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.2020.6255

Comparative Analysis of Different Lateral Load Resisting System for High Rise Building

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Abstract: In the early structures at the beginning of the 20th century, the building height is observed more and more slender, and more susceptible to sway and hence dangerous in the earthquake and the world's population growth rate is increasing day by day. Meeting to the demands of population growth, the decrease of available free land and increase of land prices especially in urban areas has tended to develop buildings vertically.it has been a task of a structural engineer to come out with a good structural system. In the seismic design of the buildings, reinforced concrete structural walls or shear-wall, act as major earthquake resisting members. Structural walls provide an efficient bracing system and offer great potential for lateral load resistance. In the present study, various lateral load resistance systems have been introduced that can inhibit lateral forces which improves the strength and stiffness of column such as Shear wall system, Tube system, Beam Column System & Diagrid System. A regular G+16 storey buildings with plan size (18x18) m, located in a seismic zone IV having type II soil condition is considered. The modelling is done by ETABS Software to examine the effect of different cases on seismic parameters like base shear, storey displacements, storey drifts and model time period for the zone-IV in medium soil as specified in IS: 1893-2002 and obtained results were presented in both graphically and tabular format.
Keywords**: 1**Structural wall, Shear wall system, Tube system, Beam Column System, Diagrid System, High rise buildings, storey displacement, storey drift, storey stiffness, Time period, ETABS

I. INTRODUCTION

The rapid increase in the population and scarcity of land has increased the demand of taller buildings. Expanding the building vertically seems to be an efficient option considering all the factors. The resistance of tall buildings to wind as well as to earthquakes is the main determinant in the formulation of new structural systems that evolve by the continuous efforts of structural engineers to increase building height while keeping the deflection within acceptable limits and minimizing the amount of materials. As the building height increases role of lateral load (Wind and Seismic) resisting systems becomes more prominent as compared to gravity load resisting system. Basically, there are three main types of buildings: steel buildings, reinforced concrete buildings, and composite buildings. Most of the tallest buildings in the world have steel structural system, due to its high strength-to-weight ratio, ease of assembly and field installation, economy in transport to the site, availability of various strength levels, and wider selection of sections. Innovative framing systems and modern design methods, improved fire protection, corrosion resistance, fabrication, and erection techniques combined with the advanced analytical techniques made possible by computers, have also permitted the use of steel in just any rational structural system for tall buildings. As a result, various structural systems have erupted over the years. Though the modern day's systems have paved the way for different methods of structural systems, the structural system of the building may be consisting of two component (i) horizontal framing system and (ii) vertical framing system. the selection of a particular type of structural system depends upon two important parameters i.e. seismic risk of zone and the budget. The lateral forces acting on any structure are distributed according to the flexural rigidity of individual components.

II. CONFIGURATION OF BUILDING

Modelling is carried out using ETABS software. Four different regular 16 storey buildings are modelled with M-45 grade concrete, Fe-500 steel and 11 KN/m^3 density of the concrete. All the buildings are having plan dimension of 18m in width and 18m in Y-direction, which includes 4 types of lateral load resistance systems namely beam column system, shear wall system, tube system and diagrid. System. Slab thickness provided in modelling is 130mm in all buildings.

The first system is Beam Column System & Frame Structure of 450mm x 300mm Beam and 550mm x 550mm Column used. In the beam column system, the column is provided at a spacing of 3 m. In the shear wall system, the shear wall is in the center of the structure at the exterior walls. 450mm x 300mm &550mm x 550mm Column Structure with 130mm Thick Shear wall placed in outer periphery of building.

The tube system is a building, by designing the earth as a hollow cantilever at center portion and all the dimensions of structural elements are same as other system. In the diagrid system, the pair of braces are located on the periphery of the structure. The inclination angle of the diagrid member is kept constant throughout the height of the structure. The diagonal member's (Diagrid) of size 475mm x 475mm with optimum angle 70^0 provided at a distance of 3 m along the perimeter of the structure. Different beams used in each floor as B1- 650x400 B2- 500x300 B3- 450x300 and column size of 750mmx750mm provided. The internal structural framework of diagrid structures is designed only for gravity loads. The design dead load and live loads on floor slab are 2 kN/m2 and 1.5 kN/m2 respectively.

