Analytical Study on Performance of Diagrid and Hexagrid Structure with Different Geometric Pattern

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Abstract: World – wide trend of people to migrate to urban area is also Followed in India and limitation of available land will increase the density of urban area. Diagrid structure and Hexagrid structure are prevalently used for today's high rise building due to their efficiency and architectural aesthetic potentials. For this purpose, we proposed a new system of combination of both structures. It is characterized by regular patterns are compared in terms of story drift, story displacement and base shear. In this research, we are using the different size module of Diagrid structure and Hexagrid structure, different arrangement of module is carried out using software name ETABS 2018. The whole analysis is based on Indian standard code.

***Index Terms* – Diagrid, Hexagrid, Combine Geometry, Tall – Structure**

I. INTRODUCTION

1.1 General background:

The current population of India is 1,391,197,718 as of Friday, April 30, 2021, based on Worldometer elaboration of the latest United Nations data. The growth of urban population is increasing very fastley and also limitation of available land. For, that kind of reason evaluation of the taller structures are preferable now a day. So, when the height of structure increases then the consideration of lateral load is very much important. For that the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. The lateral load resisting systems that are widely used are rigid frame, shear wall, wall frame, braced tube system, outrigger system and tubular system. Recently the diagrid – diagonal grid and hexagrid structural system is widely used for tall buildings due to its structural efficiency and aesthetic potential provided by the unique geometric configuration of the system. Hence the diagrid and hexagrid for structural effectiveness and aesthetics has generated renewed interest from architectural and structural designers of tall buildings.

1.2 Diagrid structure:

Diagrid is a form of space truss. It contains of perimeter grid made up of a chain of triangulated truss system. Diagrid is placed by crossing the diagonal and horizontal members. Diagrid has good look and it is recognizable from far. For less obstruction to the elevation, it is necessary to the diagrid system is lessen the number of vertical column as well as horizontal column and rises the diagonal members on the aspect of the buildings.

1.3 Hexagrid structure:

In hexagrid structural system, all the vertical columns are reserved. Hexagrid structural system is mostly of two type, vertical hexagrid system and horizontal hexagrid system. It will be designed of Hexagon which is a group of hex-angulated truss system. Hexagrid is accumulated by crisscrossing the diagonal and horizontal members. The unit of the hexagrid module is extending over multiple floors, which is transitionally repeats along horizontal direction of the building perimeter and transitionally repeats along vertical direction of the building elevation. The geometrical parameters of the module are: the diagonal angle, the diagonal member length, the module height, the amount of story covered by one module, the number of modules along elevation and therefore the number of modules along the perimeter.

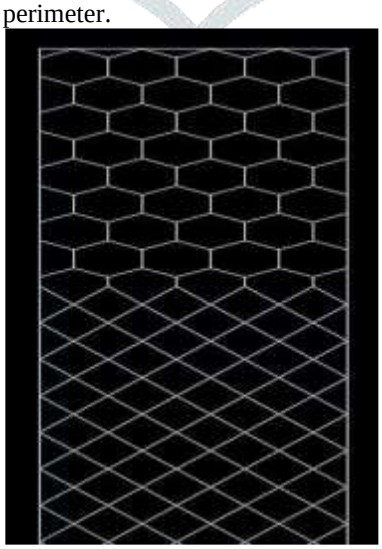

FIG 1: INTRODUCTION ABOUT COMBINE GEOMETRY

II. AIM, OBJECTIVE & SCOPE OF WORK

Aim of current work is that:

- The aim of my study is "Analytical study on performance of Diagrid and Hexagrid structure with different geometric pattern."

Objective of current work is that:

- To observe the behavior of tall building by using the combine geometry of diagrid structure and hexagrid structure.
- To observe the various effect of combine geometry with change position of hexagrid module, modules size and module length.
- To compare the analysis result of building like Story Displacement, Story Drift, Time period and Story shear.

