Comparative Analysis and Design of Diagrid structure and Orthogonal structure

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***Abstract*— This paper present analysis and design of diagrid structure and orthogonal structure. Analysis and design of both the structure is done by using ETABS 2016 software. In this project 8th, 16th, and 24th storey R.C.C. building, each of diagrid and orthogonal (frame) structure is analysed and designed and accordingly comparative analysis is done on various factors such as Time Period, Response Spectrum, Maximum Top Storey Displacement, Maximum Storey Shear, Maximum Storey Drifts and Costing.**

Index Terms- Time Period, Response Spectrum, Displacement, Drifts.

I. INTRODUCTION

In tall buildings, the main problem that governs the design is lateral loads, instead of the gravitational loads in shorter building. Thus, systems that are more efficient in achieving stiffness against lateral loads are considered better options in designing tall buildings. This paper aim to prove that diagrid structure to be more efficient than orthogonal structure. Orthogonal structure is the simple frame structure with vertical columns. Diagrid structure is advance system in which the peripheral column are inclined with particular angle designed and inner column are vertical.

All the buildings is analysed and designed in Etabs 2016 software. All the relevant information is taken from Indian standard code.

II. METHODOLOGY

For the parametric comparison, a symmetrical building is selected. Three RCC (Reinforced Cement Concrete) buildings for different heights are modelled, analysed and designed in Etabs for two structural systems; diagrid and orthogonal. Analysis and design is carried out for dead load, live load, lateral earthquake load and lateral wind load. For earthquake loads, both static and response spectrum analysis is done. To consider extreme conditions of lateral loads, the buildings are considered to be located in Zone V. The parameters selected for the comparison are fundamental time period, maximum top storey lateral displacement, maximum storey shear, maximum storey displacement and maximum storey drift. Following geometry details is given as follows"

1. Plan dimension- 24m X 24m
2. Storey height- 3 m
3. Number of floors- 8, 16, 24 storeys
4. Slab thickness- 0.120 m.
5. Characteristic strength of concrete: 40N/mm^2
6. Characteristic strength of steel: 500N/mm^2
7. Diagrid Angle: 68.19^o, 4 Storey Model.

As the building is assumed as residential building the live load is considered as 2 kN/m^2 as per IS 875 (2). The floor load is considered as 1 kN/m^2. This load is applied on all the slab panels for all floors. A member load of 8.4 kN/m is considered on all the beams for the wall load considering the wall to be made of light weight bricks. The design earthquake load is computed based on the Zone V, zone factor 0.36 as per IS 1893 (1), soil type II, Importance factor 1, Response Reduction 5 as per IS-1893-2002 [3]. Design wind load is consider based on location, Wind speed 47 m/s, Terrain category 3, Structure class B, Risk Coefficient 1, Topography factor 1 as per IS 875(Part 3) -1987 [4]. Modelling, analysis and design of diagrid structure are carried out using ETABS 2016 software. Column and Diagrid are consider hinged at free end. The support conditions are assumed as fixed. IS code 456-2000 is used for design consideration.

III. DESIGN SECTION

TABLE.1 DESIGN SECTION

Design Sections for 8, 16, 24 Storey Building					
Storey/Sections	Beam	Beam (S)	Column	Column (S)	Diagrid
8 Storey					
Diagrid	450 X 800	300 X 600	700 X 700	300 X 450	400 X 400
Frame	450 X 800	300 X 600	700 X 700	300 X 450	-
16 Storey					
Diagrid	450 X 900	300 X 800	800 X 800	300 X 450	500 X 500
Frame	450 X 900	300 X 800	800 X 800	300 X 450	-

24 Storey					
Diagrid	500 X 900	300 X 800	950 X 950	300 X 450	600 X 600
Frame	500 X 900	300 X 800	950 X 950	300 X 450	-
All dimensions are in mm.					