A. 3D - Model

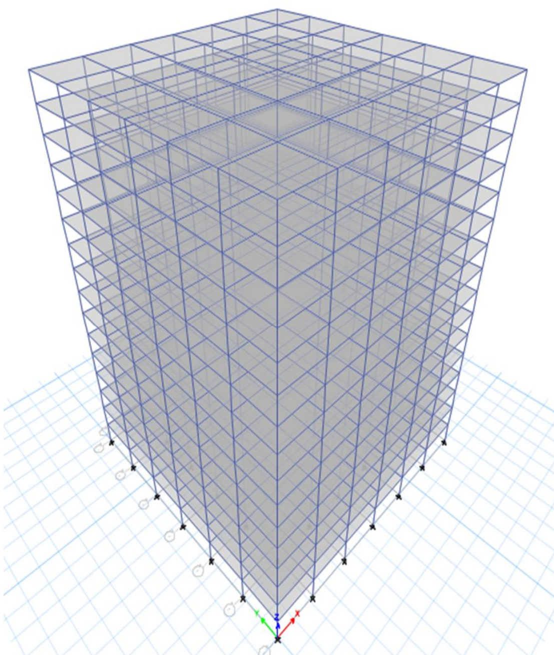

Fig 1: Beam Column System

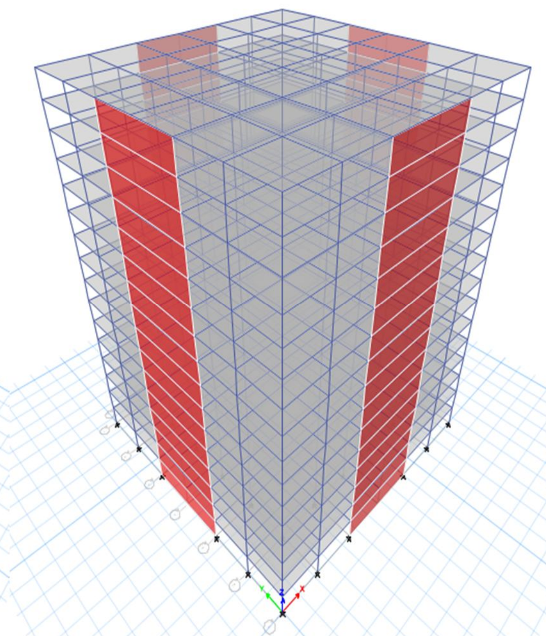

Fig 2: Shear Wall System

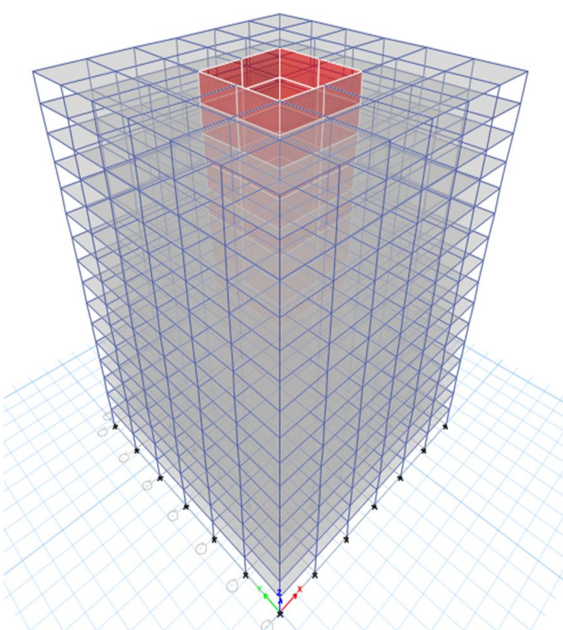

Fig.3: Frame Tube System

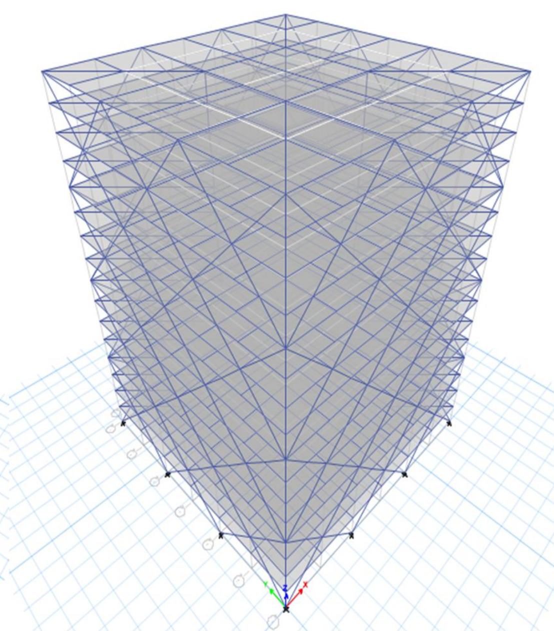

Fig 4: Diagrid System

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429
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III. RESULTS AND DISCUSSIONS

Comparative analysis is performed for the beam column system, shear wall system, tubular system and diagrid system. In terms of modal Time period, Storey Displacement, storey drift and Storey Stiffness.

