COMPARATIVE STUDY OF CONCRETE DIAGRID BUILDING AND CONVENTIONAL FRAME BUILDING SUBJECTED TO SEISMIC FORCE

Bhavani Shankar[1], Priyanka M V[2]

[1] Assistant Professor, Department of Civil Engineering, Srinivas School of Engineering, Mangaluru, India
[2] M. Tech Student, Department of Civil Engineering, Srinivas School of Engineering, Mangaluru, India

---***---

Abstract - *In present decades, demands of population growth, scarcity of land and increase of land prices has made engineers to develop the structures vertically. Along with the structural efficiency, the aesthetic appearance has also to be considered parallely during the construction. For such type, diagrid structural systems are recently been adopted for high rise buildings. Diagrid structure consist diagonal columns in the periphery which resist the seismic forces. In the current work, the comparison is made on concrete diagrid building and conventional building of similar plan size (15x15)m, and study is made on the response of the structure by varying the storey height from G+5 to G+15. Another analysis is carried for diagrid and conventional structure of similar plan size (18x18)m with same storey height G+15,and the effect of angle of diagrid and length of diagrid is studied and is compared with the conventional system. The results are obtained in terms of storey drift, base shear, storey shear, time period and storey displacement. Software adopted for the current work is ETABS. For the analysis of structures Equivalent Static Analysis method is adopted. The structures located in zone V is considered.*

Key Words: **Storey displacement, Story drift, Story shear, Base shear, Time period, ETABS***.*

1. INTRODUCTION

Diagonalized grid structures –"Diagrid" are the array of triangles formed as a framework, made by the intersection of distinct materials like timber, steel or concrete. Diagrids are capable to resist both gravity and lateral loads acting on the building. Provision of diagonal members enhances both strength and stiffness. The loads acting on the building are countered and well distributed due to its triangular arrangements. Provision of complex geometry and curved diagrids are widespread. Modular geometry of diagrid is mainly depends on optimal angle of diagrid. Since, both moment and shear are carried by triangular member, optimal angle of placing ranges from 35 to 90 degrees. Usually adopted range falls in between 60 to 70 degrees. From the facts, it is evident that, optimal angle of placing increases with the height of structures. The base of concrete diagrid is restrained and the base of metal diagrid is pinned. Restrained base possesses moment. Diagrids carry shear by axial action. Conventional frame carries shear by buckling of members. The major difference between conventional structure and diagrid structure is that, most of vertical columns are eliminated in diagrids. Whereas, vertical columns are must in conventional structure. In diagrid structural system, gravity and lateral loads are resisted by its triangular configuration. Diagrid members are effective more than conventional in minimizing shear deformation. Diagrids carry shear by axial actions while conventional frame carries shear by vertical columns and horizontal spandrels. Diagrid structure is modeled as horizontal cantilever beam on the ground. Then are subdivided into different modules longitudinally according to repetitive diagrid patterns. Single module concept of diagrid plays major role in the internal axial force distribution and conferring shear and bending rigidity to the structure. In diagrid structural system, structural pattern is manipulated to optimize the performance, by manipulating the structural members into particular manner, efficient structure can be built and unique architectural appearance can be obtained.

1.1 SCOPE OF STUDY

Study on diagrid can be made by providing dampers and base oscillators. Diagrids by providing corner columns can be studied. Analysis of diagrid can be done by Response Spectrum Analysis.

1.2 OBJECTIVES OF STUDY

- To compare concrete diagrid structure with conventional frame structures.
- To study behavior of structure by ESA.
- To study the response of structures by varying the building height.
- To compare the effect of angle of diagrid and length of diagrid.
- To study the response of structure such as storey drift, storey displacement, time period, storey shear and base shear

2.NARRATIVE OF MODEL

The major intent of current work is to analyze the performance of G+15 storey structure with height of about 49.5meters. The bay length of the structure is 3mX3m. The diagrids with various angles (45^0, 63^0, 53.13^0 and 75.96^0) and lengths (4.24m,6.70m,12.36m and 15m) are studied. Diagrid buildings are compared with the conventional buildings. Another comparative study was made on the structures by varying the floor height. Ten such diagrid models were compared with similar plan size conventional

buildings by increasing floor height from G+5 to G+15. Then the results are obtained in terms of responses like time period, storey drift, storey displacement, storey shear and base shear. ETABS software is used for the analysis. Indian Standard IS 1893:2002 code of practice is adopted for the seismic analysis of structure.

