

# Comparative Study on Diagrid Structure and Conventional Structure

Akarsha G E<sup>1</sup>, Dr. M D Vijayananda<sup>2</sup>

P.G. Student, Department of Civil Engineering, BIET, Davangere, Karnataka, India<sup>1</sup>

Professor, Department of Civil Engineering, BIET, Davangere, Karnataka, India<sup>2</sup>

**ABSTRACT:** The evolution of tall building structural systems based on structural concepts with adopted high strength materials and construction methods have been towards “stiffness” and “lightness”. Structural systems are become “lighter” and “stiffer”. It is common knowledge that rather than directly standing the forces, it is better to reduce them and dissipate the magnitude of vibrations. A new system is being in the building as two parts namely exterior system and interior core. The exterior system will be located in the perimeter of the structure whereas the inner core located at the centre which mainly accounts for the transfer of gravity load and the exterior system takes care of lateral loads rather than gravity load. The exterior shell is nothing but a diagonal grid which are effective as both gravity and lateral support to the tall buildings and this structural system. In this project, the comparison study of 20-storey simple frame building and diagrid structural system building is presented here. The comparison of analysis of results in terms of storey displacement, storey drift and storey shear are presented here.

**KEYWORDS:** Diagrid system, Tall Buildings, Response Spectrum analysis, Storey displacement, Storey drift and Storey shear.

## I. INTRODUCTION

Nowadays, the population of urban areas is growing rapidly and also the scarcity of land. Thus, the high rise buildings or structures are preferred in these days. Here, the most important thing in high rise building is lateral loads which are coming on the structure. Therefore, the gravitational load resisting structural system given less importance than the lateral load resisting structural system. Braced system, the tubular system, wall frame system, shear wall, an outrigger system and rigid frame structural system etc. are some of the widely used lateral load resisting system. In recent times, the diagrid system is widely used in the high rise buildings, for its structural performance and aesthetic potential that is given by the unique geometric configuration of the system.

The term “diagrid” is the combination of the two terms “diagonal” and “grid”, and a diagrid system is one which replaces vertical structural elements with diagonal elements. In diagrid structures the diagonal members act as inclined columns and they carry both gravity loads and lateral forces, due to their design in the form of the triangle, firstly, the internal axial forces arise in the members, eventually decreasing shear racking effects.

Diagrids are nothing but doing an arrangement of inclined columns, as resist t conventional vertical columns, diamond shaped modules along floors are made at the periphery of a structure. As there are no vertical columns at the perimeter, the diagrid system is not the same as the braced system since in the former system.

The diagonal members will carry both moment and shear here in the diagrids. Hence, the height of the building confirms the optimal angle of diagonal members. For maximum bending rigidity of the column the optimal angle is 90 degrees and the optimal angle for the maximum shear rigidity of the diagonal members is about 35 degrees, the diagrid structure’s optimal angle of diagonal members is expected to be fall between those angles and the optimal angle increases as the rise in height of the building. 60 -70 degree is the usually adopted range.

## II. RELATED WORK

The concept of diagrid systems was studied by Khushbu Jani and Paresh V. Patel (2013). “Analysis and design of high rise steel buildings”. Here, in this journal paper it is concluded that development in materials, construction technology, structural system and analytical methods for simplify analysis and design of high rise buildings. Because of wind or earthquake design of tall structures influenced by lateral lodes. A usual plan of 36m×36m size is taken into consideration. ETABS software is employed in modelling and also for analysing the structure. Considering every load combination, the structural members are always designed by using a code, IS 800:2007. The load distribution in diagrid system is additionally studied for the 36 storey building. Design and analysis of 50, 60, 70 and 80 story diagrid structure results are also conferred. This study determines that entire lateral load is taken by diagrid columns on the

periphery, whereas the interior columns and peripheral diagonal columns will resist the gravity loads. Hence, design of the internal columns is done only vertical load.