A. Modal Time Period

The time period for Beam Column system, Shear wall system, Tube system and diagrid structure are shown in Fig3.1. From the above figure, comparison of time period for all the building systems is examined and it is observed. that as the building height increases, time period of diagrid remains lower than that of the conventional frame, core wall and shear wall building systems. It can be seen that for Beam Column system the time period is more when compared with rest of lateral load resisting system. The maximum reduction in time period of first mode is 53% compared to beam column system which will directly affect the displacement of structure.

Table 3.1 Modal Time Period (in second) for 16 Storey.

Mode	Beam Column System	Shear Wall System	Tube System	Diagrid System
1	1.621	1.306	1.121	0.852
2	1.621	1.306	1.121	0.85
3	1.5	0.963	0.921	0.474
4	0.527	0.39	0.315	0.274
5	0.527	0.39	0.315	0.273
6	0.493	0.286	0.306	0.159
7	0.299	0.198	0.182	0.153
8	0.299	0.198	0.155	0.152
9	0.287	0.144	0.155	0.108
0	0.206	0.124	0.128	0.108
1	0.206	0.124	0.099	0.097
2	0.198	0.088	0.099	0.086

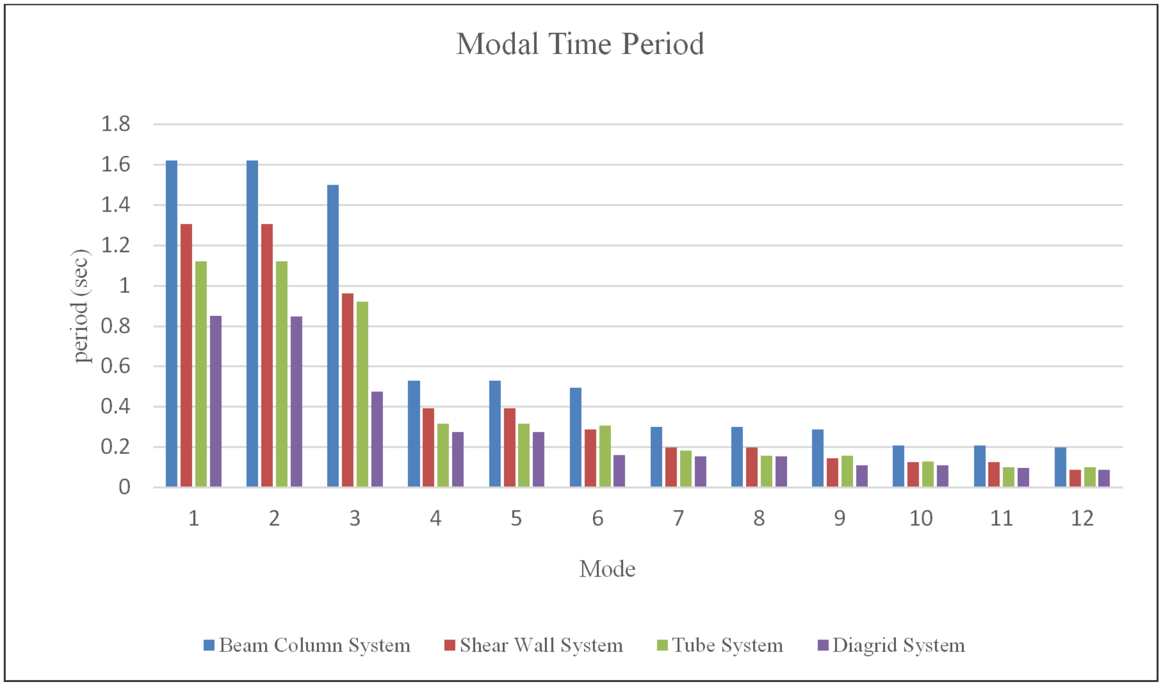

Figure 3.1 Modal Time Period of 16 storey

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B. Storey Displacement

