Analysis of Diagrid Structure

Gauri Dethe[1], Mayur Banagar[2], Prajakta Kenjale[3], Ajay Das[4], Prof. Mohan Dusane[5], Prof. Kartik Prajapati[6]

[1,2,3,4] Student, Dept. of Civil Engineering, VCET, Maharashtra, India
[5,6] Professor, Dept. of Civil Engineering, VCET, Maharashtra, India

---***---

Abstract - *Diagrid structural systems are emerging as structurally efficient as well as architecturally significant assemblies for tall buildings. Diagrid structures are efficient in providing solution both in term of strength and stiffness. But nowadays a widespread application of diagrid is used in the large span and high rise buildings, particularly when they are complex geometries and curved shapes. The 70 storey diagrid structural system with different angles are modelled and analyzed by using Etabs Software. The comparison of analyzed results in terms of top storey displacem and storey drift is presented here.*

Key Words: Angle of Diagrids, Displacement, Storey drift, High rise building, Diagrid structural system.

1. INTRODUCTION

1.1 General

Diagrid is a design for constructing large buildings with steel that creates triangular structures with diagonal support beams. It is a system of triangulated beams, straight or curved, and horizontal rings that together make up a structural system for a skyscraper.

The diagrid system offers several advantages in addition to eliminating perimeter columns. Most notably it optimizes each structural element. Typically, columns are used to provide vertical-load-carrying capacity, and diagonals or braces provide stability and resistance to large forces, such as wind and seismic loads. The diagonal member of the diagrid carries both shear and moment. So the optimal angle of placing of the diagonals is dependent of building height. The present work is carried out using different angle by considering different storey models. The analysis is done using Etabs 2016 software.

In this paper we are considered four different models which are having different angle of inclination i.e. 45°, 55°, 66°, 70°. The building dimension used is 42mX42m and total height of the building is 238m.

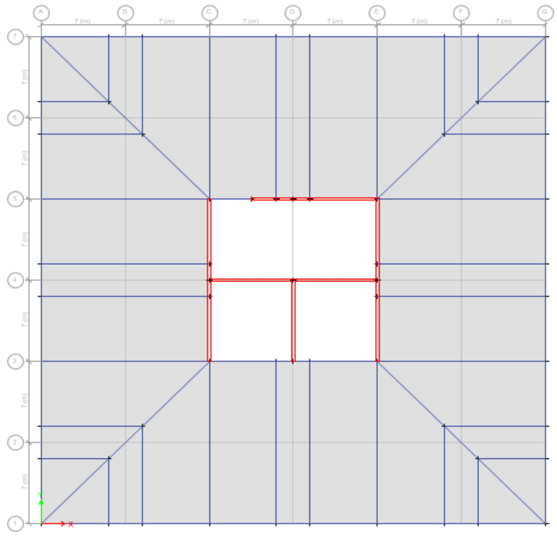

Fig. -1: Plan view of the diagrid structure

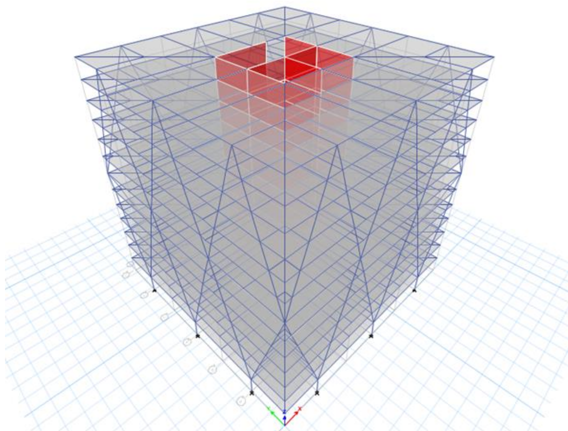

Fig. -2: 3D view of diagrid model

2. MODEL DESCRIPTION

These are the geometric and structural details of the models are as follows.