Scope of current work is that:

- Building layout 30m x 30m with 36, 48 and 60 numbers of storey are considered.
- Building height 115.2m, 153.6m and 192m consider.
- Hexagrid module location is Top and Bottom of elevation.
- Diagrid and Hexagrid module are 2 story and 4 story considered.
- Ahmedabad city is considered for seismic zone and dynamic wind calculation.
- Modelling and Dynamic analysis are carried out on ETABS software.

III. BEHAVIOR OF COMBINE STRUCTURE

- Systems are redundant and load path following.
- In this system angled element are allow the natural flow of forces through the nodes Because of the truss assembly are created.
- Keep trying to planning a model such that the load paths are continuous and
- uninterrupted throughout the top to bottom of the structure.
- In this way the vertical load and lateral loads are transfer to top to bottom of the structure.
- The exploitation of steel's compressive and tensile abilities creates requirement for fewer steel during a building using the both systems.

Combine structural system is consists of Diagrid and Hexagrid modules which is on perimeter of a building. Make a network of multi-story angulated truss system. Hexagrid is made by intersecting the diagonal and horizontal components. Diagrid is made by inclined vertical column. This innovation transfers both gravity load and lateral load by redirecting member forces, and eliminates the necessity for vertical columns on the outside of the building. Most of members are connected through a node. So proper connection is required to load transfer mechanism smoothly without disturbing. First thing is observed the performance combine structure after that investigating the connection of member.

FIG 2: CONNECTION OF MEMBER

IV. BUIDING DATA AND NOTATION

Here we are going to analyses of D + HH and D + VH pattern model with two module size covered 2 – story and 4 – story. For broader comparison we will use all module size and pattern of each 36 – story, 48 – story and 60 – story building. Total 27 building model of various pattern are used for study having a symmetric plan of 30m x 30m. For hexagrid module nearly one – third portion of total height to be covered and remaining portion should be diagrid module on facade of structures.

4.1 Structure Data for modelling:

- Plan = 30m x 30m
- Height of each story = 3.2m & N.O.S = 36, 48, 60
- Structural steel grade = Fe 250
- Grade of concrete = M30
- Considered steel section = ISMB 500, ISMB 550
- Column = 500mm x 500mm
- Thickness of shear wall = 250mm

4.2 Dead load and Live load data:

For dead load on slab is considering 2 kN/m^2 and uniform dead weight of masonry wall 12.42 kN/m and for live load on slab is considering 2.5 kN/m^2.

4.3 Zone considering:

- Seismic zone & zone factor = III & 0.16
- Response reduction factor = 5
- Importance factor = 1
- Basic wind speed = 39 m/s

4.4 Notation:

- HH & VH → Horizontal hexagrid & Vertical hexagrid respectively
- S & M → 2 – story module & 4 – story module respectively
- T & B → Top & Bottom, NG → No grid, D → Diagrid

Consider notation for all different heights are as follow:

HHST, HHSB, VHST, VHSB, HHMT, HHMB, VHMT, VHMB, NG.

