ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 2, February 2018

# Seismic Performance of RC DIAGRID Frame Structures

[1] Pradip S. Mali, [2] D. S. Wadje, [3] G. R. Gandhe
[1] Student, M.E. Structural Engineering, [2] Asst.Professor, Civil Engineering [3] Professor& HOD Civil Engineering
[1][2][3] DIEMS Aurangabad, 431001, Dist. Aurangabad (M.S), India

***Abstract:* -- Development in construction technology, structural systems, material, and analysis and design software facilitated the growth of the tall structures. Now, the diagrid structures are widely used due to the structural efficiency and aesthetic view. The diagrid is a framework of diagonally intersecting steel, concrete or timber members that is used in the construction of buildings. A triangular shape is formed in the diagrid structural systems because of the modules. These modules are effective in the carry of all the loads i.e. lateral as well as gravity and distribute all these loads in a very uniform and regular pattern by an axial action of the diagrid. In this paper, analytical study of 24 storey building with a square floor plan of 18 m × 18 m size with conventional frame system and diagrid frame system is carried out. There are four models are chosen for the study. For modeling and analysis of both structure i.e. conventional and diagrid frame structure ETABS software is used. For seismic analysis structure, the linear dynamic approach i.e. response spectrum method is used as per IS 1893 (Part I): 2002. The comparison of analysis of results in terms parameters such as top story displacement, story drift, story shear and the time period is presented here.**

***Key words*: Building Configuration, ETABS-2015, Linear Static Analysis, Pushover Analysis, Response Spectrum.**

## I. INTRODUCTION

Increasing growth of population continuously and consequent pressure of limited space has been affected on the residential development of city. The high cost of land and the need to preserve important agricultural production are contributed to drive residential buildings upward. As the height of building increases, the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. The lateral load resisting systems are rigid frame, shear wall structure, outrigger structure these are interior structures and exterior structures such as tube system, bracings, diagrid system, space truss, exoskeleton structure, and super frame. The diagrid structural system is widely used for tall buildings because of its structural flexibility and aesthetic view. Due to the configuration and efficiency of a diagrid system reduces the number of structural element required on the façade of the buildings, results less obstruction to the outside view. A diagrid's module contains a number of stories which have a diamond shape. Modules are divided into 4 different groups' i.e. small modules (2-4 stories), mid-size modules (6-8 stories), large modules (more than 10 stories) and irregular modules. Diagrid structures carry lateral shear by axial action of diagonal members so more effective in minimizing shear deformation. As in diagrid structures lateral shear can be carried by the diagonal members located on the periphery, they do not need high shear rigidity cores [3]. The distribution of load in diagrid structure is as shown in fig.1.

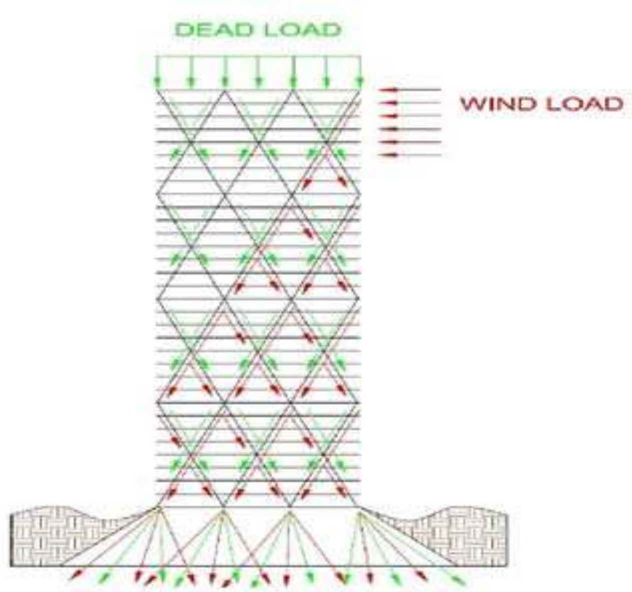


***Fig.1: Distribution of load in diagrid structure***

 

IFERP

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 2, February 2018

In this paper, comparative analysis of 24-storey conventional frame building model and 3 models of diagrid frame building total 4 models are analyzed by response spectrum method. A regular floor plan of 18m x 18m size is considered. Modeling and analysis of structure is done using ETABS software. Results obtained from analysis like displacement, storey drift, storey shear and time period are presented here.

