SOME COMPARATIVE STUDY ON STEEL DIAGRID STRUCTURE WITH CONVENTIONAL STEEL STRUCTURE

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Abstract-*Tall building construction is increasing rapidly throughout the world. Now a day the structure must have aesthetic expression, structural efficiency and geometric versatility. Recently diagrid structures construction has been developed, in which the lateral load and gravity loads are carried by the diagonal member provided at the outer periphery of the structure. Seismic forces are resisted by composed triangulated sections provided at the outer periphery.In this study five models are considered, one is conventional steel frame and other four are diagrid frames in which diagrid is connecting to one, two, three storeys. All models are of G+ 25 storeys. They are modeled and analyzed in seismic and wind load conditions using ETABS 2013, for seismic analysis zone 4 is considered, wind speed of 44 m/s is considered in wind analysis. The five models are analyzed and the parameters like storey displacement, story drift, time period, axial force, bending moment are compared. Finally it is concluded that model 3 gives the better results for all above parameter*

Keywords- Diagrid Structure; Seismic Analysis; Wind Analysis; Storey Displacement; Storey Drift; Time Period; Axial Force; Bending Moment.

1. INTRODUCTION

There are many new design and analysis methods are available now a days for high rise buildings. Structural design of high rise buildings is governed by lateral loads as a result of wind or earthquake. The interior or exterior structural system supplies the lateral load resistance. Lateral load is resisted by centrally located elements in shear wall core, braced frame and their combination, these frames are interior system. The lateral load is resisted by the elements provide at the periphery in the framed tube structure, braced structure. For the better efficiency and flexibility diagrid structural system is adopted in the structure. The utilization of structural elements is very important in structural design. Compared to closely space vertical columns in framed tube, diagrid structure contains inclined columns on the surface of building. In the diagrid structural system lateral loads are resisted by inclined columns provided at the outer periphery. Diagrid structures generally don't require core because lateral shear can be carried by the diagonals on the periphery of building.

It is necessary to preserve the high cost land for the agricultural, and for the transportation purpose. Therefore high rise buildings are constructed in the city. When high rise buildings matters come there should be a strong lateral load resisting system for resisting earthquake and wind loads, when compared to low rise buildings.

1.1 Literature Review

Khushbu Jania, Paresh V. Patel (2013)[1] a 36 storey Building is analyzed and designed using ETABS, and they explained, a typical floor plan of 36 m × 36 m size is considered. Structural members are considered as per IS 800:2007 code book. all load combinations are considered as per code. The diagrid system is studied for 36 storey building for load distribution. Also diagrid structures of 50, 60, 70 and 80 storey are analyzed. From the study it is concluded that most of the lateral load is resisted by diagrid columns on the periphery, while interior columns and peripheral diagonal columns are carried the gravity load. So for vertical load internal columns must be designed. diagrid structural system is more effective in lateral load resistance Due to boost in lever arm of peripheral diagonal columns.

Moon K.S (2008)[2] concluded that for uniform angle diagrid structures, with aspect ratios ranging from about 4 to 9, the range of the suitable angle is approximately 60 to 70 degrees. For very tall diagrid structures with an aspect ratio larger than 7, varying angle diagrid configuration which has gradually steeper angles towards the foot of the building generates a better design with less material than the uniform angle configuration.

Ravish Khan, S.B. Shinde(2015)[3] performed the dynamic analysis of a 16-storey diagrid structure and studied the load distribution in this system. A comparative study between a diagrid structure and a corresponding conventional framed structure was also presented to demonstrate the benefit of using diagrid system in high rise structures. It was seen that the diagrid systems resist load by axial action as no significant amount of shear or moment was observed under gravity in addition to lateral loading. The diagrid structures gave far better results against earthquake and wind load when compared to a conventional frame.

1.2 Objective of the Study

i. The main objective is to study the performance of diagrid structure in different seismic and wind load conditions.
ii. Comparison of analyzed results with conventional steel structural steel frame.
iii. Five different models are modeled in ETABS, and they are analyzed in seismic and wind load conditions.
iv. Performance of Diagrid structures with Diagrid connecting one, two, three stories is to be studied.
v. The seismic and wind Load parameters are applied to the all five models as per the IS code conditions.
vi. The parameters like storey drift, story displacement, natural time period, bending moments and axial force are to be studied.

