iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** VI **Month of publication:** June 2020

DOI: http://doi.org/10.22214/ijraset.2020.6263

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VI June 2020- Available at www.ijraset.com

Comparative Study of Diagrid and Hexagrid Exterior Structural Systems

Deepika R[1], Prabina Sharma[2], Amit Prasad Sah[3], Anfaz Ali M A[4], Kumaraswamy N M[5]
[1]*Department of Civil Engineering, R R Institute of Technology, Bengaluru*

Abstract: An increased growth of population and modern life style has increased the need of the tall structures. Tall building is very much affected due to action of wind and earthquake forces. To produce Resistive action towards lateral load, lateral load resistive systems are used; it can be divided into two types' interior structures and exterior structures. In current project work an attempt has been made to study the exterior lateral load resisting systems i.e. diagrid and hexagrid systems. The analysis and comparative work is carried through software "Extended Three-Dimensional Analyses of Building Systems" (ETABS V16). A regular floor plan of square shape is considered, all structural members are designed as per IS 456-2000. Wind and earthquake parameters are considered from IS875- 1987 (part III) and IS1893-2002 respectively. Analysis results are compared in terms of storey drift, storey displacement and time period.
Keywords: diagrid, hexagrid, tall structures, storey displacement and storey drift.

I. INTRODUCTION

The tall buildings are products of advanced structural and construction methods, economic prosperity and the scarcity of lands has increased need of tall building or high-rise structures. The main parameter we need to be taken care is height of the buildings is height. Due to vast advantages; demand for tall structures is also very high now a days, it can be used for business and residential spaces. But analysis and behavioural study of tall structures is quite complicated so analysis and design is carried by using various commercial software like Etabs, Staadpro, Sap etc. Tall buildings are constructed and mainly used for commercial office buildings, apartments etc. As compared to normal conventional buildings, construction of tall buildings is not easy. This is due to the action of lateral loads; lateral displacement induces bending and shear lag effects will be more. Therefore, in order to resist wind and earthquake loads lateral load resisting systems are used.
Lateral load resisting systems are classified into two types, namely:

A. Exterior Structures

1) Tube system
2) Diagrid system
3) Space truss
4) Exoskeleton structure
5) Super frame structure

B. Interior Structures

1) Rigid frame
2) Shear wall structure
3) Outrigger structure

Lateral loads or horizontal loads are main criteria in case of tall buildings and these loads depend upon zone type. In order to minimize the effect of these horizontal loads many lateral load resisting systems were introduced like core wall system, tube system, outrigger system, bracings etc. Diagrid system was an evolutionary step that has been taken in construction of high rise structures. Diagrid and hexagrid exterior structural systems have many advantages over conventional constructions and also over interior structural systems, because it is possible to eliminate all vertical compression members from tall structures, it offers more space and aesthetical appearance can also be increased. Diagrid and hexagrid structural systems are used in case of skyscrapers (above 150m or 40 stories) and it is more economical. Diagrid buildings are made up of diagonal elements; all diagonal members are connected to node along with supporting beams. This system provides more flexibility to designer for interior planning and façade appearance is also improved because requirement of number of structural elements are reduced. The diagrid structures are more efficient than conventional exterior braced systems. This is only because almost all the vertical columns are eliminated; diagonal grid element alone can carry all lateral and vertical loads whereas conventional exterior braces carry only vertical loads.

One of main advantage of this system is that up to 20% to 30% of steel can be saved at outer periphery as compared to normal conventional building. The high-rise structures can be built to any shape like square, rectangle and curved structures by using this system.

Figure 1: Examples of diagrid structures The bow string tower, West Bay Office Tower and Tornado Tower

II. OBJECTIVES

Following are the objectives of current project work

A. Detailed study of structural behaviour of diagrid and hexagrid systems and comparison of results with convention building
B. Structural responses of structures under dynamic loading (i.e. wind load and earthquake load)

III.METHODOLOGY

In this project work comparison between conventional structure, hexagrid and diagrid with varied diagonal angles under dynamic loading are carried out. For the analysis a suitable plan of square shape and total height 90m (30 stories) along with dead loads and live loads are considered as per Indian standard code provisions.

Response spectrum method is adopted for the evaluation of structural responses, columns are not provided at outer periphery for both diagrid and hexagrid and same dimensions are maintained.