## II. BUILDING CONFIGURATION

The 24-storey building is having 18m x 18m plan dimension and 86.4m total height of building. The storey height is 3.6m. The typical plan and elevation for different models are shown in fig.2 to fig.7. There are four models for comparative study. First model is for simple frame building and second, third and fourth models are for diagrid frame structure of one storey, two storey and four storey module respectively. The building data is kept same for all models. The beam sizes and column sizes for both models are 300mm x 450mm and 500mm x 500mm respectively. The slab thickness is 120mm. The diagonal members (Diagrid) size is 300mm x 300mm. The angles of one storey, two storey and four storey diagrid frame buildings are 50.19°, 67.38° and 78.23° respectively. The characteristic strength of concrete is 35 N/mm$^2$ and is steel is 415 N/mm2. The live load on terrace level is 1.5kN/m2 and for typical floor slab 4kN/m2. The end condition for diagrid is assumed as hinged. The support conditions are assumed as fixed. The design of member is carried out on the basis of IS 456-2000. For seismic analysis following parameters are considered. Seismic zone -V, soil type - medium, Importance factor 1, Response Reduction 5 as per IS-1893-2002. Modeling and analysis of above structures are carried out using ETABS software. For analysis, linear dynamic approach i.e. response spectrum method is performed as per IS 1893 (Part I): 2002.