2. PROJECT MODELS DETAILS

For the analysis and comparison of conventional and diagrid steel structures 5 different models are considered; they are analyzed and results are compared. They are as follows.

MODEL 1: A conventional Regular steel frame of G+25.
MODEL 2: A steel Diagrid frame of G+25 considered, Taking Diagrid in between each storey as steel tube.
MODEL 3: A steel Diagrid frame of G+25 considered, Taking Diagrid in between two storey's as steel tube.
MODEL 4: A steel Diagrid frame of G+25 considered, Taking Diagrid in between three storey's as steel tube.
MODEL 5: A steel Diagrid frame of G+25 considered, Taking Diagrid in between two storeys as steel tube at 0.5m offset.

2.1 Geometric Parameters of Models

Structure Type	:	Steel structure
Number of storey	:	G+25
Size of Plan	:	48 m x 48 m
Number of Bays along X & Y	:	12
Each Bay Length	:	4m
Height of each storey	:	3.5 m
Grade of Concrete (Fck)	:	M30
Grade of Steel (Fy)	:	Fe 345

2.2 Section Properties Details (as per IS 800-2007)

Column Details

Type	:	Hollow Square Column
Size	:	900 x 900 x 30 mm

Beam Details

Primary Beam	:	ISHB 450-2
Secondary Beam	:	ISHB 300-2

Slab Details

Type	:	RCC Deck Slab
Thickness	:	150 mm

Diagrid Details

Type	:	Hollow Square Column
Size	:	600 x 600 x 30 mm

Load Calculations

Live load	:	4 KN/m^2
Floor finish	:	1 KN/m^2

Wall load Calculation

Thickness of wall	:	230 mm
18X0.23X (3.5-0.45)	:	12.62 KN/m^2

2.3 Seismic Parameters Details (as per IS 1893-2003)

Seismic Zone	:	Zone V
Type of soil	:	medium
Response reduction factor	:	5
Importance factor	:	1.5

2.4 Wind Parameters Details (as per IS 875-1987 Part-3)

Place	:	Hyderabad
Wind Speed	:	44 m/s
Terrain Category	:	4(Center of city)
Structure Class	:	C (Height >50)
Risk coefficient	:	1
Topography	:	1

