

A Study on Behaviour of Structural System of a Diagrid Structure along with Shear Wall and Conventional Structure by using Dynamic Analysis Method

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ABSTRACT: Nowadays a new system named diagrid system has been adopted as a replacement of framed structure. Structural system is an important factor in the construction of high rise buildings. The aim of structural system is to transfer loads to ground efficiently. Lateral loads are dominating over gravity loads in high rise building. Hence structural system with high rigidity is required. one of such structural system i.e. diagrid structural system has been studied. The comparison of high rise building having 20 storey with diagrid structural system with shear wall along with different angle of diagrid, and conventional building has been analysed in the present study using Etab software. The study was to know the structural performances of all models and get the best configuration of diagrid structural system.

KEYWORDS: Diagrid, Conventional structure, Structural system, Shear wall, Seismic forces, Response spectrum.

I. INTRODUCTION

As cities become more populated within urban areas and space becomes much scarcer, the demand is increasing for the tall structures in cities ever. Many buildings over 200 meters were built in 2015 than any other year on world-wide, as 103 buildings being completed which is record breaking, and a prediction was made that this record will be broken again in the year 2016. There is an increasing demand for residential and business space, and a need for aesthetics in urban places. The 20th century saw sudden changes in the structural systems. Since the decline of conventional rigid frame as primary type of structural system for steel or concrete structures, research completed in the Preliminary Report of tall structures indicated that the main limitation is lateral wind loading to a tall structure. As the height of structures increases, the effects of wind loading becomes the major limitation of a structures.

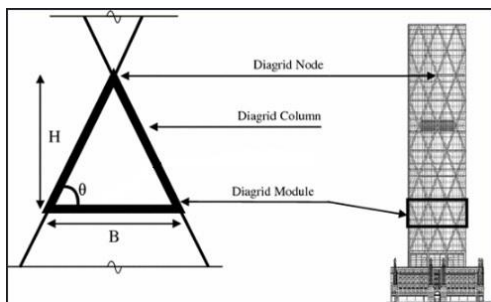
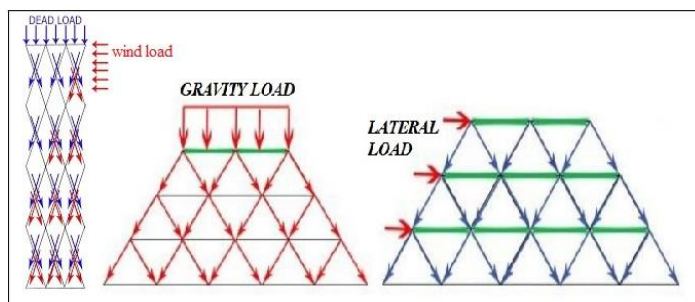
Diagrid structural system

Diagrid structural system is a column less diagonalized grid structure, where the diagonal grids replaces the column which may be exterior, interior or both. Diagrids is a perimeter structural configurations categorised by a narrow grid of diagonal elements which are involved both in lateral and in gravity loading resistance. The new era of tall structures gave rise to faster constructing and innovative structural systems like diagrid system, tube system, core and outrigger system, mixed concrete systems. Due to very complex geometric forms of tall structures, it has recently been very popular to use the diagrid structural system for both reinforced concrete and steel.

The lateral stiffness of diagrid structures is provided basically by perimeter structural members. The innovative structural systems like Diagrid has been briefly discussed in the papers as possible solutions to earthquake and wind loading limitations, as the forces in the lateral direction are more evenly spread across the structural components.

Shear wall system

The reinforced cement concrete walls in a structure provided mainly to resist the lateral forces is known as shear walls. Lateral forces is the forces which will act parallel to the plane of the wall, and that are naturally seismic and wind loads. In simple terms, lateral forces could push over parallel structural panels of a building. Major portion of wind forces and lateral seismic forces are taken up by these rcc shear walls.

**Figure 1 : Module of Diagrid****Figure 2 : Load transfer in diagrid**

Diagrid has an ability to transfer the gravimetric load types (such as dead, live, and snow & rain) and lateral load (wind load, earthquake load) as well so effectively to the foundation, this is why diagrids structural systems are so greatly valued. It has a good efficiency which allows it to handle static loads which don't need for any overdesign

II. LITERATURE REVIEW

VirajBaile et.al [1] (2017), conducted a comparative study of diagrid, shear wall and simple frame system. From the analysis results and comparative study put forth in this paper and it was found that diagrid structure overall performs better as lateral load resisting system than shear wall and simple frame systems. Diagrid structure has least lateral displacement and storey drift. Diagrid structure has higher stiffness when compared to other models. Diagrid structure is lighter than other models and thus it will be more economical.