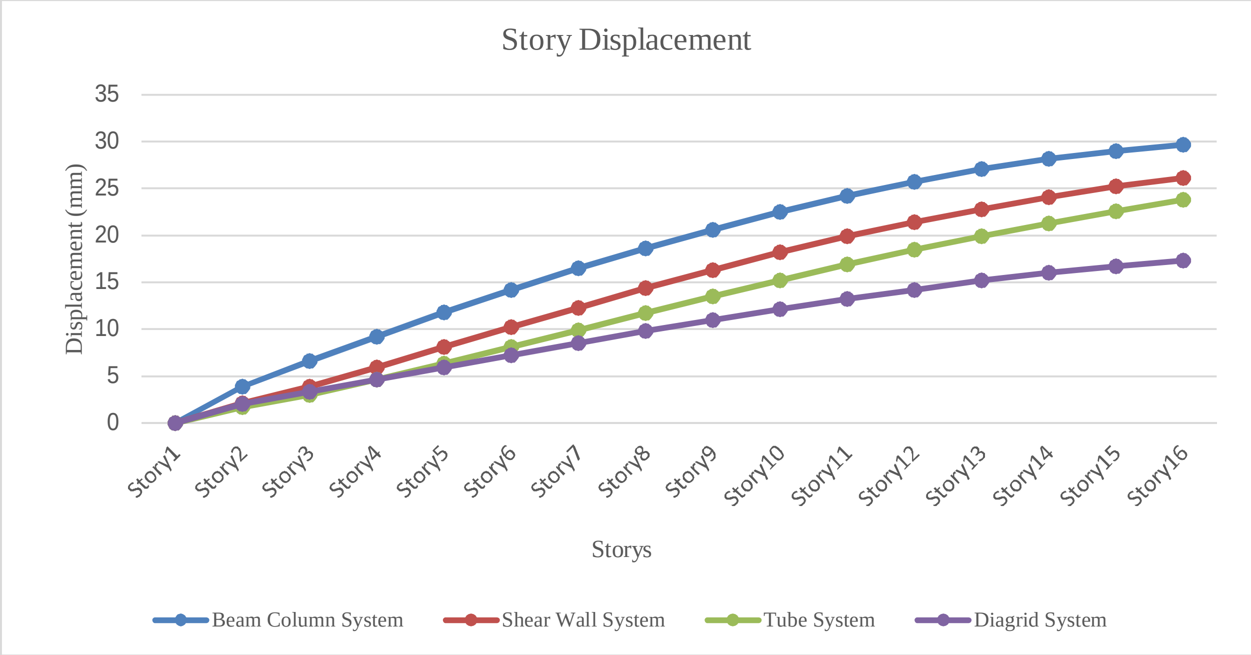

Figure 3.2: Storey displacement of 16 storey structure under earthquake loading

Storey displacement for Beam column system, shear wall system, tube system and diagrid structure is shown in Fig 3.2. It can be observed that amongst 4 lateral load resisting systems, diagrid system shows less displacement. The maximum reduction in storey displacement is 58.24% compared to beam column system compare to diagrid system.

Table 3.2 16s Storey displacement (in mm) in Rx and Ry Direction

Storey	Beam Column System	Shear Wall System	Tube System	Diagrid System
1	0	0	0	0
2	3.9	2.1	1.7	2
3	6.6	3.9	3	3.3
4	9.2	5.9	4.6	4.6
5	11.8	8.1	6.3	5.9
6	14.2	10.2	8.1	7.2
7	16.5	12.3	9.9	8.5
8	18.6	14.4	11.7	9.8
9	20.6	16.3	13.5	11
10	22.5	18.2	15.2	12.1
11	24.2	19.9	16.9	13.2
12	25.7	21.4	18.5	14.2
13	27.1	22.8	19.9	15.2
14	28.2	24.1	21.3	16
15	29	25.2	22.6	16.7
16	29.7	26.1	23.8	17.3

C. Storey Drift

Storey drift for Beam column system, shear wall system, tube system and diagrid structure is shown in Fig 3.3. It is found that storey drift for 16 storey of diagrid structure system is less than relatively in frame tube system, shear wall system and beam column system. Also the performance of diagrid system is better than rest of lateral load resisting system.