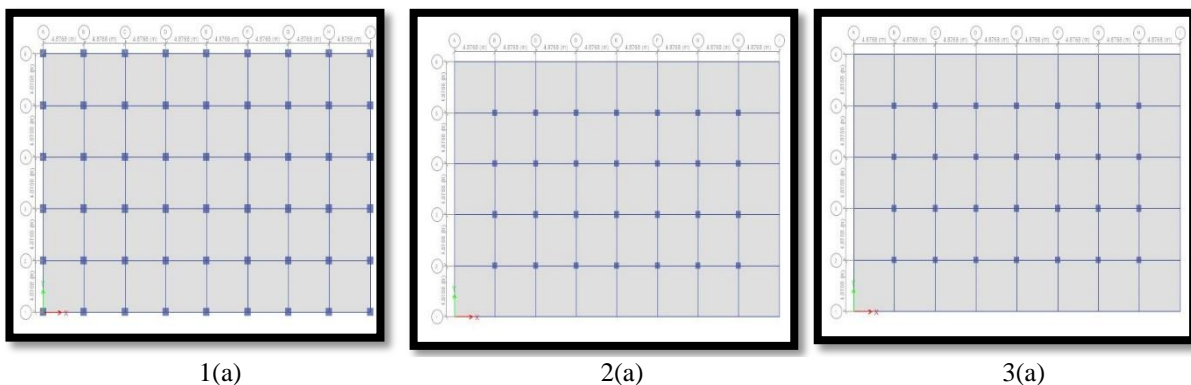
Simos Geresimidis, Ponos Pantidis et.al., (2016). “Diagrid Structural system for High-Rise Buildings, applications of a Simpler Stiffness based Optimised design”. This journal paper indicates the simple effective technical for design of diagrid tall steel buildings. For diagrid structure this technique was applied to three building geometry. This work should be considered as inspiration and preparation for future work on the concept of diagrid optimization. This paper also discusses the concept of tall building strength and optimization.

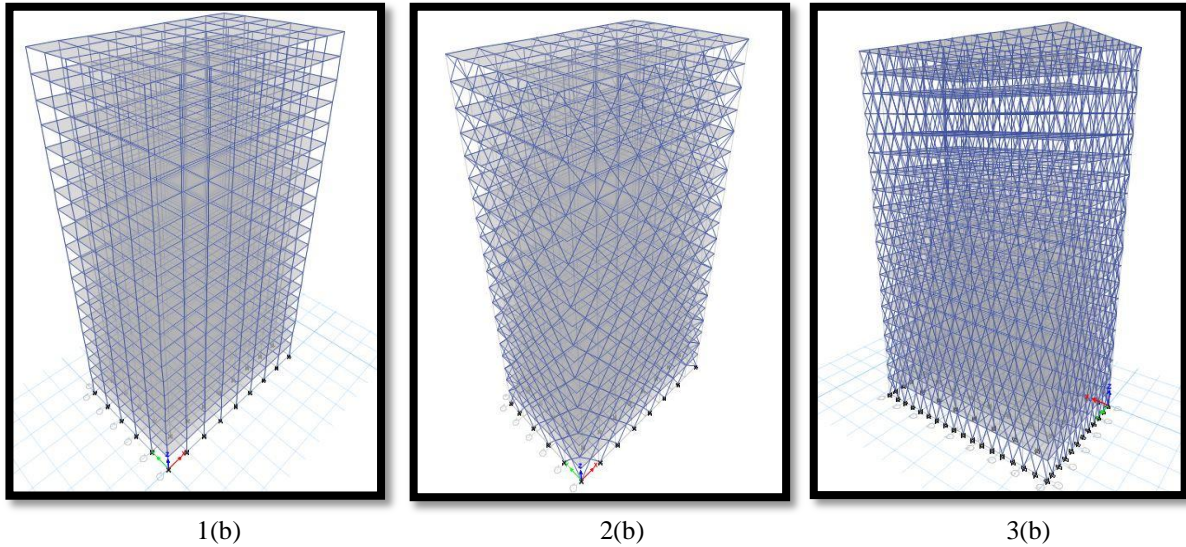
Jerzy Szolomicki and Hanna Golasz-szolomicka, (2017). “Application of the diagrid system in high rise buildings”. The aim of this journal paper indicates mutual relative progress of the current architectural appearance and construction system of tall structures with assessment of the diagrid system. Increase in the load of constructional elements due to complicated shapes and needs obtained from the height of the building. Perimeter diagrids are used to bear the corners of slab floors to sustain the gravity and horizontal loads.

### III. METHODOLOGY

Analysis and design of the diagrid structure is performed on E-Tabs software in accordance with IS 1893-2002 and IS 456-2000. The method used for analysing the structures is response spectrum analysis. It is the better and far most technology which has been utilized from few years ago which supports the results helps in obtaining from the monotonically increasing lateral forces which is varied along with the building height and also studying the displacement which is reached the maximum values. This kind of analysis helps in getting the elastic analyses. Also the extra ordinary values like superimposed to approximate a force and its values of the displacement. Unlike static analysis this method uses the stiffness property of the structure to calculate the base shear. It doesn't depend on the mass of the structure.

