

Comparative Study of Diagrid Structures over Braced tube Structures

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ABSTRACT: In this era increasing in the population limiting in the land space and high in the cost of land, to save agricultural land we go for tall buildings. When height of the building increases, the lateral loads will be increases this cause failure of structure. In order to resist this lateral loads resisting systems have been introduced. Some of lateral resisting systems are of diagrid and Braced tubes are taken for this study.

The plan of square and hexagonal are modeled for both Diagrid and Braced tube structures. The models are compared for different plans of the structure, such as square and hexagonal, the maximum storey displacement, storey drift, base shear, and time period, the structure is analyzed for seismic zone III and zone V and medium soil condition as per IS 1893:2002 using ETABsv15 software. From the model braced structures is stiffer than the diagrid structures, since the columns are provided in periphery. Diagrid structures can be made effective by providing additional columns near periphery of the structure.

KEYWORDS: Tall building, Lateral load, Diagrid, Braced tube, Shear wall, Displacement, Drift, Base shear.

I. INTRODUCTION

1.1 Tall building:

A common man may decide that anything over 5 Storey's is a tall building and from this decision he may categorize accordingly and be very satisfied. For a structural engineer it is not so simple. A tall building is, from a structural engineer's perspective, to be considered tall when, due to its height, the lateral forces suffered by the structure play a significant role in the design.

Engineers find disagreement over how to measure height and classify structures; engineers have invested over different definitions for criteria of buildings and other structures. One contain the absolute height of a building another contain only spires and other permanent architectural features, but not antennas. The tradition of including the spire on top of a building and not including the antenna dates back to the rivalry between the Chrysler Building and 40 Wall Street. A modern-day example is that the antenna on top of Willis Tower (formerly Sears Tower) is not considered part of its architectural height, while the spires on top of the Petronas Twin Towers are counted.

Due to the action of lateral loads in tall building is not easy to construction of tall buildings as that of normal building. In tall buildings lateral displacement will have bending effects and shear will be more so lateral load resisting systems are introduced. The lateral load resisting systems are Rigid frame, Shear wall structure, Outrigger structure these are interior structures. And Exterior structures such as Tube system, Diagrid system, Space truss, Exoskeleton structure, and Super frame structure.

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1.2 Diagrid:

The diagrid is a framework of diagonally intersecting metal, concrete or wooden beams that is used in the construction of buildings and roofs. It requires less structural steel than a conventional steel frame.

The origin of 'diagonal' structures is surely the Russian genius Vladimir Shukhov.



Fig1: Diagrid system

The diagrid structural systems carry both gravity loads and lateral loads because of triangulation configuration. Diagrid structures are effective in minimizing shear deformation because they carry lateral shear by axial action of diagonal members. Diagrid structures generally don't need high shear rigidity cores because lateral shear can be carried by the diagonal members located on the periphery.

1.3 Braced tube:

The Braced tube, which are resist lateral loads in tall building. It gives structural efficiency in tall building, they are in the form of tube frame and truss.

A Bracing is a structural system which is designed primarily to resist wind and earthquake forces. Members of a bracing are designed to work in tension and compression, similar to a truss. Most of the structural systems deployed for early tall building were steel frames with diagonal bracing of various configurations such as X, K, V and inverted V.



Fig2: Braced tube structure

However, while the structural importance of diagonals was well recognized, their aesthetic potential was not explicitly appreciated. Thus, diagonals were generally embedded within building cores that are widely used are: rigid frames, shear wall, wall-frame, braced tube systems, outrigger system and tubular system. In 19th century early designs of tall building recognized the diagonal bracing members in resisting lateral forces.

1.4 Shear wall

In structural engineering, a shear wall is a structural system to counter the effects of lateral load acting on a structure. Wind and seismic loads are the most common loads that shear walls are designed to carry.

Shear wall is a structural element used to resist lateral/Horizontal/Shear forces parallel to the plane of the wall.

