Analysis of Diagrid structures and Bare frame structures using E-TABS with Comparing both Symmetric and Asymmetric Plan .

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Abstract : The present study is an effort towards analysis of the structure located on a normal ground during the earthquake. An ordinary moment resisting building of G+10 stories located over a medium soil is considered. In the symmetric building the number of bays will be kept as 5 along both direction and the bay size will be kept as 4m with the storey height being 3m and in asymmetric building 4 bays along x direction and 5 bays along y direction. The building will be analyzed considering zone V by response spectra method using ETABS 2016 software and the parameters are considered as lateral story displacement. Story drift, story shear, base shear and modal time period.

1. INTRODUCTION

The fast development of the population and the shortage of land have affected the residential advancement of the city. The high expenses of the land and the want to safeguard a critical agricultural creation have prompted the development of the buildings. Tall business structures are fundamentally a reaction to the exceptional inaccessibility of land. Advances in materials, development innovation, scientific techniques and auxiliary frameworks for examination and configuration have quickened the improvement of high-rise structures.

In recent years, diagrid structures have received increasing attention among both designers and researchers of tall buildings for creating one-of-a-kind signature structures. The term “diagrid” is a combination of the words “diagonal” and “grid” and achieves its structural integrity through the use of triangulation. Diagrid is a particular form of space truss. It consists of perimeter grid made up of a series of triangulated truss system. Diagrid is formed by intersecting the diagonal and horizontal components. Diagrid systems can be planar, crystalline or take on multiple curvatures. Diagrid structures consist of modules which are in diamond shape and lateral stiffness is provided more in diagrids than the other conventional type of structures. Diagrid structures are more effective in minimizing shear deformation because they carry lateral shear by axial action of diagonal members. Diagrid came as an evolution of the Geodesic Dome invented by Fuller in the late 40’s the actual origins consisting in triangular structures with diagonal support beams.

In fact, the diagrid system is not a new invention. An early example of today’s diagrid-like structure is the 13-story IBM Building in Pittsburg of 1963. However, the implementation in a larger scale of such tall building was not practical due to high cost related to the difficult node connections. It is only in recent years that technology allowed a more reasonable cost of diagrid node connections.

The Hearst Tower in New York City, is nowadays one of the most iconic and awarded “green” diagrid buildings in the world. Completed in 2006, the 182 meter high building, embraces a highly efficient diagrid frame that uses 20% less steel than a conventionally framed structure. The building is also significant in environmental terms: it was built using 85% recycled steel, and it consumes 25% less energy than an equivalent building that complies minimally with the respective state and city codes. It is also the first building in Manhattan to achieve a gold rating under the US Green Building Council’s Leadership in Energy and Environmental Design (LEED) programme.

Figure 1.1 Diagrid structure

1.1 MERITS OF DIAGRID STRUCTURAL SYSTEM

- The diagrid structures have mostly column free exterior and interior, hence free and clear, unique floor plans are possible.
- The glass facades and dearth of interior columns allow generous amounts of day lighting into the structure.
- The use of diagrids results in roughly 1/5th reduction in steel as compared to braced frame structures.
- The construction techniques involved are simple, yet they need to be perfect.

- The diagrids makes maximum exploitation of the structural material.
- The diagrid structures are aesthetically dominant and expressive.

1.2 DEMERITS OF DIAGRID STRUCTURAL SYSTEM

- As of yet, the diagrid construction techniques are not thoroughly explored.
- Lack of availability of skilled workers. Construction crews have little or no experience creating a diagrid skyscraper.
- The diagrid can dominate aesthetically, which can be an issue depending upon design intent.
- It is hard to design windows that create a regular language from floor to floor.
- The diagrid is heavy-handed if not executed properly.
- There is a height limitation of 100 storeys for diagrid constructed of steel and 60 storeys for diagrid constructed of concrete.

2. OBJECTIVES

- Aimed to study the behaviour of tall building without any lateral load resisting system.
- To examine response of high rise building with diagrid system
- An attempt is made to study response of buildings under dynamic loadings(i.e earthquake load)
- Diagrid systems are analysed for different Zones in india.
- Storey shear of all the modals are compared.
- Storey drift and displacement of all the structures are plotted and results are compared to know responses of these buildings.
- To analyze the diagrid structure with plan irregularity for seismic loading.
- To study the behavior of diagrid structure with plan irregularity under seismic loading.
- To study and compare the parameter such as like base shear, top storey displacement, top storey shear, time period, storey drift.