There are three models as been built, all the buildings used in this study are twenty storeys with the dimension of 39x24.3m. All building models have same floor plan. Structure type is commercial, G+19, Floor to floor height is 3.5 m, Ground floor height 4m, Thickness of slab is 150 mm, Grade of concrete used for Beams and Slabs is M45 and for columns is M60, Fe550 grade of steel is used, masonry wall load, live load and floor finish are 13.8 kN/m, 4 kN/m<sup>2</sup> and 1.5 kN/m<sup>2</sup> respectively, damping ratio 0.05, soil type is II (MEDIUM), seismic zone factor (Z) is 0.36, importance factor is 1.5, response reduction factor is 3 (OMRF), basic wind speed is 33 m/s, terrain category is taken as 1, Risk coefficient [k<sub>1</sub>]=1, terrain roughness and height co-efficient [k<sub>2</sub>]=1, topography co-efficient [k<sub>3</sub>]=1, structure class is B, windward co-efficient is 0.8, leeward co-efficient=0.5. Data for the conventional building are - Size of the column (16th to 20th storey) is 750x750 mm, size of the column (1st to 15th storey) is 900x900mm, size of the beam (16th to 20th storey) is 600x300 mm and size of the beam (1st to 15th storey) is 800x600mm. Dimensions taken for the diagrid structure is size of the column (16th to 20th storey) is 400x400 mm, size of the column (1st to 15th storey) is 600x600mm, size of the beam (16th to 20th storey) is 500x300mm, size of the beam (1st to 15th storey) is 600x300mm and size of the diagrid (Steel tube) is 450x450x20mm.





1(b)

2(b)

3(b)

Fig. 1. Conventional structure, (a) Floor plan, (b) 3d view.

Fig. 2. 53.33-degree diagrid structure, (a) Floor plan, (b) 3d view.

Fig. 3. 71.66-degree diagrid structure, (a) Floor plan, (b) 3d view.

#### IV. EXPERIMENTAL RESULTS

##### Maximum Storey Displacement

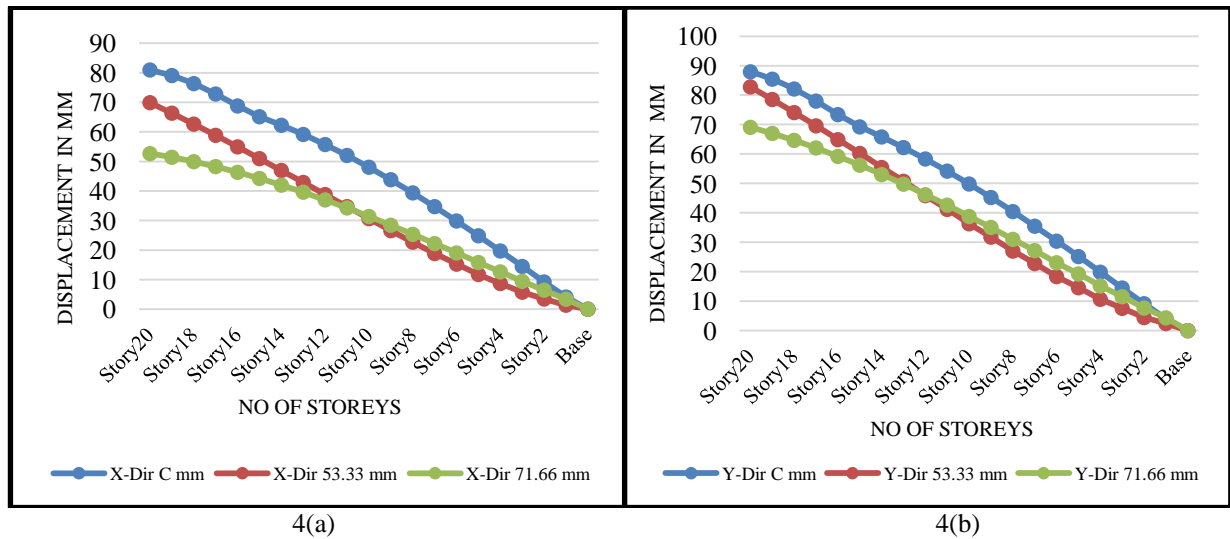


Fig. 4. Graph of Maximum Storey Displacement, (a) Variation of Storey Displacement in the X direction of all the three models. (b) Variation of Storey Displacement in the Y direction of all the three models.

