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Comparison of Hexagrid and Diagrid Structural System in Tall Buildings

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Abstract

The taller and higher structures results in the effects of lateral loading, lateral loads dominates when the height of building increases, lateral loads such as earthquake, wind causes the building larger displacement, to avoid larger displacement in high rise buildings lateral load resisting systems are deployed. Apart from other structural system, the diagrid and hexagrid system are adopted to improve structural performance of tall buildings. The various types of structural system in tall buildings have become obsolete and the new structural skeletons such as hexagrid and diagrid are being used. The present research shows analysis of 40 storey steel structure with composite columns with diagrid and hexagrid structural system along the periphery has been modelled in ETABS v.16 software. The structure is situated in zone II, both the model diagrid as well as hexagrid has been analysed for same gravity loading. The parameters such as displacement, base shear, storey drift, displacement due to wind. Equivalent static method is used for seismic analysis and force coefficient method is used for calculation of wind pressure.

Keywords: *Lateral Loads, base shear, storey drift, equivalent static method, diagrid, hexagrid, deflection.*

INTRODUCTION

Recent design trends have posed new challenges in the field of structural engineering. As the height of building increases the buildings become more susceptible to lateral loads as compared to gravity load and lateral load dominates over gravity loads and hence it becomes more important to design building considering lateral loads. To resists lateral loads there are various types of lateral load resisting system some of them are flat slab–beam system, flat slab–frame with shear walls, coupled shear walls, rigid frame, tube system with widely spaced columns, rigid frame with haunch girders, core-supported structures, shear wall–frame interaction, frame tube system, exterior diagonal tube, bundled tube, etc. In order to improve efficiency of the structural system the new structural system diagrid structural system and hexagrid structural system. Diagrid structural system is the large bracing system made of steel sections. In nature, bees have a fascinating, meticulous way of forming their beehives, which serve as their homes, their protection and their source of life. The beehive internal structure is a densely packed matrix of hexagonal cells called honeycomb. The bees use the cells to store food, and to house the breed. The hexagonal shape perfectly distributes and disperses the external man made or Environmental forces thus protecting its contents. Thus the literature related to diagrid as well as hexagrid structural system has been studied.

LITERATURE VIEW

Lateral load resisting system are not a new phenomenon it was used early century and

was implemented in USA John Hancock Center of Chicago in 1970 Hal Iyengar, lateral load resisting systems in tall buildings has been used from the late 19th century. Historically diagonal truss system was introduced in bridge construction.

Apart from various structural system i.e. flat slab–beam system, flat slab–frame with shear walls, coupled shear walls, rigid frame, tube system with widely spaced columns, rigid frame with haunch girders, core-supported structures, shear wall–frame interaction, frame tube system, exterior diagonal tube, bundled tube system the new structural system such as diagrid and hexagrid system are being used in tall buildings improve the efficiency of load carrying capacity of structure. A comparison of diagrid with hexagrid structural system has been performed (Niloufer Mashhadiali et.al 2012).Further studies in the diagrid and hexagrid system has been carried out by different geometrical configuration and by changing the diagonal grids into different angels (Giovanni Maria Montuori *et.al.* 2012).

(Han-Ul Lee *et. al* 2017) have studied both the structural system diagrid as well as hexagrid in terms of structural as well as architectural point. Their study concluded buildings with smaller modules are more efficient than buildings with larger modules.

BUILDING DETAILS

The building considered here is a commercial building. The plan dimension is 42.875M X 25M. The research is carried out on the same building plan for diagrid and hexagrid structural system as shown in Figure 1. The basic loading on all types of structures are kept same.