3. METHODOLOGY

Three dimensional space frame analysis will be carried out for 4 different building configurations resting on flat ground under the action of seismic load. The configurations include symmetric bare frame, asymmetric bare frame, symmetric structure with diagrid and assymtric structure with diagrid in seismic zones V. The main frame remains same having constant height, constant area and constant exposures in all sides and materials with same properties are considered for all configurations.

MODELS ARE CONSIDERED

Model 1: Symmetric Bare Frame Structure in zone V
Model 2: Symmetric Diagrid Frame Structure in zone V
Model 3: Asymmetric Bare Frame Structure in zone V
Model 4: Asymmetric Diagrid Frame Structure in zone V

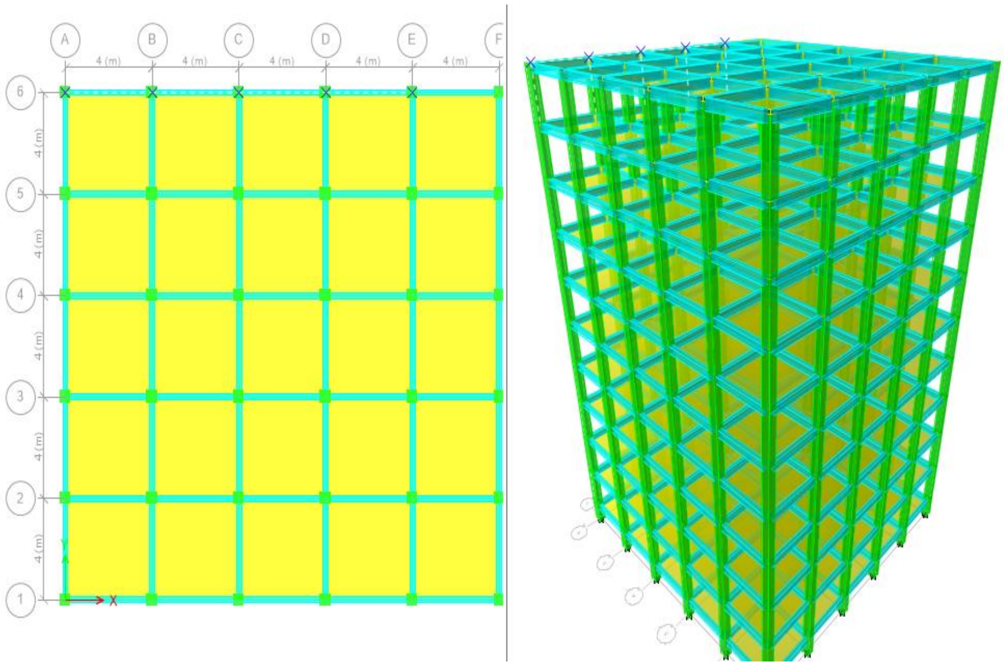

Figure 3.1 Plan and 3D view of Symmetric Bare frame

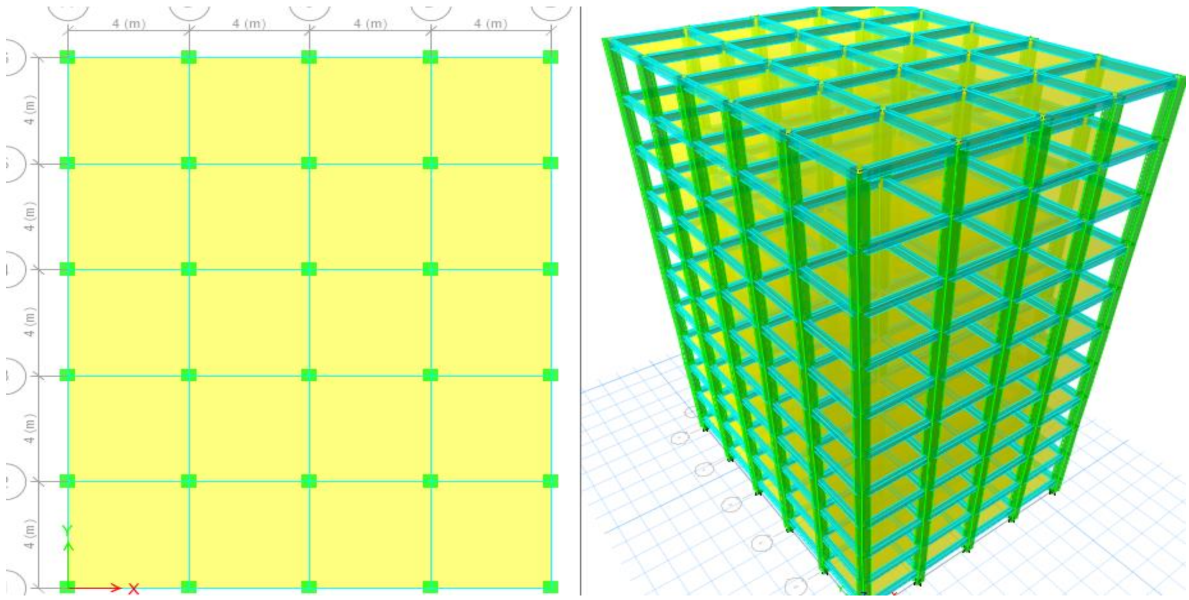

Figure 3.2 Plan and 3D view of Asymmetric Bare frame

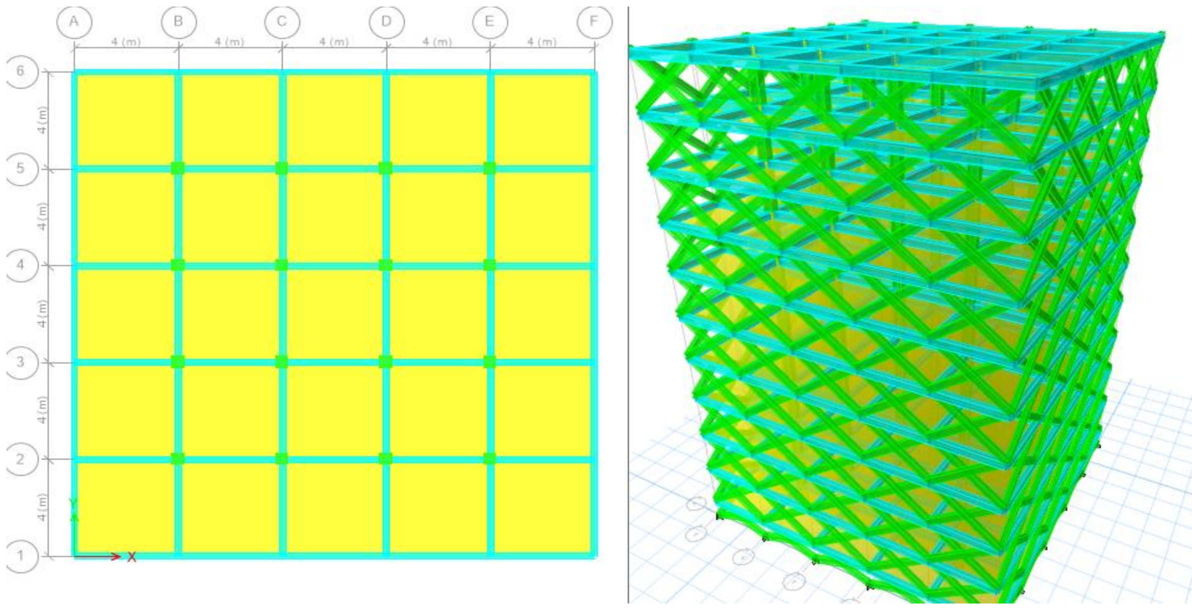

Figure 3.3 Plan and 3D view of symmetric Diagrid structure

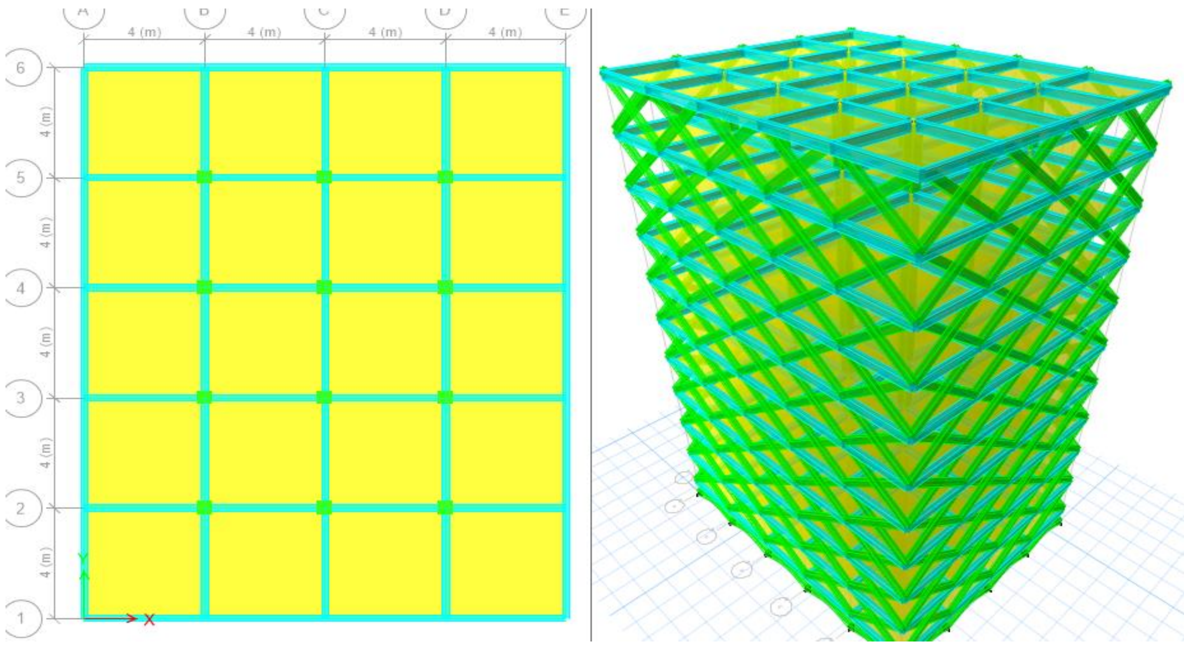

Figure 3.4 Plan and 3D view of Asymmetric Diagrid structure

4. RESULTS AND DISCUSSION

The performances of all the models are observed and their results are extracted. The behaviour of various models for different loading conditions are considered and these results are compared to obtain the most suitable model.

4.1 LATERAL STOREY DISPLACEMENT

Table 4.1: Lateral Displacement for symmetric frame along X - Direction

	X - Direction	
Storey Level	**Symmetric Bare Frame**	**Symmetric Diagrid Frame**
11	44.102	30.895
10	42.408	27.803
9	39.73	24.523
8	36.134	21.157
7	31.794	17.761
6	26.893	14.405
5	21.598	11.158
4	16.059	8.1
3	10.439	5.298
2	5.03	2.813
1	0.743	0.796
0	0	0

Table 4.2: Lateral Displacement for Asymmetric frame along X - Direction

	X - Direction	
Storey Level	**Asymmetric Bare Frame**	**Asymmetric Diagrid Frame**
11	44.562	35.918
10	42.795	32.18
9	40.052	28.266
8	36.392	24.286
7	31.99	20.303
6	27.029	16.392
5	21.678	12.636
4	16.09	9.124
3	10.434	5.933
2	5.01	3.128
1	0.739	0.785
0	0	0