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II. OBJECTIVE OF PROJECT

The main objectives of the present study are:

- To study the comparative behaviour of Diagrid and Braced tube structures subjected to Static and Dynamic earthquake loading.
- In addition to the objective (1) the study will be extended to different plan like Square and hexagon.
- Here structural analysis software like ETABS.v15 will be used and the results are in terms of Storey displacement, Storey Drift, Base Shear, Storey Stiffness.
- Displacements, Drifts are compared for the above models.
- Base shear, Fundamental natural time period and Storey Stiffness for all the models are compared.
- Finally, the analysis will be concluded based on the behaviour for diagrid and braced structures.

2.1 Modeling and Analysis Method

Following are the building configurations for the modeling and analysis of structures.

- 3D modeling for analysis of multistory building having 2 different plans such as square and hexagonal models are designed for both diagrid and bracing systems using ETABS.
- G+30 storey Building with Square of 40mx40m, and hexagonal of 20m each side of dimensions.
- Each storey height is 3m.
- Slab thickness 125mm for both the systems.
- Size of diagrid 300 mm pipe sections with 12mm thickness at an angle of 72°.
- For braced frame model inverted –V type bracings back to back double angle sections of 180x180x15mm
- The dead load is taken 3kN/m². The live load is taken 3kN/m².
- Load combination of (DL+0.5LL) is considered as per IS-875-part 5-1987.
- The earthquake load parameters are taken as zone factor 0.16 and 0.36, soil type II, Importance factor 1, Response Reduction 5 as per IS-1893-2002.
- Supports are taken as fixed.
- The building is analyzed by Equivalent static method, Response Spectrum method.

2.2 Parameters to be studied

- Storey displacement
- Storey drift
- Base shear
- Time period

Table 1: Sizes of structural members for all models

Member	Member no.	Diagrid building	Braced building	Property
Beam	B	300x1000mm	300x1000 mm	concrete
	b1	300x600mm	300x600 mm	
Inner Column	C	1200x1200mm	1200x1200 mm	concrete
Peripheral column	c		400x400mm	
Diagrid	d	300mm pipe with 12mm thickness		steel
bracing	b		ISA 180x180x15mm	steel

III. METHODOLOGY

This chapter explains the methodology used in the study. It explains the methodology in detail, various assumptions made, and details of structures used in the study.

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- Finite element software ETABS v15 will be used for the modeling and analysis.
- All the dimensions and loads were considered according to IS codes.
- Lateral load resisting systems such as diagrid system and braced tube system are used.
- The plan of square, rectangular and hexagonal modelling of diagrid and braced tube systems are considered.
- Both diagrid models and braced tube models are analysed for seismic zone III and zone V.
- The support conditions are considered as fixed.
- Dead load and Live load shall be considered as per IS 875 (Part-1 and Part-2).
- Load combination is considered as per IS-875 part-5-1987.
- The static seismic analysis will be performed as per Equivalent static method in IS1893:2002.
- Response spectrum method is considered for the dynamic analysis.
- Results are compared with the square, rectangular and hexagonal shape of buildings for diagrid system and braced tube system.
- Analysis results were tabulated and compared to know which lateral resisting system is better.
- Results are in terms of storey drift, storey displacement, base shear, storey stiffness.
- Results are extracted from ETABS and graphs will be plotted using MS Excel.