IV. MODELLING OF TYPICAL ORTHOGONAL (FRAME) AND DIAGRID STRUCTURE:

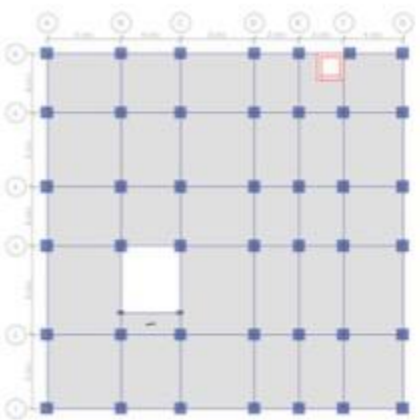

Fig.1 Floor plan-Frame

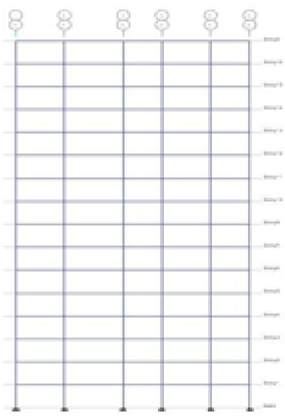

Fig. 2 Elevation-Frame

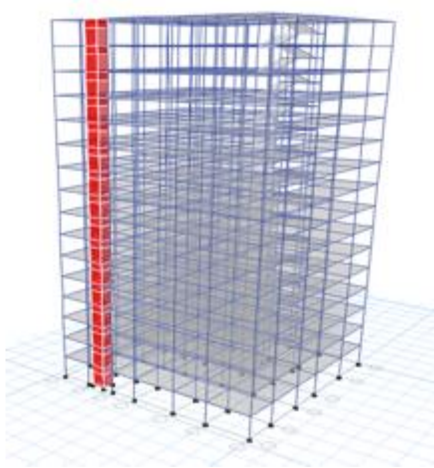

Fig.3 3D view-Frame

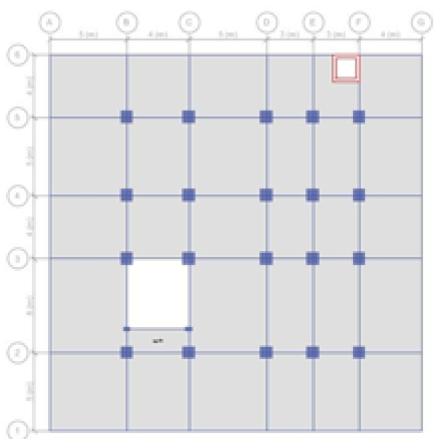

Fig.4 Floor plan-Diagrid

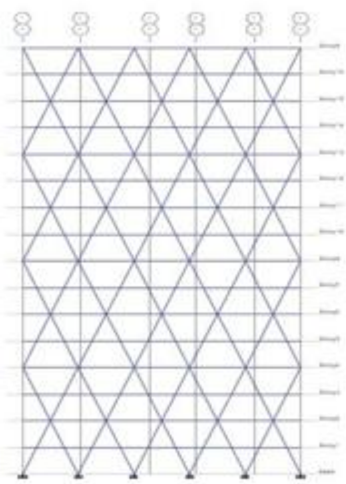

Fig.5 Elevation-Diagrid

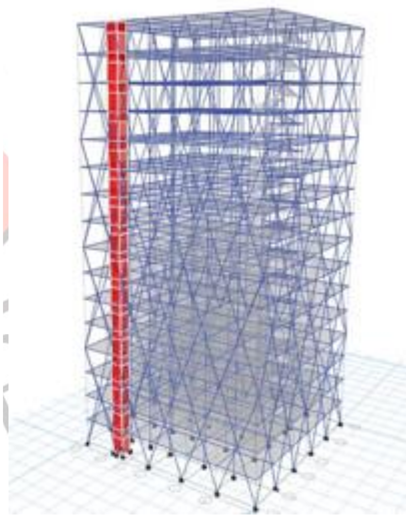

Fig.6 3D view-Diagrid

V. RESULT COMPARISON AND DISCUSSION:

After analyzing and designing diagrid and frame structure following results are obtain for above parameters discussed. In detail will we see the comparison between two structural system that is Diagrid and Orthogonal (frame).