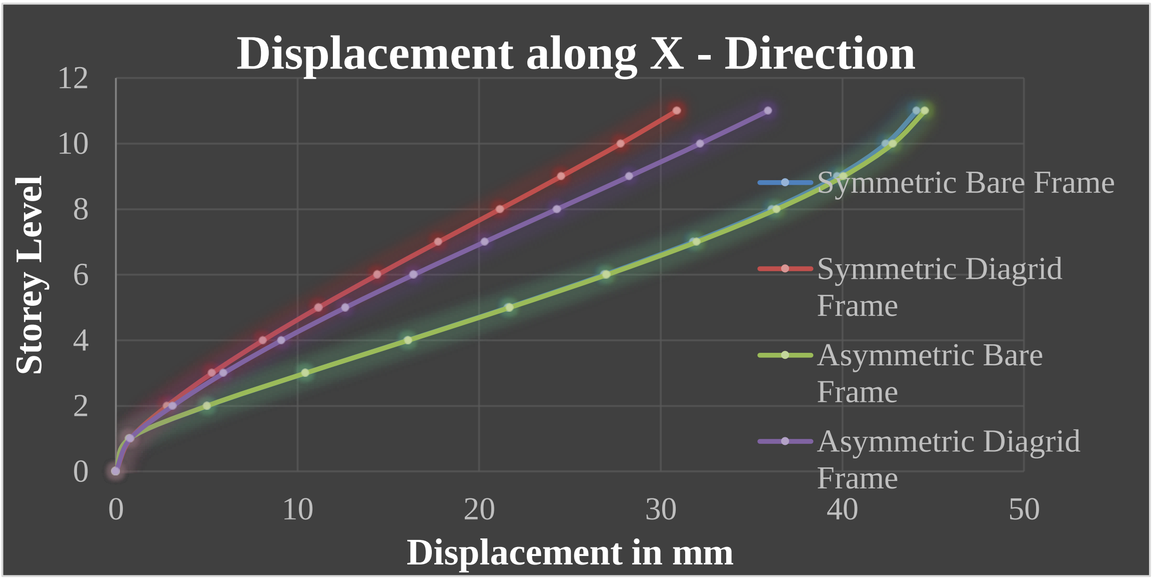

Figure 4.1 Lateral Displacement along X Direction

Table 4.3: Lateral Displacement for symmetric frame along Y - Direction

	Y - Direction	
Storey Level	**Symmetric Bare Frame**	**Symmetric Diagrid Frame**
11	44.102	30.895
10	42.408	27.803
9	39.73	24.523
8	36.134	21.157
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6	26.893	14.405
5	21.598	11.158
4	16.059	8.1
3	10.439	5.298
2	5.03	2.813
1	0.743	0.796
0	0	0

Table 4.4: Lateral Displacement for Asymmetric frame along Y - Direction

	Y - Direction	
Storey Level	**Asymmetric Bare Frame**	**Asymmetric Diagrid Frame**
11	43.507	30.277
10	41.837	27.152
9	39.198	23.879
8	35.651	20.54
7	31.37	17.188
6	26.535	13.887
5	21.311	10.706
4	15.846	7.723
3	10.301	5.009
2	4.964	2.642
1	0.734	0.755
0	0	0

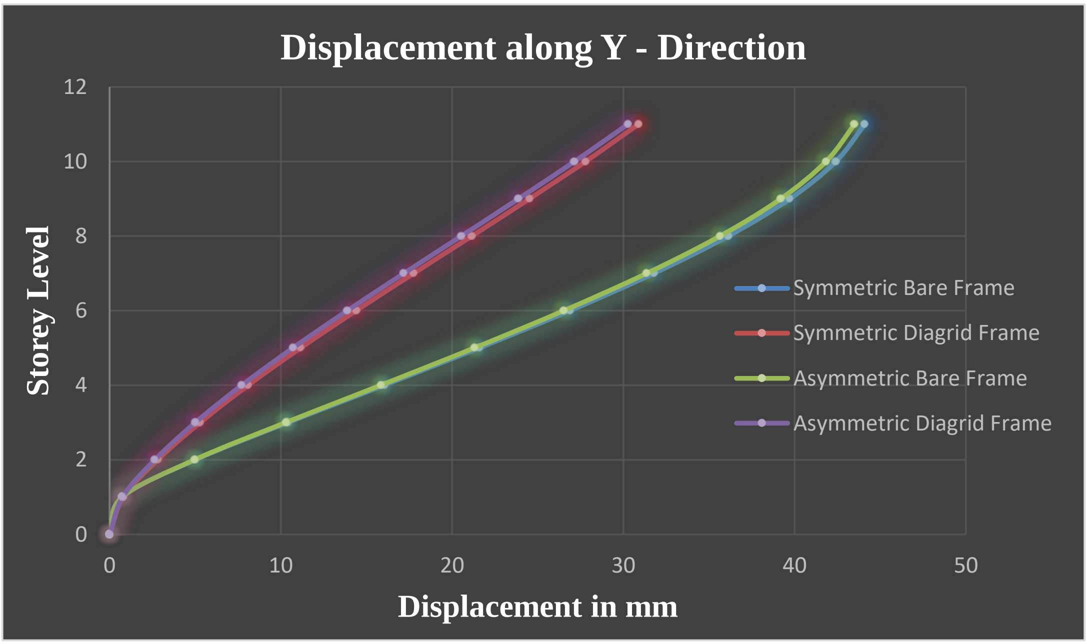

Figure 4.2 Lateral Displacement along Y Direction

4.1.2 OBSERVATION AND DISCUSSION ON LATERAL DISPLACEMENT

It is observed that the displacement values are higher in bare frame models when the building with diagrid system in zone v along x and y direction. The lateral displacement in symmetric structure is lesser then Asymmetric frame building in both direction respectively. The symmetric diagrid frame structure are showing the lesser displacement then the asymmetric diagrid frame structure and diagrid frame structure are resisting the lateral load then the bare frame structure.

4.2 BASE SHEAR

Table 4.5: Lateral Displacement for symmetric frame along X - Direction

X Direction	
Symmetric Bare Frame	**Symmetric Diagrid Frame**
2142.9295	3739.2583

Table 4.6: Lateral Displacement for Asymmetric frame along X - Direction

X Direction	
Asymmetric Bare Frame	**Asymmetric Diagrid Frame**
1726.997	2649.4614

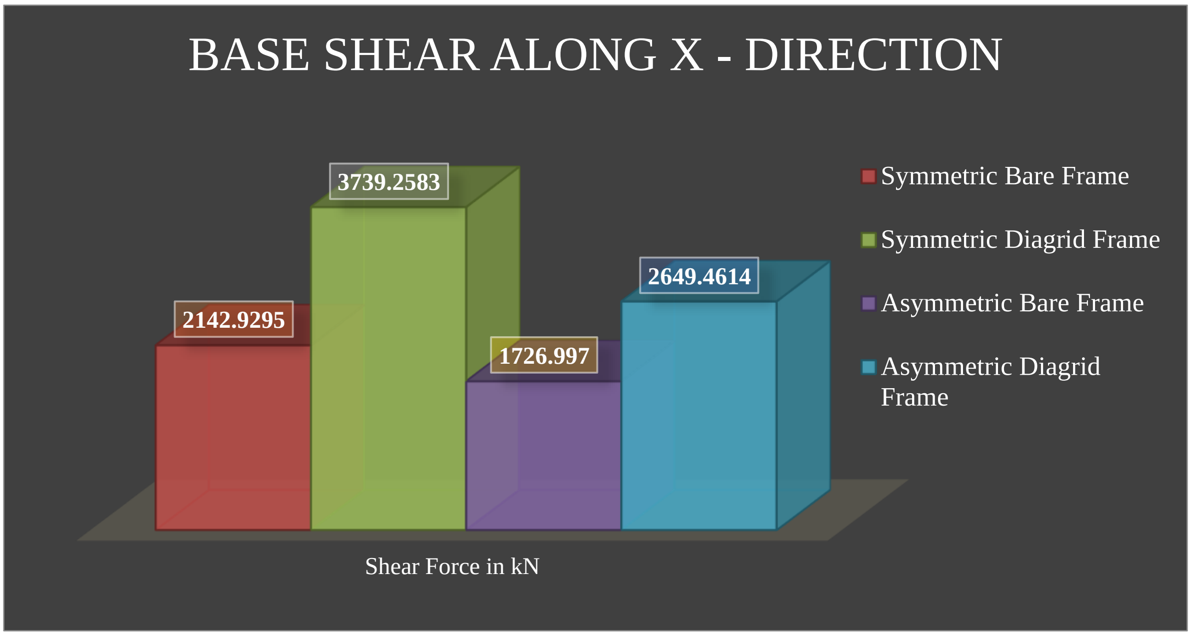

Figure 4.3 Base Shear along X Direction

Table 4.7: Base Shear for symmetric frame along Y- Direction

Y Direction	
Symmetric Bare Frame	**Symmetric Diagrid Frame**
2142.9295	3739.2583

Table 4.8: Base Shear for Asymmetric frame along Y- Direction

Y Direction	
Asymmetric Bare Frame	**Asymmetric Diagrid Frame**
1726.997	3133.7523

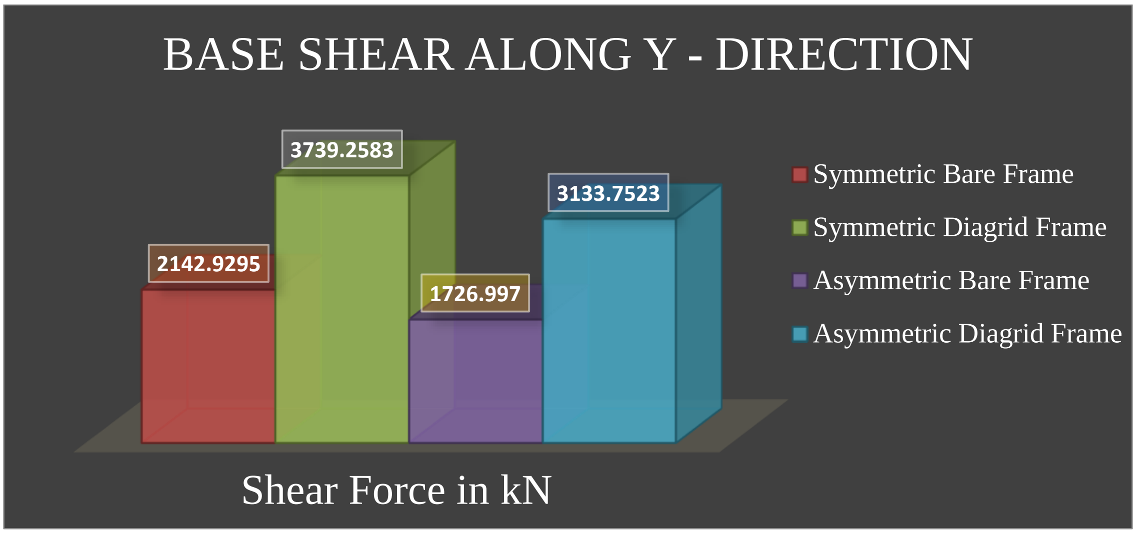

Figure 4.4 Base Shear along Y Direction

4.2.1 OBSERVATION AND DISCUSSION ON BASE SHEAR

It can be observed that the Base shear values are more in the diagrid frame structure when compare to bare frame structure in the both cases such assymmtric and asymmetric plan along the both direction x and y respectively. The Base shear in asymmetric bare frame structure are lesser shear compare to the other all models and symmetric diagrid are showing thehigher base shear along x and y direction respectively. The storey shear in x direction is lesser the shear in y direction.

4.3 TIME PERIOD

Table 4.9: Time Period for symmetric frame

Modes	Symmetric Bare Frame	Symmetric Diagrid Frame
1	1.119	0.665
2	1.119	0.665
3	1	0.195
4	0.36	0.154
5	0.36	0.154
6	0.323	0.079
7	0.202	0.079
8	0.202	0.066
9	0.183	0.057
10	0.135	0.057
11	0.135	0.046
12	0.122	0.046

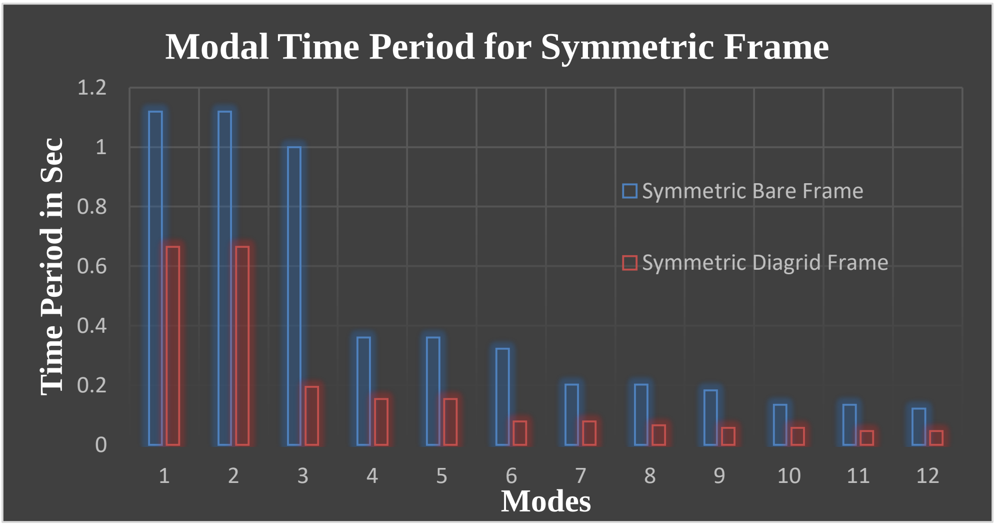

Figure 4.5 Time Period for symmetric frame

Table 4.10: Time Period for Asymmetric frame

Modes	Asymmetric Bare Frame	Asymmetric Diagrid Frame
1	1.126	0.764
2	1.104	0.646
3	0.99	0.191
4	0.362	0.168
5	0.355	0.143
6	0.32	0.084
7	0.203	0.071
8	0.2	0.064
9	0.181	0.06
10	0.134	0.05
11	0.133	0.049
12	0.121	0.042

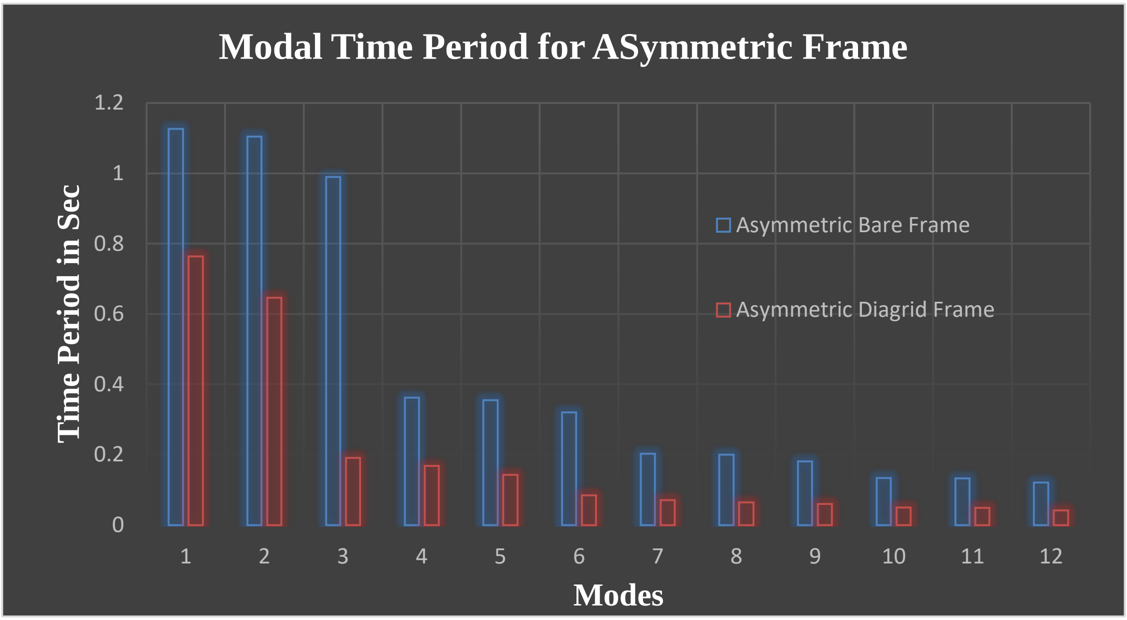

Figure 4.6 Time Period for Asymmetric frame

4.3.1 OBSERVATIONS AND DISCUSSIONS ON MODAL TIME PERIOD

It is observed that the time period is greatly higher for bare frame structure when compared to others. The use of diagrid frame structure reduces the time period required by nearly 50%. This is mainly because the presence of bracings increases the stiffness of the structure and we know that the time period is dependent on the mass and stiffness of the structure.

5. CONCLUSION

1. . Framing building without any load resisting system shows highest drift and displacement value as compared to diagrid system.
2. 2. For all the buildings considered for the study the storey displacement and storey drift values are within the permissible limit.
3. 3. Study shows that diagrid structure decreases bending moment which in results decreases reinforcement
4. requirement.
5. 4. Diagrid structural system has emerged as a better solution for lateral load resisting system in terms of lateral displacement
6. 5. The diagrid elements give sufficient efficiency to lateral loads considering the fact that all the peripheral vertical columns from the diagrid structures have been eliminated. Thus, without the presence of the peripheral columns, the diagrids are able to take a gradual amount of lateral loads.
7. 6. We can also conclude that diagrids give more resistance to lateral displacements when compared to conventional braced frame structures.
8. 7. By observing these results, we can also make a statement that the diagrids are giving more member stiffness than the conventional braced structures.
9. 8. In the end, diagrid structures give more aesthetic look and gives more interior space due to less columns and facade of the building can also be planned more efficiently.

REFERENCES

[1] Mohammed Abdul Rafey and M. A. Azeem.2018. Comparative Analysis of a Diagrid Structure and a Conventional Structure with Chevron Bracing. International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13.

[2] Jerzy Szolomicki, Hanna Golasz-Szolomicka.2017. Application Of The Diagrid System In Modern High-Rise Buildings. International Journal Of Advances In Science Engineering And Technology.
[3] Dr.Gopisiddappa.2017. Performance Study Of High Rise Building With Diagrid System Under Dynamic Loading. International Research Journal of Engineering and Technology.
[4] Chetan S.Pattar.2018. Analysis Of Diagrid Structures With Plan IrregularitY. International Research Journal of Engineering and Technology.
[5] Shubhangi V. Pawar.2017. Earthquake and Wind Analysis of Diagrid Structure. International Journal for Research in Applied Science & Engineering Technology.
[6] Akshat.2018. A Review on Structural Performance of Diagrid Structural System for High Rise Buildings. International Journal of Innovative Research in Science, Engineering and Technology.

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