A. Important building parameters

TABLE 1: Building Parameters

Sl No	Description	Value
1	Plan dimension	30mx30m
2	Height of building	90m
3	Number of stories	30
4	Depth of slab	150mm
5	Floor to floor height	3m
6	Characteristic strength of concrete	25N/mm2
7	Characteristic strength of steel	415N/mm2
8	Zone	IV

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VI June 2020- Available at www.ijraset.com

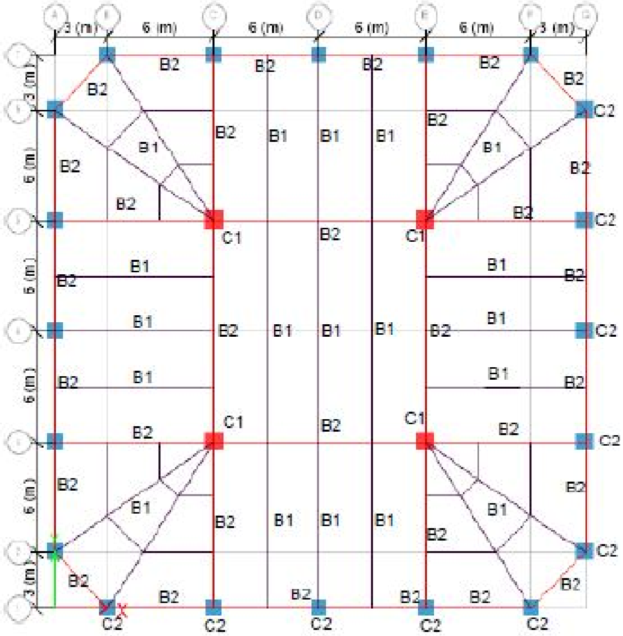


Fig 2: Plan view for convention building

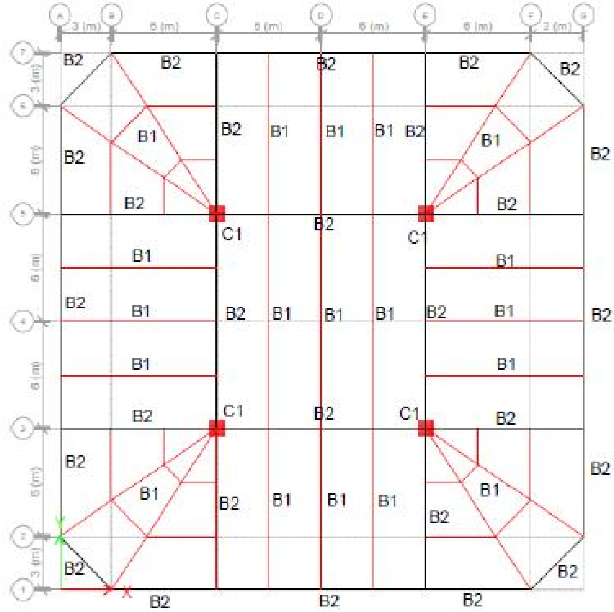


Fig 3: Plan view of diagrid and hexagrid building

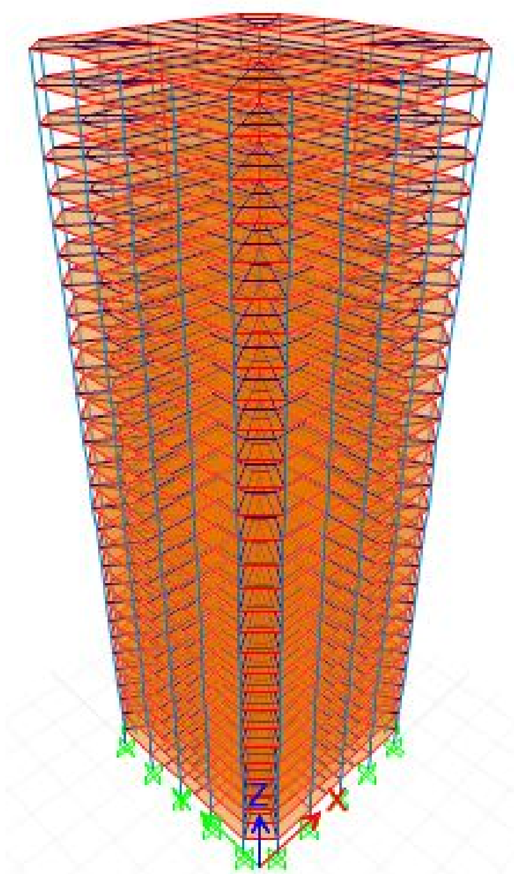