Table 3.3 16s Storey drift (in meter) in Rx and Ry Direction

Storey	Beam Column System	Shear Wall System	Tube System	Diagrid System
1	0.000481	0.000252	0.000218	0.000268
2	0.000831	0.00049	0.000369	0.000424
3	0.000891	0.000599	0.000453	0.000439
4	0.000884	0.000675	0.00052	0.000444
5	0.000859	0.000712	0.000566	0.000431
6	0.00083	0.000724	0.000596	0.000428
7	0.000799	0.000719	0.000611	0.000443
8	0.000768	0.000702	0.000615	0.00043
9	0.000735	0.000676	0.000609	0.000416
10	0.000698	0.000643	0.000596	0.000391
11	0.000654	0.000603	0.000576	0.000382
12	0.0006	0.000558	0.00055	0.000346
13	0.000552	0.000507	0.00052	0.000329
14	0.000448	0.000453	0.000486	0.000279
15	0.000348	0.0004	0.000451	0.000255
16	0.000245	0.000348	0.000409	0.000193

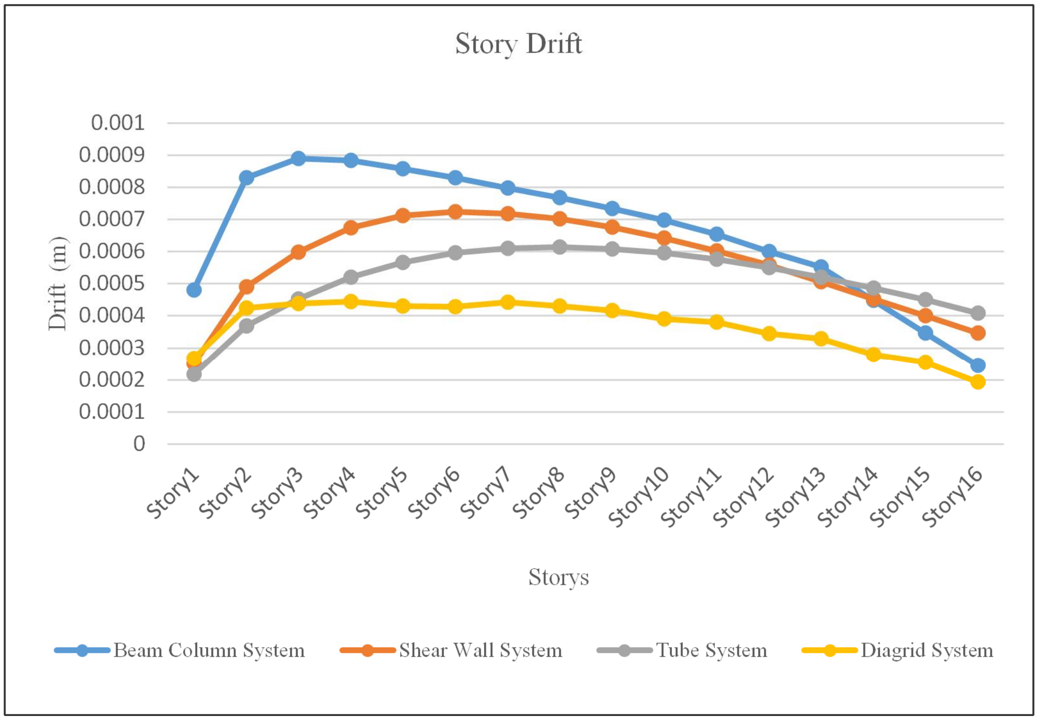

Figure 3.3 Storey drift of 16 storey structure under earthquake loading

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D. Storey Stiffness

The stability of RCC-structure increases with increase in stiffness of column. It is observed that storey stiffness for diagrid structure due to earthquake load is higher compared to beam column structure, shear wall system and tube system. Since stiffness is directly proportional to displacement. Due to increase in stiffness diagrid structures shows less displacement as given in table 3.2.