V.I Maximum Displacement and top storey displacement :

Considering the lateral load on buildings i.e Wind load and Earthquake load following results are shown in graphs. Displacement in frame structure is quite more as compare to diagrid structure in each 8th storey, 16 Storey and 24 Storey. Considering top storey displacement it is more in frame structure as compare to diagrid structure.

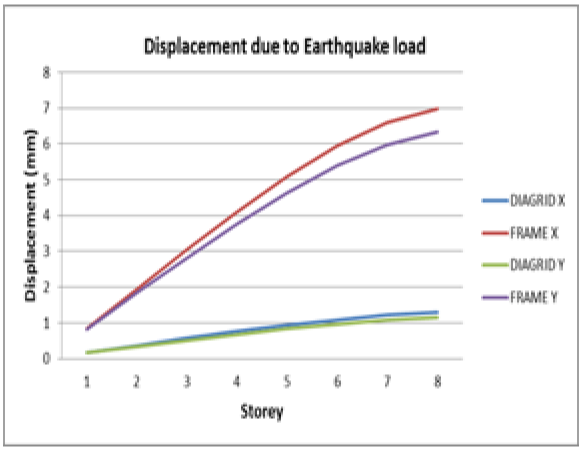

Fig.7. Displacement due to Wind load

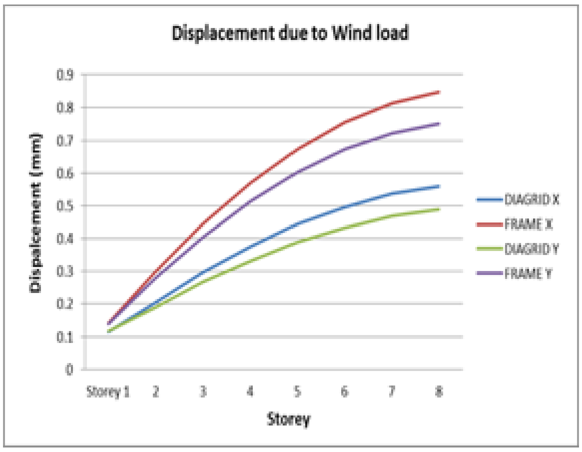

Fig.8. Displacement due to Earthquake load

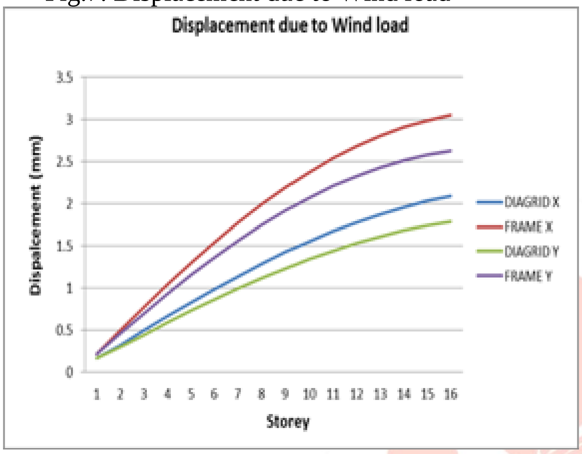

Fig.9. Displacement due to Wind load

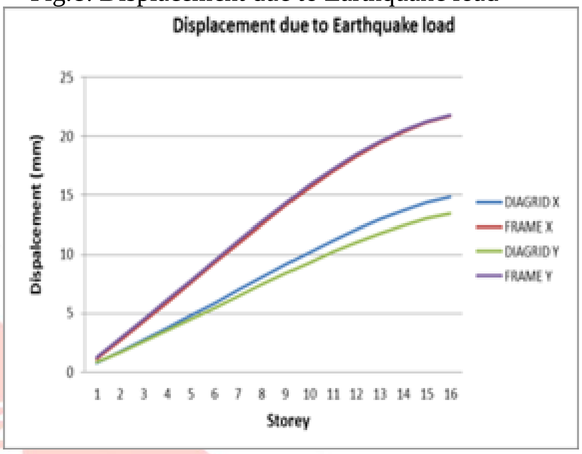