Fig 4: 3D view of conventional building

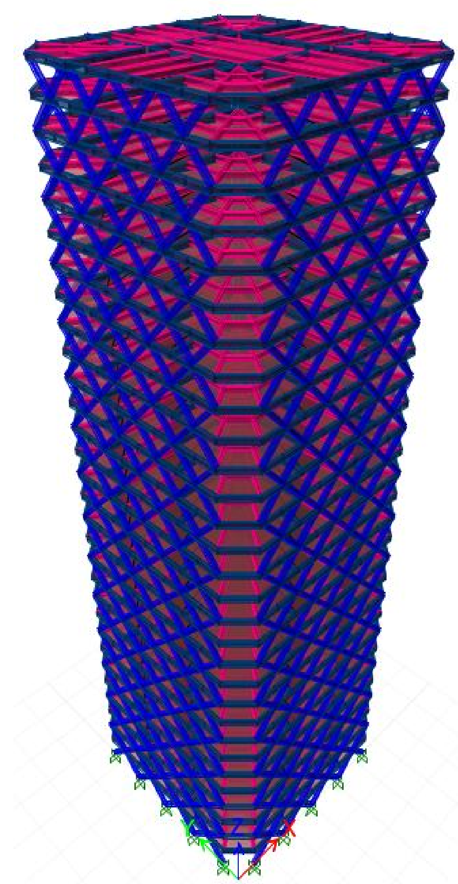


Fig 5: 3D view of diagrid building

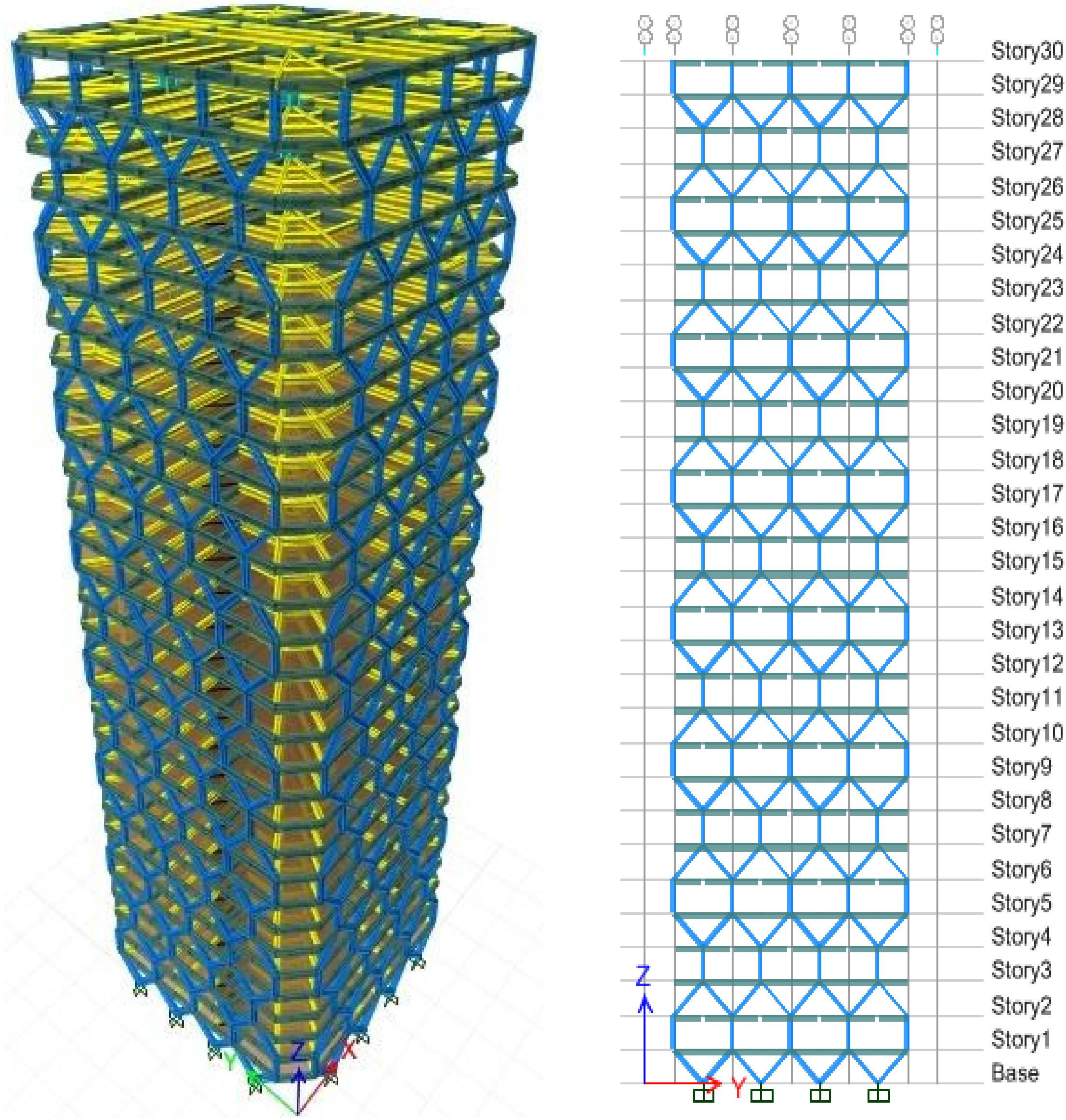


Fig 6: 3D view and elevation view of hexagrid structure

IV. RESULTS AND DISCUSSION

The analysis of conventional structure, diagrid and hexagrid structures are carried out by using one of sophisticated commercially software ETABS V15.2. The analysis results are expressed in terms of storey drift, storey displacement and time period. The plan and dimensions are maintained same for all models, in diagrid system angles are varied, following are list of models analysed in ETABS V15.2