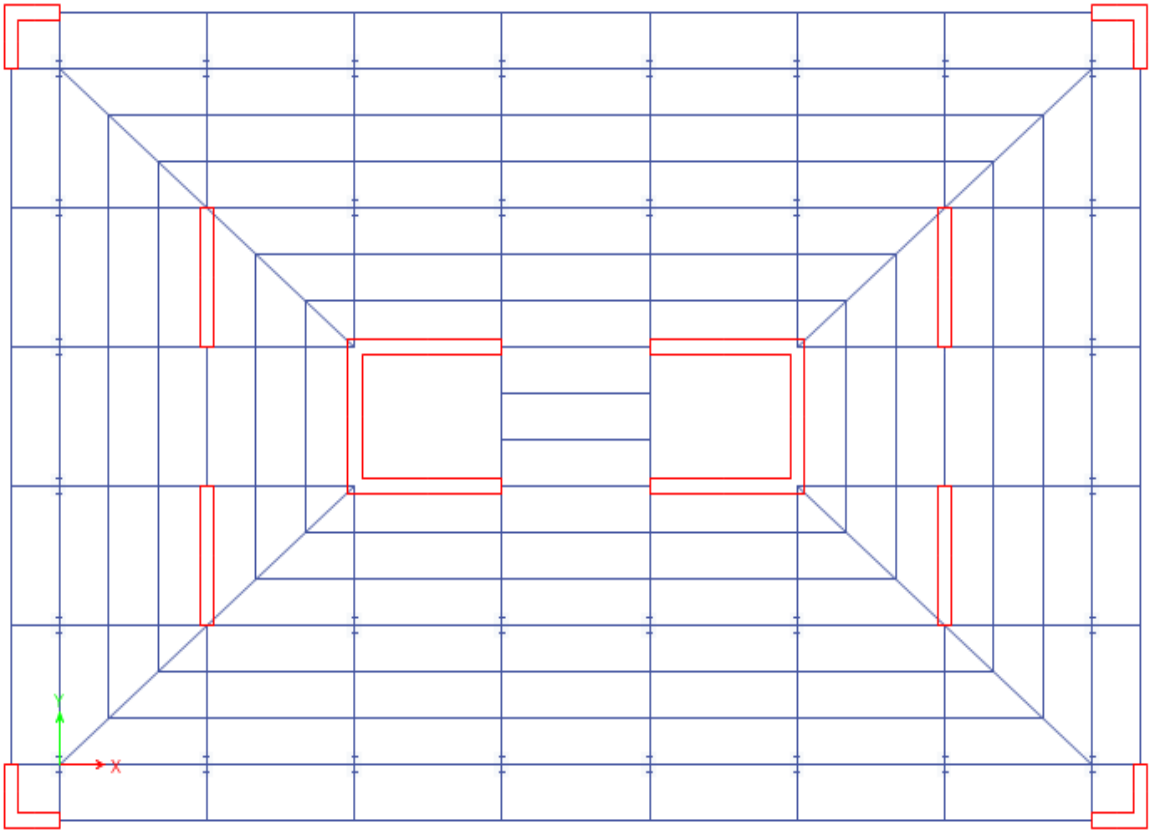

Fig: 1. *Plan showing typical floor*

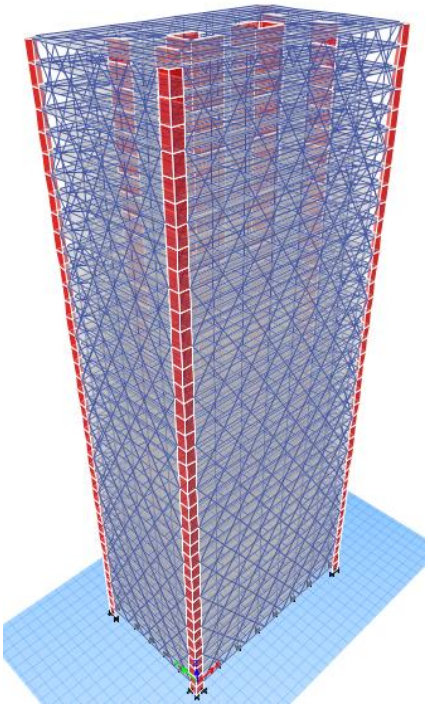

Fig: 2. *Etabs model of diagrid*

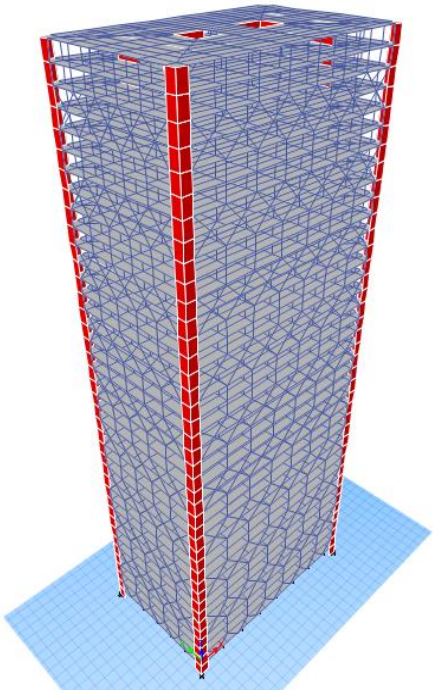

Fig: 3. *Etabs model of hexagrid*

Data for Analysis of Diagrid and Hexagrid structural system

Table: 1. *Analysis of Diagrid and Hexagrid structural system*

S.R No	Particulars	Diagrid Structural System	Hexagrid Structural System
1	Dimension of Plan	42.875m X 25m	42.875m X 25m
2	Total height of the structure	120m	120m
3	Height of each storey	3.00M	3.00M
4	Height of parapet	1.00M	1.00M
5	Sizes of beams	ISWB600	ISWB600
6	Size of columns	Composite Column Concrete-600MM X 900MM Steel-ISWB600	Composite Column Concrete-600MM X 900MM Steel-ISWB600
7	Perimeter Section	ISNB300H	ISNB300H
8	Thickness of slab	Deck Slab	Deck Slab
9	Thickness of Shear wall	600mm	600mm