2.5 Plan Area Details of Models

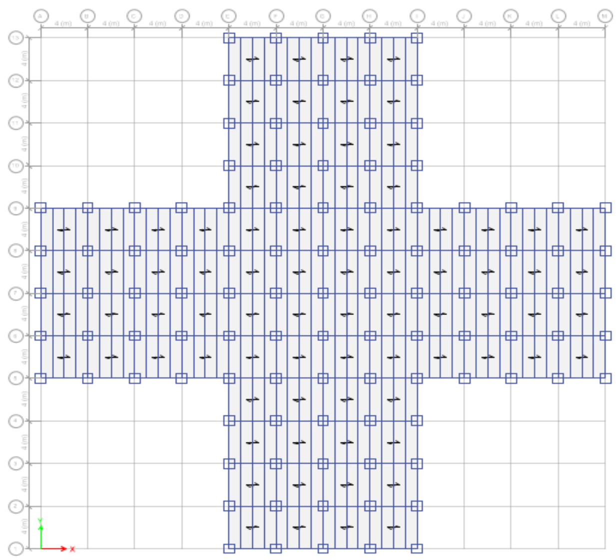

Fig. 1: Plan of model 1

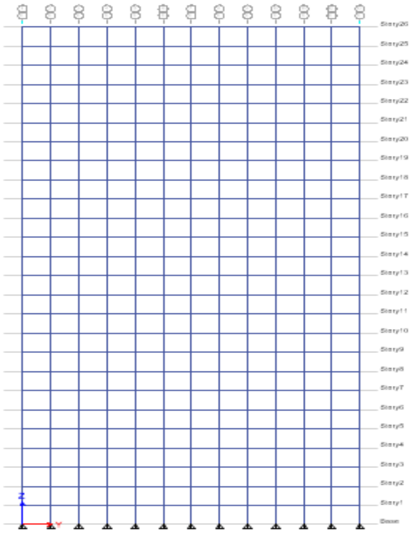

Fig. 2: Elivation of Model 1

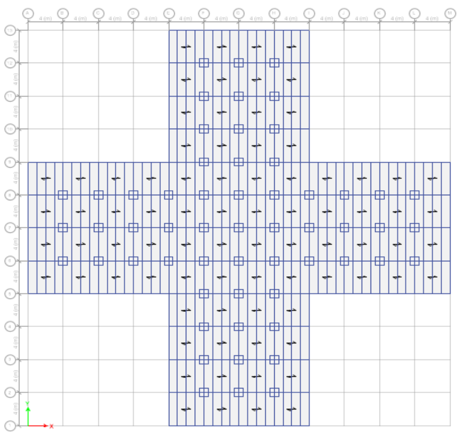

Fig. 3: Plan of Model 2

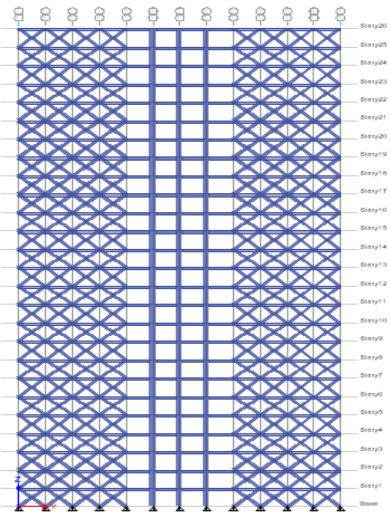

Fig. 4: Elevation of Model 2

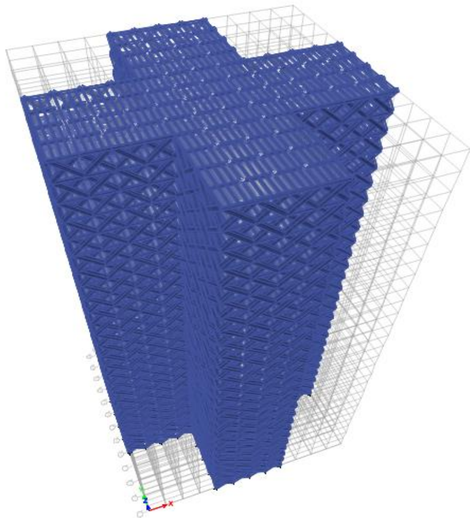

Fig. 8: Elevation of Model 5

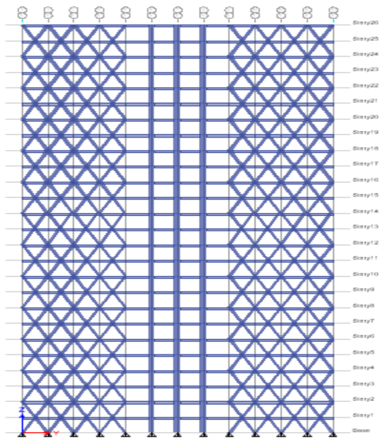

Fig. 6: Elevation of Model 3

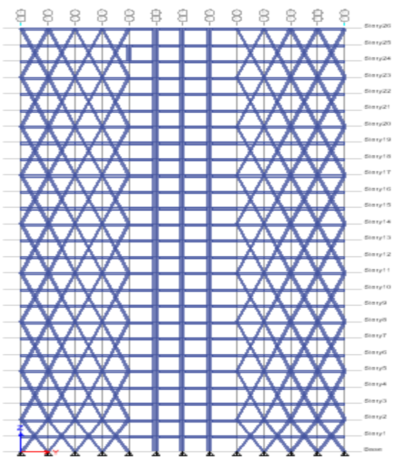

Fig. 7: Elevation of Model 4

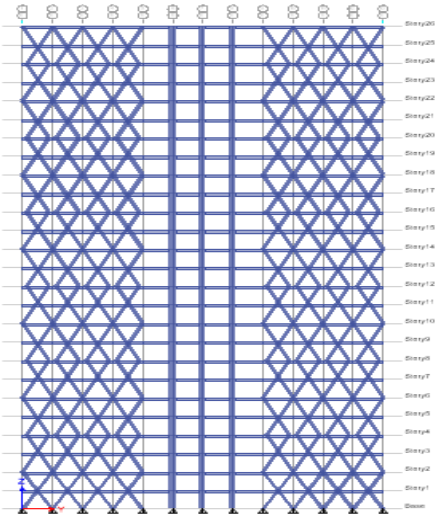

Fig. 8: Elevation of Model 5

3. ANALYSIS AND RESULTS

3.1 Seismic Analysis