4.5 GEOMETRY OF HEXAGRID:

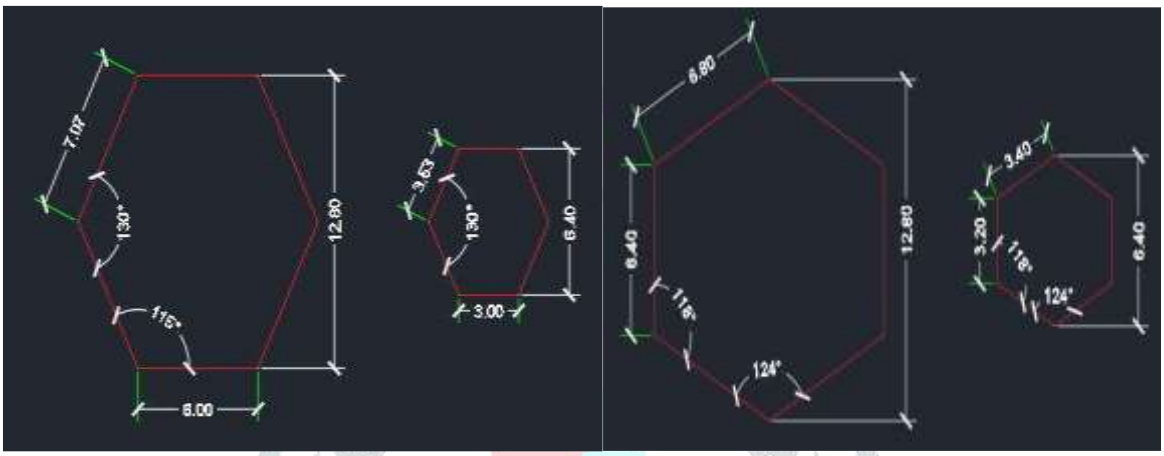

FIG 3: DIMENSION FOR HH & VH

- Angle for diagrid in D + HH is 65 degree
- Angle for diagrid in D + VH (2 – story module) is 44 degree
- Angle for diagrid inn D + VH (4 – story module) is 47 degree