**Maximum Storey Drift**

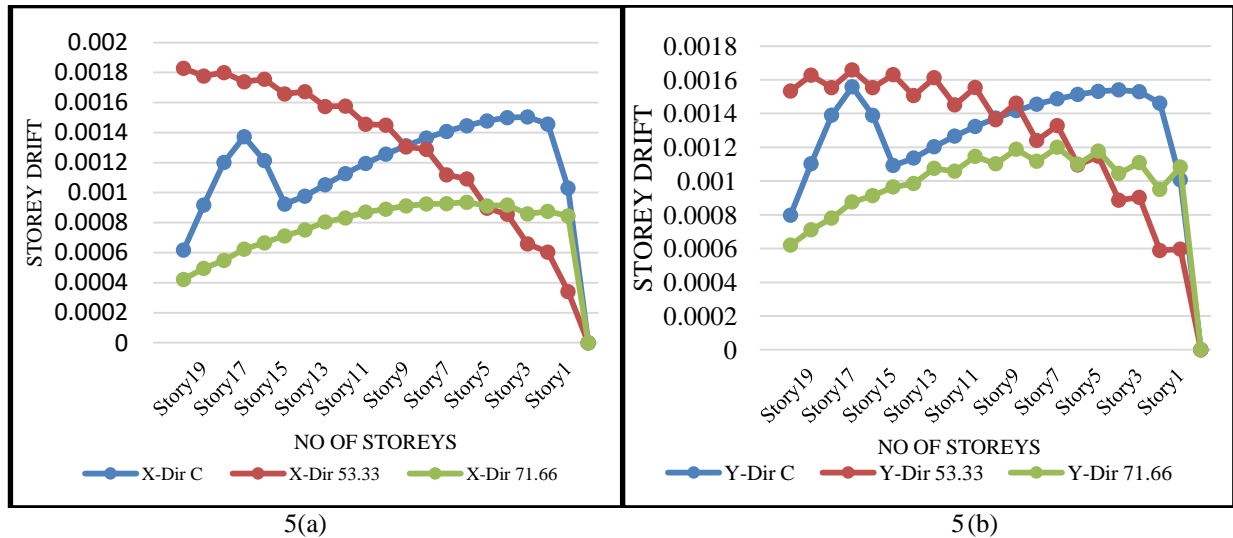


Fig. 5. Graph of Maximum storey drift, (a). Variation of Storey Drift in X-direction of all the three models. (b). Variation of Storey Drift in Y-direction of all the three models.

**Maximum Storey Shear**

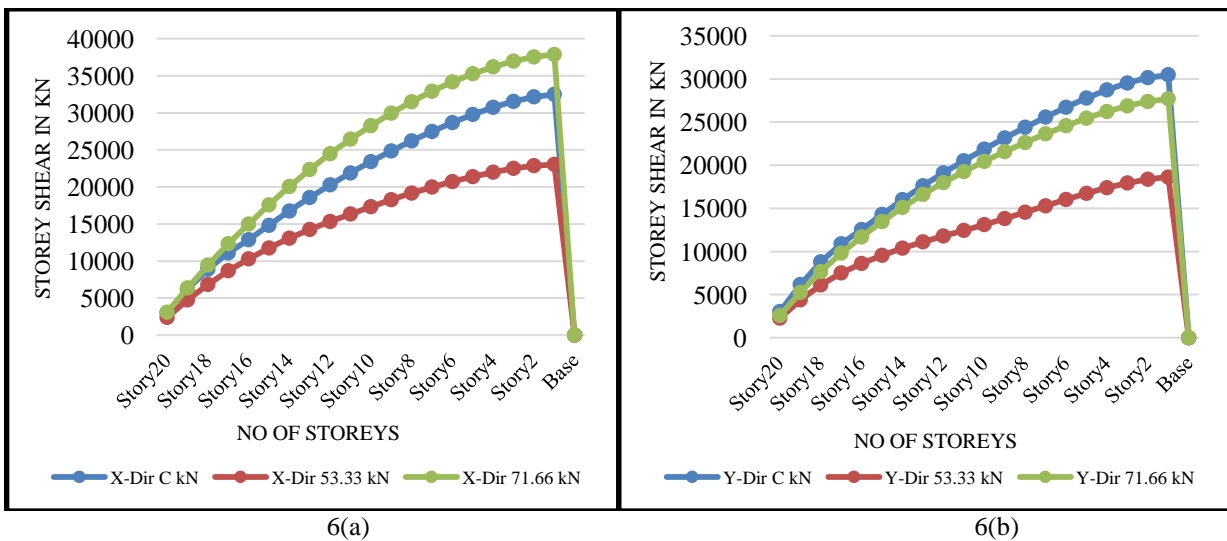


Fig. 6. Graph of Maximum Storey Shear, (a) Variation of Storey Shear in X direction of all the three models. (b) Variation of Storey Shear in Y direction of all the three models.