Nischay J et.al [2] (2016), conducted a comparative study of the performance of tall structures with diagrid and shear wall systems subjected to seismic loading. The essential objective of this project was to study the performance of the tall structures with the diagrid systems and the major lateral loading resisting part of the building. Hence three distinct shapes of the plans were considered: they are Square, octagon and circular. All the three models are symmetric in plan. For each shape three storey heights are modelled: that is 30 stories, 45 stories and 60 stories. From the past researches it was found the optimum angle for diagrid is around 70 degrees.

PallaviBhale et.al [3] (2016), studied the structural performance of diagrid and conventional building. It is observed that, due to diagonal columns or diagrid in periphery of the structures, the diagrid structure is having more lateral load resisting capacity. Due to this structural ability of diagrid structure, interior column is made up of smaller size for gravity load resisting purpose, and only small quantity of lateral load is considered for the interior column. While in case of conventional framed building, both lateral and gravity load is resisted by interior and also exterior column. It also shows that diagrid building shows less lateral displacement and drift in comparison to conventional building.

Literature summary: Most of the researchers did analysis on diagrid structure under wind loading. Some of them worked out on structural performance of diagrid nodes and its geometrical patterns. But still there is a lack of study on structural behavior, design criteria and performance of the diagrid structural system. So now it is necessary to find out seismic behavior of diagrid structure with shear walls and compare its analytical results such as top-storey displacement, inter-storey drift and storey shear with conventional structure.

III. METHODOLOGY

Response spectrum method

The analysis and design of structure is performed on E-Tab software. Response spectrum is an important tool in the seismic analysis and design of structures. It describes the maximum response of damped single degree of freedom system to a particular input motion at different natural periods. Response spectrum method of analysis is advantageous as it considers the frequency effects and provides a single suitable horizontal force for the design of structure. Response Spectrum methods allow determination of maximum modal response of a singly supported structural system or a multiple supported system.

Building description

The building used in this study is twenty storied of size 39x24.3m. All building models have same floor plan and size.