4.6 MODELING

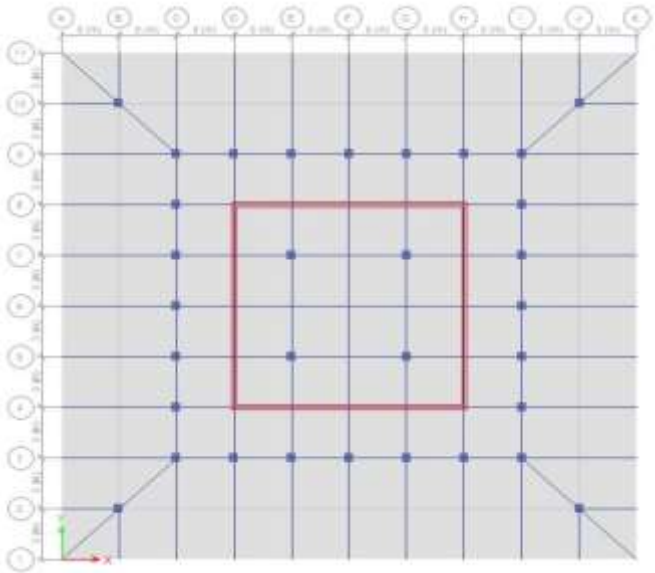

FIG 4: PLAN OF MODEL

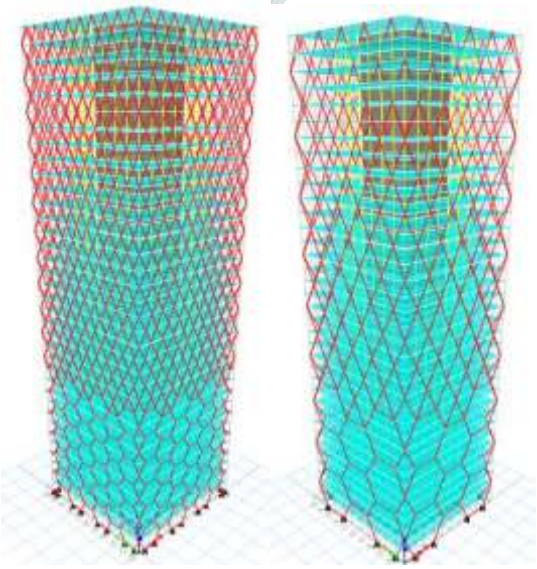

FIG 5: HHSB & HHMB model

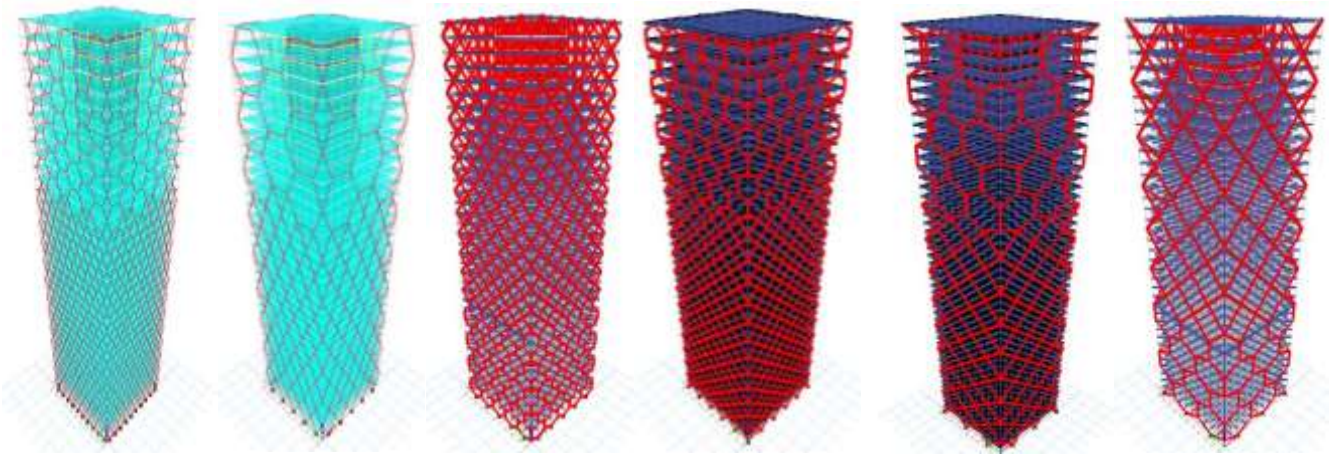

FIG 6: HHST, HHMT, VHSB, VHST, VHMT & VHMB model respectively

V. RESULT AND DISCUSSION

The results are obtaining from the Dynamic wind analysis and compared with each other to identifying most efficient geometry. Most of time DL + LL + WL load combination is governing, so result comparison based on that load combination.

