Systems at Varying Depth

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Abstract - *The need for tall buildings are increasing due to heavy urbanization and population growth. As the height of the building increase, the need for lateral load resisting are increased. Some of the lateral load resisting systems are rigid frame, braced frame, shear wall, tubular, diagrid, pentagrid, hexagrid and octagrid structures. Hexagrid has highly aesthetic and high structural performance and effective in minimize shear deformation because it carry shear by axial action of the diagonal members, while other structures carry shear by the bending of the horizontal spandrels and vertical coloumns. The aim of the present work is to study the performance of tall structures with hexagrid systems provided at varying depths and compare with the performance of structures when hexagrids are provided throughout the full depth of the building. A square shaped plan building of 36 storey with storey height 3.6m with size 36m x 36m, is considered. Modelling and analysis of the structure are considered in ETABS. Analysis and design are carried out for dead load, live load, lateral load, earthquake load and wind load. As compared with conventional frame, by providing hexagrids at varying depth, displacement and drift gradually decreases. The displacement and drift is almost similar for the models with hexagrid provided beyond mid height of the building.*

Key Words*: *Tall Buildings, Hexagrid, Storey drift, Storey displacement, Structural weight

1. INTRODUCTION

1.1 General

Due to heavy urbanization and population growth, the cost of land is increasing rapidly and the land availability has become a constraint for developers & builders and need for high rise buildings are increased. So, the lateral load resisting system becomes more important to resist lateral loads than structural system that resists gravitational loads.

In grid structures all vertical columns on the perimeter are eliminated and diagonal columns inclined at a specific angle. The angle of the diagonal members of the hexagrid are depend on the storey height. Since the number of columns in structure is reduced, the material conception is less than conventional structural system. The main objective of this work is to study the performance of tall structures with hexagrid systems provided at varying depths and compare with the performance of structures when hexagrids are provided throughout the full depth of the building.

2. BUILDING DESCRIPTION

A square shaped plan building of 36 storey with storey height 3.6m with size 36m x 36m, is considered. The elevation view and plan view of hexagrid is shown in fig. 1 and fig.2

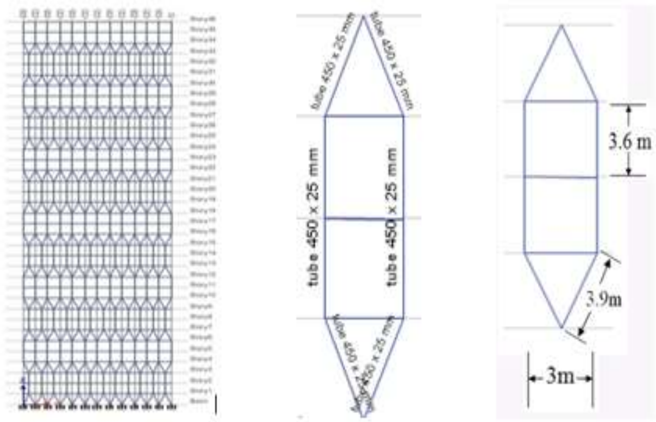

Fig – 1: Hexagrid with 3 metre module (3 m base width)

Hexagrids with 3 metre modules are provided at the exterior periphery of the building with varying hexagrid height. Hexagrid with 3m module is the model that contains hexagrid modules whose base width is 3m in length there are no vertical columns in the exterior of the structure and only 8 in the interior. For linear static analysis, the beams and columns are modeled by flexural elements and braces are modeled by truss elements. The support conditions are assumed as fixed. The design live load on floor slab is taken as 2.5 kN/ m^2 and dead load is 3.75kN/m^2. The basic wind speed is taken as 30 m/sec and terrain category III as per IS: 875 (III)-1987. The design earthquake load is calculated considering zone factor of 0.16, medium soil, response reduction factor of 5 and importance factor of 1 (IS: 1893 (Part-I), 2002).