1) Normal conventional building without any load resisting system [R1]
2) Diagrid building with diagonal angle of 45° [M1]
3) Diagrid building with diagonal angle of 63 °[M2]
4) Diagrid building with diagonal angle of 73 °[M3]
5) Diagrid building with diagonal angle of 75 °[M4]
6) Diagrid building with diagonal angle of 78 °[M5]
7) Diagrid building with diagonal angle of 81 °[M6]
8) Hexagrid building [M7]

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VI June 2020- Available at www.ijraset.com

A. Storey Drift

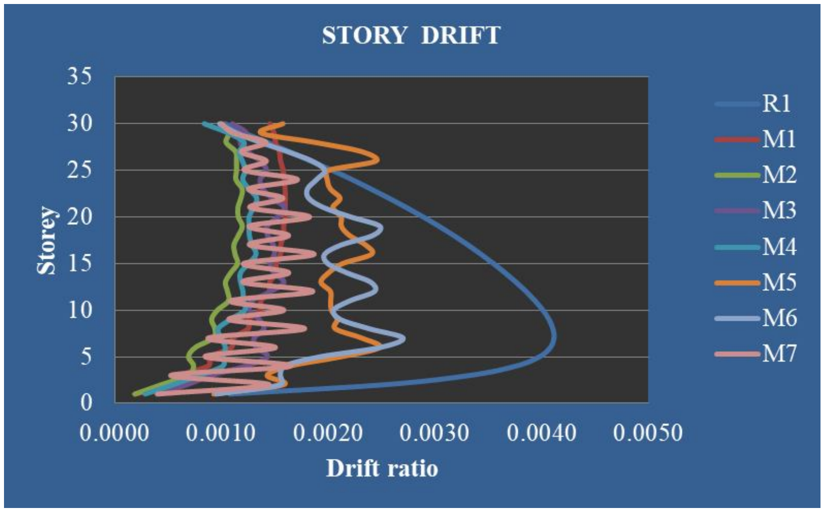


Fig 7: Inter-storey drifts ratio for different grid systems under response spectrum case

