"Analysis of Multi Storied Diagrid Structure using ETABS Software"

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Abstract -The increasing requirement to achieve larger heights has fueled the growth of structural system concepts for tall buildings. Structural engineers have been able to design and construct buildings that have grown higher and higher for over a century. Many new ideas have arisen as a result of this process, including the relatively new and ground-breaking high-rise diagrid structural system. The diagrid structure was born from the development of this notion to a system without vertical columns. For tall buildings, digrid structural systems are developing as structurally efficient and architecturally remarkable assemblies. Diagrid structures are effective in terms of both strength and stiffness in giving solutions.A tall skyscraper with a G+16 storey structure is investigated and compared under various circumstances. We explore three modules in our project: structures without diagonal grids, structures with diagonal grids at selected bay's outer face, and structures with diagonal grids at selected bay's inner face. Storey drifts and displacement will be compared, as well as axial forces and bending moments, and shear forces in the column.

Keywords: Displacement, Story Drift, Bending Moment, Axial Forces, Shear Forces,

INTRODUCTION: - The diagrid is a type of diagonal member that is used in both gravity and lateral load resisting systems. Braced tube structures have evolved into diagrid systems. Engineers can now use cutting-edge structural systems to construct structures that are more than 100 stories tall. Researchers began using the term diagrid, which is a mix of diagonal and grid, in 1970. Diagrid is a steel-frame construction method that results in triangular structures with diagonal support beams. Aside from eliminating perimeter columns, the diagrid design has other advantages. Vertical load carrying capability is often provided by columns, with diagonals or braces providing stability and resistance to large forces like as wind and seismic stresses. The diagrid's diagonal member carries both shear and moment. As a result, the best angle for placing diagonals is determined by the height of the building.

1. Objective of Study:

1. ETAB Software Diagrid Structure Analysis
2. To learn how high-rise constructions react to earthquakes.
3. To comprehend the behaviour of high-rise constructions in a certain location when subjected to diagrid loading.
4. Determine whether a diagonal grid is suitable for a certain construction.

LITERATURE REVIEW:-

- **"Diagrid: An innovative, sustainable, and efficient structural system," by Esmaeel Asadi and Hojjat Adeli, published in 2016.**

This study discusses several diagrid configurations, as well as the primary aspects that influence their behaviour and design parameters. The diagrid applications for free form steel and concrete structures are presented, demonstrating the diagrid's applicability in structural design for complicated buildings. It also covers diagrid connections, nonlinear diagrid behaviour, and diagrid structural control. The article suggests that diagrid has the potential to become a more extensively employed structural system in mid to highrise buildings due to its exceptional lateral stiffness and aesthetic qualities. The adjustability of diagrid density and diagonal angle, as well as the flexibility of triangulated diagrid parts to produce complex forms, are the essential structural properties of diagrids.

- **"Improving the seismic performance of diagrid buildings with buckling constrained braces," Saman Sadeghi and Fayaz R. Rofooei, 2019.**

The seismic performance of diagrids with buckling limited bracing is investigated in this study (BRBs). The seismic performance factors of six three-dimensional diagrid structures with varied heights and diagonal angles that were modelled using the Open sees programme are evaluated using nonlinear static analysis. The findings show that utilising BRBs enhances the seismic performance of the models investigated by collecting plastic damages in the BRBs and spreading plastic hinges more uniformly across the models.

- **"Seismic fragility evaluation of a diagrid structure based on energy approach," Majid Moradi and Moein Abdolmohammadi (2020).**

The goal of this research is to use energy approach principles to analyse the seismic behaviour of diagrid structural systems under near-field and far-field earthquakes in order to acquire a better understanding of their seismic behaviour and the benefits of adopting energy approaches. The Incremental Dynamic Analysis (IDA) method and a finite element model are used to investigate the behaviour of a 50-story skyscraper. The results reveal that the structure is more vulnerable in far-field earthquakes than in near-field earthquakes, using both the maximum story drift and energy approaches.

METHODOLODY

The following is the methods used to attain the aforementioned goals:

i) Conduct a literature review

ii) In ETAB Software, choose a building model for the study.

iii) Create a diagonal column model of the chosen structure (diagrid bracing).

Model 1: Plain hexagonal structure with no bracing.

Model 2: A structure featuring diagonal bracing (diagrids) on the ground, first, and second floors.

Model 3: A structure having diagonal bracing on the 13th, 14th, and 15th floors.

Model 4: A structure featuring cross bracing on the 7th and 8th floors.

iv) A comparison assessment of the data produced from the analysis in ETAB Software and a seismic analysis of the selected building model.

v) Discussions and observations of outcomes

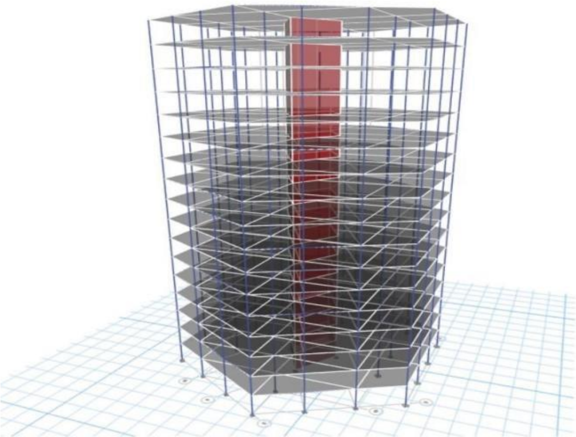


Figure 1: 3D view of G+16 Storey Model without diagrid

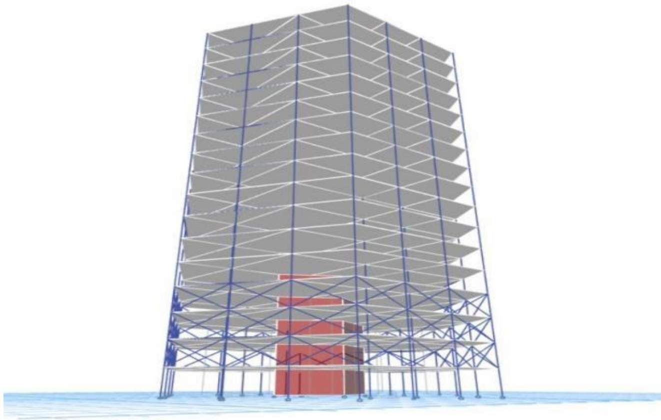


Figure 2: 3-D View of Model 2

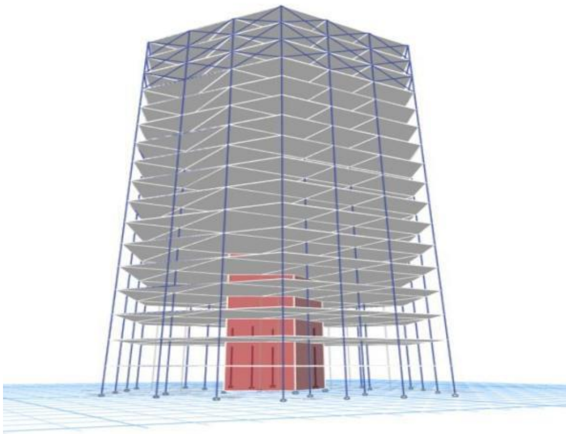


Figure 3 : 3-D View of Model 3

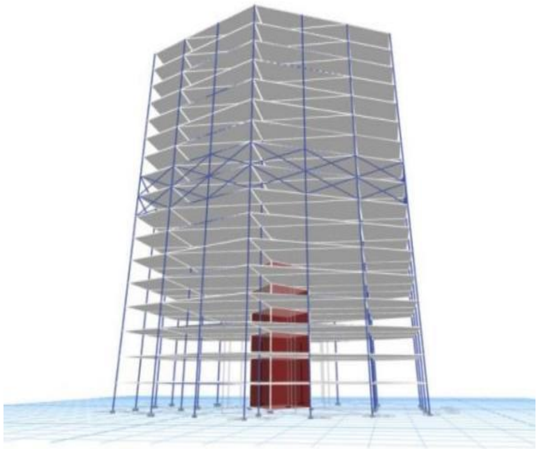


Figure 4 : 3-D View of Model 4

Model 1: Plain hexagonal structure with no bracing. ETAB Software was used to create a basic hexagonal model that included columns, beams, and slabs. The following are the sizes, concrete grades, and rebar grades:

Item	Storey	Size	Grade of Concrete	Grade of Rebars
Beam	All Storeys T	230 X 600 mm	M30	HYSD500
Column	First 3 Storey	1000 X 1000 mm	M30	HYSD500
	4 To 6 Storey	975X975 mm		
	7 To 9 Storey	950X950 mm		
	10 To 12 Storey	925X925 mm		
	13 To 15 Storey	900X900 mm		
	16 Storey	875X875 mm		
Two Way Slab	All Storeys	150 mm thick	M30	-
Shear Wall		200 mm thick	M30	-

Table 1. Item Specification

The load pattern applied on the structures is as follows:

Define Load Pattern	Type of Load	Load
Dead Load (DL)	Dead	-
Live Load (LL)	Live	2 kN/m
Floor Furnish Load	Super Dead	1.5 kN/m
Wall Load	Super Dead	10 kN/m
Earthquake Load in x-dir (EQX)	Seismic	Seismic Zone Factor Z- 0.16 Importance Factor I- 1.2
Earthquake Load in y-dir (EQY)	Seismic	Seismic Zone Factor Z- 0.16 Importance Factor I- 1.2

Table 2. Load Specifications

Basic Load Combinations as per [IS 456:2000, Table 18, pg. no. 68].

1. 1.5(DL+LL)
2. 1.2(DL+LL+WLX)
3. 1.2(DL+LL+WL-X)
4. 1.2(DL+LL+WLY)
5. 1.2(DL+LL+WL-Y)
6. 1.5(DL+WLX)
7. 1.5(DL+WL-X)
8. 1.5(DL+WLY)
9. 1.5(DL+WLY-Y)
10. 0.9DL+1.5WLX
11. 0.9DL+1.5WL-X
12. 0.9DL+1.5WLY
13. 0.9DL+1.5WL-Y

14. 1.2(DL+LL+EQX)
15. 1.2(DL+LL+EQ-X)
16. 1.2(DL+LL+EQY)
17. 1.2(DL+LL+EQ-Y)
18. 1.5(DL+EQX)
19. 1.5(DL+EQ-X)
20. 1.5(DL+EQY)
21. 1.5(DL+EQY-Y)
22. 0.9DL+1.5EQX
23. 0.9DL+1.5EQ-X
24. 0.9DL+1.5EQY
25. 0.9DL+1.5EQ-Y

14. Various load combinations as per [IS 1893 part-1:2016, 6.3.2.2, pg. no. 8] have been implemented on the structure. They are as follows:
15. 1.2DL+1.2LL+1.2EQX+0.36EQY
16. 1.2DL+1.2LL-1.2EQX-0.36EQY
17. 1.2DL+1.2LL+1.2EQY+0.36EQX
18. 1.2DL+1.2LL-1.2EQY-0.36EQX
19. 1.5DL+1.5EQX+0.45EQY
20. 1.5DL-1.5EQX-0.45EQY
21. 1.5DL+1.5EQY+0.45EQX
22. 1.5DL-1.5EQY-0.45EQX
23. 0.9DL+1.5EQX+0.45EQY
24. 0.9DL-1.5EQX-0.45EQY
25. 0.9DL+1.5EQY+0.45EQX 12. 0.9DL-1.5EQY-0.45EQX

Model 2: Building with diagonal bracing(diagrids) at Ground floor, 1st floor and 2nd floor.

Item	Storey	Size	Grade of Concrete
Diagrid	On ground floor, 1st and 2nd floor	230 X 230 mm	M30

Table 3. Diagrid Specifications

Model 3: Building with diagonal bracing at 13th storey, 14th floor and 15th floor.

Item	Floor	Size	Grade of Concrete
Diagrid	On 13th, 14th and 15th floor	230 X 230 mm	M30

Table 3. Diagrid Specifications

Model 4: Building with cross bracing at 7th floor and 8th floor.

Item	Storey	Size	Grade of Concrete
Diagrid	On 7th and 8th floor	230 X 230 mm	M30

Table 3. Diagrid Specifications

Conclusion and Discussion:

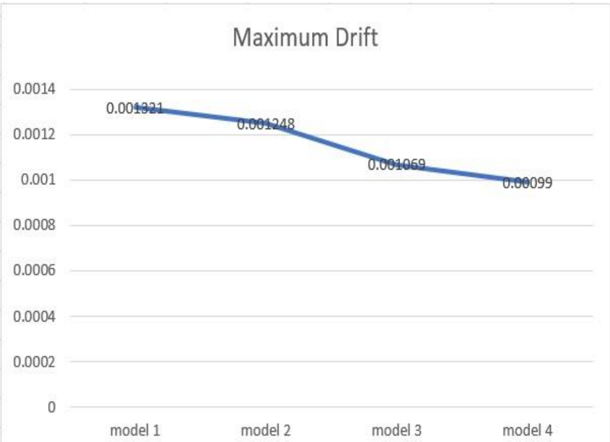
Model 1: Plain hexagonal structure with no bracing.

A hexagonal building with G+16 stories and no diagrid is considered. The greatest drift found after the analysis was 0.001321. Under the operation of the design base of shear, storey drift in any storey shall not exceed 0.004 times the storey height [IS 1893 part1:2016]. As a result, the structure is not safe since it shows more deflection than is required, namely 0.0012.

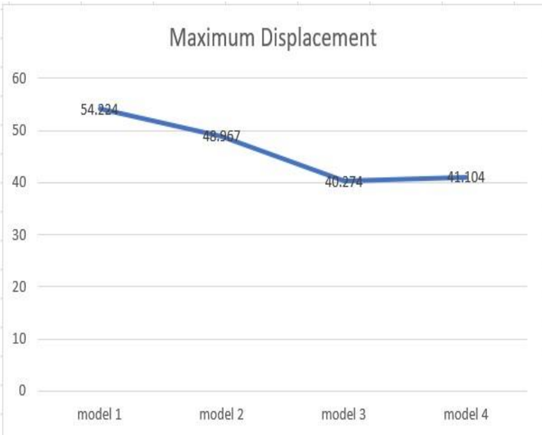
Model 2: A structure featuring diagonal bracing (diagrids) on the ground, first, and second floors.
A 16-story hexagonal building with diagrids on the ground, first, and second floors is considered. The largest drift found after the analysis was 0.001248.As a result, the structure is safe because it has the same deflection as the required 0.0012.

Model 3: A structure having diagonal bracing on the 13th, 14th, and 15th floors.
A 16-story hexagonal skyscraper featuring diagrids on the 13th, 14th, and 15th floors is being considered. The largest drift found after the analysis was 0.001069.As a result, the structure is safe because it has less deflection than required, namely 0.0012.

Model 4: A structure featuring cross bracing on the 7th and 8th floors.
A 16-story hexagonal structure featuring diagrids on the 7th and 8th floors is being studied. The greatest drift found after the analysis was 0.00099. As a result, the structure is safe because it has less deflection than required, namely 0.0012.



Graph 1. Maximum drift of the four models.



Graph 2. Maximum displacement of the four models.

CONCLUSION

1. According to IS 1893 part-1 2016, the lateral displacement of hexagonal buildings is greater than envisaged.
2. It was discovered that the maximum drift was correct to the required drift according to IS code after installing diagonal bracings (Diagrid) at the ground 1st and 2nd floors.
3. After installing diagonal bracings (Diagrid) on the 13th, 14th, and 15th floors, it was discovered that the maximum

drift was less than the IS code-mandated drift.

4. After installing diagonal bracings (Diagrid) on the 7th and 8th floors, it was discovered that the maximum drift was far less than the IS code required drift.
5. As a result, the building's drift when diagrids are installed at the bottom storeys is greater than the building's drift when diagrids are positioned at the top storeys. Also, when the diagrids are put in the structure's middle stories, the drift is reduced to a minimum.
6. When comparing the four models of each column, there is no such variance in axial force and shear force.
7. The bending moments of the models differ slightly.

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