Fig.10. Displacement due to Earthquake load

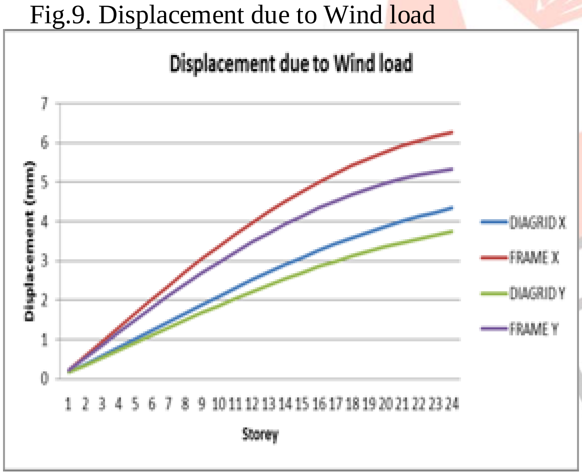

Fig.11. Displacement due to Wind load

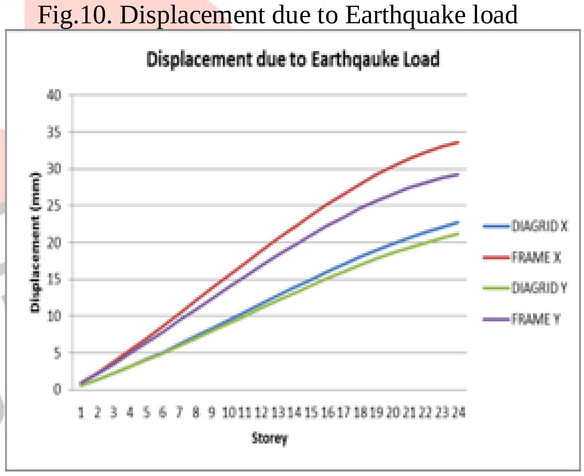

Fig.12. Displacement due to Earthquake load

V.II Maximum Storey Drift

Considering the lateral load on buildings i.e Wind load and Earthquake load following results are shown in graphs. Drift in frame structure is slight more as compare to diagrid structure in each 8th storey, 16 Storey and 24 Storey. Drift caused by the earthquake is more than wind load in top storey as analysed. Drift due to wind load is less at top storey as compare to bottom storey and vice versa in earthquake load it is more in top storey.