All models are modeled using ETABS, seismic and wind analysis is carried out and following results are compared. For seismic analysis equivalent static method is used. The following parameters are compared.

- Storey displacement
- Storey drift
- Time period
- Axial force
- Bending moment

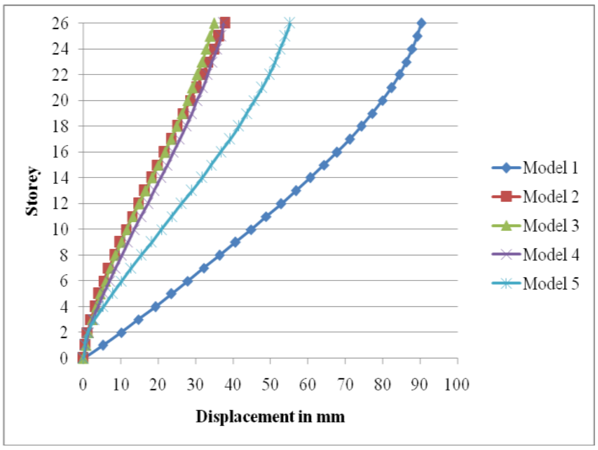

Fig. 9: Maximum storey displacement in X-Direction

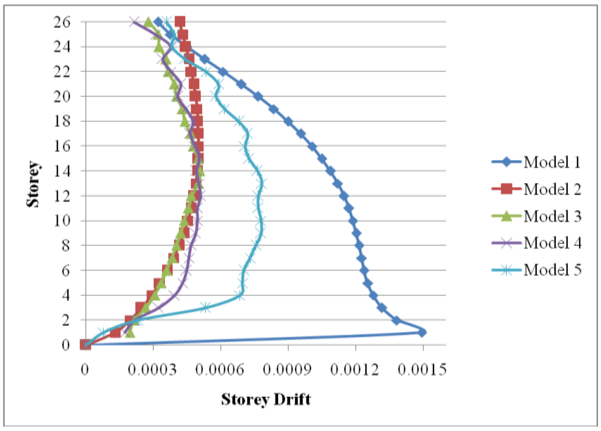

Fig. 10: Maximum Storey Drift in X- Direction

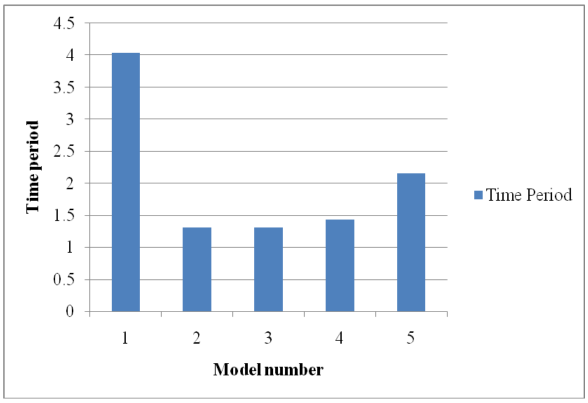

Fig. 11: Time Period due to seismic analysis

The following column position is selected for axial force and bending moment consideration. The axial force and bending moment are analyzed and tabulated for all five models.