10	Thickness of walls	230MM	230MM
11	Seismic zone Importance factor Zone factor Damping ratio	II 1 0.1 5%	II 1 0.1 5%
12	Floor finish Live load at all floors Density of concrete Density of brick	1.5 kN/m^2 2 kN/m^2 25 kN/m^3 20 kN/m^3	1.5 kN/m^2 2 kN/m^2 25 kN/m^3 20 kN/m^3
13	Grade of concrete Grade Steel Section Soil condition	M40 Fe345 Medium soil	M40 Fe345 Medium soil

PERFORMANCE ANALYSIS

Storey Displacement

Storey Displacement is the absolute value of Displacement of the storey under action of the lateral forces.

Table: 2. *Storey Displacement*

Storey displacement (mm)	
Diagrid	**Hexagrid**
33.64	34.49

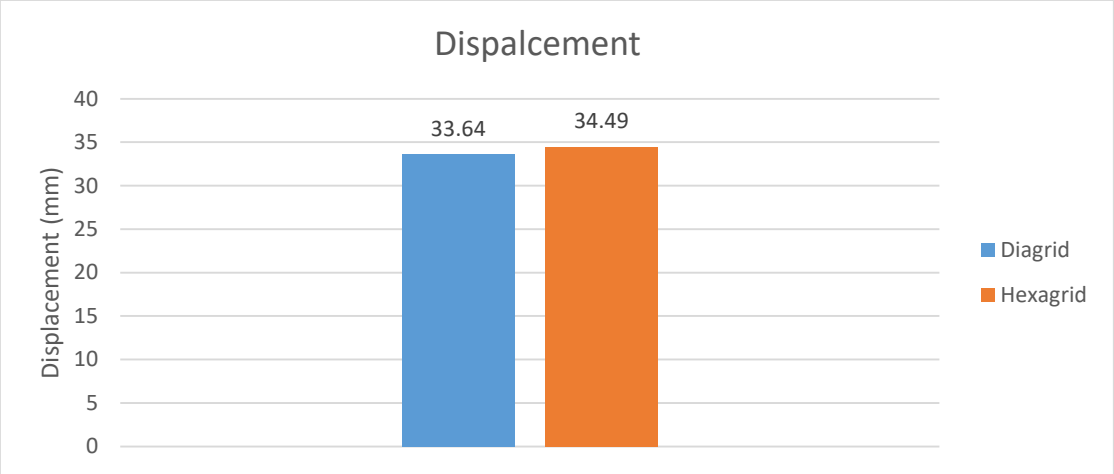

Fig: 4. *Maximum Storey Displacement.*

Storey Shear

Base Shear is an estimate of the maximum Expected lateral force that will occur due to seismic ground motion at the base of structure.