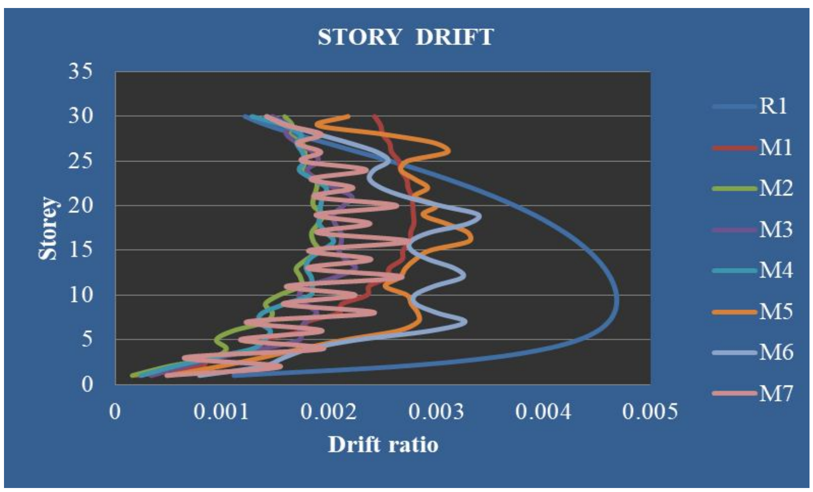


Fig 8: Inter-storey drifts ratio for different grid systems under earthquake load case.

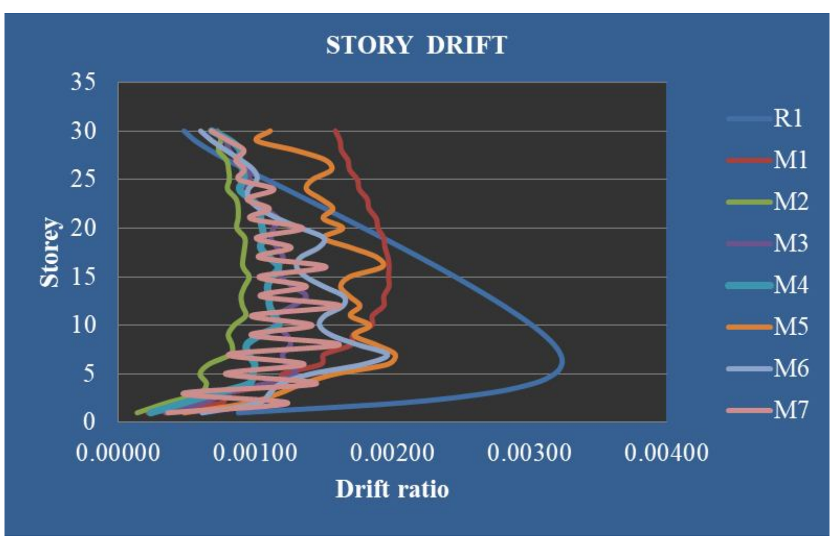


Fig 9: Inter-storey drifts ratio for different grid systems under wind load case.

B. Storey Displacement

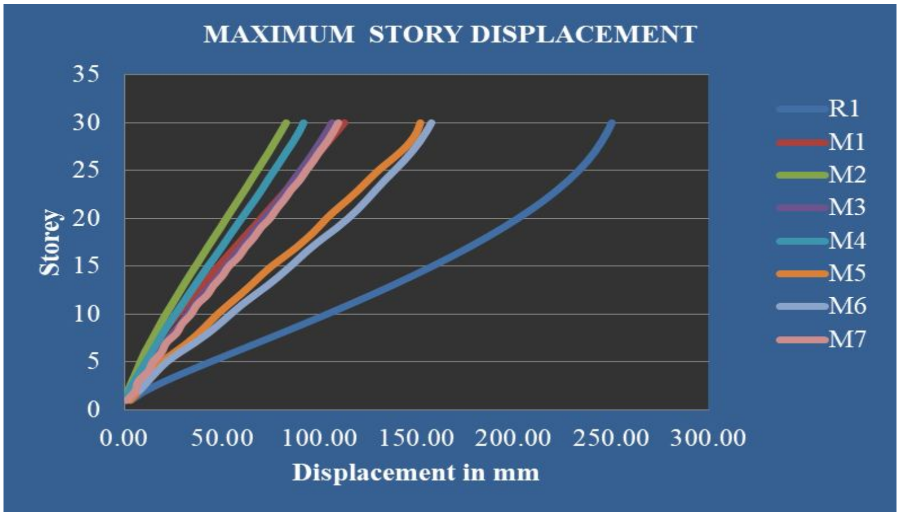


Fig 10: Storey displacement for different grid systems under response spectrum load case