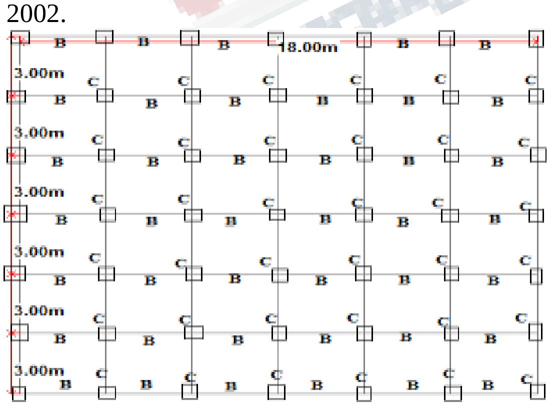


*Fig.2: Plan for conventional building*

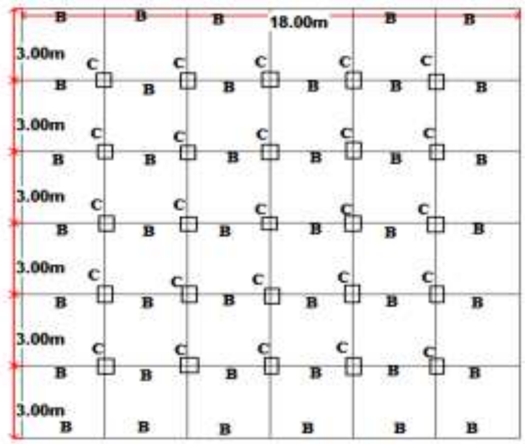


*Fig.3: Plan for diagrid frame building*

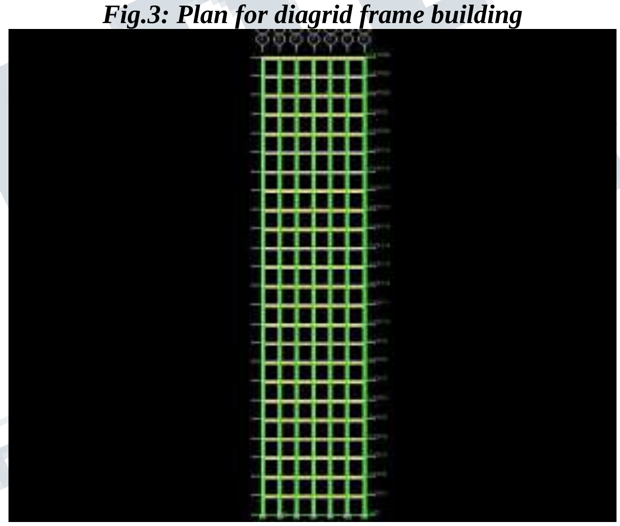

*Fig.4: Elevation of conventional frame building (CF)*

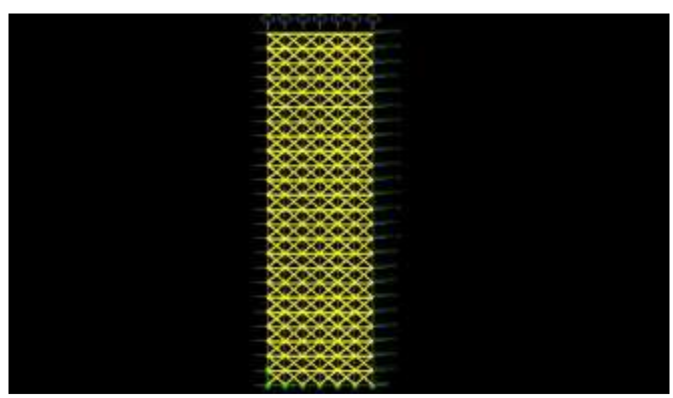

*Fig.5: Elevation of 1 storey diagrid frame building (1 SDF)*

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 2, February 2018

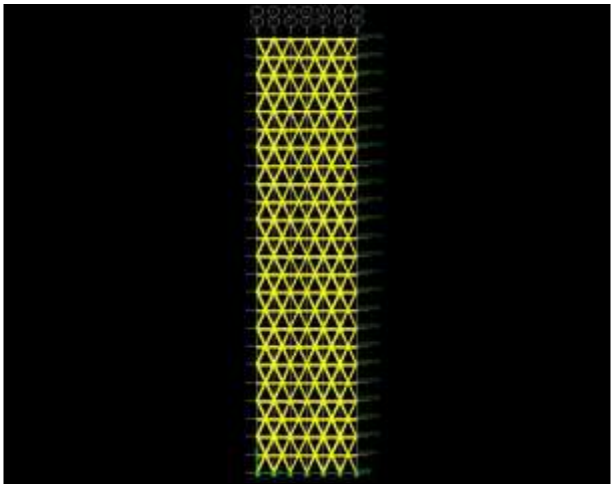

*Fig. 6: Elevation of 2 storey diagrid frame building (2 SDF)*

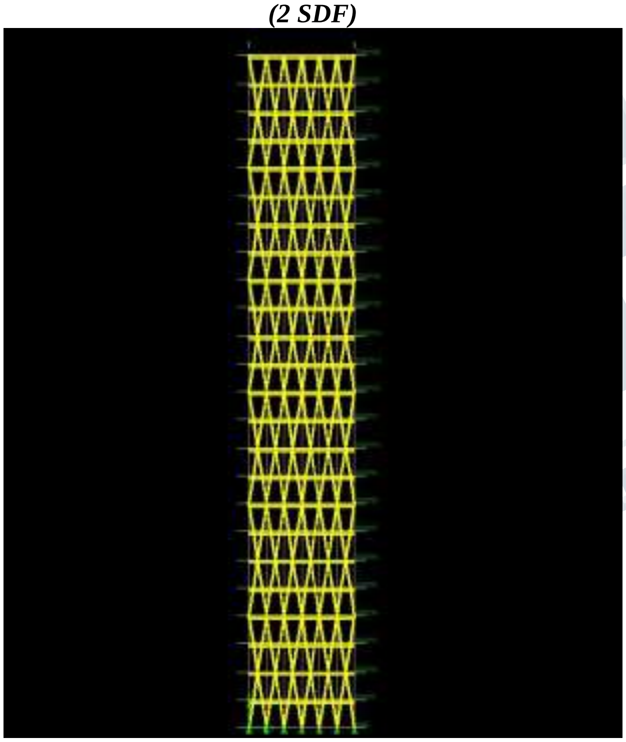

*Fig.7: Elevation of 4 storey diagrid frame building (4 SDF)*

### III. ANALYSIS AND RESULTS

The response spectrum analysis results for all the models are presented here in terms of storey displacement, inter storey drift, storey shear and time period.