Table 3.4 16s Storey Stiffness (in meter) in Rx and Ry Direction

Storey	Beam Column System	Shear Wall System	Tube System	Diagrid System
16	438639.1	373473.8	362759.7	735397.4
15	614919.1	624925.2	640123.6	1146889.7
14	674463.3	761072.4	825842.2	1522008.6
13	700631.6	830415.7	945240.8	1649450.1
12	715907.4	869827.9	1028699.7	1870611.0
11	727302.4	895687.2	1094724.3	1934766.9
10	736908.0	915613.6	1154391.2	2107066.0
9	746135.4	935651.8	1216116.8	2160404.7
8	756498.0	961402.1	1287742.9	2251133.8
7	768574.4	996885.0	1376626.9	2326563.1
6	781867.8	1046234.4	1491346.2	2540739.1
5	796277.7	1118401.1	1646364.5	2643978.9
4	813875.4	1232943.2	1869918.0	2663681.1
3	843874.2	1438996.1	2224073.8	2777342.4
2	935997.3	1869168.7	2872506.9	3071046.8
1	1634214.6	3792009.5	5004361.2	5010644.0

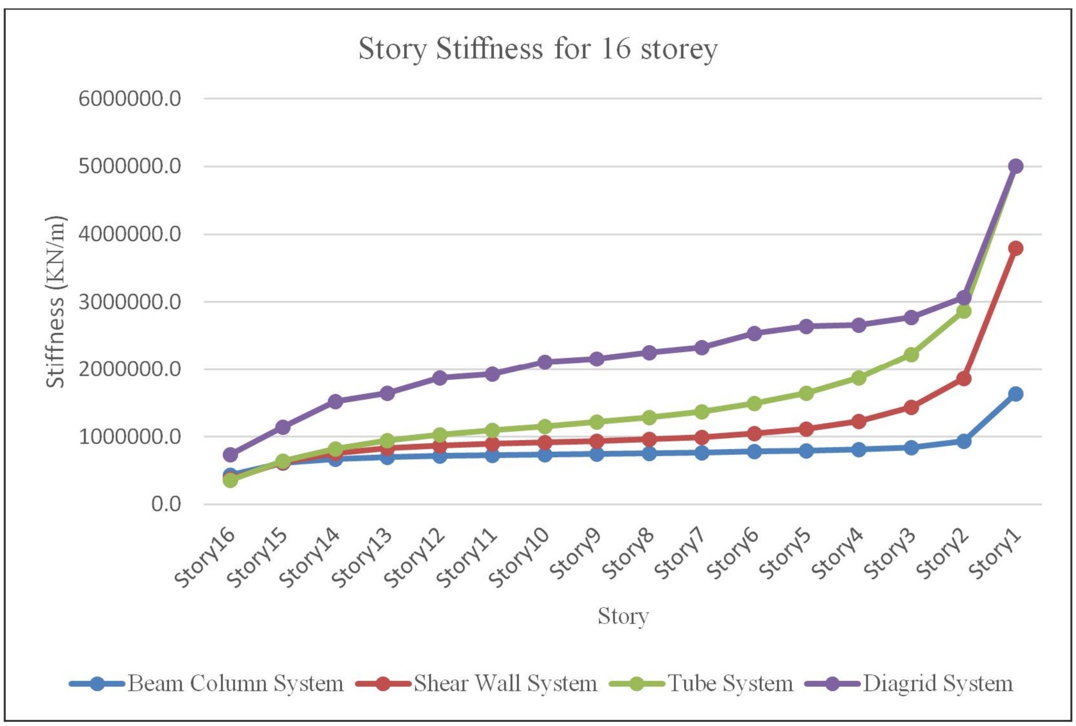

Figure 3.4 Storey Stiffness of 16 storey structure under earthquake loading

IV. CONCLUSION

In this Project Report, comparative analysis and design of different lateral load resisting system, i.e. beam column system, shear wall system, tube system and Diagrid system building is presented. In this project the analysis results of storey displacement, storey drift storey stiffness and modal time period are presented here. From the detail result analysis following conclusions can be drawn.

A. Since laterals loads are restricted by diagonal joints, the maximum top storey displacement is much smaller in the diagrid structure compared to the other lateral system and is therefore more effective in resisting lateral loads.
B. Storey Drifts of diagrid structure system is less than proportional to the tube system, shear wall system and beam column system. And the performance of the diagrid system is better than beam column system, shear wall system and tube system. Displacements on each storey and storey drifts are noticed to be less in diagrid systems when matched with other conventional frames
C. Diagrid provides additional resistance to lateral loads on the structure that makes the system more efficient. Also the weight of the diagrid formation is more due to its increased base shear but ultimately gives better performance under seismic loading.
D. The stability of structure increases with increasing column stiffness. As the column stiffness increases, the maximum displacement of the structure decreases.
E. It can be concluded that the stiffness of the diagrid system is more than the beam column system, shear wall and tube system. As a result of the increase in stiffness, storey displacement and modal time period are reduced, which means that the damping of the structure increases, i.e., the stresses induced by displacement of structure is reduced.
F. Diagrid structural system with columns gives more opposition in the building which makes system more operative. Diagrid structural system gives more flexibility in planning inner area and elevation of the building.

