A Comparative Study on Behaviour of Structural System of Diagrid Structure and Conventional Structure

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Abstract - *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.*

Key Words: **Diagrid, Conventional structure, Structural system, Shear wall, Seismic forces, Response spectrum.**

1. INTRODUCTION

There is a need for engineering and the construction industry to update and innovate the existing structural systems used in tall structures is much important than before. Many buildings over 200meters 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.

1.1 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.

1.2 Shear wall system

The reinforced 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

2. LITERATURE REVIEW

Kyoung Sun Moon (2017), published a research paper in this paper a comparative structural performances between outrigger structures and diagrids structures of the conventional rectangular box form, tilted forms and twisted forms is done. For the rectangular box form, it was found that diagrids system are more efficient than outrigger structural system, in terms of providing more lateral stiffness against wind loads.

Terri Meyer Boake (2016), Has conducted study on the emergence of the diagrid - it's all about the node, some of the most significant developments in the design of diagrids, have laid in the creation of the node as a key-structural connection strategy. This technology and invention is being transferred to the greater application of structures of steel, creating buildings that while not being of a "pure" diagrid type structure, are taking advantages of the advanced technique in the development of diagrid.

Jinkoo Kim (2010), Have conducted an comparitive study on the seismic behaviour of 36-storey diagrid structures with various brace angles were evaluated, using nonlinear static and dynamic analyses. According to the results of analysis, it was observed that a slope of braces increased the shear lag effect increased, and the lateral strength decreased. The diagrid structures with the brace angle between 60 to 70 degree, seemed to be most efficient in resisting gravity and also lateral loads.

3. METHODOLOGY

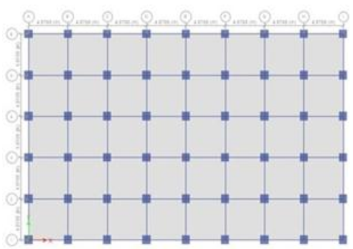
ETABS stands for extended three-Dimentional analysis of building system. The FEM based structural software is used for modelling and analysis of the structure. The analysis is carried out by using ETABS software. The concept of ETAB software is based on storeys, and it is dominantly used for regularly shaped high-rise buildings, often office-buildings, ETABS handles this by enabling the user to draw a plan of the floor and copy the floor to the number of stories required. Each story may be edited individually if required. beams, walls, Columns and shafts may be auto-generated.

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 allows determination of maximum modal response of a singly supported structural system or a multiple supported system

Building description

Three G+19 storey building is modelled in this study and of size 39 x 24 m. All building models have same floor plan and size.



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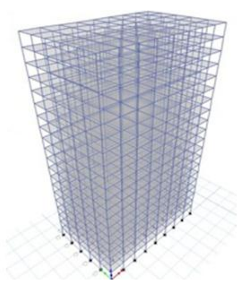

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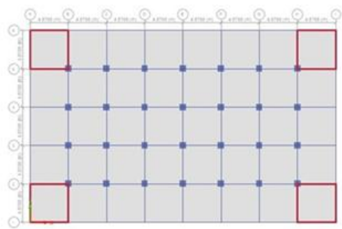

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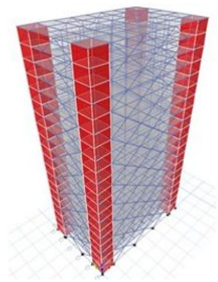

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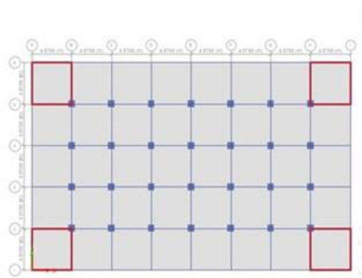

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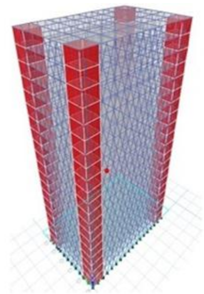


(f)