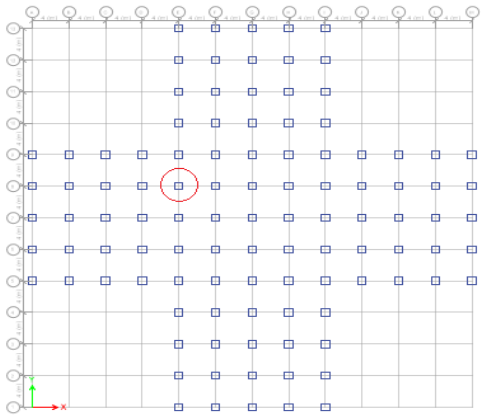

Fig. 12: Column position for axial force and bending moment

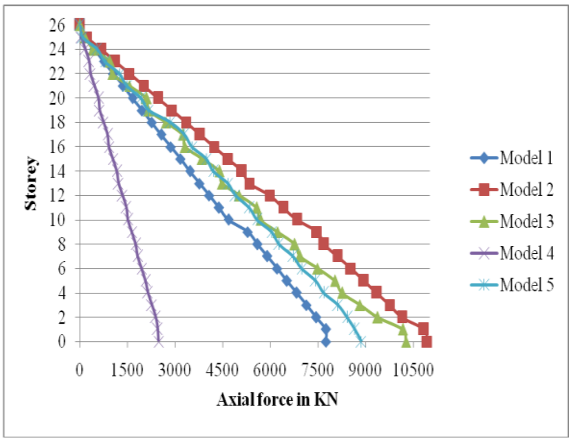

Fig. 13: axial force due to seismic analysis

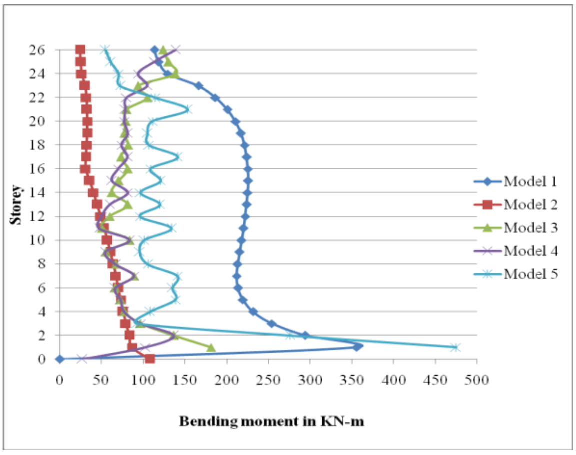

Fig. 14: Bending Moment due to seismic analysis

3.1.1 Observation on Seismic Analysis

Storey displacement in X-direction for diagrid structure is 41.35mm, where as storey displacement of conventional steel structure is 90.3mm.that is diagrid structure gives 54.20% less storey displacement. In Diagrid structure the Storey displacement is less for diagrid connecting two stories, which is model 3. The natural time period is less in model 3 that is diagrid connecting two stories. As compared to conventional steel structure the diagrid structure gives better results in natural Time Period Axial Force, Bending moment.

3.2 Wind Analysis

All five models are modeled in ETABS, the geometric parameters and load patterns are taken same as seismic analysis. These models are analyzed for wind loads also. The wind load is taken in X and Y direction. The following wind parameters are selected as per IS 875-1987(part-3) Code Book