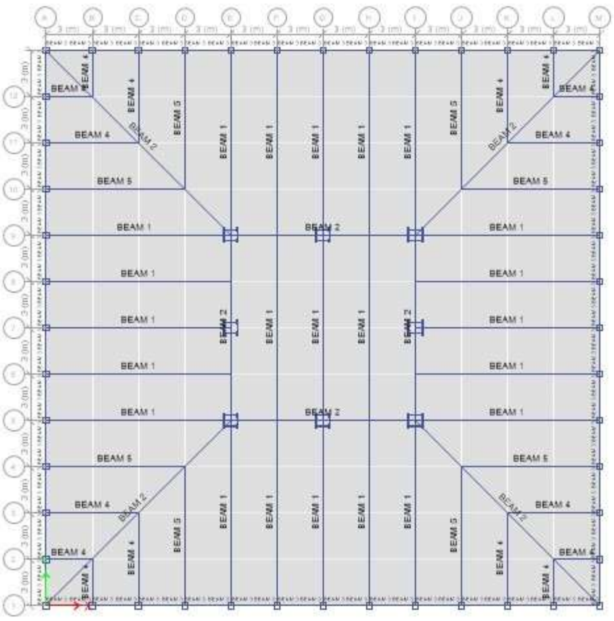

Fig – 2: Plan View of building

2.1 Section Properties

The floor slab is made up of M 30 grade concrete with 150mm thickness and rigid diaphragms are applied to all floors. The interior columns provided in the core for hexagrid are built up columns. The diagonal columns are tube sections of a particular thickness. The beams provided are I section with top and bottom cover plates. Table.1 shows the section properties.

Table- 1: Section Properties

Section	Element Type	Section
Built up	Column	870 X 250 mm
BEAM 1	Beam	ISWB600 with 250 x 25 mm top and bottom plates
BEAM 2	Beam	ISWB600 with 250 x 50 mm top and bottom plates
BEAM 3	Beam	ISMB 550
BEAM 4	Beam	ISLB 600
BEAM 5	Beam	ISWB 600
Tube	Braces	450 X 25 mm

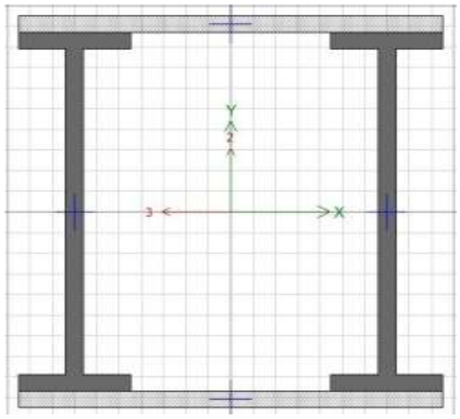

Fig- 3: Built up column

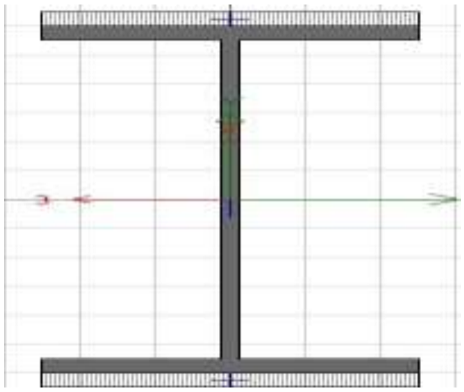

Fig – 4: Beam 1(ISWB600)

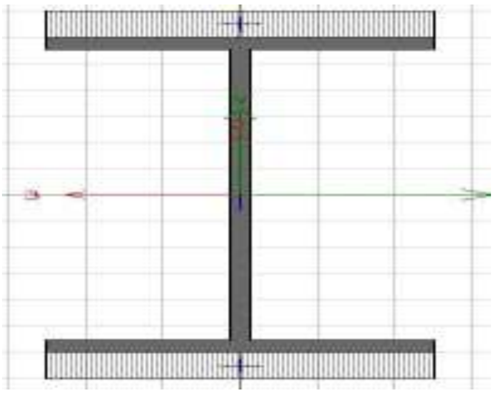

Fig -5: Beam 2(ISWB600)

In model 1, there is no hexagrids are provided in the stories. For the full stories conventional frame systems are provided. The support conditions are assumed as fixed. The beams and columns in the conventional frame system, are I section with top and bottom plates. Hexagrids are provided at the top 6^{th} stories, 12^{th} stories, 18^{th} stories, 24^{th} stories, 30^{th} stories from model 2 to model 6 respectively. In model 7, the hexagrids are provided at the top 33^{th} stories. In model 8, the hexagrids are provided at the full stories.