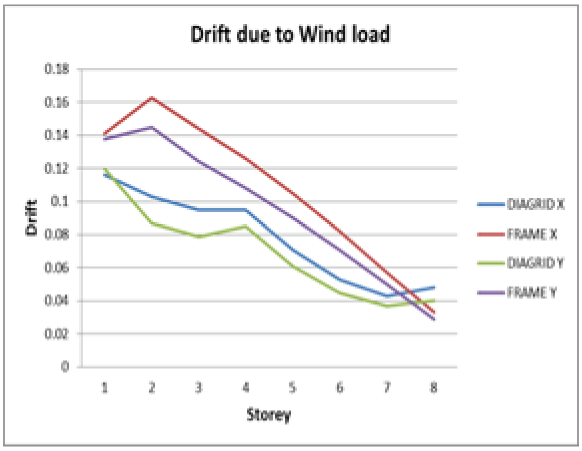

Fig.13. Drift due to Wind load

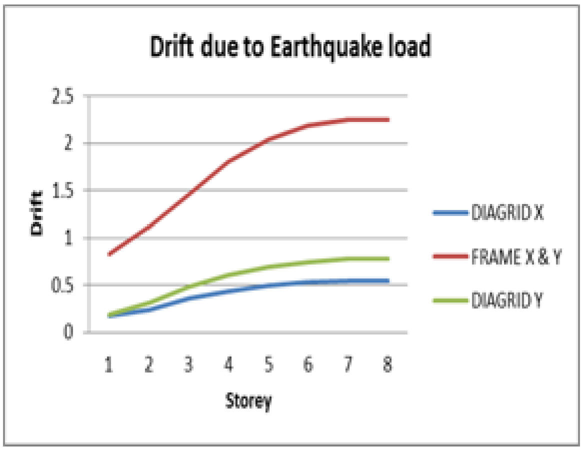

Fig.14. Drift due to Earthquake load

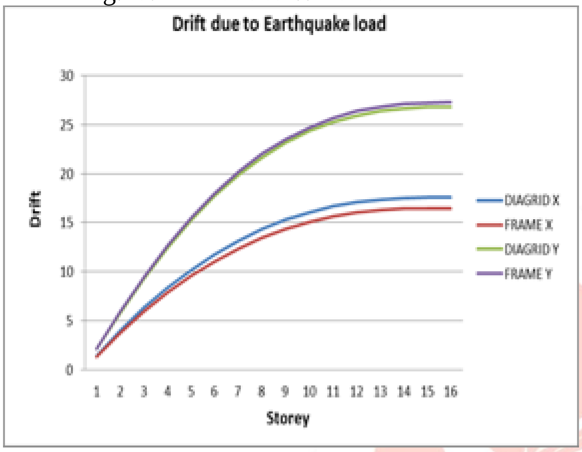

Fig.15. Drift due to Wind load

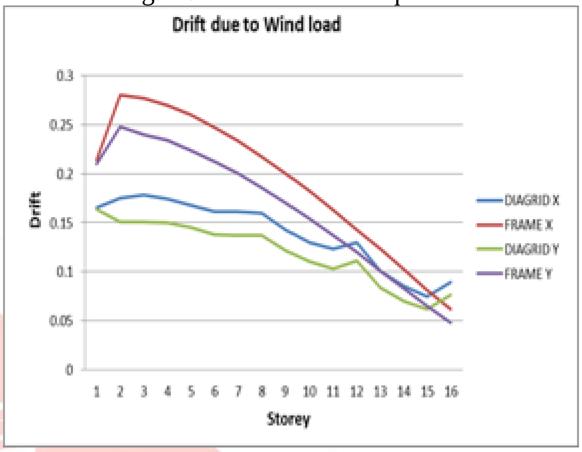

Fig.16. Drift due to Earthquake load

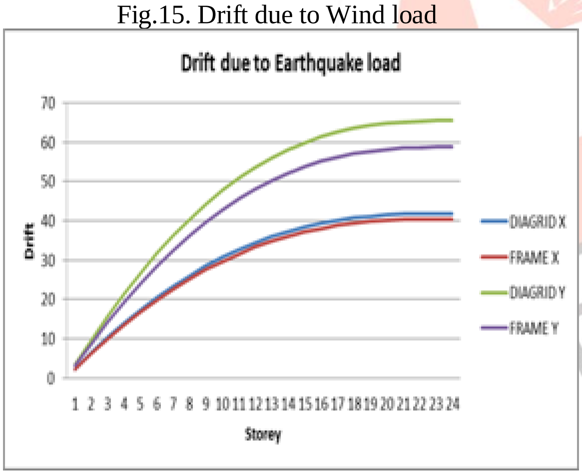

Fig.17. Drift due to Wind load

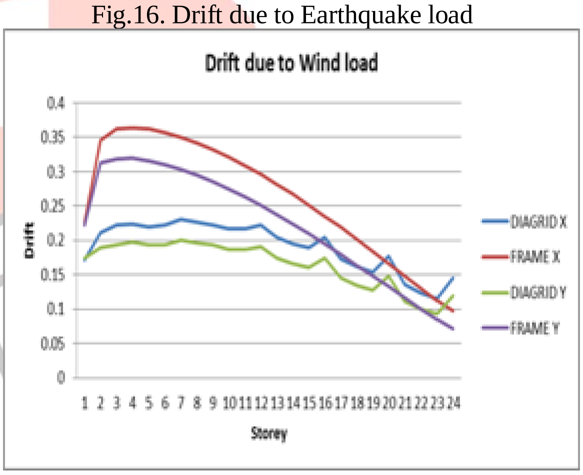

Fig.18. Drift due to Earthquake load

V.III Maximum Storey Shear and Base Shear

Maximum shear occurs at base of any structure from result obtained max shear has occurred in diagrid structure as compare to frame structure for all three case analysed. Considering Earthquake load for lateral shear.