Fig - 1 : Plan and elevation of all models

Figure 1 (a),(b) shows the plan and elevation view of conventional building and figure 1 (c),(d) shows the plan and elevation view of diagrid structure 35 degree angle respectively, figure 1 (e),(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 : 3.5 m

Slab thickness : 150mm

Live Load : 4 KN/m2

Wall load : 13.8 KN/m2

Floor Finish : 1.5 KN/m2

Data for conventional building

Column 1 (1 to 15 storey) : 1000x1000 mm

Column 2 (16 to 20 storey) : 800x800 mm

Beam 1 (1 to 15 storey) : 1000x750mm

Beam 2 (16 to 20 storey) : 750x350 mm

Data for diagrid building

Column 1 (1 to 15 storey) : 800x800 mm

Column 2 (16 to 20 storey) : 600x600 mm

Beam 1 (1 to 15 storey) : 750x350mm

Beam 2 (16 to 20 storey) : 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 : 0.24

Importance factor : 1.5

Response reduction Factor : 3.0

Soil Type : Medium

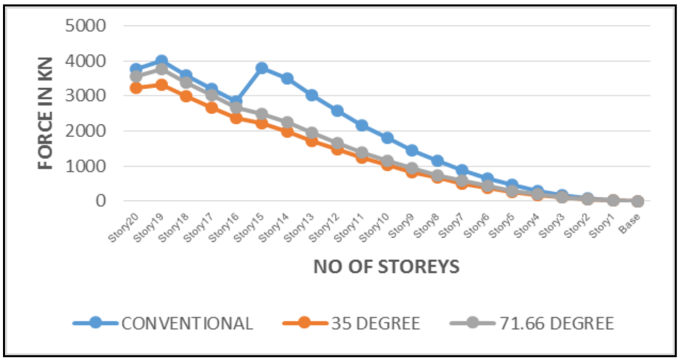
For wind load the basic wind speed taken is 33m/s, structure class is B, and terrain category, Risk coefficient factor k1, sTerrain roughness and height factor k2, Topography factor k3 is taken as 1, Windward and Leeward coefficient 0.8, 0.5 respectively.

4. EXPERIMENTAL RESULTS AND DISCUSSIONS

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 Auto Lateral load, Lateral storey Displacement and Overturning moments.

- **Auto Lateral load**

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



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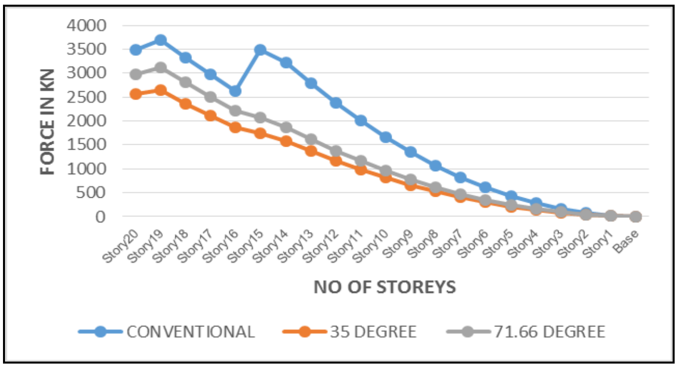