Table: 3. Storey Shear

Storey Shear		
	Diagrid	**Hexagrid**
EQX	3419	3448
EQY	3419	3448

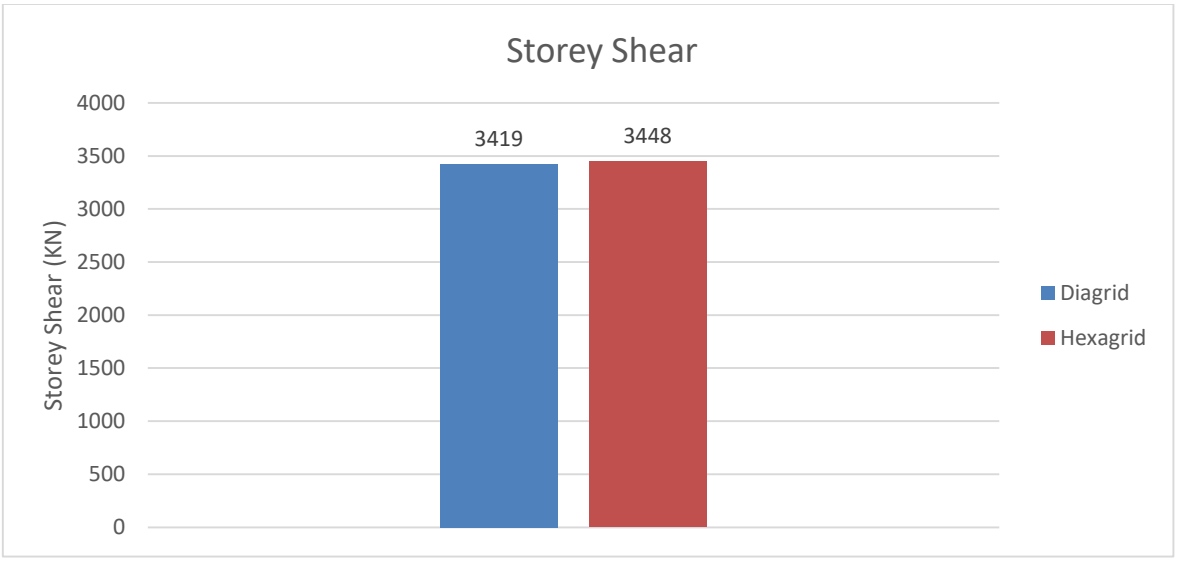

Fig: 5. *Storey Shear*

Storey Drift
Storey Drift is the drift of one level of a multi-storey building relative to the level below.

