Seismic Analysis of Multistory Irregular RC Building with Hexagrid Structure on Sloping Ground

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Abstract— **High rise buildings are subjected to lateral loading such as earthquake or wind. Lateral load resisting system such as shear wall frame tube, diagrid, hexagrid, outrigger, etc., are being used according to load acting on it and type and height of the building. In this study, 26 story building with C and L type floor plan is considered for the analysis. Hexagrid system is provided around the periphery of the building. Earthquake parameters are considered as per IS 1893(Part I):2016. Modelling and analysis is done by using analysis and design software ETABS. For dynamic analysis response spectrum method is used. Analysis results are compared based on the story displacement, story drift base shear, overturning moment and time period.**

Index Terms— **Lateral load, hexagrid, sloping ground, story displacement, story drift, time period.**

I. INTRODUCTION

In modern world, high rise building is playing a crucial role in the development of any country. Lateral load resisting system is provided to resist seismic load and wind load. Lateral load resisting systems such as shear wall, Bundle tube, Frame tube, Diagrid, outrigger, etc., which are used according to the load acting on it and type and height of the building. These systems increase the stiffness of the structure and absorb lateral forces acting during earthquake and wind. [1]

The scarcity of plain ground in hilly areas compels construction activity on sloping ground. Since, the behavior of buildings during earthquake depends upon the distribution of mass and stiffness in both horizontal and vertical planes of the buildings, both of which vary in case of hilly buildings with irregularity and asymmetry due to step back frame and step back & set back frame configuration. [2]

Diagrids and hexagrids are special tubular structures that adopt inclined members instead of conventional vertical columns to carry both vertical and lateral loads. It is well-known that perimeter grids are an efficient solution to cope with horizontal forces in high-rise buildings. Diagrids employ diagonally intersecting members that give rise to triangular shapes. Hexagrids draw inspiration from honeycombs, in which hexagonal cells make the resisting structure. [3].

Diagrid structures generally do not require gravity core because lateral shear can be managed by the diagonals on the periphery of building. The Hexagrid system offers several advantages in addition to eliminating perimeter columns. It optimizes each structural element. [4]

II. BUILDING DETAILS

A 26 story hexagrid building on plain and sloping ground is considered for analysis. The story height is 3.5m and total height of building is 91m. The c/c distance between column is 4m in both X and Y direction. The slopes considered for hexagrid building is 20^0, 30^0 and 40^0. Irregular floor plan such as C and L shape are considered for this study. The analysis of all the models is done by using ETABS software. The plan and elevation are shown in Fig1. (a), (b) and (c). The live load and floor load are $3KN/m^2$ and $1.5KN/m^2$ respectively. The thickness of slab is 150mm. The beam sizes are 350X500, 230X500 mm and column sizes are 800X800, 750X750, 700X700, 650X650, 600X600, 550X550, and 500X500 mm. The seismic parameters are zone IV with zone factor 0.24, soil type medium, response reduction factor 5 (SMRF), importance factor 1 and damping 5%.

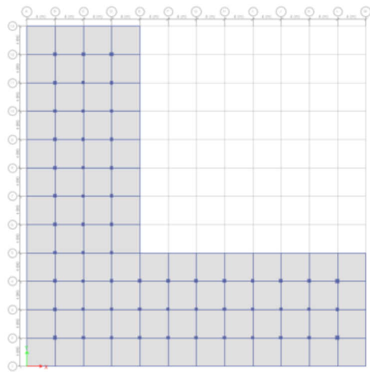

Fig.1 (a) Floor Plan of L-Type Hexagrid Structure

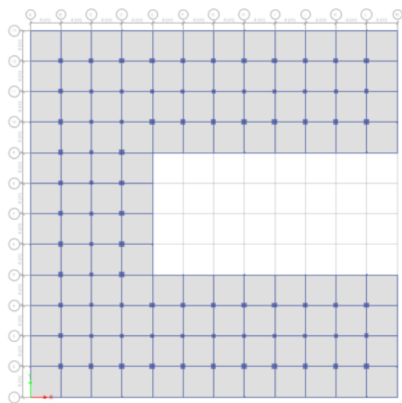

Fig.1 (b) Floor Plan of C-Type Hexagrid Structure

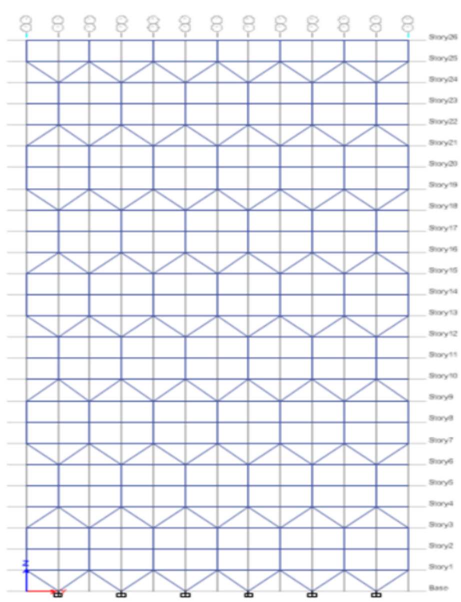

Fig.1 (c) Elevation of Hexagrid Structure

III. ANALYSIS, RESULT AND DISCUSSION

Linear static and dynamic analysis is performed. For dynamic analysis response spectrum method is used. Analysis results in terms of story displacement, story drift, base shear overturning moment and time period are represented below:

A. STORY DISPLACEMENT

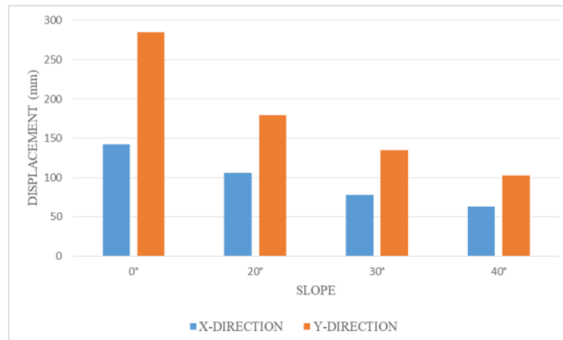

Fig.2 (a) Graph for Story Displacement for C-Type Hexagrid Structure

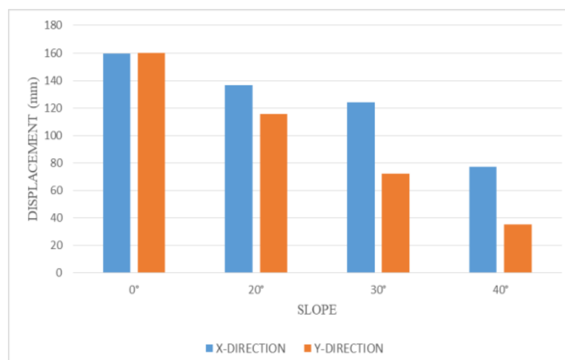

Fig.2 (b) Graph for Story Displacement for L-Type Hexagrid Structure

Permissible allowable displacement is H/250 = 91000/250 = 384mm where H is the total height of building. Fig.2 (a) and Fig.2 (b) represents story displacement for C and L-Type Hexagrid structure shows maximum displacement occur when building is on plain ground in both X and Y direction. When building is on plain ground, L-Type hexagrid structure shows same displacement in both X and Y direction. For C-Type hexagrid structure maximum displacement in Y direction and for L-Type hexagrid structure maximum displacement in X direction.

B. STORY DRIFT

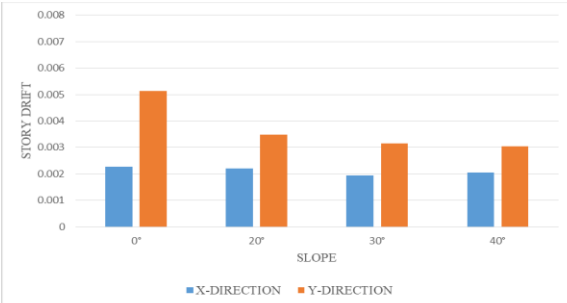

Fig.3 (a) Graph for Story Drift for C-Type Hexagrid Structure

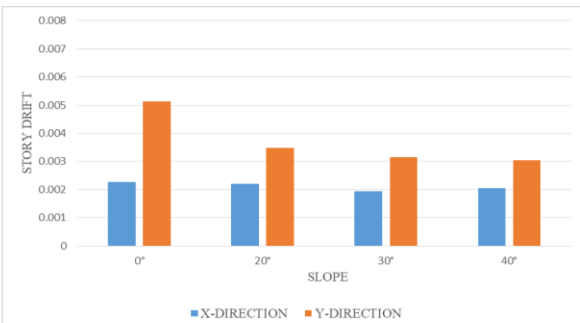

Fig.3 (b) Graph for Story Drift for L-Type Hexagrid Structure

As per IS 1893: 2016, story drift in any story shall not exceed 0.004 times story height. Maximum story drift is 0.004X3.5=0.014. Fig.3 (a) and Fig.3 (b) represents story displacement for C and L-Type Hexagrid structure shows maximum story drift occur when building is on plain ground in both X and Y direction.

C. BASE SHEAR

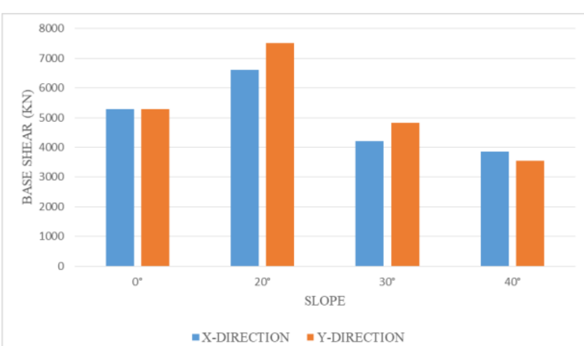

Fig.4 (a) Graph for Base Shear for C-Type Hexagrid Structure

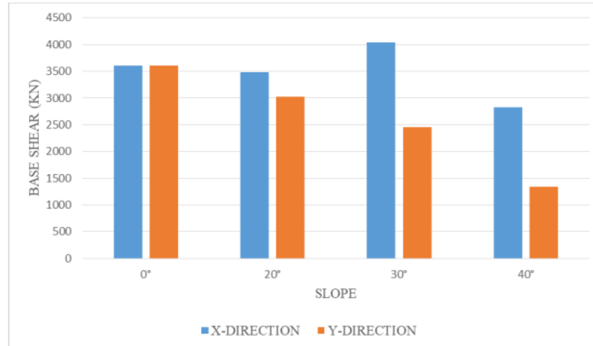

Fig.4 (b) Graph for Base Shear for L-Type Hexagrid Structure

Fig.4 (a) and Fig.4 (b) represents base shear for C and L-Type Hexagrid structure. For C-Type hexagrid structure maximum base shear is for building resting on 20^0 slope of ground and for L-Type hexagrid structure maximum base shear is for building resting on 30^0 slope of ground. When building is on plain ground, L-Type hexagrid structure shows same base shear in both X and Y direction.

D. OVERTURNING MOMENT

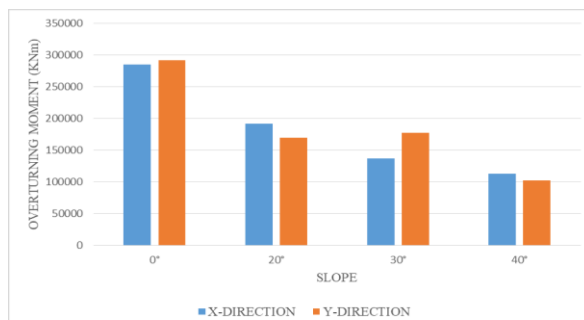

Fig.5 (a) Graph for Overturning Moment for C-Type Hexagrid Structure

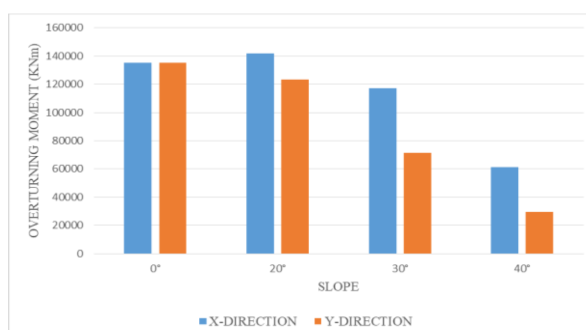

Fig.5 (b) Graph for Overturning Moment for L-Type Hexagrid Structure

Fig.5 (a) and Fig.5 (b) represents overturning moment for C and L-Type Hexagrid structure. When building is on plain ground, L-Type hexagrid structure shows same overturning moment in both X and Y direction. For C-Type structure maximum overturning moment occur when building is on plain ground and for L-Type structure building resting on ground slope 20^0.

E. TIME PERIOD

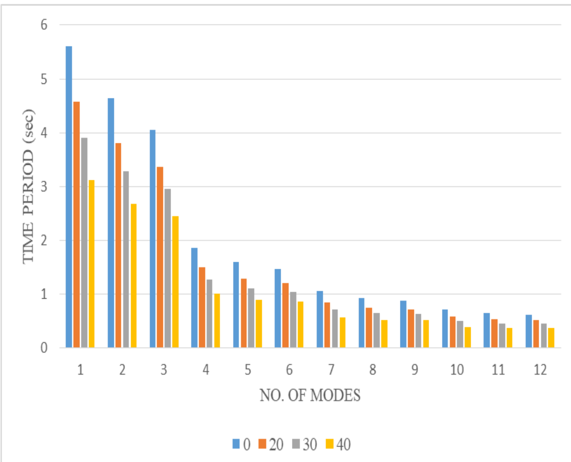

Fig.6 (a) Graph for Time Period for C-Type Hexagrid Structure

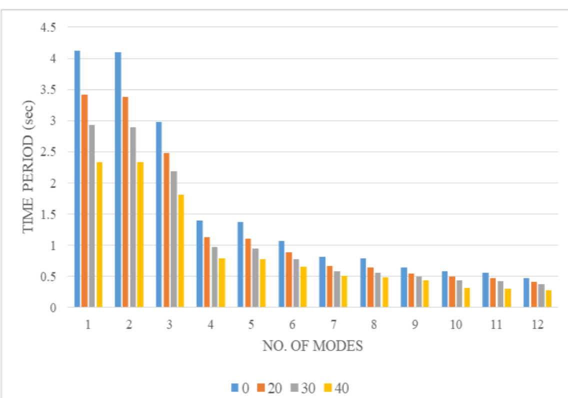

Fig.6 (b) Graph for Time Period for L-Type Hexagrid Structure

Fig.6 (a) and Fig.6 (b) represents time period for 12 different modes for C and L-Type Hexagrid structure. Time period is maximum for building resting on plain ground for both C and L-Type hexagrid Structure. As the slope of ground increases time period decreases.

IV. CONCLUSION

From the above study following conclusions were drawn.

1. Story displacement, Story drift is more for plain ground than the sloping ground in both C and L-Type hexagrid structure and overturning moment is more for plain ground than the sloping ground for C-type hexagrid structure.

2. Maximum base shear of C and L-Type hexagrid structure is for 20^0 and 30^0 respectively. Maximum base shear for both structure occur at different slope of ground due to plan irregularity.

3. As the slope of ground increases the height of building decreases. For sloping ground time period is less than the building resting on plain ground.

REFERENCES

[1] Jayant Shaligram, Dr. K.B Parikh, "Comparative Analysis of Different Lateral Load Resisting Systems in High Rise Building for Seismic Load & Wind load: A Review", International Journal for Research in Applied Science & Engineering Technology (IJRASET). 6(2), (2018), 459-461.

[2] Dr. S. A. Halkude, Mr. M. G. Kalyanshetti, Mr. V. D. Ingle, "Seismic Analysis of Buildings Resting on Sloping Ground with Varying Number of Bays and Hill Slopes", International Journal of Engineering Research & Technology (IJERT). 2(12), (2013), 30632-3640.

[3] Matteo Bruggi, "Conceptual Design of Diagrids and Hexagrids by Distribution of Lattice Structure", Frontiers in Built Environment. 6, (2020), 1-13.

[4] Rahul Birla, Sourabh Dashore, "Structural Behaviour of Hexagrid and Diagrid Comparison System in Staad pro", International Journal of Scientific Research & Engineering Trends. 6 (5), (2020), 3206-3211.

[5] Safiya Daliya Ahammed, Shahla C. P, "Seismic Behavior of Hexagrid Type Stuctural System", International Journal of Engineering Research and Technology (IJERT). 8 (2), (2019), 169-173.

[6] Sindhu Nachiar S, Anandh S, Mohamed Anas A, "A Comparative Study on Seismic Analysis of Diagrid and Hexagrid Structural System", IOP Conference Series: Materials Science And Engineering. (2021), 1-14.

[7] Manisha S. Kumbhar, H.S.Jadhav, “Seismic Behaviour of Multistorey RC Frame with Shear wall and Octagrid Sructure”, International Research Journal of Engineering and Technology (IRJET). 9 (6), (2022), 991-996.
[8] Anjeet Singh Chauhan, Rajiv Banerjee, “Seismic Response Of Irregular Building On Sloping Ground”, International Journal Of Advanced Research In Engineering And Technology (IJARET). 12 (5), (2021), 181-202.