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Analytical Study on the Effect of Different Geometric Configuration on the Performance of Hexagrid Structure

Nikul Dholakia[1]

[1]*PG Student, Structural Engineering, Department of Civil Engineering, L.J.I.E.T, Ahmedabad, Gujarat, India*

Abstract - *Worldwide trend of people to migrate in urban area is also followed in India. And limitation of land will increase the density of urban area. So, we are designing high-rise structures to eliminate this problem. Structure designer faces so many problems to keep stable this building with new innovative technique system like grid, tube in tube, outrigger etc. Here we adopt a new grid system called HEXAGRID. This study is conducted for the analysis of the behavior of structure with different size and pattern of hexagrid. Non-Linear Dynamic wind analysis will be applied on (1) module size (2) module pattern (3) arrangement & placement of grid (4) height of the structure to optimize the structure for various criteria.*

Key Words: **Hexagrid, Dynamic Wind, Hexagrid Pattern, Hexagrid module, ETAB, High rise building,**

1. INTRODUCTION

With the rise in urbanization and increase the necessity for top rise buildings. Diagrid building possesses much attention in high rise structures and are well explored. And Architectures are constantly changing their design to seem their project unique and better than other. So, as a structure designer we've to upgrade our self to compete with this new era. Now a replacement structural system is developed which has high aesthetic and structural performance called HEXAGRID. This beehive design concept is taken from nature and that we all know that nature takes thousands of years to develop this. So, basically, we are getting to adopt this for Highrise building and can analyze the result.

The topology of the hexagrid system is a crucial design variable since the degree of an angle between diagonal members consisting of hexagrid determines stress distribution resisting internal forces. Therefore, the consequences of diagonal angles within the hexagrid system should be considered so as to get an optimal hexagrid topology with the very best stiffness in design phases.

The unit of the hexagrid module is extending over multiple floors, which repeats horizontally along the building perimeter and stacks vertically along elevation. The geometrical parameters of the module are: the diagonal angle, the diagonal member length, the module height, the amount of storeys covered by one module, the number of modules along elevation and therefore the number of modules along the perimeter.

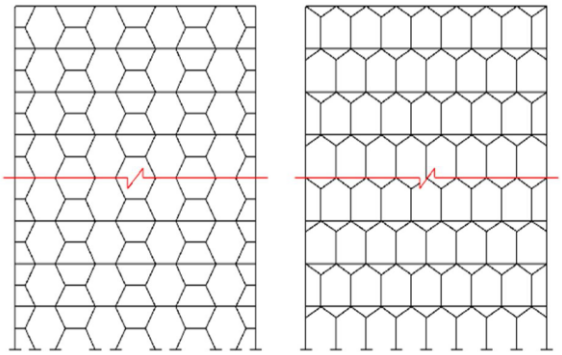

Fig -1: Types of Hexagrid

1.1. Load Transfer Path of Hexagrid

The Hexagrid system offers several advantages additionally to eliminating perimeter columns. Most notably it optimizes each structural element. Typically, columns are used to provide vertical-load-carrying capacity, and diagonals or braces provide stability and resistance to large forces, like wind and seismic loads.

But here hexagons and diagonals are participating within the vertical load transfer, and therefore the lateral load under ideal assumptions during a in a typical high-rise. In a hexagrid system the 2 functions are working together, like couple. The hexagons and diagonals are all one.

2. HEXAGRID MODULE AND BUILDING CONFIIGURATION

Here we are going to analyses of vertical and horizontal grid pattern with 3 types of module size covered 2-storey, 4-storey and 6-storey. For broader comparison we will use this all module size and pattern in each 30-storey, 40-storey and 50-storey.

Total 18 building model of Hexagrid with various pattern and module size with symmetric plan of 35m x 35m is used in the study. A constant floor height of 3m. Here in Hexagrid various angle been used to maintain symmetry in elevation and for proper analysis in ETAB.

Table -1: Notation of various Hexagrid

Hexagrid Orientation	Storey cover by One hexagrid unit	Hexagrid module notation
Vertical	2	V2
	4	V4
	6	V6
Horizontal	2	H2
	4	H4
	6	H6

