Seismic Analysis of Hexagrid Structure with Various Patterns

Mathew Thomas[1], Dr. Alice Mathai [2]

[1] PG Student, Department of Civil Engineering, Mar Athanasius College of Engineering, Kerala, India
[2]Associate Professor, Department of Civil Engineering, Mar Athanasius College of Engineering, Kerala, India

---

Abstract - *With the increase in urbanization and population growth the need for high rise buildings are increasing. Diagrid building has got much attention in high rise structures and are well explored. Now a new structural system is developed which has high aesthetic and structural performance. In this paper the seismic analysis of the building is conducted for hexagrid buildings with vertical and horizontal orientation of the hexagrid module. The size of the hexagrids are varied to obtain optimum module size in both orientation. The study is conducted for 60-stored steel building with symmetric floor plan by using same the volume of steel. Equivalent static analysis of the buildings are conducted in SAP 2000 software to optimum module size.*

Key Words: **Hexagrid building, hexagrid orientation, module size, module density, SAP2000, High rise building.**

1. INTRODUCTION

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. This creates a picture of vertical growth as natural process. As the height of building increase, the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. More recently, the diagrid structural system with tubular behaviour is being employed as structurally efficient as well as architecturally satisfying structural system for tall buildings. In order to improve the efficient of tube-type structures in tall buildings, a new structural system called Hexagrid (Beehive) is introduced in this paper[5].

The hexagrid consists of multiple hexagonal grids at the exterior perimeter surfaces of building. The hexagrid system is a particular form of belt trusses mixed tubular system and resists lateral loads acting in tension or compression[6]. The hexagrids resist both gravity as well as lateral loads by the axial stress of hexagrid members. Therefore, these system simply act in tension or compression without bending.

The main parameters in the study are the size of the hexagrid module and hexagrid orientation. Two orientation are used: a hexagrid with horizontal patterns and one with vertical patterns. The roof displacement, drift and load distribution in the building is used to find out the optimum module size and orientation in the building.

2. BUILDING CONFIGURATION

There are two hexagrid patterns: vertival hexagrid (VH) and horizontal hexagrid(HH). In each hexagrids pattern three modules with varying module size are used. The models were named according to the number of storeys required to form an additional hexagrid layer. The shape of the hexagrid and volume of steel are kept constant for all the buildings.

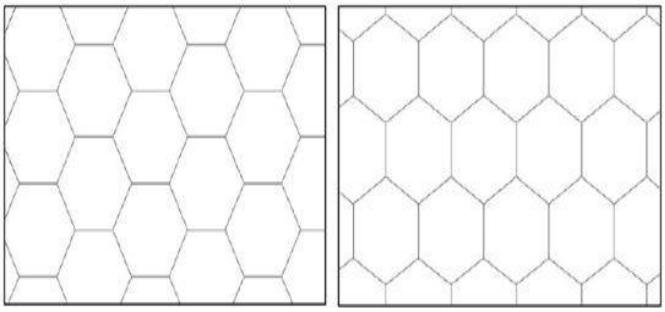

Fig -1: Horizontal and vertical hexagrid pattern

2.1. BUILDING MODELS

Six hexagrid models of 60-storeys with a symmetric floor plan of 36m x36m is used in the study. A constant floor height of 3.6m is adopted.

Table -1: Model Patterns

Model pattern	Model name	Model designation	Angle of inclined column	Number of hexagrid layers	Number of hexagrid unit cells
Vertical hexagrids	VH1	2-storey module	67.38°	30	1440
	VH2	4-storey module		15	360
	VH3	6-storey module		10	160
Horizontal hexagrids	HH1	2-storey module		30	1440
	HH2	4-storey module		15	360
	HH3	6-storey module		10	160

2.2 STRUCTURAL MODELLING AND ANALYSIS

The hexagrid members are connected as pinned members. The floors are subjected to a live load of 2.5kN/m^2. The design earthquake load is calculated considering medium soil, zone factor of 0.16, response reduction factor of 5 and importance factor of 1 (IS: 1893 (Part-I), 2016).