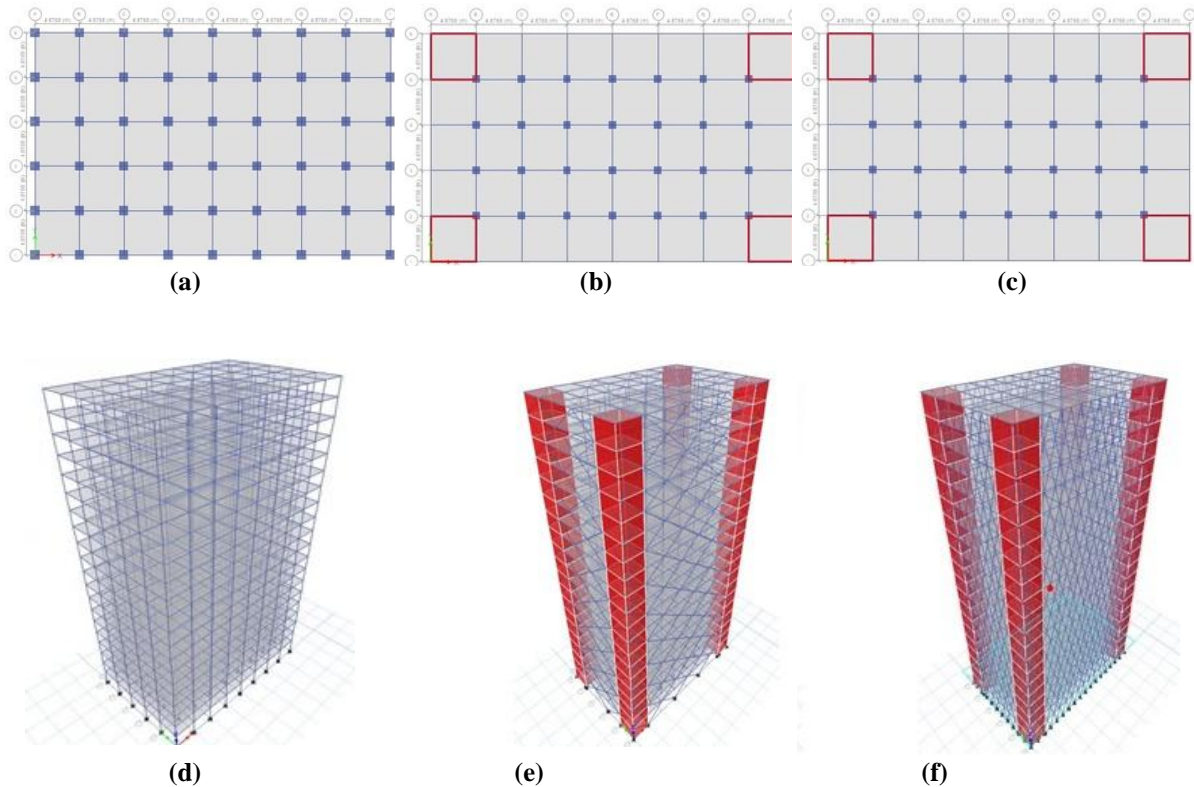


Figure 3 : Plan and elevation of all models

Figure 3 (a),(d) shows the plan and elevation view of conventional building and figure 3 (b),(e) shows the plan and elevation view of diagrid structure 35 degree angle respectively, figure 3 (c),(f) shows the plan and elevation view of diagrid structure 71.66 degree angle respectively.

The general data taken for the analysis is as follows:

Grade of concrete	:	M45,M60
Grade of steel	:	Fe 550
Floor Height	:	3.5m
Slab thickness	:	150mm
Live Load	:	4 KN/m ²
Wall load	:	13.8KN/m ²
Floor Finish	:	1.5 KN/m ²

Data for conventional building

Column 1 (1to 15storey)	:	1000x1000 mm
Column 2 (16to 20storey)	:	800x800 mm
Beam 1 (1to 15storey)	:	1000x750mm
Beam 2 (16to 20storey)	:	750x350 mm

Data for diagrid building

Column 1 (1to 15storey)	:	800x800 mm
Column 2 (16to 20storey)	:	600x600 mm
Beam 1 (1to 15storey)	:	750x350mm
Beam 2 (16to 20storey)	:	650x350 mm
Size of diagrid pipe section	:	350mm dia 20mm thick
Angle for diagrids	:	35 and 71.66 degree

Seismic and Wind load

Seismic design shall be done in accordance with IS: 1893:2002. The building is situated in earthquake zone III. The parameters to be used for analysis and design are given below (As per IS: 1893:2002 (Part I)).

- Zone factor : 0.36
- Importance factor : 1.5
- Response reduction Factor : 3.0
- Soil Type : Medium

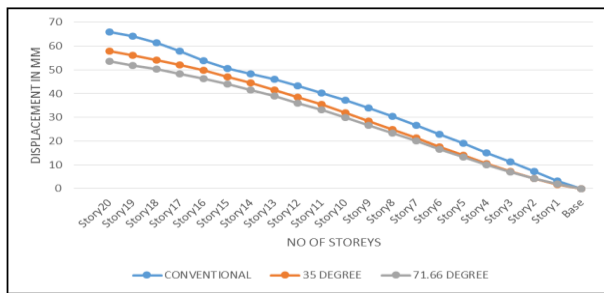
For wind load the basic wind speed taken is 33m/s, structure class is B, and terrain category, Risk coefficient factor k1, Terrain roughness and height factork2, Topography factork3 is taken as 1, Windward and Leeward coefficient 0.8, 0.5 respectively.

IV. EXPERIMENTAL RESULTS

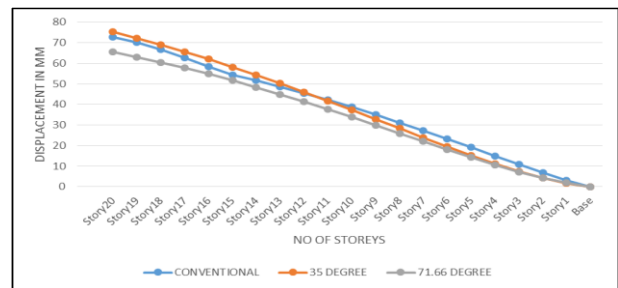
After the Response Spectrum Analysis of the conventional buildings and diagrid buildings with shear walls for different diagrid angle, a few parameters are considered for the comparison. The parameters considered are Lateral Storey Displacement, Storey Drift and Storey Shear.

• Storey Displacement

The below graph will show the displacement of the model along X and Y direction where we can clearly identify the better model performance of conventional and diagrid structures.