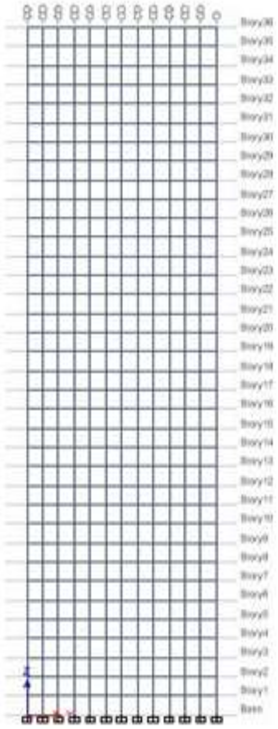

Fig – 6: Model 1

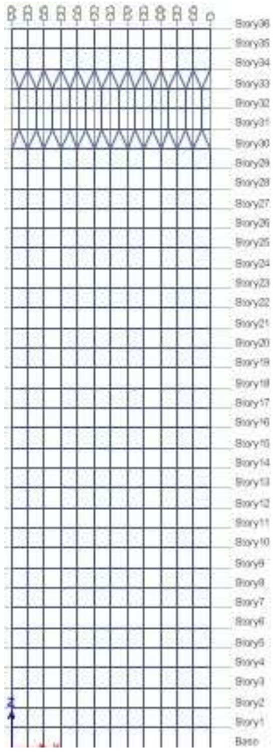

Fig – 7: Model 2

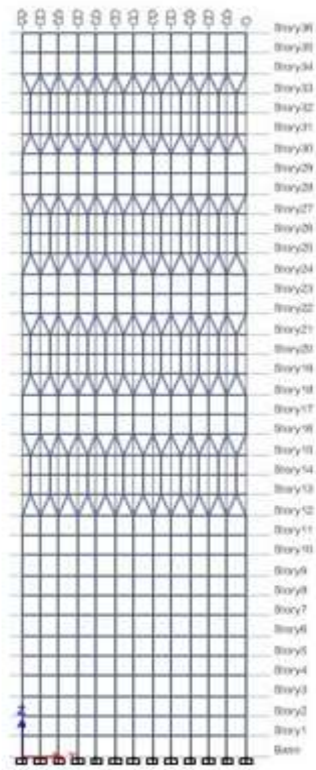

Fig – 10: Model 5

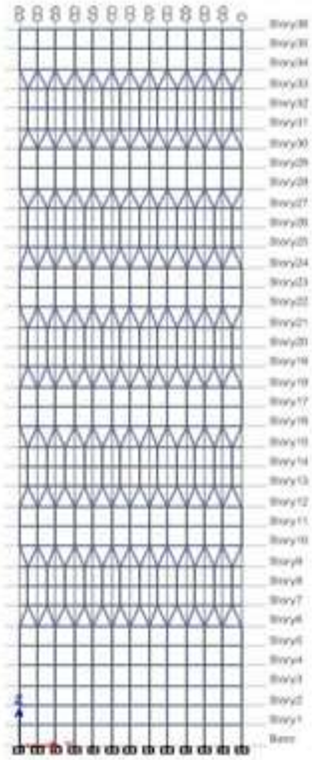

Fig – 11: Model 6

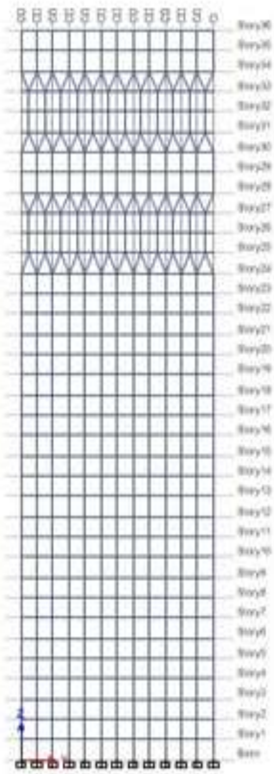

Fig – 8: Model 3

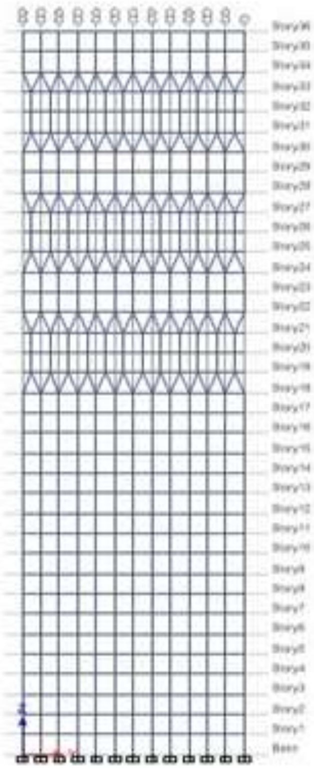

Fig – 9: Model 4

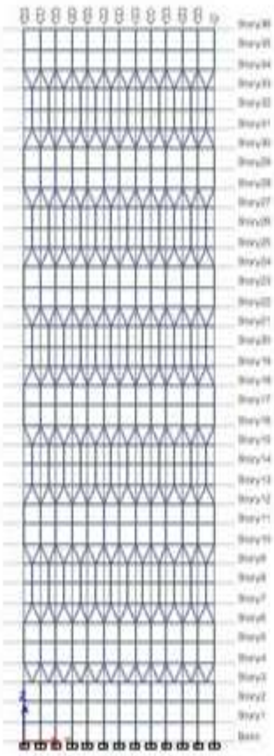

Fig – 12: Model 7

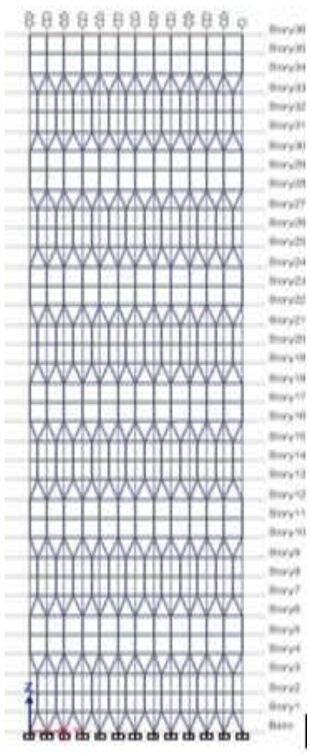

Fig – 13: Model 8

3.RESULTS AND DISCUSSION

3.1 Displacement

The displacement of the models are graphically represented on fig.14.The maximum displacement is for 1st model with no hexagrids, only conventional frames are provided. Then there is a sudden decrease at mid height of the building. Last 3 models have similar displacement values. There is a gradual decrease in the maximum