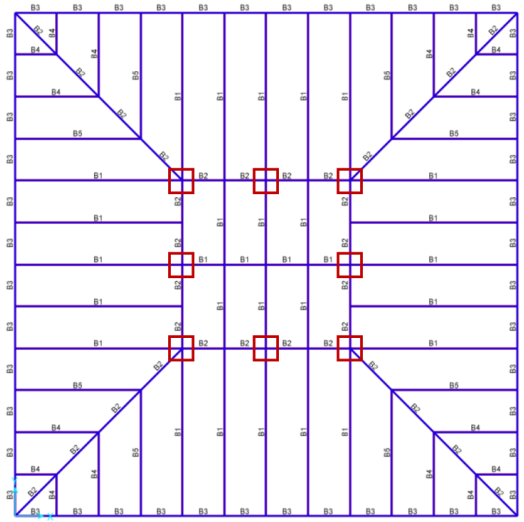

Fig -2: Floor plan

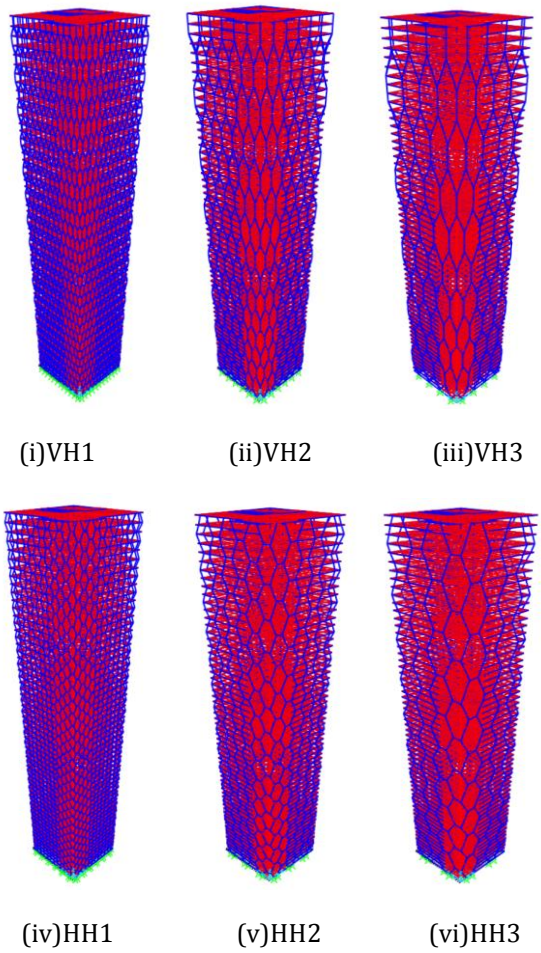

Fig -3: 3D view of the models

3. ANALYSIS RESULTS

3.1 DISPLACEMENT

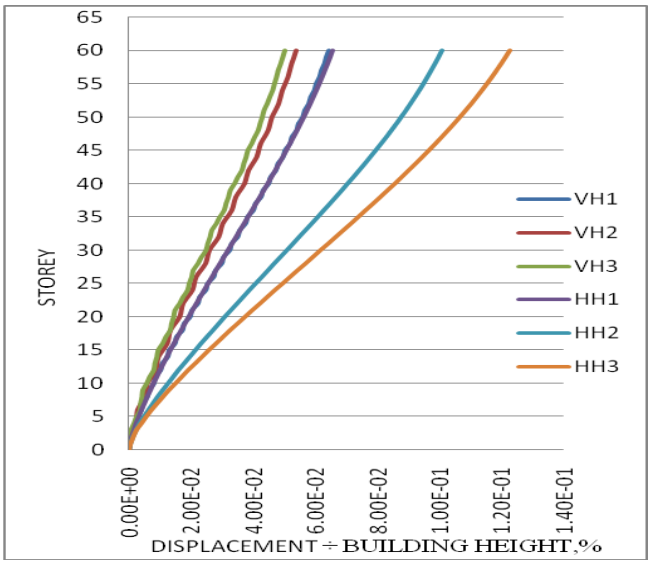

Fig -4: Displacement per building height for the six models

As module size increases displacement of vertical hexagrid decreases whereas in horizontal hexagrids the displacement increases with the increase in module size. The vertical hexagrids are found to be less displaced than the horizontal ones.

3.2 STOREY DRIFT

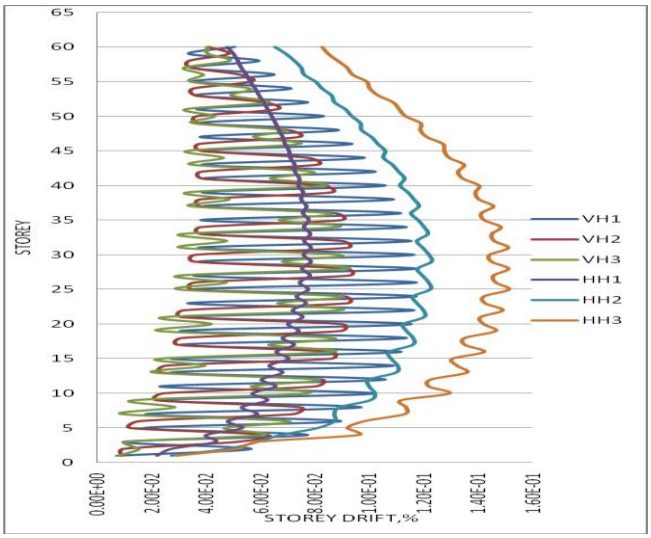

Fig -5: storey drift graph of the six models

The maximum drift values in the buildings are in accordance with the displacement results. In vertical hexagrids the drift decreases with increase in module size and in horizontal hexagrid the drift increases with increase in module size. So it is preferable to have vertical hexagrids with larger module size.