**3.1 Lateral Displacement**

The displacement of all four models is as shown in fig.8. It is observed that displacement in conventional frame building is higher as compared to the other models. 1 storey diagrid frame building gives less displacement by 17.41%. 2 storey diagrid frame building gives minimum displacement by 24.21%. 4 storey diagrid frame building gives less displacement by 14.67%.

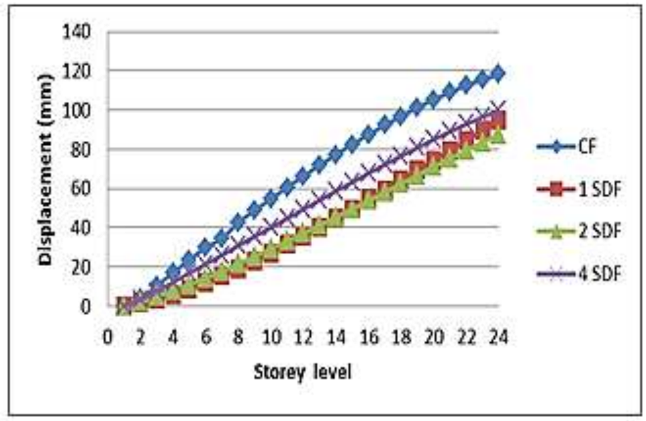


*Fig.8: Displacement results*

**3.2 Storey drift**

The inter storey drift of all four models is as shown in fig.9. For earthquake load, as per IS: 1893-2002, clause: 7.11.1, the storey drift in any storey due to minimum specified lateral force with partial load factor of 1.0 should not exceed 0.004 times storey height that is h/250, where h = storey height in meter. The storey drift values of all models are within the permissible limit. It is observed that inter storey drift in conventional frame building is higher compared to the other models. 1 storey diagrid frame building gives minimum storey drift by 17.23%. 2 storey diagrid frame building gives minimum storey drift by 27.01%. 4 storey diagrid frame building gives minimum storey drift by 21.63%.

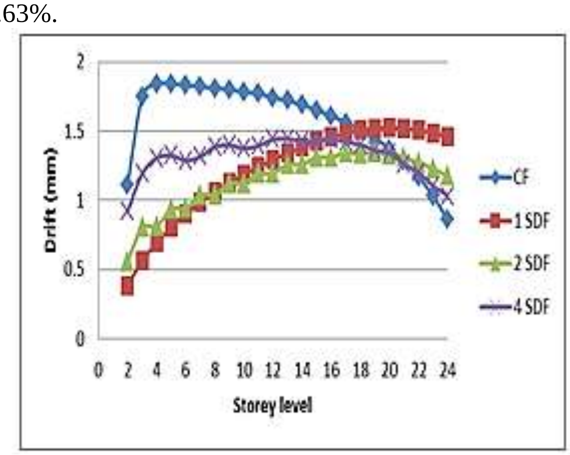


*Fig.9: Storey drift results*

 

### 3.3 Storey shear

The distribution of storey shear along the height of 24-storey of all four models is as shown in fig.10. The storey shear is more for diagrid structural system as compared to the conventional frame building by 42.45%.

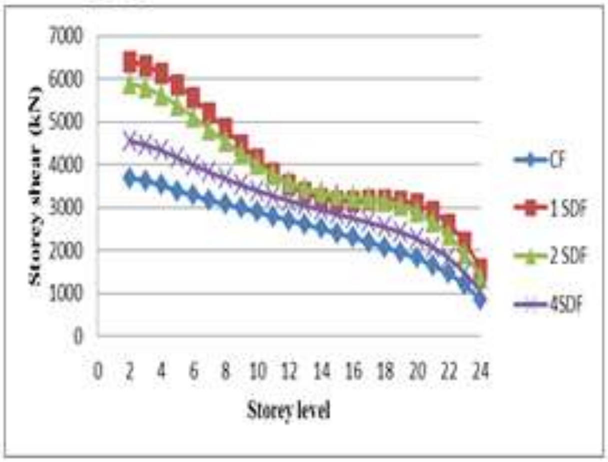


*Fig.10: Storey shear results*

### 3.4 Time Period

By performing the Response spectrum analysis, time period is found out by considering 12 mode shapes for all models, is presented here as shown in fig.11. The building's natural time period is obtained as follow,

$$T = 2\pi\sqrt{\frac{m}{k}}$$

Where, m = mass of the structure and k = stiffness of the building, from the above equation, it can be period depends upon the mass and stiffness of the structure. If the time period is more, the modal mass is more but the stiffness of the building is less vice-versa. It can be observed that the time period is minimized for the 2 storey diagrid frame building. It means that 2 storey diagrid frame structure is stiffer than conventional frame structures by 30.3%.