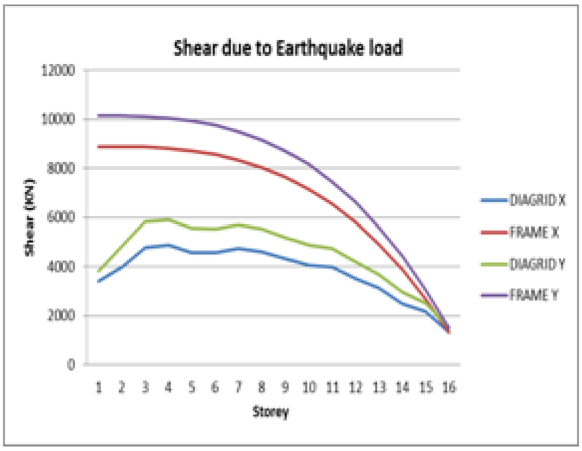

Fig.19. Storey shear due to Earthquake load

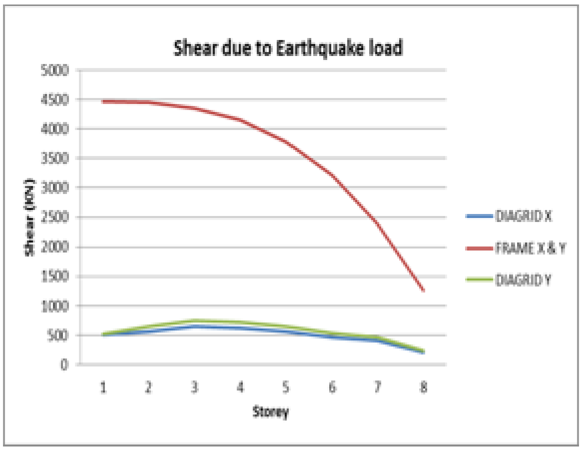

Fig.20. Storey shear due to Earthquake load

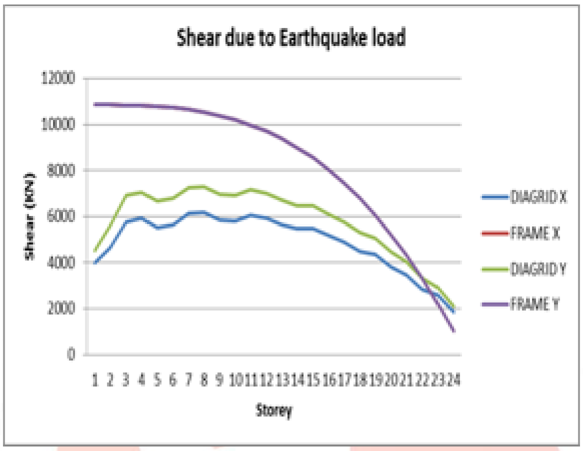

Fig.21. Storey shear due to Earthquake load

V.IV Time Period

As we know that time period is defined as time required in seconds to complete one cycle of oscillation for a given system. If the time period for a given structure is more, structure is considered less stiff. As per result obtained time period is more for frame structure as compared to diagrid structure for the three cases.