5.1 Displacement results of all the model

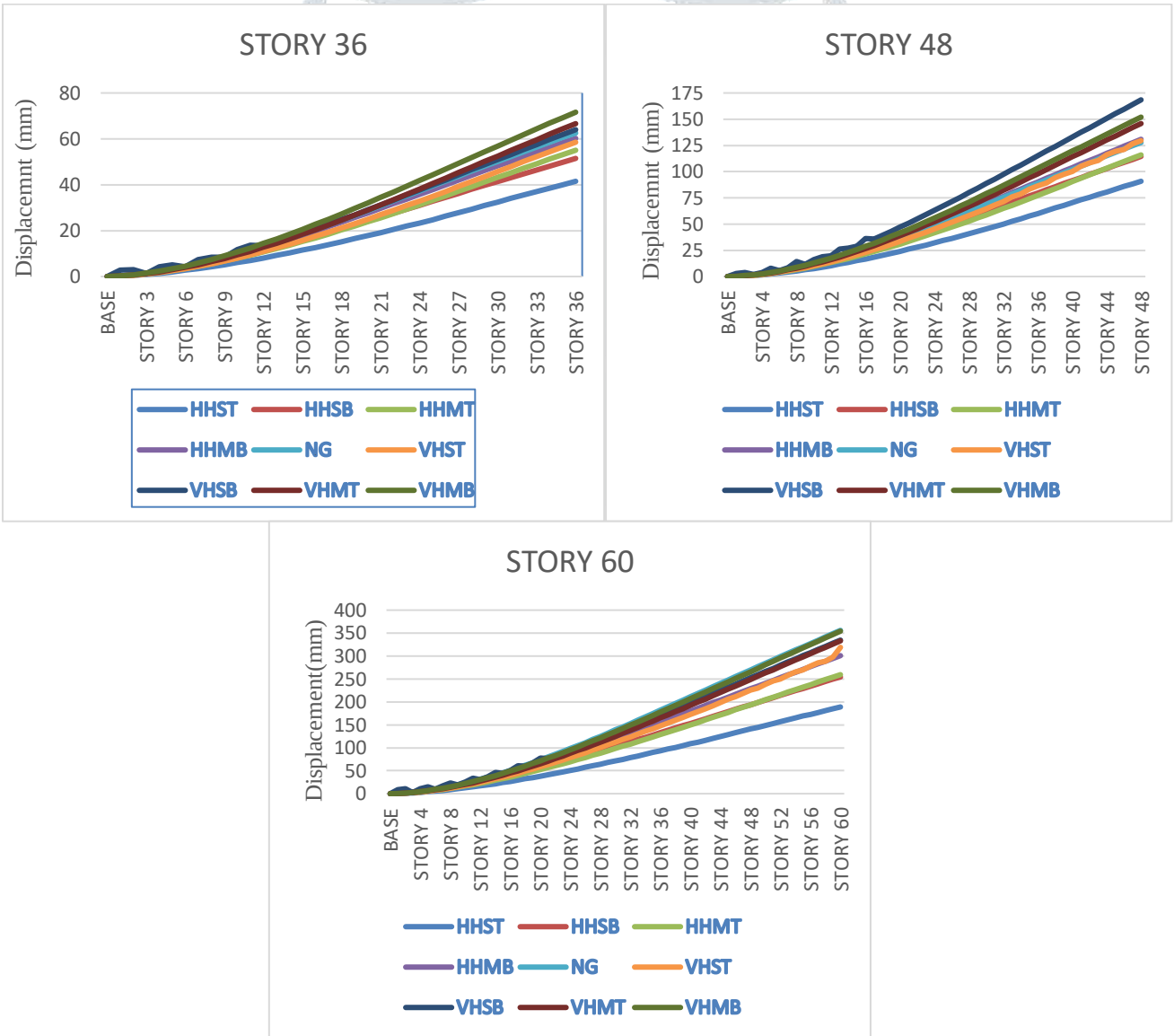

FIG 7: DISPALCEMENT OF ALL MODEL

5.2 Story drifts results:

TABLE 1: MAXIMUM STRORY DRIFT FOR ALL MODEL

MODEL TYPE	STORY					
	36		48		60	
	EQ	WL	EQ	WL	EQ	WL
HHST	0.000307	0.000234	0.000501	0.000604	0.000731	0.001171
HHSB	0.000304	0.00027	0.000562	0.000714	0.00093	0.001506
HHMT	0.000391	0.000311	0.000642	0.000777	0.001097	0.001633
HHMB	0.00041	0.00033	0.000728	0.000846	0.001162	0.001811
VHST	0.000394	0.000337	0.000695	0.000863	0.0029	0.001909
VHSB	0.000403	0.000351	0.000769	0.000949	0.002323	0.002038
VHMT	0.000413	0.000376	0.000785	0.000972	0.0014	0.002093
VHMB	0.000445	0.000388	0.000842	0.001007	0.00145	0.002164

From the table 1 identifying drift value due to dynamic wind load is higher than the seismic load. Also drift value for hexagrid at the bottom is higher than hexagrid at the top.