2.1. Hexagrid Dimension

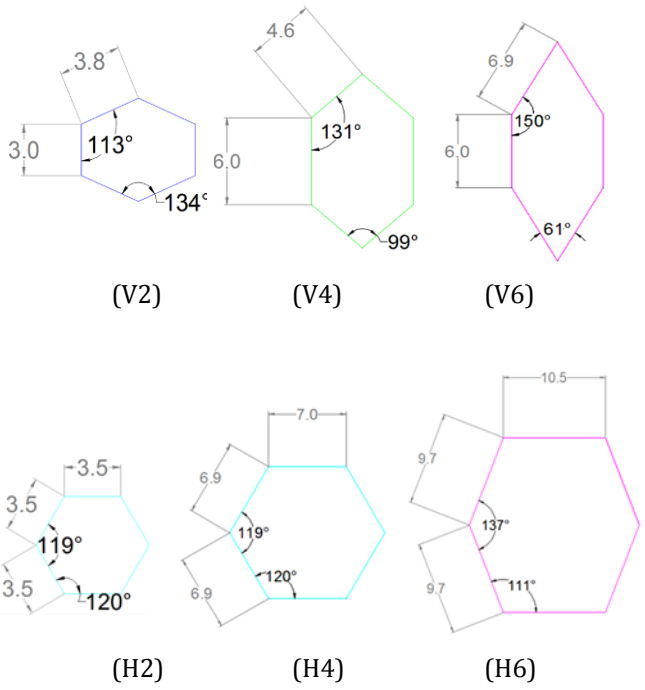

Fig-2: Configuration of Hexagrid

2.2 Structural Data for Modelling

Length of building in X-direction = 35 m
Length of building in Y-direction = 35 m
Bay width in both direction = 3.5 m
No. of Stories = 50, 40, 30
Height of each storey = 3 m
Total Height of the building = 150m, 120m, 90m
Structural steel grade = Fe 250
Section to be used = Indian Standard Section
=ISMB 500
=ISMB 550
Grade of concrete = M 35
Size of concrete column = 750 mm x 750 mm
Thickness of shear wall = 300 mm

2.3 Loading Data

A. Dead Load

Height of the block masonry is 3 m and of 230 mm thick wall which induces uniformly distributed load 9.65 kN/m and Floor finish of 1 kN/m^2.

B. Live Load

Live Load on slab is considered as 2.5 kN/m^2
All buildings were analyzed for dynamic wind analysis and the zone.
Seismic zone = III
Seismic zone factor = 0.16
Response reduction = 5
Importance factor = 1
Wind zone = III
Wind speed = 55 m/s
Importance factor = 1
Risk Co-efficient (k1) = 1
Topography factor (k3) = 1

2.4 Modelling

All 18 models are designed and analyzed in 3D structural analysis software named ETABS.

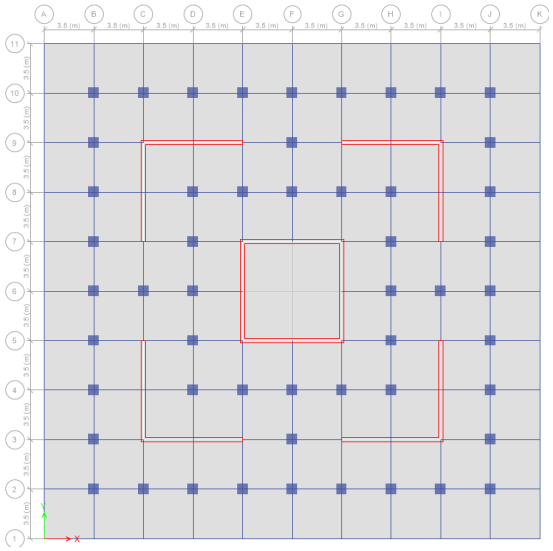

Fig- 3: Plan of the building

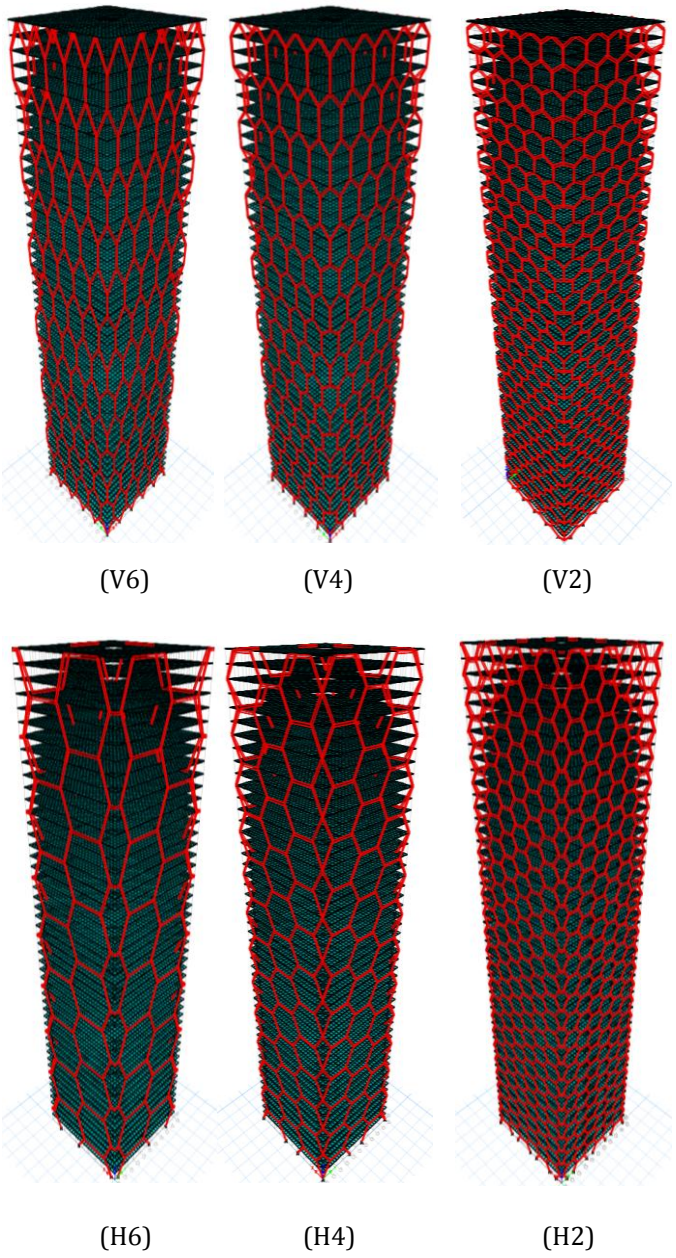

Fig-4: 3D view of the models from ETABS

3. ANALYSIS RESULT

The results are obtained for the dynamic wind analysis and compared with each other to obtain the most efficient Hexagrid module against lateral loading.

The comparison is based on, which one is best for 50-stories, 40-stories and 30-stories.

These results are obtained from the various unfactored load combination. And governing combination for most of the time was DL + LL + WL.

3.1 Displacement

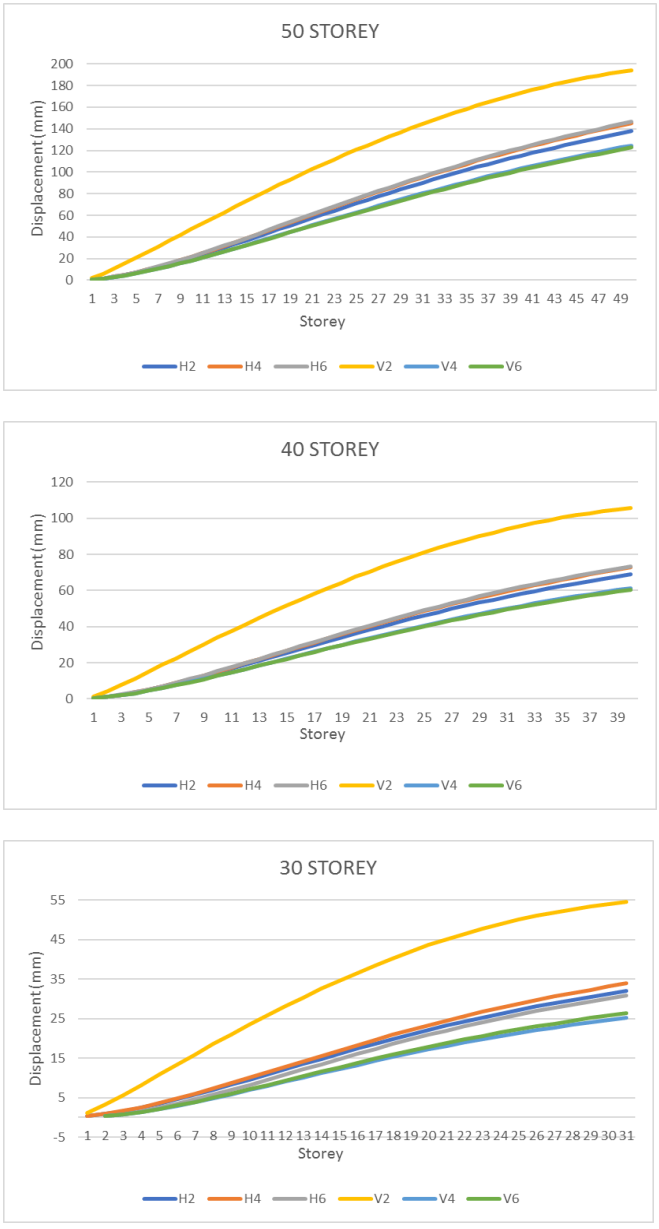

Fig-5: Displacement of various hexagrid module

From the result can say that as the module size decreases displacement is increases in vertical grid pattern, but results are almost nearer in all the horizontal pattern. Overall as from the result vertical grid of module size 4 (V4) and size 6 (V6) are stiffer than all other.

3.2 Storey Shear

Base shear value of smaller grid V2 is less than any other grid module. Base shear bit more in V4 module than V6 and more than double compare to V2. Base shear value in H2, H4 and H6 are almost same and it also nearer to V4.

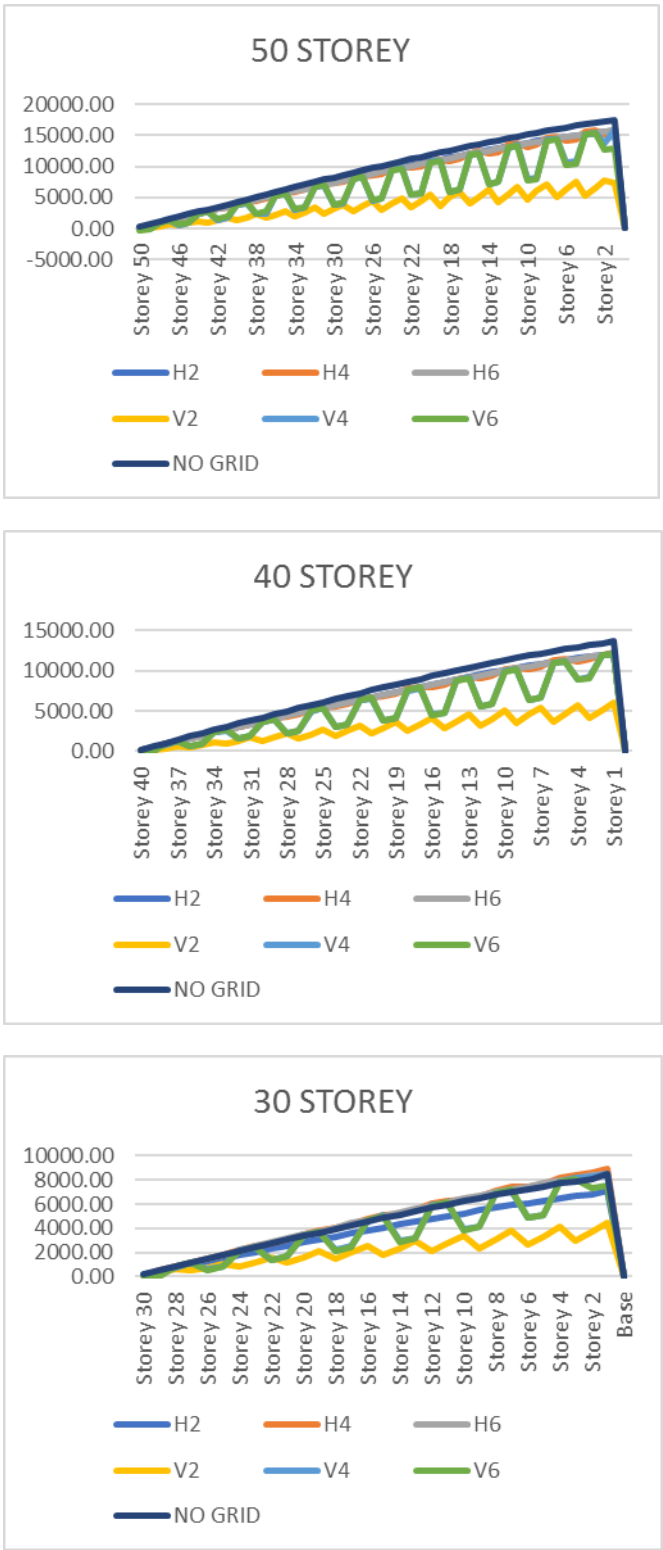

Fig-6: Storey shear value of various hexagrid module

3.2 Storey Drift

All values of storey drift in all the pattern module of hexagrid are under 0.004xh and are permissible. Storey drift graph of V2 module is different than all other module pattern and peak value is also on higher side. V4 and V6 show least storey drift value among all pattern module of hexagrid and values or graph are identical as well. Same graph of storey drift of H2, H4 and H6 are identical, but formation is different than V4 and V6.

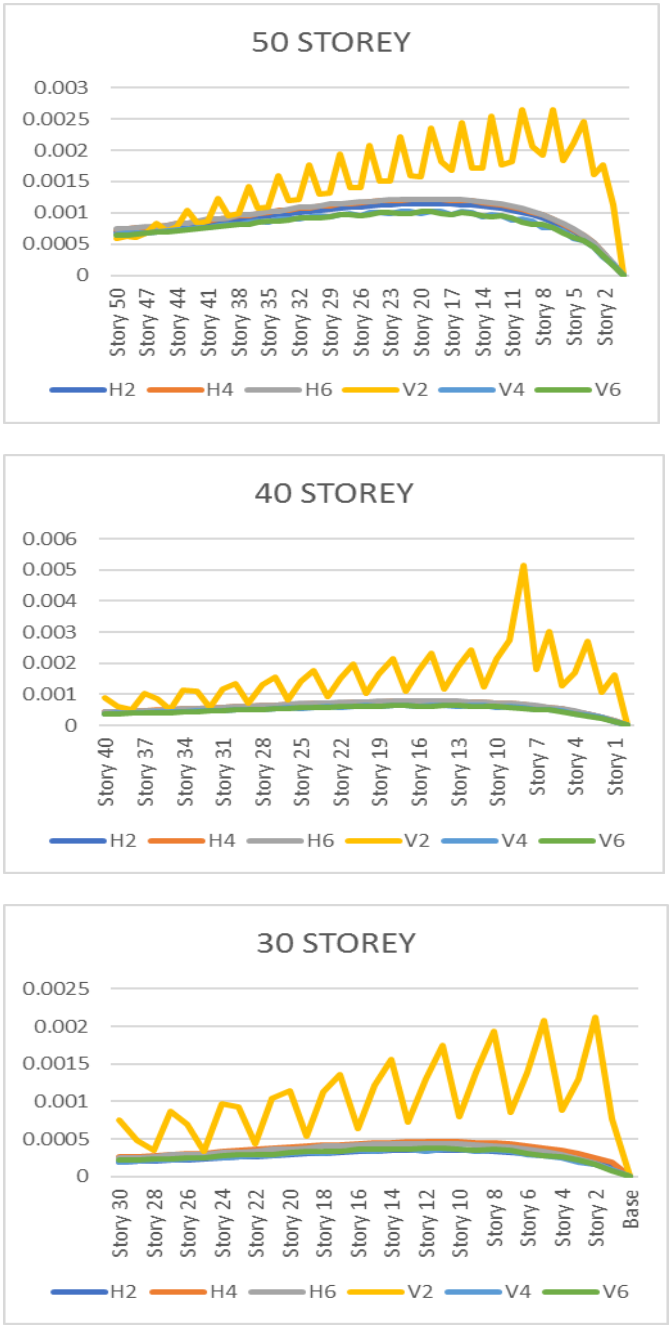

Fig-7: Storey drift value of various hexagrid module

4. CONCLUSION

The structural performance of hexagrid building with dynamic wind non-linear analysis with 30,40 and 50 storey is investigated. The study results are summaries as follows

1] The Hexagrid structure system is particular form of belt trusses mixed tubular system and resist lateral loads acting in tension or compression.

2] Structure response against lateral load is depends on the grid parameter like size, pattern, angle, structure height, material.

3] As the dead weight of the honeycomb structure is reduced the moments as a result are reduced to a greater extent. The lighter is the structure the lighter is the earthquake force or wind force action on the structure and hence the honey comb structure is very effective method.

4] Similar like a moment frame, the hexagrid effectively spreads structure mass from its center and thus develops strength and resistance ability to forces from multiple sources and direction.

5] Increment of module size is inversely proposal to the displacement for the building. So, increasing the module size of vertical module increase the stability of the building.

6] Decreasing the module size in vertical hexagrid pattern also decrees the base shear. While in horizontal pattern values are nearly same like medium and large size of vertical module pattern.

7] Storey drift graph of small module in vertical pattern is different than all other module pattern and peak value is also on higher side, though all values are less than permissible values.

8] Graph of storey drift of horizontal pattern are identical, but formation of graph is different than V4 and V6.

5. ADVANTAGES OF HEXAGRID

1] The angled setting of the columnar elements allows for a natural flow of forces through the structure. During this manner, both gravity load and lateral load are transferred through the Hexagrid to the bottom below.

2] Load paths are continuous and uninterrupted.

3] Generous amounts of day lighting due to dearth of interior columns and structure.

4] Free and clear, unique floor plans are possible.

5] Aesthetically dominate and expressive.

6] Better ability to redistribute load than a Moment Frame.

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