**V. CONCLUSION**

After, study of the project in depth and its different models by applying similar conditions but different kinds of constructions, shapes or factors,

- [1] In the planning of interior and elevation of the building, the diagrid structural system gives more flexibility.
- [2] Considering the final results that are obtained from the displacement values in the X and Y-direction the diagrid model of angle 71.66 degree provides more resistance to the displacement, when compared with the other two models.
- [3] Hence we can conclude that the model with diagrid of angle 71.66 degree will perform better in displacement.

- [4] By the final results that are obtained from the storey drift values in X and Y-direction the diagrid model of angle 71.66 degree performs better when compared with that of all other two models.
- [5] We can conclude that the model with diagrid 71.66 degree is better performing in comparison with story drift.
- [6] Considering the end results that are obtained from the shear values in X and Y-direction the diagrid model of angle 53.33 degree offers more resistance to shear above all other two models.
- [7] Hence we can conclude that the model with diagrid 53.33 is performs better in storey shear when compared with other two models.
- [8] Here, we observed that, from all the results, for Storey Displacement and Storey Drift of Diagrid model with angle of 71.66 degree performed better. But, the diagrid model with angle of 53.33 degree is performed better in shear.
- [9] Finally, can conclude that the diagrid structural system is the better choice than the conventional buildings in aesthetic potential, architectural purposes and structural efficiency.

#### REFERENCES

- [1] Khushbu Jani and Paresh V. Patel (2013). 'Analysis and Design of Diagrid Structural System for High Rise Steel Buildings', *Procedia Engineering*, Elsevier B.V., 51, pp. 92–100. doi: 10.1016/j.proeng.2013.01.015.
- [2] Szolomicki, J. and Golasz-szolomicka, H. (2017). 'Application of the Diagrid System in High-Rise Buildings', (3), pp. 7–13.
- [3] Dhaval N. Sorathiya, Jasmin Gadhiya and Abhishek Raturi. (2017). 'Behavior of Diagrid Structural System in High-Rise Building', 02(11), pp. 2–5.
- [4] Deeksha T Ballur and M Manjunath (2017). 'Analytical Study of Diagrid Structural System for Rectangular and Rectangular-Chamfered Multistory Building', pp. 1572–1578.
- [5] Simos Geresimidis, Ponos Pantidis et.al., (2016). 'Title Diagrid Structural System for High-Rise Buildings: Applications of a Simple Stiffness-based Optimized Design'.
- [6] Bhale, P. and Salunke, P. P. J. (2016). 'Analytical study and design of diagrid building and comparison with conventional frame building', pp. 226–236.
- [7] Milana, G. Et. al. (2015). 'Ultimate Capacity of Diagrid Systems for Tall Buildings in Nominal Configuration and Damaged State', pp. 381–391.
- [8] Panchal, N. B. and Patel, V. R. (2014). 'DIAGRID STRUCTURAL SYSTEM: STRATEGIES TO REDUCE LATERAL FORCES ON HIGH-RISE BUILDINGS', pp. 374 – 378.
- [9] Panchal, N. B., Patel, V. R. and Pandya, I. I. (2014). 'Optimum Angle of Diagrid Structural System', (6), pp. 150–157.
- [10] Mele, E. et al. (2014). 'Diagrid structures for tall buildings: case studies and design considerations', 145(July 2012), pp. 124 – 145. doi: 10.1002/tal.
- [11] Congress, S. (2013). 'Design of Diagrid Structural System for High Rise Steel Buildings as per Indian Standards', pp. 1070–1081.
- [12] Kim, J. and Lee, Y. (2012). 'Seismic performance evaluation of diagrid system buildings', 749(November 2010), pp. 736–749. doi: 10.1002/tal.
- [13] Moona, K. S. U. N. (2011). 'Procedia Engineering Diagrid Structures for Complex-Shaped Tall Buildings', 14. doi: 10.1016/j.proeng.2011.07.169.
- [14] IS: 456-2000. Plain and Reinforced Concrete- Code of Practice, Bureau of Indian Standard, New Delhi.
- [15] IS: 1893(Part-I)-2002, Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standard, New Delhi.
- [16] IS: 875(Part-I, II, III)-1987, Code of Practice for Design Loads for Buildings and Structures, Bureau of Indian Standard, New Delhi.