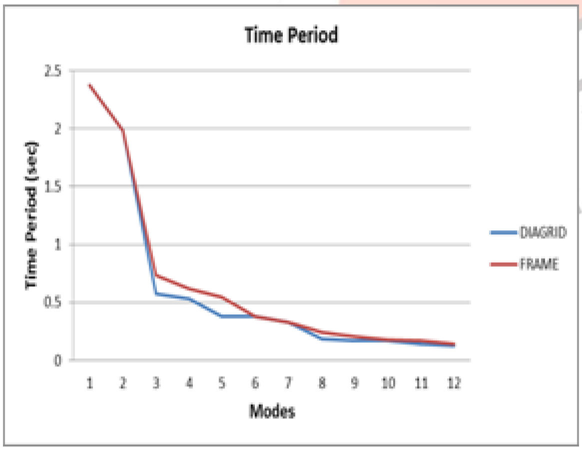

Fig.22. Time Period for 8 Storey

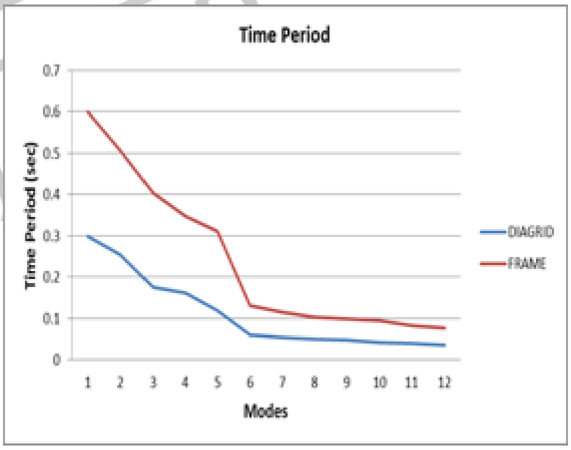

Fig.23. Time Period for 16 Storey

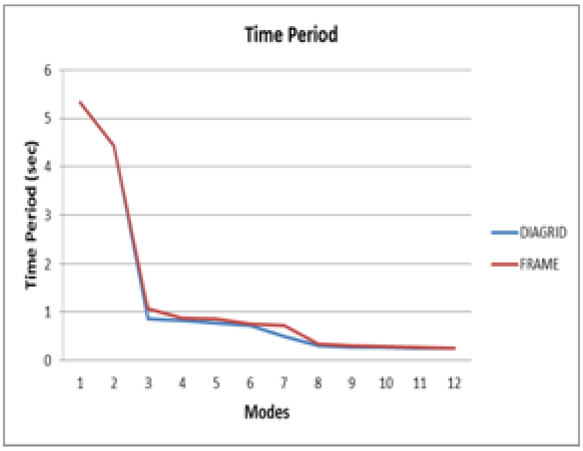

Fig.24. Time Period for 24 Storey

VI. CONCLUSIONS

As per result obtained for diagrid structure and frame structure considering various factor.

We conclude that displacement for frame structure is more than compare to diagrid structure. Top storey displacement is more for frame structure. Therefore diagrid structure has more stiffness than frame structure. In case of drift, drift is more in frame structure and less in diagrid structure making it more stiffer. Maximum storey shear occur to the frame structure which have to resist more lateral load as compare to diagrid.

Time Period is more in frame structure as compare to diagrid structure. Less time period more stiffer the system is. Sectional properties used are same for diagrid and frame structure also reinforcement required is quite same, as per result obtained after designing. Costing is slightly same for diagrid and frame structure. Concluding above all factor we can say that diagrid structre is more stiffer than frame structure. Diagrid structure is most suitable system for high rise building to resist lateral load efficiently than any other structure.

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