COMPARATIVE STUDY OF SEISMIC BEHAVIOUR OF DIAGRID STRUCTURE WITH CONVENTIONAL STRUCTURE

Saurabh Babhulkar¹, Kuldeep R Dabhekar², S.S. Sanghai³, Isha P khedikar⁴
¹M-Tech. Student, Structural Engineering, G.H. Raisoni College of Engineering, Nagpur, India.
²,³,⁴Assistant Professor, Department of Civil Engineering, G.H. Raisoni College of Engineering, Nagpur, India.
¹babhulkar_saurabh.mtechstr@ghrce.raisoni.net

Abstract: Diagrid framework has arisen as an inventive underlying framework with a stylish view in the plan of tall structures. In this investigation, seismic execution of 15-story diagrid structures with fluctuating points are assessed utilizing reaction range examination further more in request to assess the impact of diagrid center on conduct of designs. Actually diagrid essential system is gotten in tall constructions on account of its basic usefulness and versatility in plan organizing. Stood out from solidly scattered vertical areas in illustrated chamber, diagrid structure includes skewed sections outwardly surface of building. Because ofslanted sections horizontal burdens are opposed by hub activity of the askew contrasted with twisting of vertical segments in customary construction. Plan and development of counterfeit foundation on the lines of biomicking standards require the improvement of exceptionally advance primary framework which has the characteristics of style articulation, underlying effectiveness and above all mathematical adaptability. Diagrid the most recent change of cylindrical constructions, have an ideal mix of the above characteristics. In this paper, the peculiarities of the diagrid its essential lead under stacking and the arrangement and advancement of diagrid centers are portrayed A context oriented examination of some new diagrid tall constructions, to be explicit the Swiss Re in London, the hearn tower in New York, and the west Guangzhou Tower in china is moreover presented.

Keywords: Diagrid Structural System, High rise buildings, Structural design, STAAD Pro.

1. INTRODUCTION

Tall structures are blasting right now particularly in significant urban communities of world, because of the movement of productive primary frameworks, progresses in the development innovation and lack of metropolitan land accessible for development. Equal stacking in light of wind or seismic quake are the directing components in the arrangement of tall constructions close by the movement of gravitational stacking. In request to oppose the sidelong loads, either inside or outside primary frameworks are utilized. The broadly utilized inner horizontal burden opposing primary situation incorporate inflexible casing, supported edge, shear divider and outrigger structure though the outside frameworks establish rounded, diagrid, Penta grid, hex grid and octagrid structures. Of late, diagrid underlying frameworks are embraced in tall structure [1]

In the diagrid structures, the upward fragments from the edge of the advancement are gotten out and it incorporates important stone formed modules. A found arrangement is outlined in the diagrid structures, the upward regions from the edges of the improvement are shed and it includes significant stone formed modules. A discovered game plan is laid out in the diagrid covered up structures due to
the modules and thusly, diagrids can pass on gravity and equal loads and pass on them in an incredibly uniform and typical model. What's more, by the utilization of diagonals, lesser measure of material is utilized. Likewise, because of the end of segments, much space is accessible to make the design more adaptable. Module size or diagrid module height is the amount of stories in the Diagrid module. Furthermore, diagrid's awry point is the point between the corner to corner people and the level columns in the outside of the development.

Figure 1. Diagrid buildings (a) Swiss Re in London (b) Hearst Tower in New York (c) Cyclone Tower in Asan(Korea) (d) Capital Gate Tower in Abu Dhabi and (e) Jinling Tower in china.

Diagrid is a specific type of room bracket. It comprises of edge network comprised of a progression of located bracket framework. Diagrid is framed by converging the askew and flat parts. The celebrated instances of diagrid structure from one side of the planet to the other are the Swiss Rein London, Hearst Tower in New York, Cyclone Tower in Asan (Korea), Capital Gate Tower in AbuDhabi and Jinling Tower in China as demonstrated in Fig 1. The new settle for Central China Television (CCTV) in Beijing is one of the instances of use of diagrid primary framework to help the difficult shape [4].