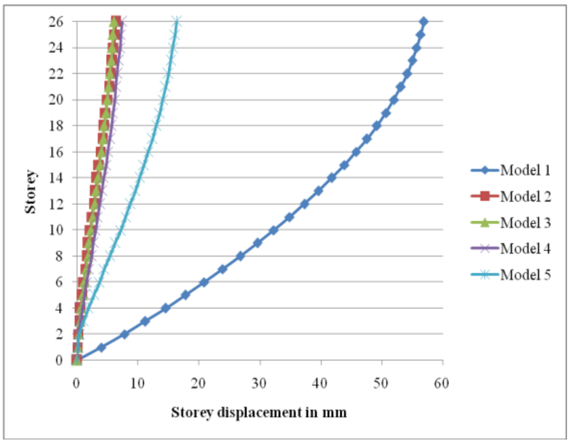

Fig. 15: Maximum storey displacement in X-Direction

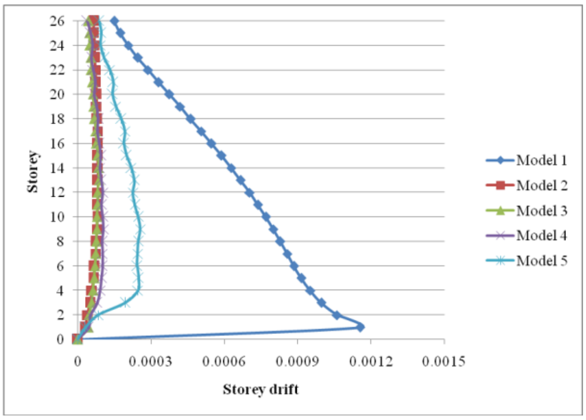

Fig. 16: Maximum Storey Drift in X- Direction

For axial force and bending moment consideration the same column position is selected as in seismic analysis. Axial force and bending moment at a particular column position for all 5 models are analyzed,

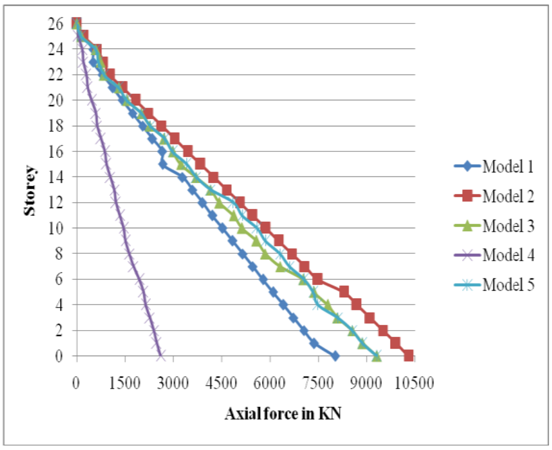

Fig. 17: Axial Force due to Wind Analysis

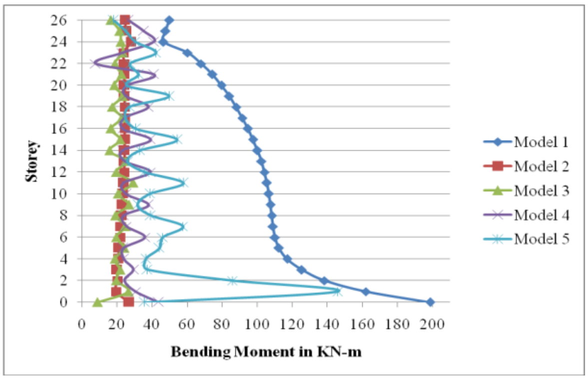

Fig. 18: Bending Moment due to Wind analysis

3.2.1 Observation on Wind Analysis

The diagrid structure gives the minimum displacement in X direction as compared to conventional steel structure, in Wind X-direction Load. The diagrid structure gives 84.3% less displacement as compared to conventional steel frame. The diagrid model in which diagrid connecting to two storey's gives less displacement in X-direction as compared to other models. Conventional structure has the maximum storey drift as compared to diagrid structure therefore diagrid structure is better than conventional structure. In the diagrid models the model 3 that is diagrid connecting to two storey's gives better results than other Models.

4. CONCLUSION

i. From the study it is concluded the Diagrid structure is gives better results in seismic and wind analysis than conventional steel structure.
ii. The storey displacement is minimum in Diagrid structure as compared to conventional frame.
iii. Storey drift is also less in diagrid structure, where it is maximum in conventional steel structure
iv. Natural time period is minimum for diagrid structure as compared to the conventional steel structure.
v. The diagrid structure in which diagrid connecting two floors gives the better results in seismic and wind analysis as compared to other models.
vi. In different seismic and wind load analysis the model 3 gives the better results, in storey displacement, storey drift, bending moment, axial force conditions.

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CODES

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9. IS 875-1987(Part-3) Code of practice for Design loads (Wind loads)
10. IS 1893 (Part-1): 2002 for seismic loads.
11. IS 800: 2007 General Constructions in Steel-Code of Practice, Bureau of Indian Standard, New Delhi.

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