5.3 First Mode Time Period:

TABLE 2: FIRST MODE TIME PERIOD FOR ALL MODEL

STORY	FIRST MODE TIME PERIOD (sec)		
	MODEL	TIME PERIOD	TIME PERIOD (%)
36	NG	3	100
	HHST	2.405	80.17
	HHSB	2.738	91.67
	HHMT	2.778	92.6
	HHMB	2.954	98.47
	VHST	2.859	95.3
	VHSB	3.036	101.2
	VHMT	3.067	102.23
	VHMB	3.147	104.77
48	NG	4.911	100
	HHST	4.059	82.65
	HHSB	4.717	96.05
	HHMT	4.606	93.79
	HHMB	4.968	101.16
	VHST	4.85	98.76
	VHSB	5.299	107.90
	VHMT	5.181	105.50
	VHMB	5.315	108.23
60	NG	7.9	100
	HHST	6.212	78.63
	HHSB	7.347	93.00
	HHMT	6.918	87.57
	HHMB	7.512	95.09
	VHST	7.792	98.63
	VHSB	8.045	101.84
	VHMT	7.877	99.71
	VHMB	8.094	102.46

5.4 Story Shear

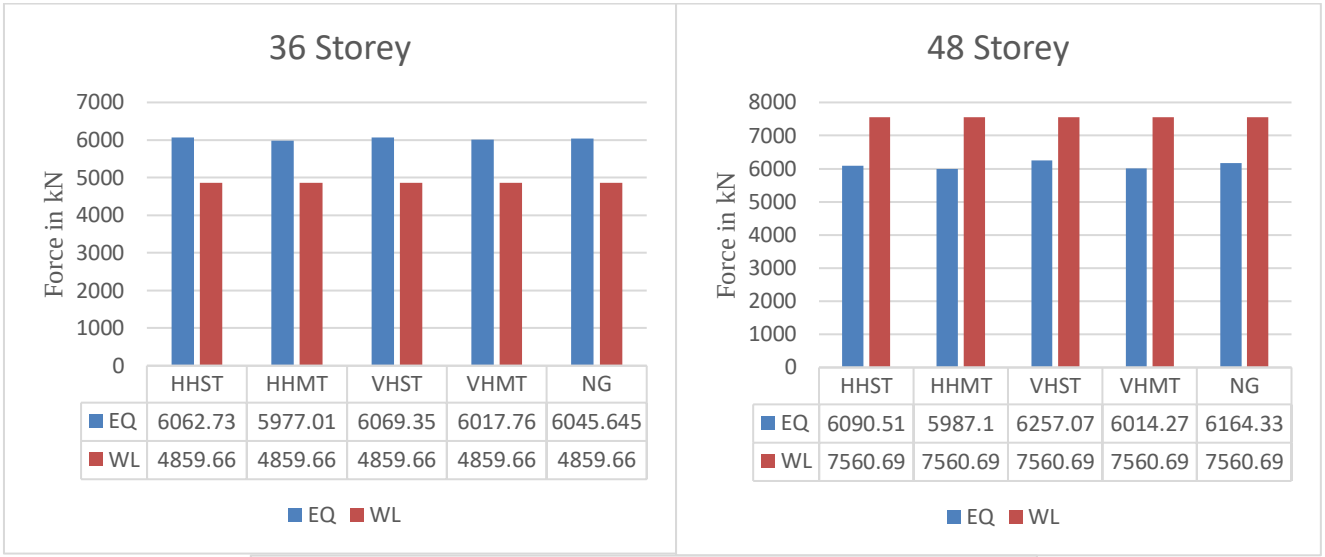

FIG 8: STORY SHAER FOR HEXAGRID AT TOP

VI. CONCLUSION

- Combine structure of Diagrid and Hexagrid response against lateral loads is depends upon the geometry of diagrid and hexagrid like size, pattern and angle.
- Increasing the height of structures effect of Dynamic wind load higher compare to the Earthquake load.
- In all the systems, placement of hexagrid module at top portion is better to placement at bottom in terms of displacement.
- Increasing the size of diagrid and hexagrid module is directly proportional to the displacement.
- The first mode time is increase with increasing the size of storey module.
- Also observed from the study that, the first mode time for Hexagrid module at top is lesser than the hexagrid module at bottom of the structures.
- Story drift value for D + HH type is lesser compare to the D + VH type systems.
- From the study observe that, Base shear for small size D + HH and D + VH is lesser compare to the Medium size D + HH and D + VH systems.

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