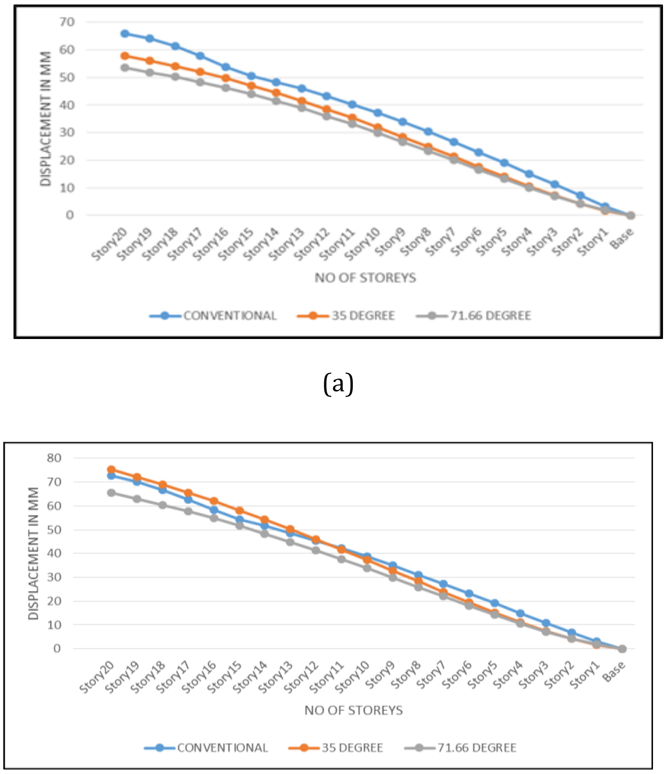
(b)

Fig- 2: Comparison of Auto Lateral load (a) In X Direction (b) In Y Direction

Considering the final results which are obtained from the comparission of all models Auto Lateral load in both X and Y direction the conventional building model has higher Auto Lateral load when compared with that of all other two models, and the diagrid model of angle 35 degree has lesser Auto Lateral load when compared with that of all other two models.

- **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)

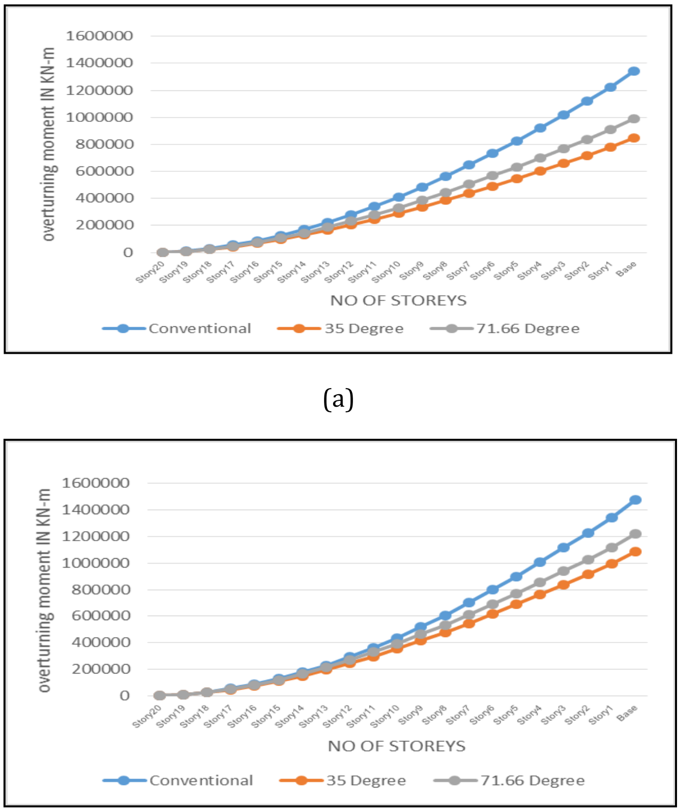
Fig - 3: Comparison of Storey displacement (a) In X Direction (b) In Y Direction

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

- **Overturning moments**

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



(a)

(b)

Fig- 4: Comparison of overturning moments (a) In X Direction (b) In Y Direction

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

3. CONCLUSIONS

1. The Auto lateral load of conventional building in X and Y direction is higher when compared to other models and 35 degree diagrid structure has lesser values of Auto lateral load in both X and Y direction
2. The storey 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.
3. The overturning moments of conventional building in X and Y direction is higher when compared to other models and 35 degree diagrid structure has

lesser values of overturning moments in both X and Y direction

Hence we can conclude diagrid structures structural performance is better compare to conventional building and 35 degree diagrid structures overall structural performance is better than 71.66 degree in these parameters.

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