I. Plan area – 42mX42m
II. Location – Mumbai (zone-3) [wind speed – 44 m/s]
III. No. Of storey -70
IV. Storey height – 3.3m
V. Steel section – ISHB450 (for beam)
VI. Concrete:

Shear wall – M35
Slab – m30
VII. Dead load – 3 KN/m^2
VIII. Live load – 2.5 KN/m^2
IX. Slab thickness – 150 mm
X. Earthquake – IS:1893 2002
XI. Importance factor – 1
XII. Response reduction factor – 3
XIII. Wind load – IS:875 (III)-2015

3. GRAVITATIONAL AND LATERAL LOAD CALCULATION

- Floor-floor height = 3.3m
- Angle = 66
- Beam udl= (floor-floor height – beam depth)* wall thickness *wall density

=(3.3-0.45)*0.15*20 = 8.55 KN/m^3
terrace beam load = 1*0.15*20 =3 KN/m
(considering parapet = 1m)

- Super imposed dead load =floor finish thickness* density

=0.075*20 = 1.5KN/m^3
for terrace area = 0.15*20 =3 KN/m^2
(150 thick water proofing)

- live load calculation

(1) general area = 2 KN/m^2
(2)terrace area = 1.5 KN/m^2
(3) staircase = 3 KN/m^2
(as per is875-part-2)

4. CALCULATIONS OF DESIGN WIND LOAD AND SEISMIC LOAD ACTING ON STRUCTURE

4.1 Wind load calculations:

Building location: - Mumbai
Building height (avg) total : - 238 m
Building height (m) : - 234.7 m
Building base dimension B*D (m) : - 42*42 m
Basic wind speed Vb (m/s) : - 44 m/s (as per IS875-PART3:2015)

Design wind speed (m/s):

Vz = Vb * K1*K2 * K3* K4
Vz = Design wind speed at any height Z in m/s = 44 m/s for zone 3
Vb = Basic wind speed in m/s
K1= probability factor (Risk coefficient) ...clause 6.3.1
K1=1.0
K2= Terrain roughness , Height factor ...clause 6.3.2
K3= Topography factor =1.0 ...IS875(PART 3)
K4= importance factor = 1.0
(importance factor for cyclonic region (K4) due to vulnerability of east and west coast of india for severe cyclones foor a width of 60 km , values are recommended as per IS15498)

Vz = Vb * K1 * K2 * K3 * K4
Vz = 44 * 1.0 * 1.32 * 1.0 = 58.08 m/s

Design wind pressure (N/m^2):

Wind pressure, Pz:
Pz = 0.6 Vz^2 = 2023.97 N/m^2
Design wind pressure , Pd :
Pd = Kd * Ka * Kc * Pz
Pd = 2023.97 * 0.8 * 0.9 * 0.9 = 1311.53
Kd = wind directionality factor = 0.8 ...(clause 7.2.2)
Ka = area averaging factor = 0.9
Kc = combination factor = 0.9
Check for Pd:
It should not be less than 0.7 Pd = 0.7 * 2023.97
Final wind design pressure Pd = 1416.77 N/m^2

Wind force on building:

F= Cf * Ae * Pd
Cf = force coefficient
Ae = effective frontal area
Pd = Design wind pressure
a/b = 42/42 =1
h/b = 238/42 = 5.67
Cf = 1.458 ...by interpolation
Ae = Frontal Area
Ae = 42 * 238 = 9996 m^2
Pd = 1311.53
Wind forces (F) = Cf * Ae * Pd = 19114.45 KN

Dynamic wind load :

h/b ...X direction h = 238 m; b =42 m
Ta = 0.085*$h^{0.75}$ ...for steel frame building
X direction = 5.15 sec
Y direction
F_o = 1/T = 0.194 Hz

4.2 Seismic load calculations:

Steel structure with core shear wall.
Beam: - ISHB450
Column: - COL-800 dia – 800 mm t – 40mm
Floor Slab: - t-150 mm
Shear wall: - t-450 mm
Storey Height: - 3.3 m
Live load: - 2.5 kN/m^2
Type of soil: 2
Density of concrete: - 25kN/m^2

Load calculation:

Fundamental Natural Period (T)
T= 0.085* $h^{0.75}$ ...for steel frame building
= 0.085* $2.33^{0.75}$
= 5.069 sec

Modelling, analysis and design of diagrid structure are carried out using ETABS 2016 software. The end condition for diagrid is assumed as hinged. The support conditions are assumed as fixed.

5. ANALYSIS RESULT

Here, the dynamic analysis results for all models in terms of displacement, storey drift are represented separately in X and Y directions for wind and seismic loads.

5.1 Displacement Results

The displacement results for all model in X and Y directions by using Etabs 2016 software are as shown in Figure 4, Figure 5, Figure 6, Figure 7.