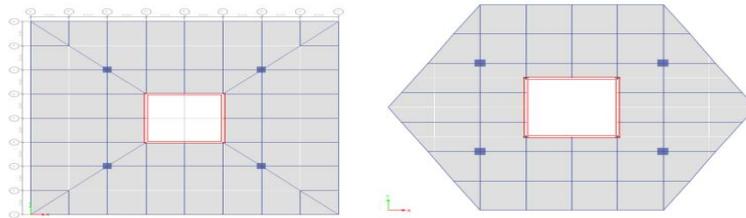


Fig 3 Plan Layout of Diagrid structures

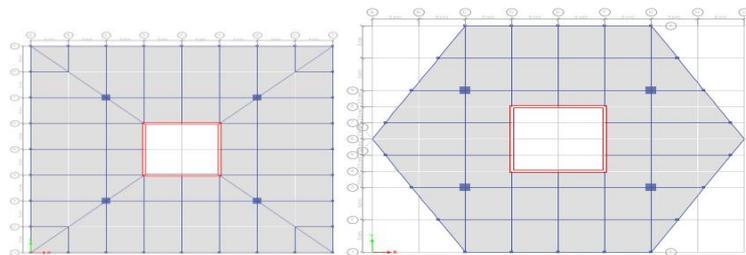


Fig 4 Plan Layout of braced structures

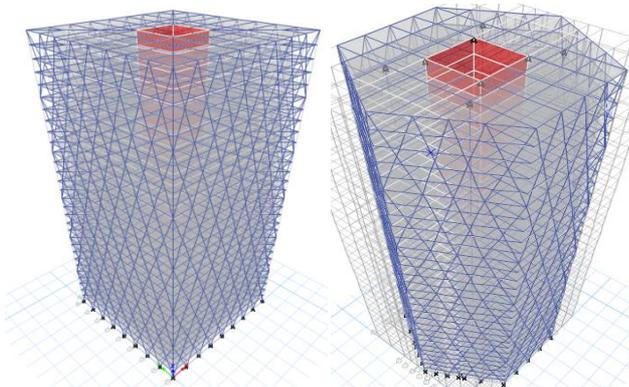


Fig 5: 3D view of diagrid structures

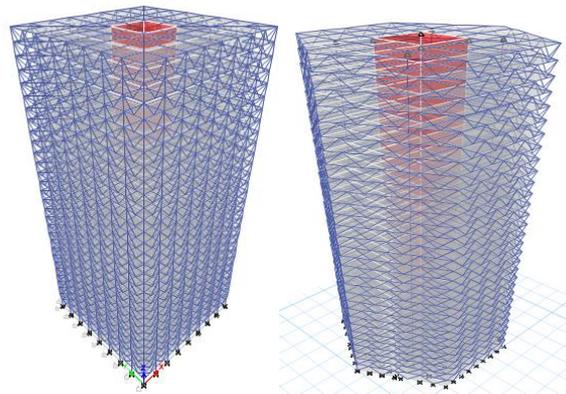


Fig 6: 3D view of braced tube structures

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IV. EXPERIMENTAL RESULTS

In this chapter, the results of models are presented and discussed in detail. The results are included for all the different buildings models. The analysis of the different building models is performed to zone III and zone V by using ETABS analysis software.

In the present study the behavior of each model is captured and the results are tabulated in the form of lateral displacement and story drift, base shear in linear Static and linear Dynamic analysis.

4.1 Storey Displacement

The maximum displacement for each models are shown in tables are obtained from equivalent static method (ESA) and response spectrum method (RSA) for Diagrid structural systems and bracing structural systems along both longitudinal (x-direction) and transverse (y-direction) are listed in the tables below and for better compatibility the displacements for each models are plotted in charts below. With reference to the square model how much % of reduction in the hexagonal models are shown.

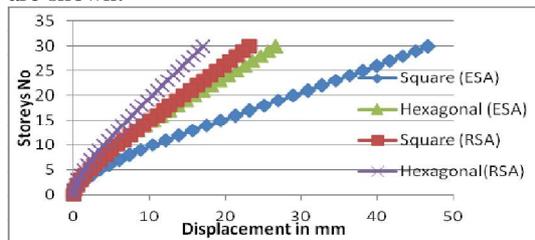


Fig 7: Graph showing Displacement of Diagrid models along X- direction v/s Storey No. for Zone 3(ESA and RSA).

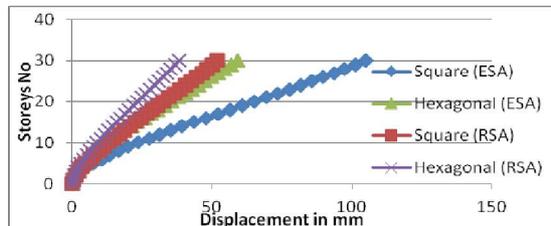


Fig 8: Graph showing Displacement of Diagrid models along X- direction v/s Storey No. for Zone 5(ESA and RSA).

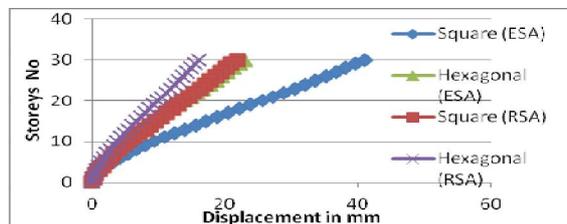


Fig 11: Graph showing Displacement of Braced tube models along X- direction v/s Storeys No. for Zone 3 (ESA and RSA).

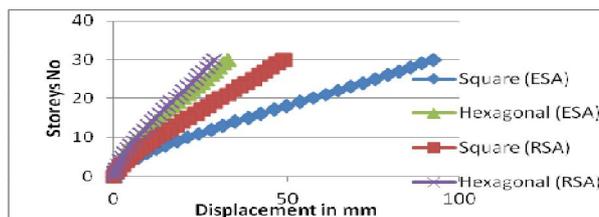


Fig 12: Graph showing Displacement of Braced tube models along X- direction v/s Storeys No. for Zone 5 (ESA and RSA).

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4.2 Storey Drift

The permissible storey drift according to IS 1893-2002 : is limited to .004 times the storey height, so the minimum damage would take place during earth quake from ETABS are show in tables below.

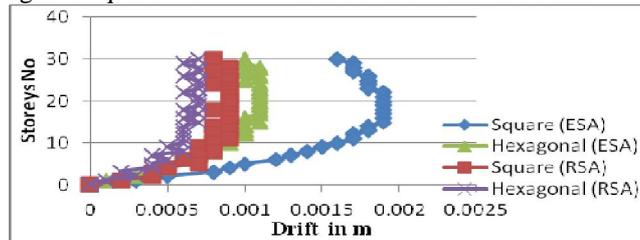


Fig 15: Graph showing Drift of Diagrid models along X- direction v/s Storeys No. for Zone 3 (ESA and RSA).

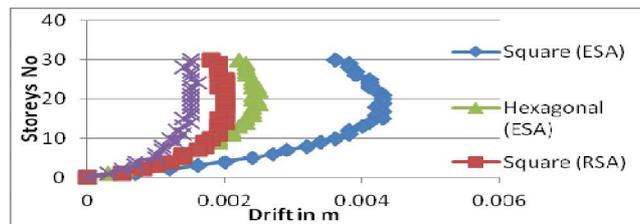


Fig 16: Graph showing Drift of Diagrid models along X- direction v/s Storeys No. for Zone 5 (ESA and RSA).

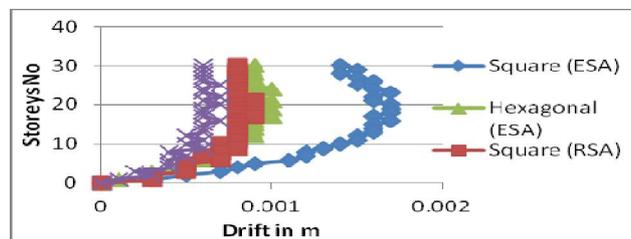


Fig 19: Graph showing Drift of Braced tube models along X- direction v/s storeys No. for Zone 3 (ESA and RSA).

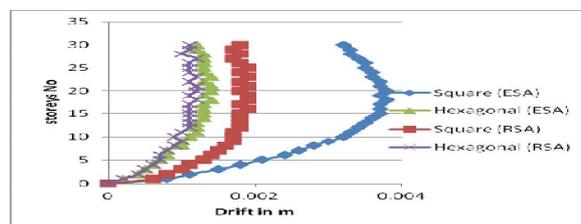


Fig 20: Graph showing Drift of Braced tube models along X- direction v/s storeys No. for Zone 5 (ESA and RSA).

4.3 Base Shear

The base shear for Equivalent static method (V_b) and the Response spectrum method (V_B) as per IS 1893: 2002 (part I) for various building models are listed in the tables below. The scale factor V_b/V_B has been multiplied as per clause 7.8.2 IS 1893:2002 (Part I)

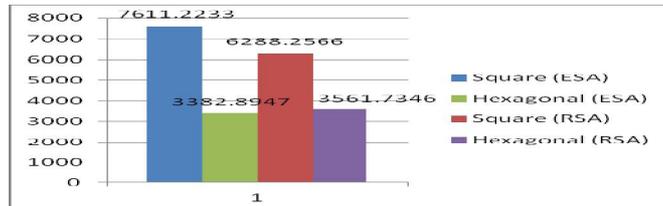


Fig 23: Model Vs Base shear for different models along X- direction for zone3 Diagrid structures.