The corner to corner individuals in diagrid primary frameworks can convey gravity stacks just as sidelong powers because of their located arrangement. Diagrid structures are more viable in limiting shear miss happening in light of the fact that they convey horizontal shear by hub activity of inclining individuals. Diagrid structures by and large needn't bother with high shear inflexibility centers since parallel shear can be conveyed by the askew individuals situated on the outskirts [2].

2. MERITS OF DIAGRID

1) The Diagrid structures have generally section free outside and inside, henceforth liberated special floor plans are conceivable.
2) The glass façade and lack of inside segments permit liberal measures of day lighting into the constructions
3) The utilization of Diagrids results about 1/fifth decrease in steel when contrasted with propped outline structures
4) The development methods include are basic yet they should be great
5) The diagrid makes greatest abuse of the underlying material
6) The diagrid structures are elegantly predominant and expressive.

3. DEMERITS OF DIAGRID

1) As of yet the diagrids development methods are not altogether investigated
2) absence of accessibility of talented specialists development groups have practically no experience making a diagrid high rises
3) The Diagrid can administer beautifully which can be an issue dependent upon plan assumption
4) it is hard to design windows that make a standard language starting with one story then onto the next
5) The diagrid is bungling if not executed true to form.
4. OBJECTIVE

Wellbeing and least harm level of a construction could be the great necessity of tall structures. The meet these prerequisite, the construction ought to have satisfactory sidelong strength and adequate malleability. In this proposal I pick two 15 story structures, one for diagrid and other for customary structures, in and investigation esteem are thought about as far as Shear, Displacement, Drift and furthermore the prudent viewpoint is looked at.

- To break down diagrid and traditional underlying frameworks utilizing staad ace programming.
- To contrast the presentation of the structure and diagrid underlying framework and convetional Structural framework.
- To acquire the reaction as far as boundaries such a story uprooting, story float, story shear.

5. RESEARCH SIGNIFICANCE

Development of multi-storey building is quickly expanding all through the world because of the fast development of metropolitan populace and limit of accessible land. As the height of development fabricates, the impact of sidelong loads increments and requires parallel burden opposing designs to oppose them. The diagrid primary framework is generally utilized for late tall structures because of the underlying productivity and tasteful potential. Hexagrid structural system can be used to challenge the limit to building height in diagrid. The work of Diagrid, Hexagrid or Octagrid primary frameworks in a structure bring about various benefits like decrease of inside sections giving enormous segment free spaces that can be utilized as indoor games amphitheaters, display corridors and so on. The slanted segments take up gravity just as sidelong loads dissimilar to the ordinary vertical sections. Likewise, these frameworks lead to immense reserve funds as far as material expense. Thus, it is important to think about the three frameworks of Diagrid, Octagrid, and Hexagrid with an outside supported steel construction to discover the proficient underlying framework. The goal of this paper is to study and look at the presentation of Diagrid, Octagrid and Hexagrid structures with changed askew points and fluctuated module thickness under unique stacking and furthermore to track down the underlying framework that displays least popular narrative uprooting and float, the ideal scope of slanting point having better solidness and relationship of time-frame to horizontal firmness. Break down the hidden weight and material cost of all construction models to choose the most reasonable option among the models.

6. METHODOLOGY

The method of analysis used for the present study are.

1. Response Spectrum method

Response spectrum analysis is a method to estimate the structural response to short non deterministic, transient dynamic events. Example of such events are earthquakes and shocks. Since the exact time history of the load is not known, it is difficult to perform a time dependent analysis.

7. BUILDING DESCRIPTION AND MODELING

A square shaped 15 storey building of size 24m x 24m, storey height 3.2m and plan area 576m² is considered for the analysis and design
Figure 2. Plan of Building

The three kinds of structures that have been demonstrated, Diagrid with 2 module, diagrid with 4 module, diagrid with 6 module structures. Diagrid structures are displayed with respect to variety in their corner to corner points addressed by their story module size. Diagrid's slanting point is the point between the askew individuals and the even pillars in the outside of the design. Askew Angle = tan-1 (module tallness/base width). Module thickness is a component of the quantity of modules in the structures. In the event that there are more number of modules, the module thickness is high and the other way around. The models are a) Diagrid with 2 story modules [2DIA] with corner to corner point = 50.19°, b) Diagrid with 4 story modules [4DIA] with slanting point = 67.38°, c) Diagrid with 6 story modules [6DIA] with askew point = 74.475°.

Figure 3. Conventional structure
Figure 4. Diagrid Structure
Figure 5. 4 - Module diagrid structure
Figure 6. 6 - Module diagrid structure
8. RESULT AND DISCUSSION

- Study shows that diagrid structure diminishes bowing second which in outcomes bring down the support necessity
- It shows that parallel dislodging can be limited by utilizing diagrids.
- Due to askew segments on its fringe, diagrid gives better protection from sidelong loads and because of this, internal segments get loose and convey just gravity loads. While in customary structure both inward and external section are intended for both gravity and sidelong loads.
- A huge abatement of bowing second in inside sections of diagrid building is found in contrast with customary structure.

8.1 Member Displacement of the Structures

Member displacement is the earthquake parameter in with on the account of an earthquake the relative displacement of each storey takes place.

![Figure 7. Member Displacement of Structure](image)

Keeping the dirt conditions medium. The segments square measure gave in outlines the base interest of the edges to deal with sufficiency of the constructions. From the investigations, it’s apparent that the standard edge structure having enormous level dislodging. To deal with the relocation in allowable limit need to give segment and light emission sizes. Inside the diagrid outline structure zone iv with medium soil condition square measure gave. while outside segments of the diagrid outline square measure askew positioned, its seen that the level removals square measure s decrease amazingly even the gave areas of inside section and bars square measure upward positioned. It’s furthermore discovered that by giving the critical size of inside section and bars in our composite diagrid outline the relocation is decreased to a far further degree.

8.2 Peak Storey Shear

![Figure 8. Peak Story Shear](image)
Peak storey shear graph shows that the lateral load acting on the structure per floor. In above result peak storey graph shows that peak storey shear of conventional building far lesser than the diagrid structure, 4 module diagrid structure, and 6 module diagrid structure. I took the value of peak storey shear in y axis and the floor which contain shear on x axis.

8.3 Base Shear

![Figure 9. Base Shear](image)

Base shear is an expected of the greatest expected sidelong power on the foundation of the construction because of seismic action. Above fig no 8 shows that the conventional structure has lower base shear value and both diagrid structure has higher base shear value than the conventional structure.

8.4 Time Period

![Figure 10. Time Period](image)

Time-frame of building is the time taken by it to go through one complete pattern of oscillation. It is an inborn property of a structure constrained by its mass and firmness. According to the different impacts regular time of a structure increments when the solidness of building increments. For the inflexible structure time span ought to be less as could be expected. Subsequently above chart shows traditional structure has higher time span as contrast with diagrid structure.

8.5 Support Reaction

![Figure 11. Support Reaction in X- Direction](image)
8.6 Storey Drift

![Figure 12. Storey Drift](image)

9. CONCLUSION

In this examination, it is shown that by giving inclining sections at the external outskirts of the constructions, the composite diagrid structure is all the more viably oppose the sidelong burden in correlation with the customary design. By giving the idea of an inclining section at the external fringe of the construction the segment at the inside piece of the design is utilized for opposing little gravity load and a little measure of parallel burden though in exposed casing structure gravity burden and sidelong burden are moved by both inside just as outside segment.

Because of this wonder of supplanting vertical segment at an external outskirt of the uncovered edge structure, there is an enormous decrease of cement in the diagrid structure while the steel may shift on bases of conditions however because of the decrease of cement in gigantic rate stills make the diagrid structure more effective than the uncovered packaging structure.