In comparison to conventional building, diagrid buildings are more aesthetic in look and it becomes important for high rise buildings.
So from results and comparison with conventional building one can adopt diagrid structure for better lateral load resistance.

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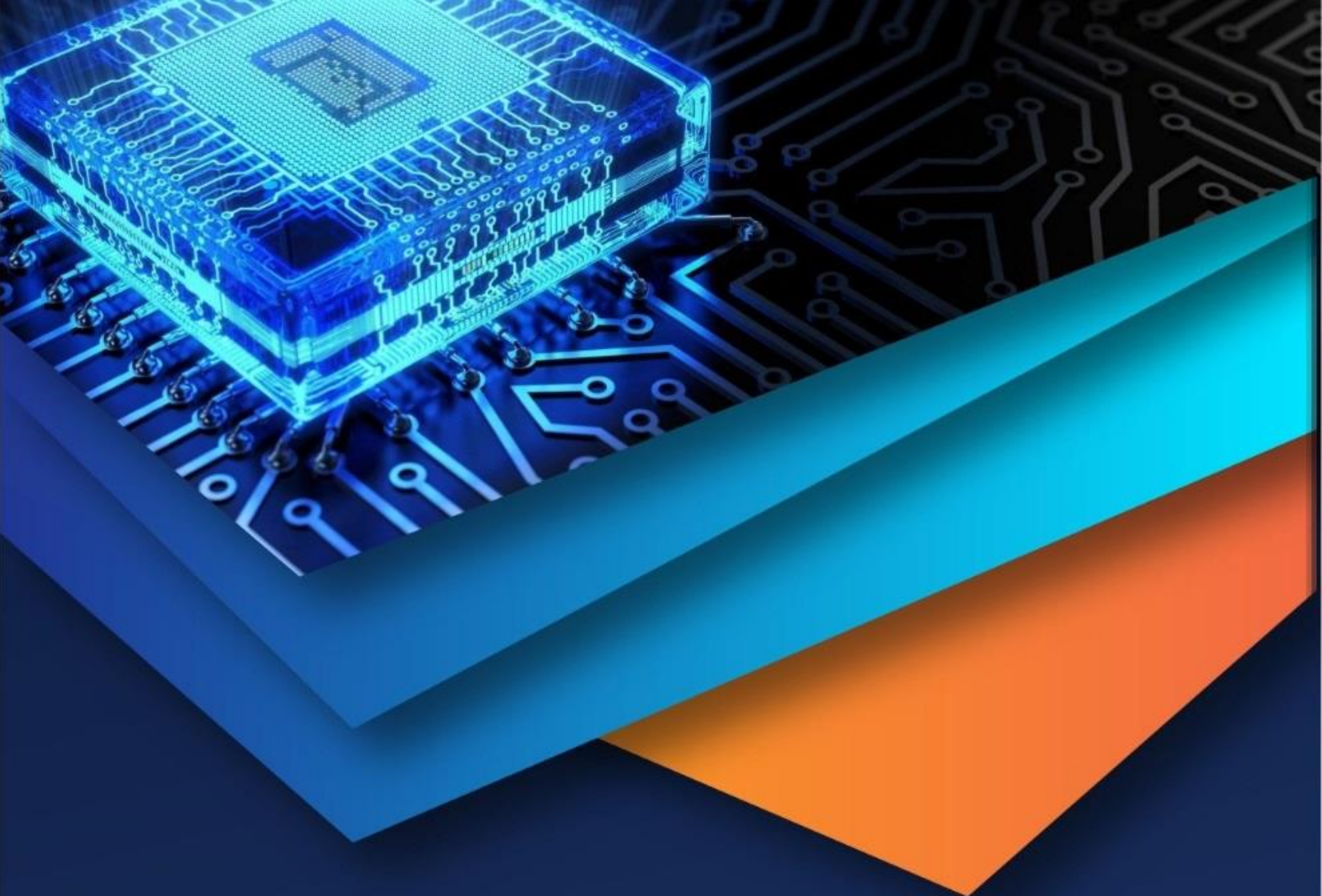

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