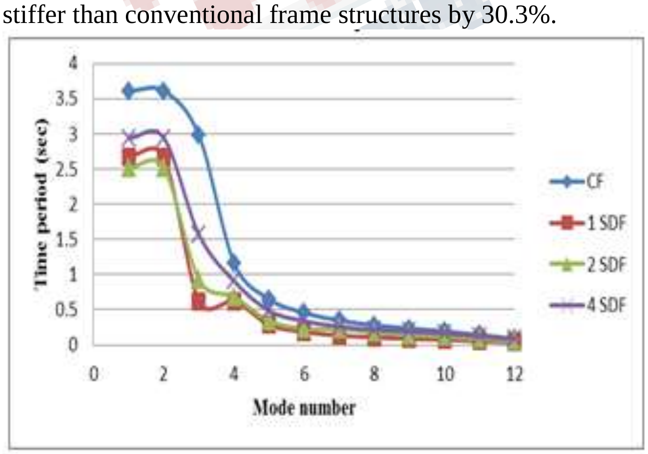


*Fig.11: Time period results*

## IV. CONCLUSIONS

- In this paper, comparative analysis of 24-storey conventional frame building and diagrid frame building with different storey module, total 4 models are analyzed by response spectrum method. A regular floor plan of 18 m x 18 m size is considered. Analysis results like displacement, storey drift, storey shear and time period are presented.
- As the lateral loads are resisted by diagonal columns, the top storey displacement is less in diagrid structure as compared to the conventional frame building by 24.21%. In diagrid structure, 2 storey diagrid frame model with an angle of 67.38° gives minimum displacement.
- The storey drift is 27.95% less for 2 storey diagrid frame with an angle of 67.38° compared to conventional frame building.
- As compare to diagrid frame models time period is maximum for conventional frame building. It can be observed that the time period is minimized for the 2 storey diagrid frame building. This diagrid frame structure is stiffer than conventional frame structures by 30.3%.
- Diagrid provide more resistance in the building which makes system more effective.
- Also, diagrid structures gives more aesthetic look and gives more of interior space due to less columns and façade of the building can also be planned more efficiently.

## REFERENCES

1. Mir M. Ali and Kyoung S. Moon, "Structural Developments in Tall Buildings: Current Trends and Future Prospects", Architectural Science Review, vol. 50.3, pp 205-223, 2007.

2. Kyoung S. Moon, "Design and Construction of Steel Diagrid Structures", School of Architecture, Yale University, New Haven, USA, pp- 398-405, NSCC2009.

3. J. Kim, Y. Jun and Y.-Ho Lee, "Seismic Performance Evaluation of Diagrid System Buildings", 2nd Specially Conference on Disaster Mitigation, Manitoba, 2010.

4. Rohit kumar Singh, Vivek Garg, Abhay Sharma, "Analysis and Design of Concrete Diagrid Building and its comparison with Conventional Frame Building", International Journal of Science,

 

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 2, February 2018

Engineering and Technology, vol. 02, pp 1330-1337, 2014.

5. Khushbu Jani and Paresh V. Patel, "Analysis and Design of Diagrid Structural System for High Rise Steel Buildings", Published by Elesevier Ltd, Procedia Engineering 51, pp 92-100,2013.
6. Nishith B. Panchal, Vinubhai R. Patel, I.I. Pandya, "Optimum Angle of Diagrid Structural System", International Journal of Engineering and Technical Research, vol. 02, pp 150-157, 2014.
7. IS: 456-2000. Plain and Reinforced Concrete-Code of Practice (Fourth Revision), Bureau of Indian Standard, New Delhi.
8. IS: 1893(Part-I)-2002, Criteria for Earthquake Resistant Design of Structures, Bureau of Indian Standard, New Delhi