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# THE EFFECTIVENESS OF DIAGRID STRUCTURE OVER CONVENTIONAL FRAME SRUCTURE FOR HIGH RISE BUILDINGS

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**Abstract –** *Diagrid structural system have emanated as an ingenious technique for high rise buildings due to its structural performance and elegance in appearance. In this study, comparison of concrete diagrid building and conventional frame building is carried out and another comparison is made by varying the spacing of diagrid and the effective model of diagrid is found out. For the comparison, five models of same storey height (G+23) and same plan area (24X24) $m^2$ are considered. The seismic effect on the structure has been studied by using the response spectrum method. The structure located in seismic zone III is considered. Modeling and analysis of the structure has been done by using STAAD.Pro software. The results are obtained in terms of storey drift, base shear, time period and storey displacement. From the study, it has been found that the diagrid structural system looks aesthetically pleasant and becomes significant for the high rise building in comparison to conventional structural system.*

***Key Words***: **DIAGRID STRUCTURAL SYSTEM, CONVENTIONAL FRAME BUILDING, STAAD.Pro, RESPONSE SPECTRUM ANALYSIS, BASE SHEAR, STOREY DRIFT, HIGH RISE BUIDING.**

## 1. INTRODUCTION

The demand for land is increasing due to the rise in the density of population and it challenges the structural engineer for maximum utilization of accessible height. High rise buildings are highly affected by lateral loads such as seismic load and wind load. Therefore, while designing the high rise structure the effect of lateral loads need to be considered carefully. Safety and minimum damage level of a structure is the prime requirement of high rise buildings. To meet these requirements, the structure should have adequate lateral strength and sufficient ductility. For such type, Diagrid structural system stands out as a highly developed technique not only in the engineering field but also in architectural field due to its structural efficiency and aesthetic appearance. The main difference between Diagrid structure and conventional frame structure is the provision of diagonal members on the outer periphery of the structure by removing the vertical columns. The word Diagrid means diagonalised grid system in which diamond shaped grids are formed due to the intersection of diagonal members which helps to carry the lateral as well as gravity loads and hence, it increases the stability of the structure. The size of the grid formed by the diagonal members depends upon the number of stories in the grid and it is determined by evenly dividing the height of the building and hence the size of the grid may be small, medium and large. The angle made by the diagonal member with horizontal line plays the major role in transfer of loads and providing lateral stability. So, in this paper the study is carried out by varying the size of the diagrid to find the effective spacing of diagrid. The grid pattern on the façade gives a unique eye-catching look to the structure. Due to the removal of columns, the steel consumption is also less in Diagrid structure than the conventional structure. This paper aims to study the effectiveness of diagrid structure over Conventional Frame Structure. Seismic analysis is done in STAAD.Pro software by using the Response Spectrum Method. During the analysis, various IS codes have been adopted such as IS 456:200for concrete design, IS 875 for loads, IS 800 for steel design, IS 1893-2016 for seismic design.

### 1.1 Objectives of the study

1. To compare concrete diagrid structure with conventional frame structure.
2. To study behavior of structure i.e. diagrid and conventional frame under the seismic zone III by response spectrum method using STAAD.Pro software.
3. To find the effective model of diagrid by varying the spacing of diagrid.
4. To study the response of structure such as base shear, storey drift, storey displacement and time period.

## 2. METHODOLOGY

In this project, five different models are considered:

- Model 1- Conventional frame building.
- Model 2- Diagrid building with spacing of diagrid after every three storey.
- Model 3- Diagrid building with spacing of diagrid after every four storey.
- Model 4- Diagrid building with spacing of diagrid after every six storey.
- Model 5- Diagrid building with spacing of diagrid after every eight storey.

All the models are regular G+23 storey reinforced concrete structure with typical storey height of 3m and same plan dimensions as 24m in X-direction and 24m in Z-direction. The number of bays in X and Z directions are 6 with bay width of 4m each. Grade of concrete is taken as M35 and grade of steel as Fe500. For the diagonal members, hollow mild steel pipes of grade Fe345 are used. The intersection joint of the diagonal members is considered as pinned joint and the support conditions are assumed as fixed.

The various parameters considered for the modeling and analysis of the structure in STAAD.Pro are given below:

**Table -1: BUILDING DESCRIPTIONS**

| | |
|---|---|
| **a. Member Dimensions** | |
| Thickness of RCC slab | 150mm |
| Beam size | 230mm x 500mm |
| Column size | 800mm x 800mm |
| Thickness of brick masonry wall | 230mm |
| Diameter of diagrid | 350mm |
| Thickness of diagrid | 12mm |
| Section of diagrid | Hollow Mild Steel Pipe section |
| **b. Seismic data** | |
| Zone factor | Zone III (0.16) |
| Importance factor | 1.5 |
| Response reduction factor | 5 |
| Soil type | Soil type 2 (Medium) |
| Damping Ratio | 5% |
| **c. Load details** | |
| Live load on floors | 3.5 kN/m$^2$ |
| Live load on roof | 1.5 kN/m$^2$ |
| Wall load on all levels | 3 x 0.23 x 20 = 13.8 kN/m |

As per the parameters considered all the models are prepared in STAAD.Pro software. Elevation and 3D rendered view of all the models is shown below:

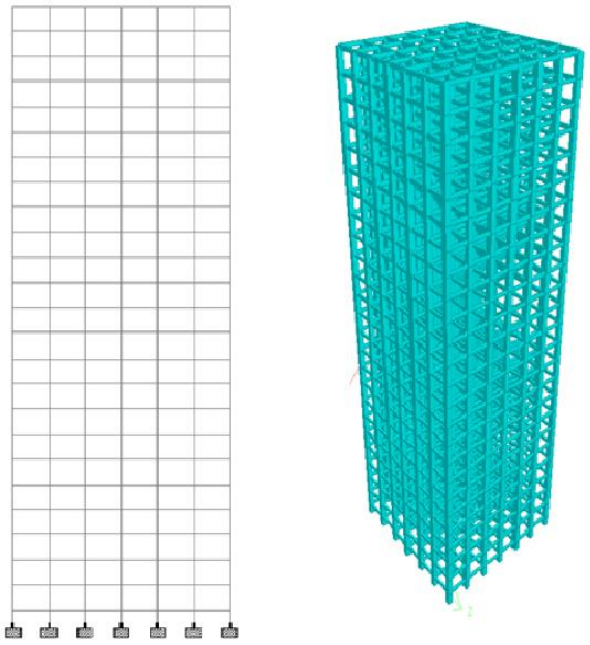

**Fig -2.1**: Model 1

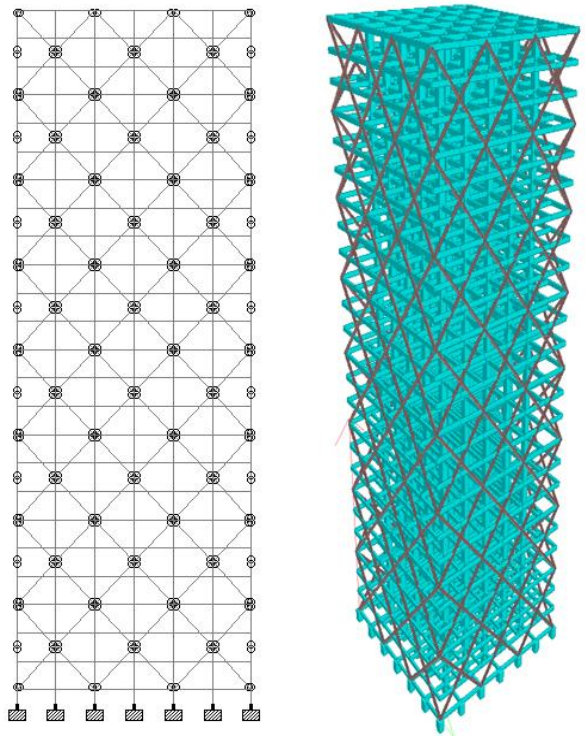

**Fig -2.2**: Model 2

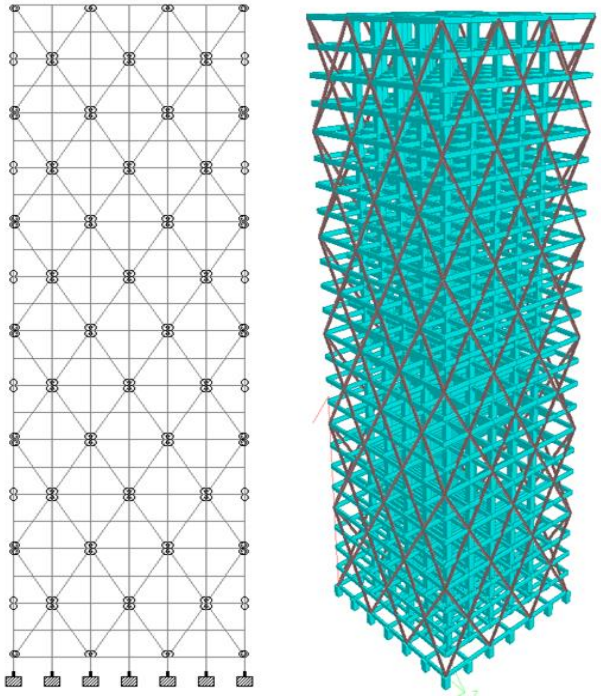

**Fig -2.3**: Model 3

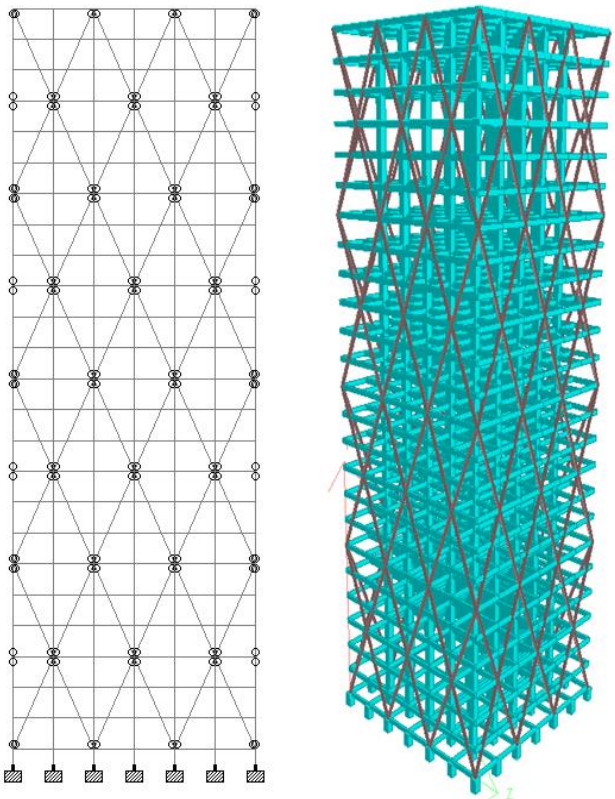

**Fig -2.4**: Model 4

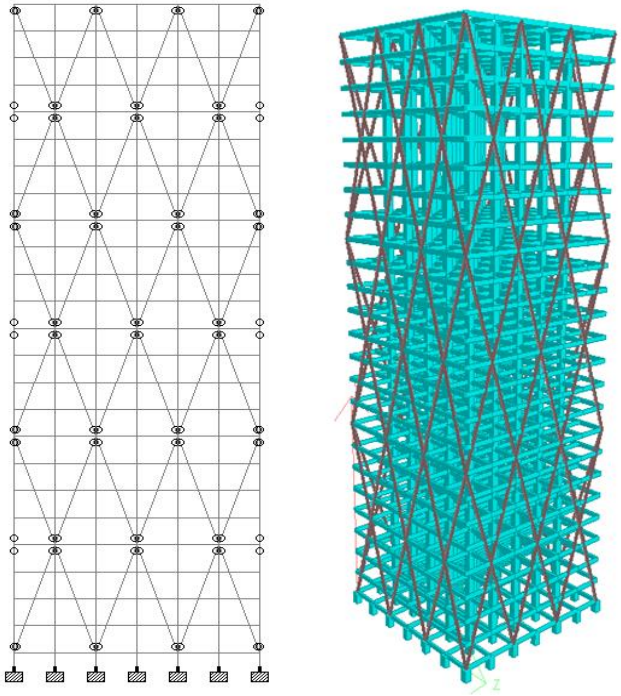

**Fig -2.5**: Model 5

Each model of the building is subjected to Dead Load, Live Load and Seismic load. After applying these loads, each model of the building is analyzed for the response spectrum method of dynamic analysis by using load combinations. After analyzing each model, results are obtained in terms of base shear, storey displacement, storey drift and modal time period.

## 3. RESULTS AND DISCUSSIONS

By comparing the results, one can easily observe the performance of Diagrid structure over Conventional structure and can predict the good diagrid system among all structures which performs well against earthquake forces. Detailed study of each graph is shown below:

### 3.1: Base Shear

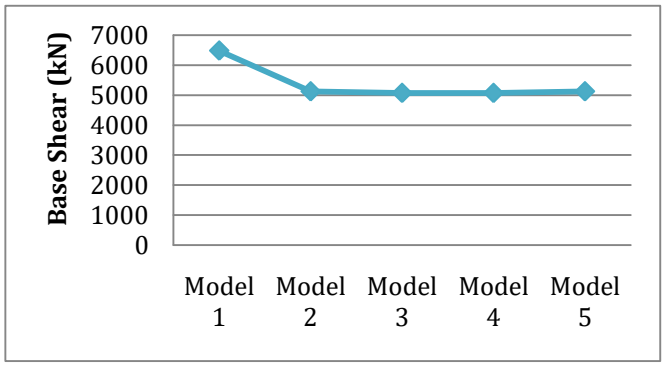


**Fig -3.1:** Base shear (kN)

### 3.2: Maximum Lateral Displacement

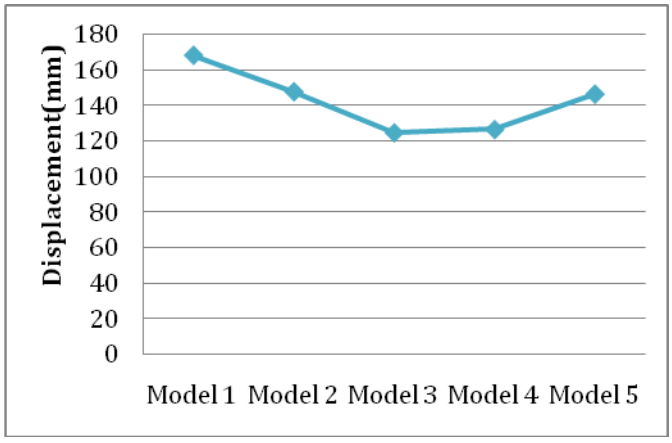


**Fig -3.2:** Maximum Lateral Displacement (mm)

### 3.3: Maximum storey drift

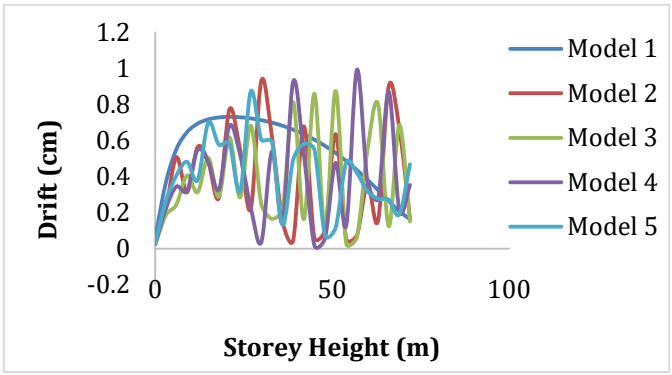


**Fig -3.3:** Maximum storey drift (cm)

### 3.4: Modal time period

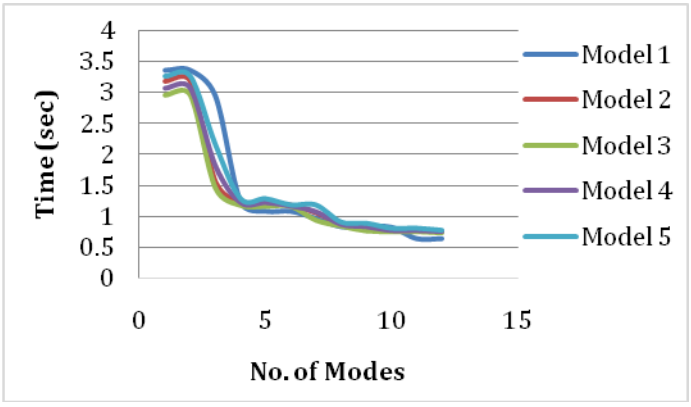


**Fig -3.4:** Modal time period (sec)

## 4. CONCLUSIONS

1. Diagrid structural system has emerged as a better solution for lateral load resisting system in terms of lateral displacements, steel weight and stiffness.
2. Figure 3.1 shows that Base shear of the conventional frame building is found to be maximum when compared with the diagrid structure.
3. Lateral displacement is caused due to the lateral forces acting on the building. Figure 3.2 shows that the lateral displacement of the diagrid structure is found to be lesser when compared with the conventional structure.
4. Maximum reduction in lateral displacement is observed to be more in diagrid structure with spacing after four storeys.
5. The value of storey displacement is found to be more for diagrid frame with spacing after three and eight storey when compared with diagrid frame with spacing after four and six storey. Hence, provision of diagrid with spacing after four storey is found to be more effective in rigidity.
6. It is evident that the value of storey drift increases as the number of storey increases upto certain level and then it reduces. The diagrid system found to be important for high rise structures as drift decreases with the increase in altitude of structure after certain level of height. Figure 3.3 shows that the drift value of diagrid structure is comparatively less than the conventional structure.
7. Figure 3.4 shows that the Time Period of conventional frame is comparatively more than other models. Lesser the time period stiffer the system is.
8. Diagrid structures have higher stiffness than other structures.
9. Diagrid structural system looks aesthetically pleasant and becomes important for high rise building in comparison to conventional structural system.
10. Diagrid performs better across all the criterions of performance evaluation, such as efficiency, expressiveness and sustainability.
11. Weight of the structure gets reduced to a greater extent due to which the structure has more resistance to lateral forces.
12. Diagrid structure system provides more economy in terms of consumption of steel as compared to other structural system. So, diagrid structure is cost effective and eco-friendly.

## 5. SCOPE FOR FUTURE STUDY

1. Study can be extended for steel structures and composite structures.
2. Comparison of Time history method and response spectrum method can be done.
3. Analysis can be carried out on sloping ground.
4. Non linear analysis can be done.
5. Analysis can be done with different soil conditions.
6. Analysis can be done with different earthquake zones.

## REFERENCES

[1] Manthan I. Shah, Snehal V. Mevada, Vishal B. Patel, "Comparative Study of Diagrid Structures with Conventional Frame Structures", Int. Journal of Engineering Research and Applications, Vol. 6, May 2016, pp. 22-29, ISSN: 2248-9622.

[2] Jayesh Akhand, Dr.J.N Vyas, "Comparative Study of Different shapes of Diagrid Structure System with Conventional System using Response Spectrum Analysis: A Conceptual Review", International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES), e-ISSN: 2455-2585 Volume 5, Issue 04, April-2019.

[3] Bhavani Shankar, Priyanka M V, "Comparative study of concrete diagrid building and conventional frame building subjected to seismic force", International Research Journal of Engineering and Technology (IRJET), Vol. 05, June 2018, e-ISSN: 2395-0056, p-ISSN: 2395-0072.

[4] Thota Sai Charan, Dumpa Venkateswarlu, Rayi Chandra Shekar, "Design and Analysis of Diagrid and Shear Wall Structures Subjected to Seismic Loads", International Journal of Innovative Technology and Exploring Engineering (IJITEE), Vol. 8, Sept. 2019, ISSN: 2278-3075.

[5] Viraj Baile, Dr. A.A. Bage, "Comparative study of diagrid, simple frame And various bracing systems", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, June 2017.

[6] Akshat, Gurpreet Singh, "A review on structural performance of diagrid structural system for high rise buildings", International Journal of Innovative Research in Science, Engineering and Technology, Vol. 7, February 2018.

[7] Shahana E, Aswathy S Kumar, "Comparative study of diagrid structures with and without corner columns", International Journal of Science and Research (IJSR), Vol. 5, July 2016.

[8] Mohammed Abdul Rafey and M. A. Azeem, "Comparative analysis of a diagrid structure and a conventional structure with chevron bracing", International Journal of Applied Engineering Research, Vol. 13, 2018, pp. 12311-12317.