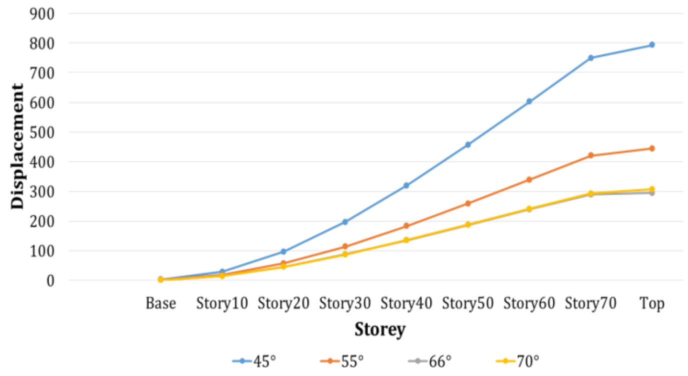

Fig. -4: Displacement results for all models in X-Direction (wind load)

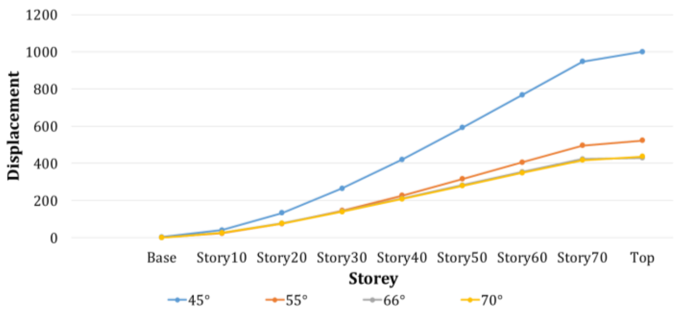

Fig. -5: Displacement results for all models in Y-Direction (wind load)

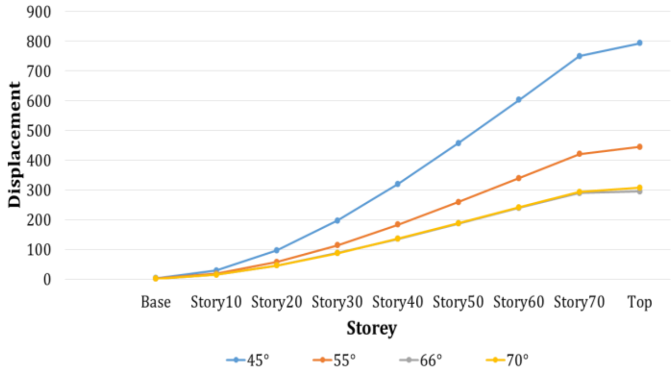

Fig. -6: Displacement results for all models in X-Direction (seismic load)

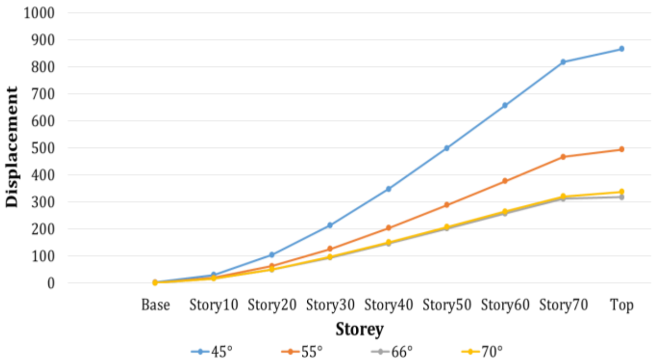

Fig. -7: Displacement results for all models in Y-Direction (seismic load)

5.2 Storey Drift Results

The storey drift results for all model in X and Y directions by using Etabs 2016 software are as shown in Figure 8, Figure 9, Figure 10 and Figure 11.

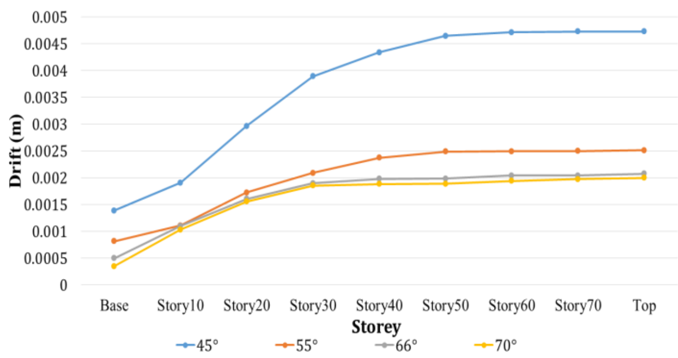

Fig. -8: Storey Drift results for all models in X-Direction (wind load)