Table: 4. *Storey Drift*

Storey Drift		
	Diagrid	**Hexagrid**
EQX	0.00018	0.00028
EQY	0.00028	0.00037

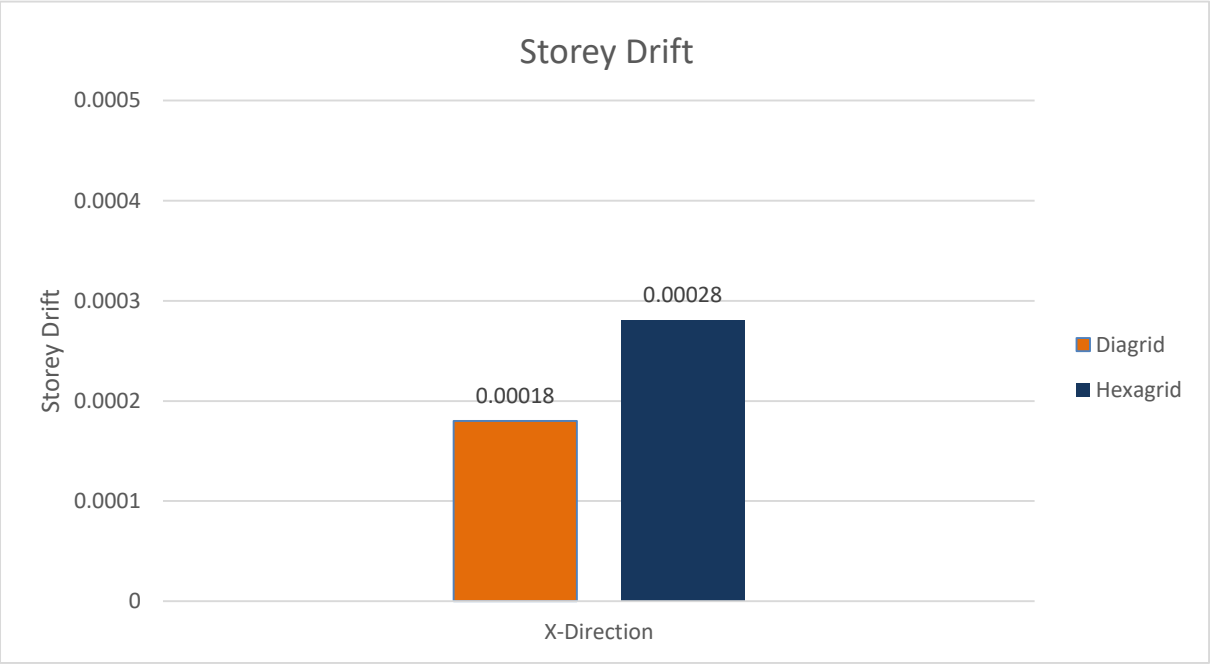

Fig: 6. *Storey Drift in X-Direction*

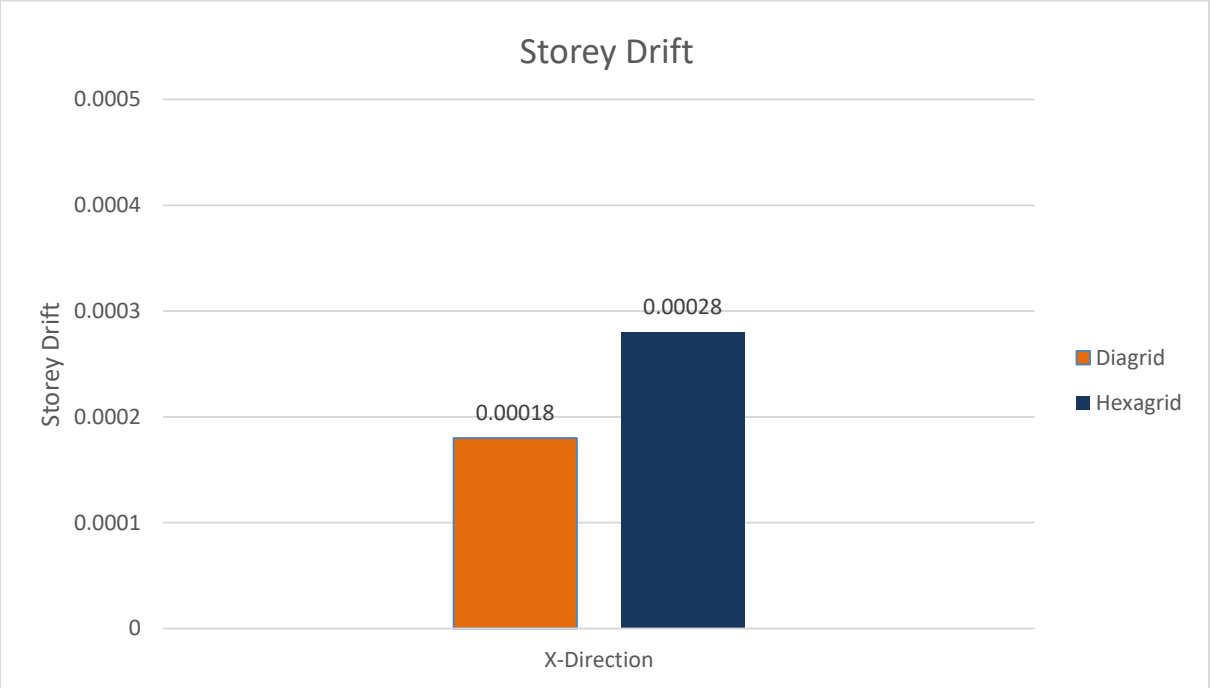

Fig: 7. *Storey Drift in Y-Direction.*

Seismic weight

Table: 5. *Seismic weight*

Mass (KN)	
Diagrid	**Hexagrid**
821860.275	828387.93

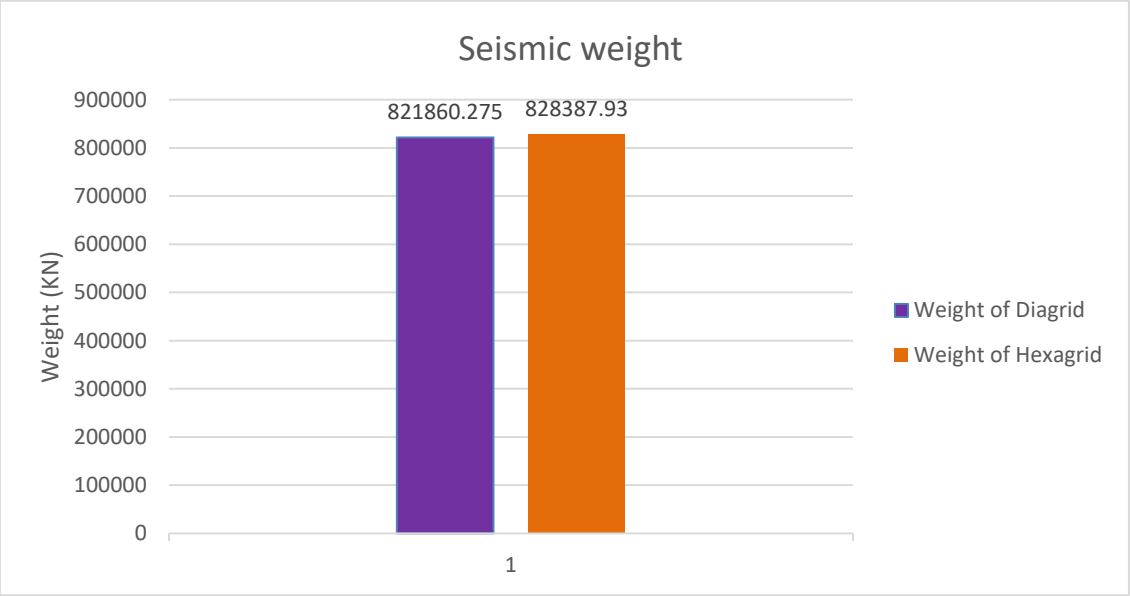

Fig: 8. *Mass*

CONCLUSION

Analysis results of G+40 storied building with diagrid as well as hexagrid structural system shows that,

1. Maximum Storey Displacement with of hexagrid structural system is 2.52% more than diagrid structural system, hence there is percentage increase of storey displacement when hexagrid structural system is used so in terms of storey displacement hexagrid system has greater ductility than diagrids system.
2. Base shear with hexagrid structural system is 0.84% more as compared to diagrid structural system structural system hence there is larger base shear when hexagrid structural system is used hence resistance to lateral force will be more in hexagrid than diagrid structural system.
3. Storey drift in x-direction with diagrid structural system is 35% less as compared with hexagrid structural system hence hexagrid system proves to be more safe in terms of storey drift than diagrid system.
4. Storey drift in y-direction with hexagrid structural system is 24% more as compared with diagrid structural system hence hexagrid system proves to be more safe in terms of storey drift than diagrid system.
5. As per above results hexagrid structural system is more economical and provide resistance to lateral forces.

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