10. SCOPE FOR FUTURE STUDY

Mixture structure with center divider and propping with second opposing casing can be contemplated. Diagrid designs can be considered utilizing base oscillators and dampers. Diagrid structures without corner segments can be considered Diagrid structures with the use of both breeze and tremor investigation be contemplated. Utilizing located diagrids in other tall structures like, cylindrical design and outrigger construction should be possible and concentrated on various territory classes with various zones.

REFERENCES

[1] Anju Krishna and Arathi S, “Analytical Study of Vertical Geometric Irregular Diagrid Structure and Comparison with Tubular Structure,” International Journal of Science and Research, Vol. 5, Issue 7, pp.1355-1361, 2016

[2] Kim J., Jun Y. and Lee Y.H., “Seismic Performance Evaluation of Diagrid System Buildings”, 2nd Specialty Conference on Disaster Mitigation, Manitoba, June 2010.

[3] Khalid K. Shadhan, “OPTIMAL DIAGRID ANGLE TO MINIMIZE DRIFT IN HIGH-RISE STEEL BUILDING SUBJECT TO WIND LOADS,” International Journal of Civil Engineering and Technology, Vol. 6, Issue 11, pp. 01-10, 2015

[4] Leonard J., “Investigation of Shear Lag Effect in High- Rise Buildings with Diagrid System”, M.S. thesis, Massachusetts Institute of Technology, 2007.

[5] Chetan S.Pattar and Prof. Smt. Varsha Gokak, “ANALYSIS OF DIAGRID STRUCTURES WITH PLAN IRREGULARITY,” International Research Journal of Engineering and Technology, Vol. 05, Issue 08, pp. 435-438, 2018
[6] Irfan Saleem and Dr. Sunil Kumar Tengdi, “Parametric Study on Asymmetric Diagrid Structures,” International Journal of Applied Engineering Research, Vol. 13, pp. 61-66, 2018

[7] Trupti A. Kinjawadekar and Trupti A. Kinjawadekar, “COMPARATIVE STUDY OF SEISMIC CHARACTERISTICS OF DIAGRID STRUCTURAL SYSTEMS IN HIGH RISE CONSTRUCTION,” International Journal of Civil Engineering and Technology, Vol. 9, Issue 6, pp. 315-323, 2018

[8] Swaral R. Naik, Dr. Satish N. Desai and Malhar P. Naik, “EARTHQUAKE RESPONSES OF DIAGRID BUILDINGS AND CONVENTIONAL MOMENT FRAME BUILDINGS HAVING DIFFERENT H/B RATIO CONSIDERING SEISMIC NON-LINEAR TIME HISTORY ANALYSIS,” International Journal of Civil Engineering and Technology, Vol. 9, Issue 13, pp. 1532-1539, 2018

[9] Akshat and Gurpreet Singh, “DYNAMIC ANALYSIS OF DIAGRID STRUCTURAL SYSTEM IN HIGH RISE STEEL BUILDINGS,” International Journal of Civil Engineering and Technology, Vol. 9, Issue 8, pp. 71-79, 2018

[10] Trupti A. Kinjawadekar and Amit C. Kinjawadekar, “COMPARATIVE STUDY OF SEISMIC CHARACTERISTICS OF DIAGRID STRUCTURAL SYSTEMS IN HIGH RISE CONSTRUCTION,” International Journal of Civil Engineering and Technology, Vol. 9, Issue 6, pp. 315-323, 2019

[11] K. Jani, P. V. Patel, “Analysis and Design of Diagrid Structural System for High Rise Steel Buildings”, Procedia Engineering, 51 (2013) 92-100.

[12] K. Kamath, S. Hirannaiah, J. C. K. B. Noronha, “An analytical study on performance of a diagrid structure using non-linear static pushover analysis”, Perspectives in Science, (2016) 8, 90-92.

[15] K. S. Moon, “Diagrid Structures for Complex-Shaped Tall Buildings”, Procedia Engineering, 14 (2011) 1343-1350.