2.1BUILDING DESCRIPTIONS

a. Material properties

Young's modulus of (M25) concrete	25*1000 kN/m^3
Density of reinforced concrete	25kN/m^3
Density of steel	Fe415
Density of Masonry	20 kN/m^3
Poisson's ratio	0.2

b. Details of building

Plan area dimension	(15*15) m (18*18)m
Story height at ground floor	3.5m
Typical floor height	3.0m

c. Loads considered

Live Load	4 kN/m^2
Floor Finish	0.75 kN/m^2
Wall Load	12 kN/m^2

d. Seismic forces

Importance factor, I	1.0
Type of structure	SMRF
Response reduction factor	**5**
Seismic zones	V
Type of soil	Medium soil

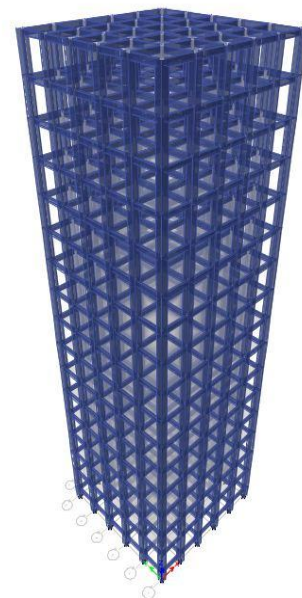## 2.2ETABS MODEL GENERATION
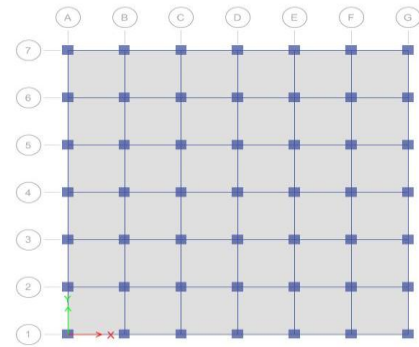
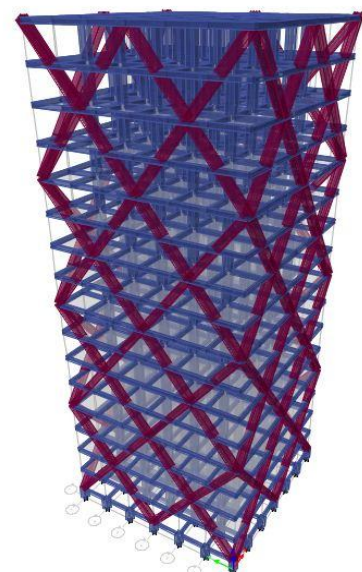Figure 1: Plan view of Model1