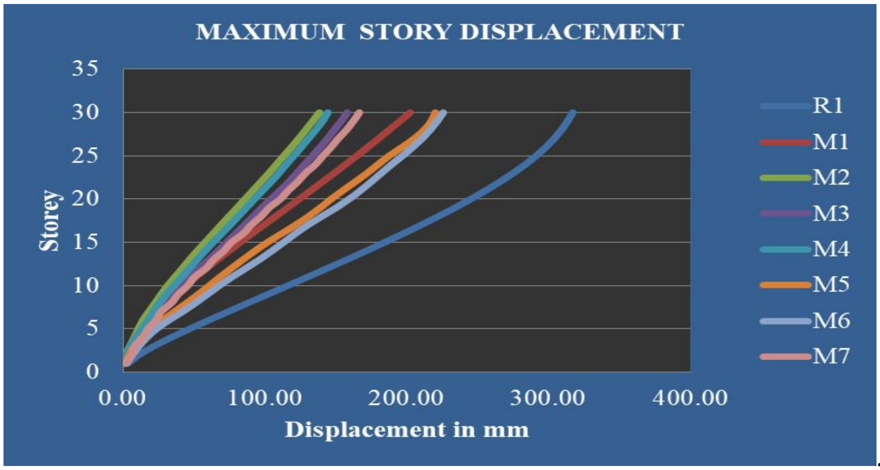


Fig 11: Storey displacement for different grid systems under earthquake load case.

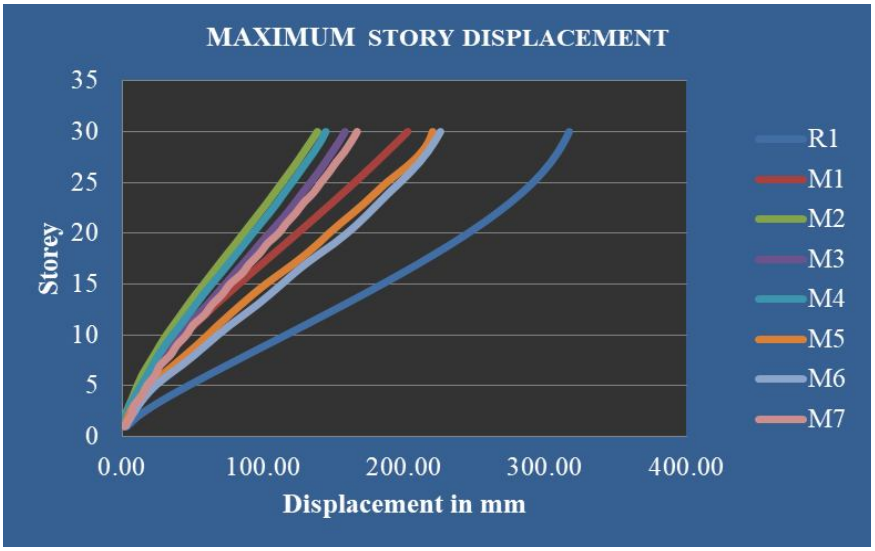


Fig 12: Storey displacement for different grid systems and framing building under wind load case.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
Volume 8 Issue VI June 2020- Available at www.ijraset.com