(a)



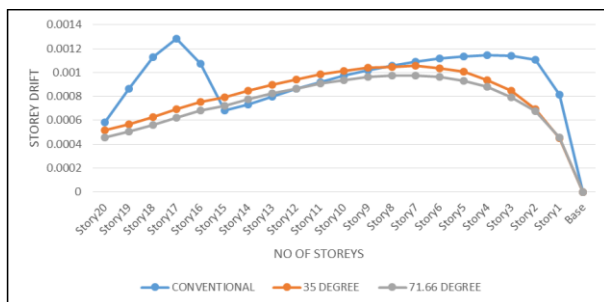
(b)

Figure 4: Comparison of Displacement (a) In X Direction (b) In Y Direction

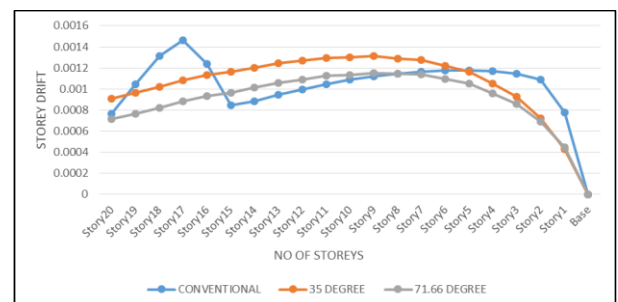
Displacement values in X direction the diagrid model of angle 71.66 degree has lesser displacement when compared with that of all other two models and conventional structure has the more displacement among all models. Displacement values in Y direction the diagrid model of angle 71.66 degree has lesser displacement when compared with that of all other two models, and 35 degree diagrid structure has the more displacement among all models.

• Storey Drift

The below graph will show the storey drift of the model along X and Y direction where we can clearly identify the better model performance of conventional and diagrid structures.



(a)



(b)

Figure 5: Comparison of storey drift (a) In X Direction (b) In Y Direction.

Considering the final results which are obtained from the comparison of all models drift values in X direction the conventional building model has higher drift values when compared with that of all other two models and the diagrid model of angle 71.66 degree has lesser drift when compared with that of all other two models

• **Storey shear**

The below graph will show the story shear of the model along X and Y direction where we can clearly identify the better model performance of conventional and diagrid structures

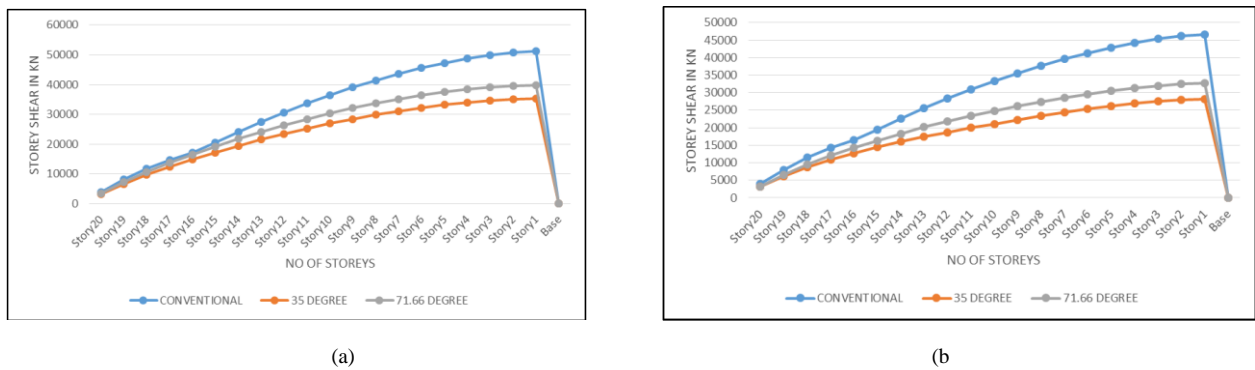


Figure 6 : Comparison of storey shear (a) In X Direction (b) In Y Direction

Considering the final results which are obtained from the comparison of all models shear values in both X and Y direction the conventional building model has higher storey shear values when compared with that of all other two models, and the diagrid model of angle 35 degree has lesser drift when compared with that of all other two models

V. CONCLUSION

1. The displacement of conventional building in X direction is higher when compared to other models, in Y direction 35 degree diagrid structure has higher values of displacement, and 71.66 degree diagrid structure has lesser values of displacement in both X and Y direction.
2. The story drift of conventional building in X and Y direction is higher when compared to other models and 71.66 degree diagrid structure has lesser values of story drift in both X and Y direction
3. The storey shear of conventional building in X and Y direction is higher when compared to other models and 35 degree diagrid structure has lesser values of storey shear in both X and Y direction
Hence we can conclude 71.66 degree diagrid structure performance is good compare to other model except in storey shear in which 35 degree diagrid performs better.

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- [3] PallaviBhale, P.J. Salunke (2016) “Analytical study and design of diagrid building and comparison with conventional frame building” ISSN: 2348-7550, Vol- 4, No- 1, Pg No:226–236.
- [4] Relevant IS codes are used.