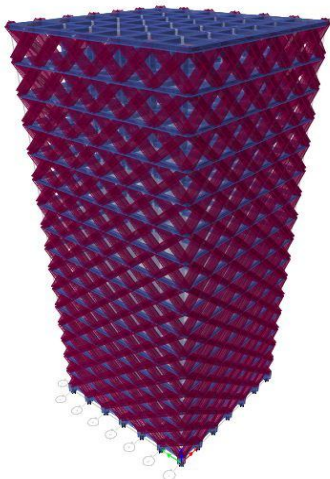Figure 2: Elevation of Model1

Figure 3: Elevation of Model10

Figure 4: Elevation of M11 of Diagrid Structure

3.RESULTS AND DISCUSIONS

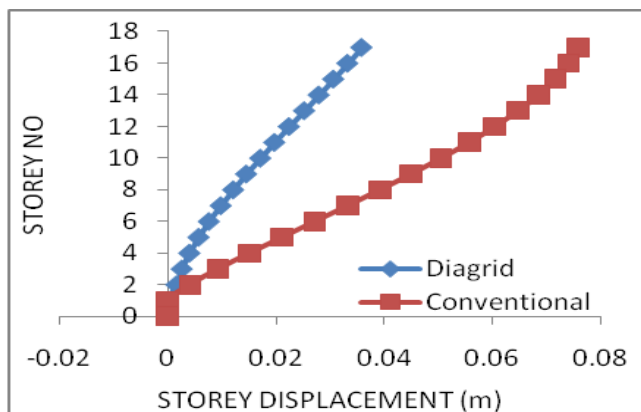### 3.1STOREY DISPLACEMENTS

3.1.1STOREY DISPLACEMENT OF M11

Figure 5: Storey Displacement by ESA of M11
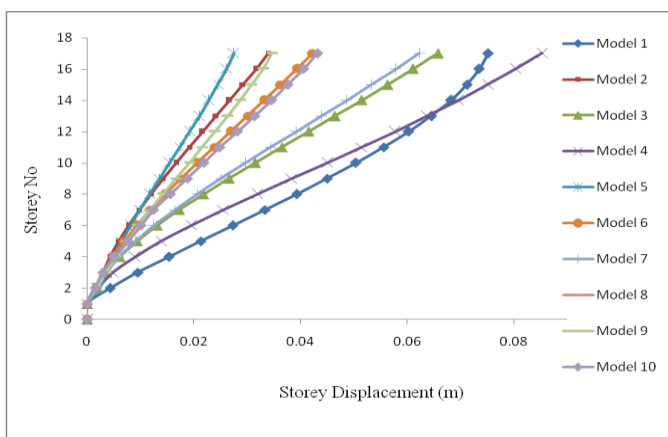
3.1.2STOREY DISPLACEMENT OF MODELS

Figure 6: Storey Displacement by ESA of Models
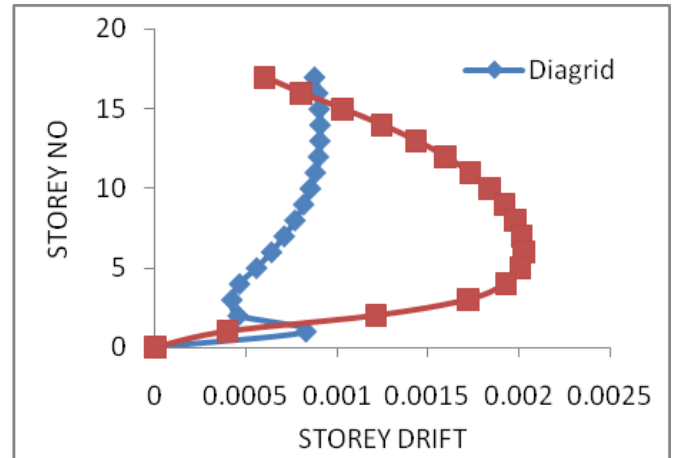
4.2STOREY DRIFTS

4.2.1STOREY DRIFT OF M11

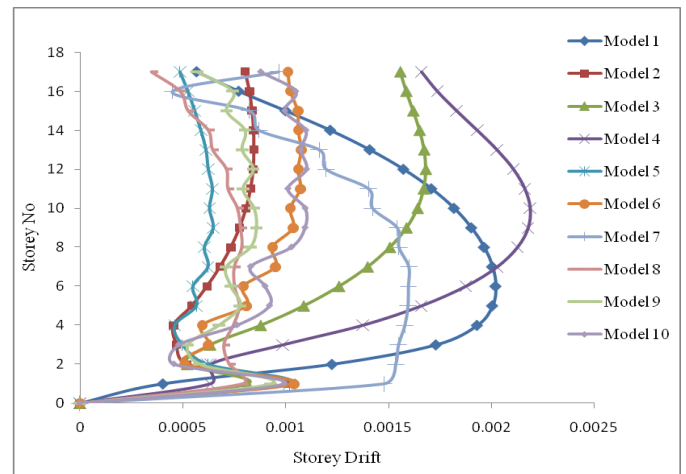Figure 7: Storey Drift by ESA of M11

4.2.2STOREY DRIFT OF MODELS

Figure 8: Storey Drift by ESA of Models
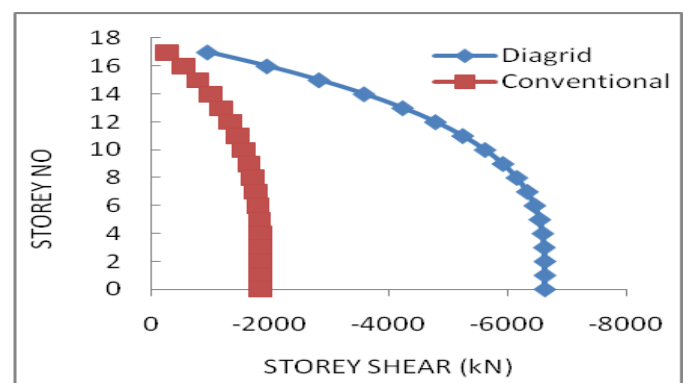
.4.3STORY SHEAR