C. Time Period

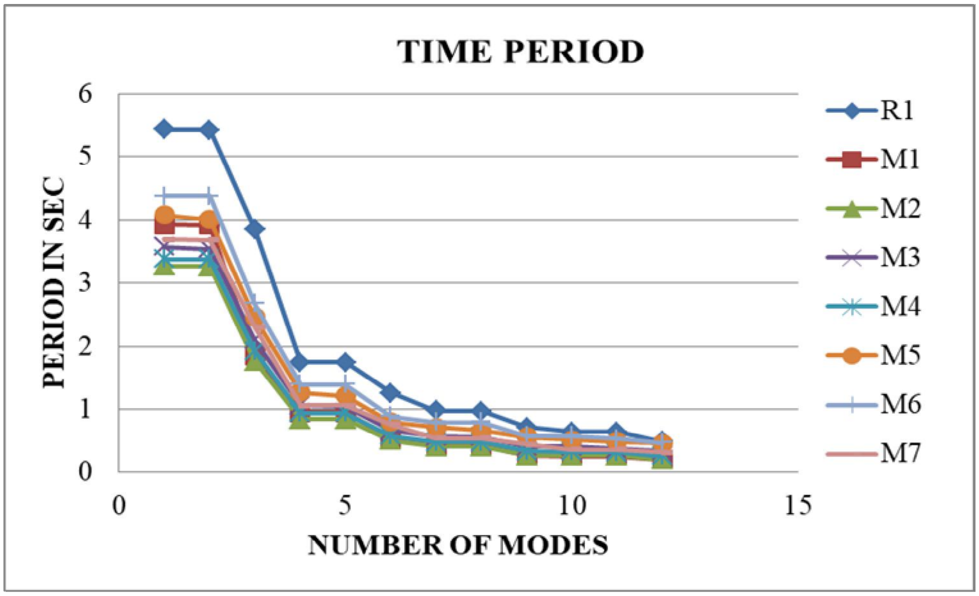


Fig 13: Time period

Table 2: Comparison of results

Modals	Drift ratio	Displacement in mm	Difference in percentage
R1	0.0010	250.22	-
M1	0.001451	112.83	55%
M2	0.001	82.98	67%
M3	0.0011	106.62	57%
M4	0.00084	91.92	63%
M5	0.00158	151.89	39%
M6	0.0009	157.6	37%
M7	0.001	109.80	56%

V. CONCLUSION

The present work is consists of analysis of diagrid systems with different diagonal angles i.e. 45°, 63°, 73°, 75°, 78°, 81° and analysis of hexagrid system. As we can see the results from above plots and we may conclude that

A. Top storey displacement is less for diagrid system with diagonal angle of 63°

B. Between the region 63° to 75° (diagonal angle) diagrid systems possess better stiffness, storey drift and storey displacement are less in this regions

C. For hexagrid system also same section properties are maintained in order to study the performances but this system shows slightly higher storey displacement and drift compared to diagrid system (63° to 75°)

D. We know that as time period increases stiffness of member decreases, 63° diagrid system has less time period compared to other systems.

REFERENCES

[1] Khan, F.R., & Sbarounis, J. (1964). Interaction of shear walls and frames in concrete structures under lateral loads. *Structural Journal of the American Society of Civil Engineers*, 90(ST3), 285-335.

[2] Khan, F.R. (1969). Recent structural systems in steel for high-rise buildings. *In Proceedings of the British Constructional Steelwork Association Conference on Steel in Architecture*. London: British Constructional Steelwork Association.

[3] A. G. Davenport, "The Response of Six Building Shapes to Turbulent Wind", *Seria A, Mathematical and Physical Sciences.* Vol. 269, No. 1199, A Discussion on Architectural Aerodynamics, 1971, pp. 385-394.

[4] Popov, E.P. (1982). Seismic framing systems for tall buildings. *Engineering Journal/American Institute of Steel Construction*, 19(Third Quarter), 141-149.

[5] H. U. Lee, Y. C. Kim, "Preliminary design of tall building structures with a hexagrid system", Procedia Engineering, 171 (2017) 1085– 1091.

[6] K. Jani, P. V. Patel, "Analysis and Design of Diagrid Structural System for High Rise Steel Buildings", Procedia Engineering, 51 (2013) 92–100.

[7] K. Kamath, S. Hirannaiah, J. C. K. B. Noronha, "An analytical study on performance of a diagrid structure using non-linear static pushover analysis", Perspectives in Science, (2016) 8, 90–92.

[8] K. S. Moon, "Diagrid Structures for Complex-Shaped Tall Buildings", Procedia Engineering, 14 (2011) 1343–1350.

[9] R. D. Deshpande, S. M. Patil, S. Ratan, "Analysis and comparison of diagrid and conventional structural system", International Research Journal of Engineering and Technology (IRJET), June 2015, Vol. 2, Issue 3, PP 2295–2300.

[10] T. H. Kim, H. U. Lee, Y. C. Kim, "Development of a building structural system using an IsoTruss® grid", Procedia Engineering, 171 (2017) 1077–1084.

[11] IS 1893 (Part 1):2002, "Criteria for Earthquake Resistant Design of Structures Part 1 General Provisions and Buildings (Fifth Revision)", Bureau of Indian Standard, New Delhi.