displacement of the models as the depth of hexagrid increases with a sudden decrease in mid height. The displacement is almost similar for the models with hexagrid provided beyond mid height of the building.

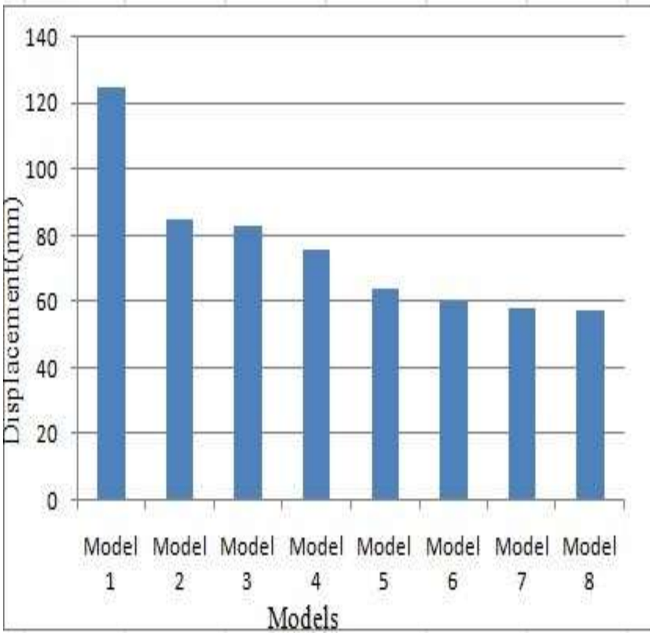

Fig – 14: Displacement of models

3.2 Drift

The drift of the models are graphically represented on fig.15.The maximum drift is for 1st model with no hexagrids, only conventional frames are provided.Then there is a sudden decrease at mid height of the building. Last 3 models have similar displacement values. There is a gradual decrease in the maximum drift of the models as the depth of hexagrid increases with a sudden decrease in mid height. The drift is almost similar for the models with hexagrid provided beyond mid height of the building. Table 2. Shows the overall comparison results of the models.