4.3.1STORY SHEAR OF M11

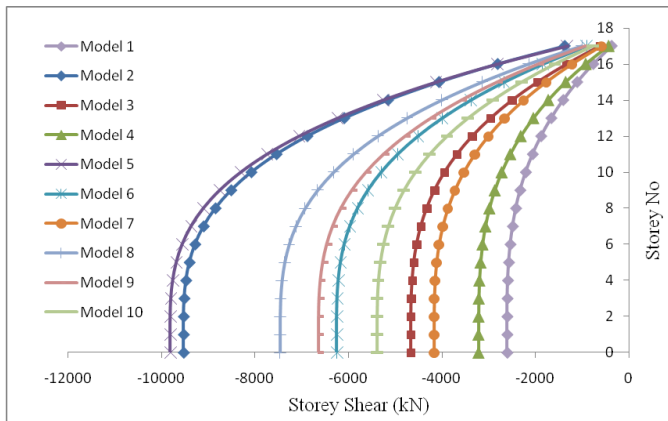Figure 9: Storey Shear by ESA of M11

4.3.2 STORY SHEAR OF MODELS

Figure 10: Storey Shear by ESA of Models

4.4 BASE SHEAR

4.4.1 BASE SHEAR OF G+5 TO G+15 STOREY

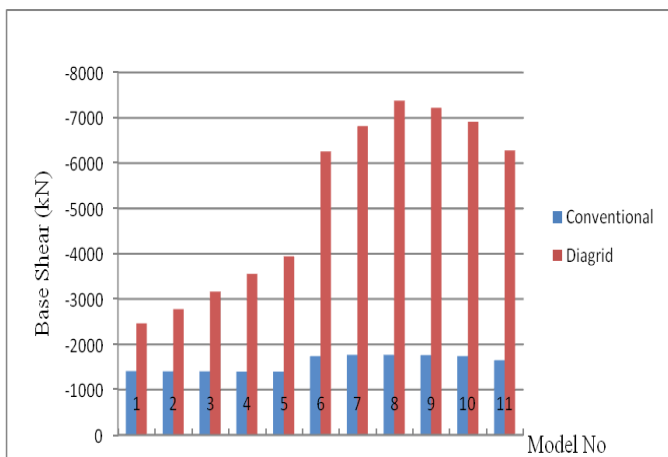Figure 11: Base Shear of G+5 to G+15 Storey
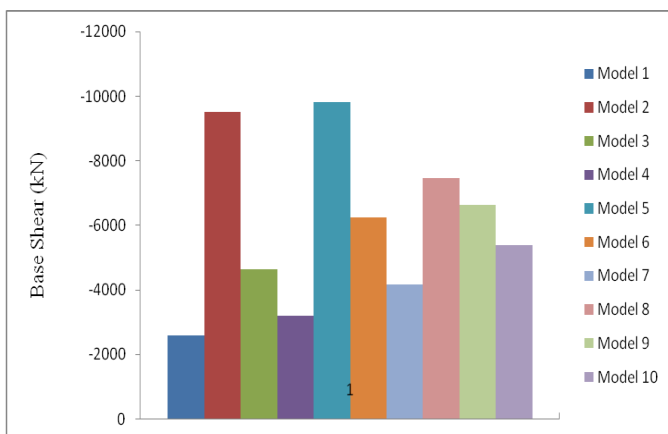
4.4.2 BASE SHEAR OF MODELS

Figure 12: Base Shear of Models

4.5 TIME PERIOD

4.5.1 TIME PERIOD OF G+5 TO G+15 STOREY

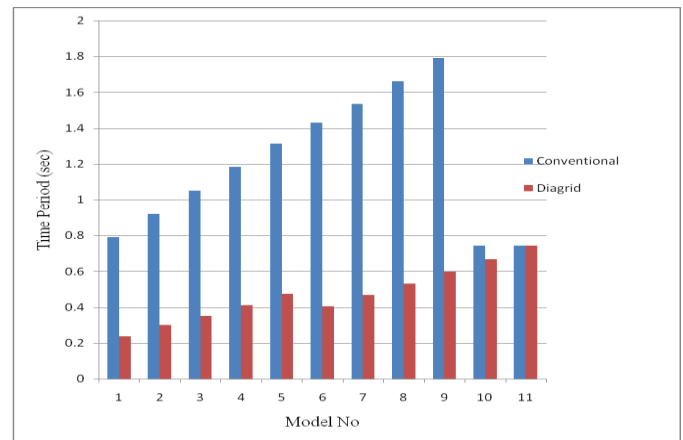Figure 13: Time Period of G+5 to G+15 Storey
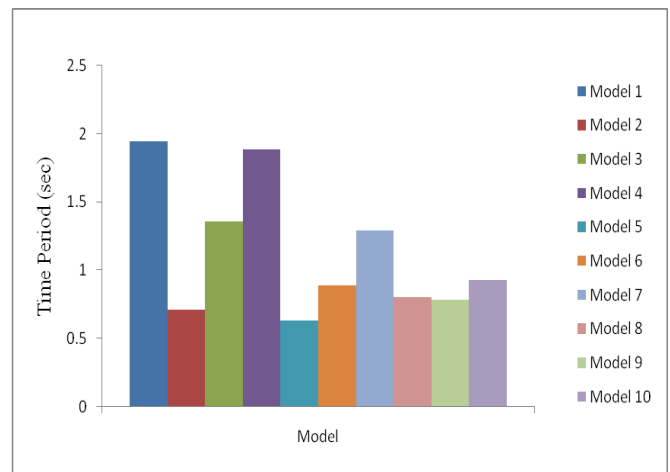
4.5.1 TIME PERIOD OF MODELS