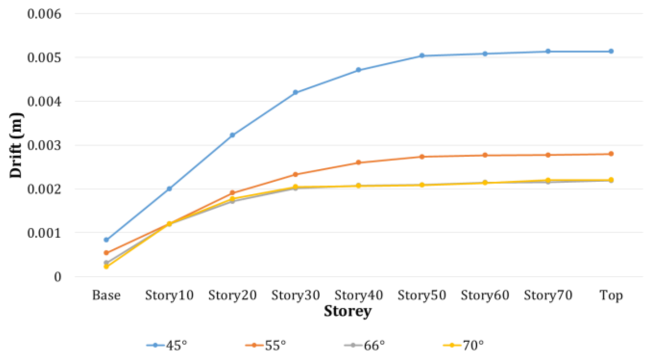

Fig. -9: Storey Drift results for all models in Y-Direction (wind load)

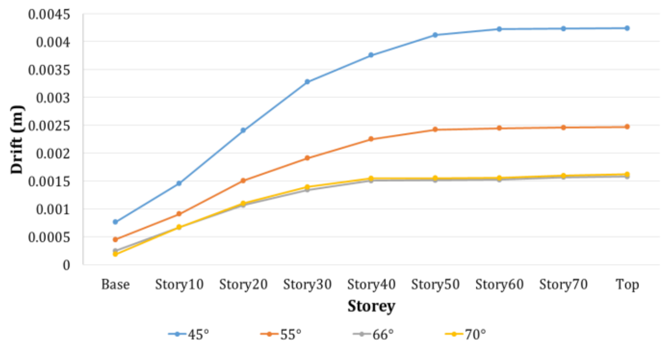

Fig. -10: Storey Drift results for all models in X-Direction (seismic load)

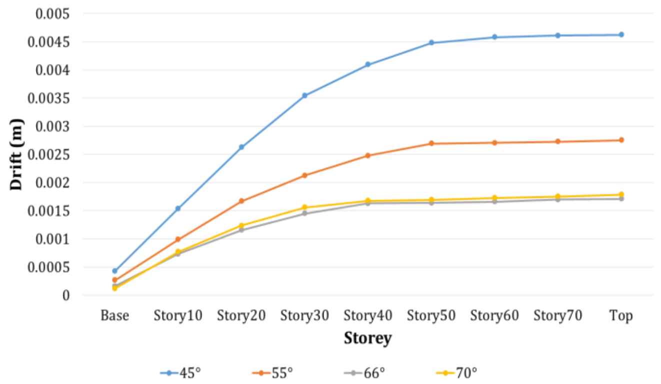

Fig. -11: Storey Drift results for all models in Y-Direction (seismic load)

6. CONCLUSION

In this paper, comparative study is carried out by considering different models having different angle of inclination i.e. 45°, 55°, 66°, 70°. Diagrid angle in the region of 66° to 70° provides more stiffness to the diagrid structural system which reflects the less top storey displacement. The storey drift results are very much lesser in the region of diagrid angle 66° to 70°. The optimal angle of diagrid is observed as 66°. Diagrid structural system provides more flexibility in planning interior space and facade of the building.

ACKNOWLEDGEMENT

This study is now on completion just because of the following people to whom which are really thanks from depth of my heart. I feel fortunate having Prof. Mohan Dusane, Prof. Kartik Prajapati as my guides.

REFERENCES

[1] Moon K.S., "Material-Saving Design Strategies for Tall Building Structures", CTBUH 8th World Congress, Dubai, March 2008.M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[2] Boake, T. Understanding Steel Design: An Architectural Design Manual (2011).

[3] IS: 1893(Part-I)-2002, Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standard, New Delhi.

[4] IS:875(Part-I, II, III)-1987, Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures, Bureau of Indian Standard, New Delhi.

[5] Nishith B. Panchal, Vinubhai R. Patel, "Diagrid Structural System: Strategies to Reduce Lateral Forces on High-Rise Buildings", International Journal of Research in Engineering and Technology, Volume: 03, Issue: 03, April-2014. pp. 374-378

[6] Khushbu Jani and Paresh V. Patel, "Design of Diagrid Structural System for High Rise Buildings as Per Indian Standards", Structures Congress 2013, ASCE 2013

[7] Harshita Tripathi, Dr. Sarita Singla, "Diagrid Structural System For R.C.Framed Multi storeyed Buildings", ISSN 2229-5518 Volume 7, Issue 6, June-2016