3.3 LOAD DISTRIBUTION

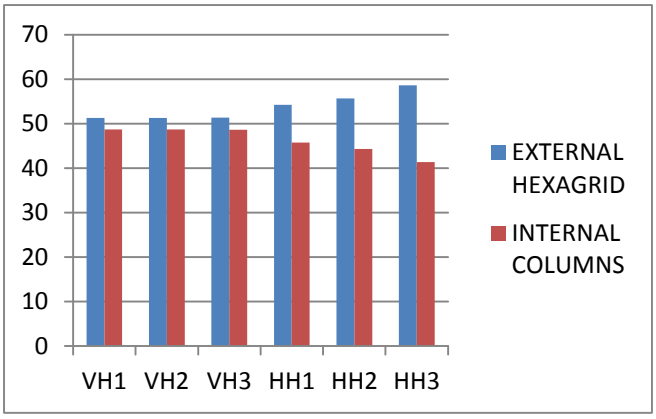

Fig -6: Gravity load distribution in the buildings.

The gravity load occuring in the vertical hexagrid buildings is distributed equally among the interior core and exterior hexagrid. The horizontal hexagrids are found to take a higher gravity load than the vertical hexagrids.

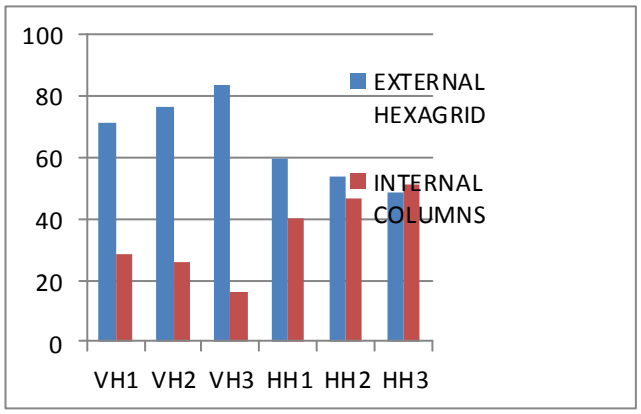

Fig -7: Lateral load distribution in the buildings.

About 50 - 80 % of the lateral forces are resisted by the exterior hexagrid system. The vertical hexagrids can resist more lateral forces occurring in the building. Among vertical hexagrids, the building with large sized hexagrid resist more lateral loads and in horizontal hexagrid building smaller nodule size are preferred.

4. CONCLUSIONS

The structural performance of hexagrid building with 60-storeys is investigated. The study results are summarised as follows:

- With the increase in module size, the displacement and drift values of vertical hexagrid models are decreasing. So increasing the module size provides more stable buildings in vertical hexagrid pattern.
- With the increase in module size , the displacement and drift values of horizontal hexagrid models are increasing. So increasing the module size reduces stability in horizontal hexagrid pattern.
- The gravity load is distributed almost equally in vertical hexagrid models. The horizontal hexagrids are found to take a higher gravity load than the vertical hexagrids.
- The lateral load carrying capacity increases with increase in module size of vertical hexagrids, whereas in horizontal hexagrid the lateral load carrying capacity increases with increase in module size.
- So in static analysis the vertical hexagrids show better performance in higher module size, and horizontal hexagrids show better performance in lower module size.

ACKNOWLEDGEMENT

I am extremely thankful to my beloved project guide Dr.Alice Mathai for her valuable guidance, encouragement and immense support throughout my humble endeavor. It is beyond words to express my sincere gratitude to all my friends and teachers for the constant inspiration in completing this work.

REFERENCES

[1] Deepika, R., G. Shivanand C, and K. Dr.Amarnath (2016). ” Performance study of high rise buildings with diagrid and hexagrid systems under dynamic loading”. International Journal of Engineering Science and Computing, 6(4).

[2] Mashhadiali, N. and A. Kheyroddin (2013).” Proposing the hexagrid system as a new structural system for tall buildings”. The Structural Design of Tall and Special Buildings, 22(17), 1310–1329.

[3] Moon, K.-S., J. J. Connor, and J. E. Fernandez (2007). “Diagrid structural systems for tall buildings: characteristics and methodology for preliminary design”. The Structural Design of Tall and Special Buildings, 16(2), 205–230.

[4] Anil K Chopra, Dynamics of Structures, Pearson (3rd Edition), 2016.

[5] Diya Susan Ebin and D. Arul Prakash (2016)." study on structural behaviour of hexagrid structural systems in multi storey buildings". Int. J. Chem. Sci.: 14(S1)

[6] Pooa Liz Isaac and Bennet A Ipe (2017)." Comparative study of performance of high rise buildings with diagrid, hexagrid and octagrid systems under dynamic loading". International Research Journal of Engineering and Technology (IRJET)