3.3 Structural Weight

The overall structural weight of the model 1 includes the weight of steel of I section provides in columns and beams and the concrete in slab. Same section are provided through out the height. The overall structural weight of the models are graphically represented as in fig.16.The models are represented on the x axis and structural weight in kN are represented on Y axis. Maximum displacement is for model 1. Structural weight is gradually decreasing from 1st model to the last model.

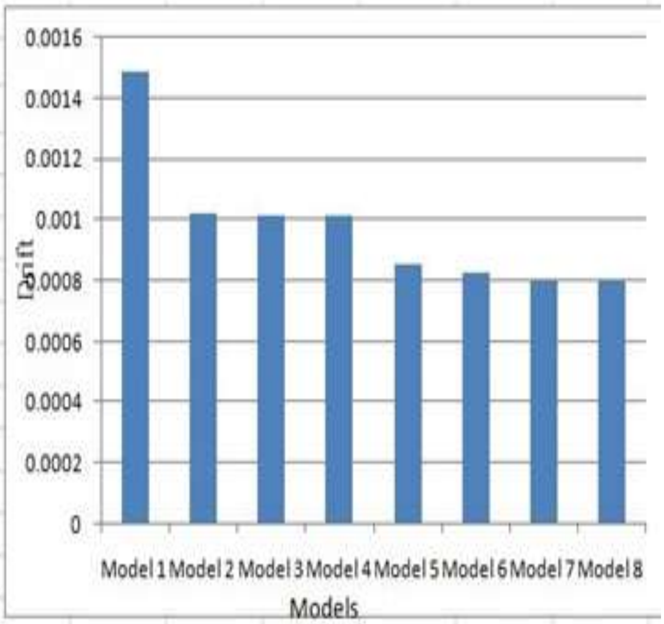

Fig – 15: Drift of models

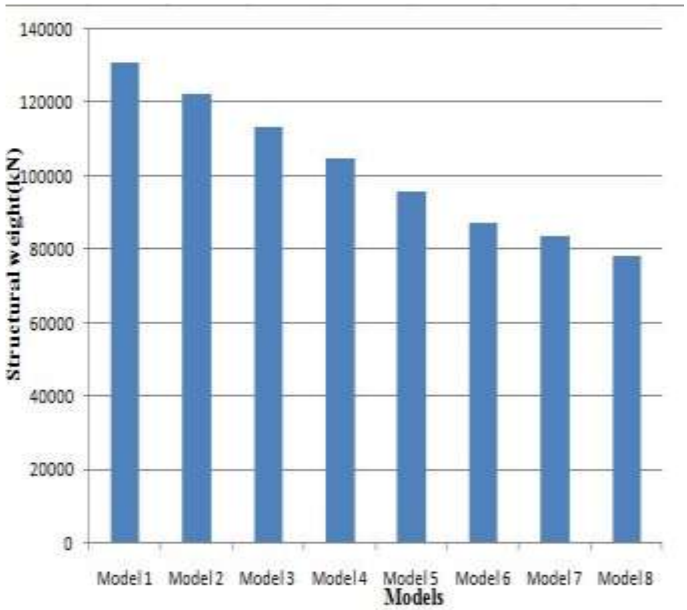

Fig – 16: Structural weight of models

Table- 2: Comparison Results of Models

Models	Displacement (mm)	Drift	Structural Weight (kN)
Model 1	125.09	0.001492	131075.4415
Model 2	85.04	0.00102	122302.4415
Model 3	82.55	0.001018	113529.3377
Model 4	75.60	0.001016	104756.2339
Model 5	63.79	0.000857	95983.1301
Model 6	59.69	0.00083	87210.0263
Model 7	58.07	0.000801	83835.4411
Model 8	57.05	0.000801	78471.0316

3. CONCLUSION

Static linear analysis is performed and results are compared. As compared with conventional frame, by providing hexagrids at varying depth, displacement and drift gradually decreases. Without hexagrid at bottom stories, similar displacement and drift are obtained compared with hexagrid provided at full depth. There is a gradual decrease in the maximum displacement of the models as the depth of hexagrid increases with a sudden decrease in mid height.The displacement and drift is almost similar for the models with hexagrid provided beyond mid height of the building. Hexagrid provided at top 30th and 33th stories are almost similar performance compared to the environmental model (full hexagrid model). So these are the most effective models.

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