Figure 14: Time Period of Models

5. CONCLUSIONS

[1]   Lateral displacement is caused due to the lateral forces acting on the building. The displacement of diagrid structure is found to be lesser when compared with the conventional structure.

[2]   Maximum percentage reduction in displacement is observed to be more in diagrid structure than that of conventional structure of similar plan size and same number of storey.

[3]   Storey shear and Base shear of the diagrid system is found to be maximum when compared with the conventional structure.

[4]   It is evident that, the value of storey drift increases as the number of storey increases upto certain level and then it reduces. The drift upto G+14

increased gradually but is found to be reduced at G+15 storey. The diagrid system found to be important for high rise structures as drift decreases with the increase in altitude of structure after certain level of height. The drift value of diagrid structure is comparatively less than the conventional structure.

[5]   The value of storey displacement is found to be more for M4 when compared with M1 to M10. In M5 maximum reduction in displacement by 63.4% is observed. Hence provision of diagrid with an angle of 63.4^0 and length of 6.7m is found to be more effective in rigidity.

[6]   Storey shear and Base shear of M5 is more when compared with M1 to M10. A maximum increment of base shear by 73.45% is observed in M5. But M4 has an increment of only 18.8%.

[7]   Compared with other models M5 shows good result in terms of Storey drift. Diagrid of angle 63.4^0 and length 6.7m is found to be more effective in stiffness.

[8]   Time Period of M1 is comparatively more than other models.

[9]   Diagrid structural system looks aesthetically pleasing and becomes important for high rise building in comparison to conventional structural system.

REFERENCES

[1]   Giovanni Maria Montuori, Elena Mele, Giuseppe Brandonisio, Antonello De Luca. "Secondary bracing system for diagrid structures in tall buildings". pg.no: 477-488

[2]   In Young Jung, Young Ju Kim, Young K. Ju, Sang Dae Kim, Sung Jig Kim. "Experimental investigation of web-continuous diagrid nodes under cyclic load". pg.no: 90-101

[3]   Khushbu D. Jani, Paresh V. Patel. "Design of Diagrid Structural System for High Rise Steel Buildings as per Indian Standards". pg.no: 1070-1081

[4]   Khushbu D. Jani, Paresh V. Patel. "Analysis and Design of Diagrid Structural System for High Rise Steel Buildings". pg.no: 92-100

[5]   Kyoung Sun Moon. "Optimal Grid Geometry of Diagrid Structures for Tall Buildings". pg.no: 239-251

[6]   Kyoung Sun Moon. "Practical Design Guidelines for Steel Diagrid Structures".

[7]   Kyoung Sun Moon. "Sustainable Design of Diagrid Structural Systems for Tall Buildings". pg.no: 37-42

[8]   Kyoung Sun Moon. "Diagrid Structural System for Complex-Shaped Tall Buildings". pg.no: 1343-1350

[9]   Manthan I. Shah, Sneha V. Mevada, Vishal B Patel. "Comparative Study of Diagrid Structures with Conventional Frame Structures". International Journal of Engineering Research and Applications. Vol-6 pg.no: 22-29

[10]   Pallavi Bhale, Prof. Pj Salunke. " Analytical Study and Design of Diagrid Buildings And Comparision with Conventional Frame Buildings". International Journal of Advanced Technology in Engineering and Science. Vol -4 pg.no: 226-236

[11]   Saket Yadav, Dr. Vivek Garg. "Advantages of Steel Diagrid Building Over Conventional Building". International Journal of Civil and Structural Engineering Research. Vol-3 pg.no:394-406

[12]   IS: 875 (Part 1-2)-1987, "Code of practice for design loads for buildings and structures", published by Bureau of Indian standards, New Delhi

[13]   IS:1893(part 1) (2002) "Indian Standard Criteria for Practice for Earthquake Resistant Design of Structures General Provisions and Building ", published by Bureau of Indian standards, New Delhi