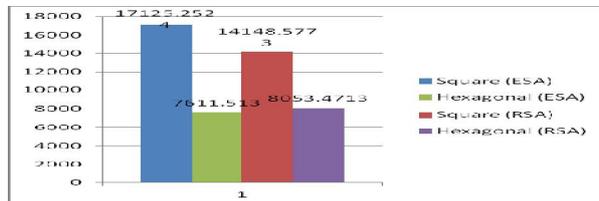


Fig 24: Model Vs Base shear for different models along X-direction for zone5 Diagrid structures.



Fig 25: Model Vs Base shear for different models along X- direction for zone3 Braced tube structures.

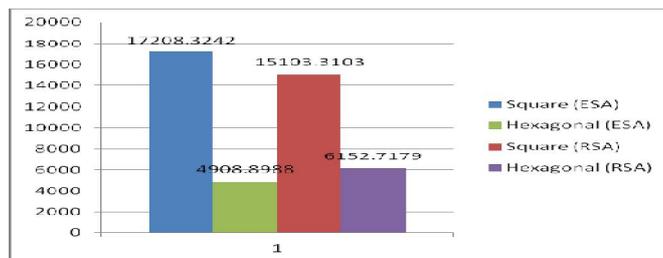


Fig 26: Model Vs Base shear for different models along X- direction for zone5 Braced tube model.

4.4 Time Period

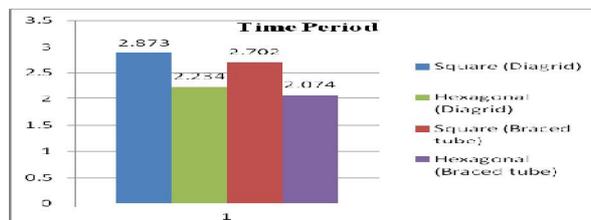


Fig 31: Graph showing Time Period for zone3 Diagrid and Braced tube structures.

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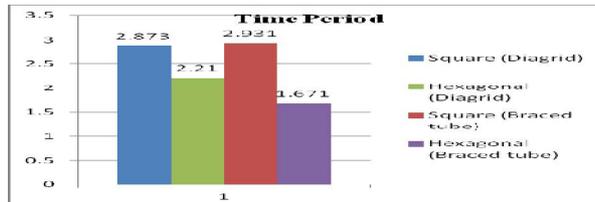


Fig 32: Graph showing Time Period for zone5 Diagrid and Braced tube structures.

Table2: Comparative Results for zone3 of Diagrid and braced tube structures.

		Zone3			
		Diagrid		Braced tube	
		Square	Hexagonal	Square	Hexagonal
Max disp.	ESA	0.0466	0.0226	0.041	0.023
	RSA	0.231	0.0171	0.0218	0.0161
Max drift	ESA	0.0019	0.0011	0.0017	0.001
	RSA	0.0009	0.0007	0.0009	0.0007
Base shear	ESA	7611.22	3382.89	7648.14	3424.64
	RSA	6288.25	3561.73	6712.58	3805.00
Time period		2.873	2.234	2.702	2.074

Table3: Comparative Results for zone5 of Diagrid and braced tube structures.

		Zone5			
		Diagrid		Braced tube	
		Square	Hexagonal	Square	Hexagonal
Max disp.	ESA	0.1048	0.0591	0.0923	0.033
	RSA	0.052	0.0384	0.043	0.029
Max drift	ESA	0.0043	0.0025	0.0038	0.0014
	RSA	0.0002	0.0015	0.0019	0.0012
Base shear	ESA	17125.25	7611.25	17208.32	4908.89
	RSA	14148.57	8053.47	8053.47	6152.71
Time period		2.873	2.234	2.702	2.074

V. CONCLUSION

The following concludes are made from the present study.

- The hexagonal plan structure is stiffer than square plan structure.
- And the displacement due to square plan is higher than the displacement due to hexagonal plan.
- Base shear due to square plan is higher compared to that of hexagonal plan.
- Time period of the diagrid structures are higher than those compared to brace structures.
- From the models considered braced structure is stiffer than the diagrid structures, since columns are provided in the periphery.
- Diagrid structures can be made effective by providing additional columns near periphery of the structures.

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