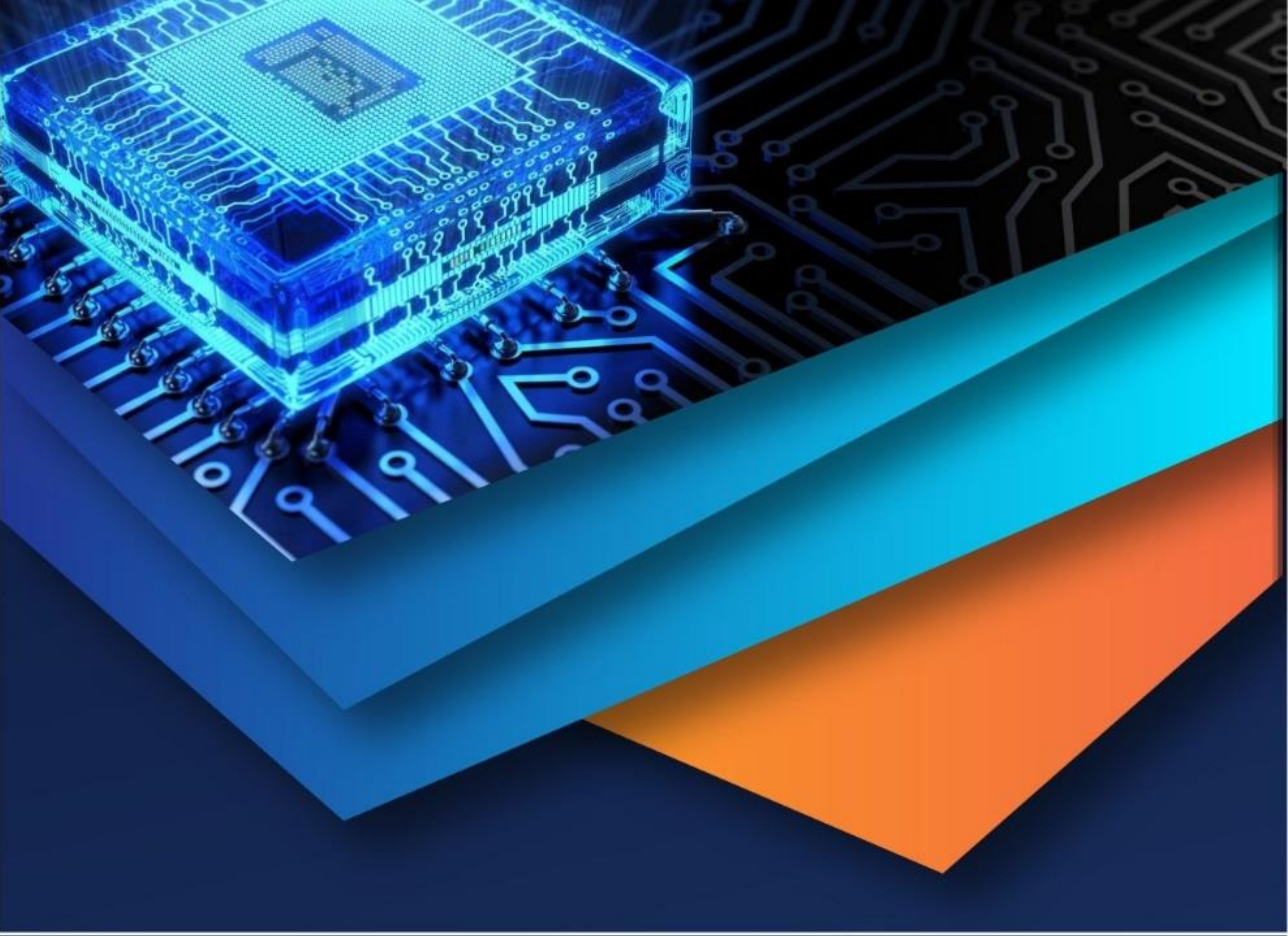
[12] IS 456:2000, "Plain and Reinforced Concrete – Code of practice (Fourth Revision)", Bureau of Indian Standard, New Delhi.

[13] IS 800:2007, "General Construction in Steel – Code of Practice (Third Revision)", Bureau of Indian Standard, New Delhi.

[14] IS 875(Part 1):1987, "Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures Part 1 Dead Loads – Unit weights of building materials and stored materials (Second Revision)", Bureau of Indian Standard, New Delhi.

[15] IS 875(Part 2):1987, "Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures Part 2 Imposed Loads (Second Revision)", Bureau of Indian Standard, New Delhi.

[16] IS 875(Part 3):1987, "Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures Part 3 Wind Loads (Second Revision)", Bureau of Indian Standard, New Delhi.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY