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Comparative Dynamic Analysis of Bare Frame and Diagrid Frame Building Structures by using Etabs with Symmetric & Asymmetric Plan

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ABSTRACT: High-rise building development is expanding quickly in the modern period all over the world. Due to the shrinking amount of undeveloped land and the widespread metropolitan area, architects and engineers have begun to build cities vertically. Due to its structural effectiveness and aesthetic possibilities, the diagrid structural system has recently been adopted extensively for tall structures. Diagrid structures resist lateral loads more effectively than traditional bare frame buildings with outside vertical columns do because they have inclined columns. The axial motion of the inclined columns that are installed at the outside periphery of the structures in the diagrid system resists the lateral loads. Diagrid structure is made up of inclined columns that are spaced more apart than the vertical columns in a framed tube. As opposed to bending of vertical columns in framed tube structures, lateral stresses are resisted by axial action of the diagonal due to inclined columns.

In the current study, a 13-story structure in zone V seismic zones is examined using ETABS software employing bare frames and diagrids frames. Results such as tale drift, shear, bending, time, and model stiffness are compared with bare frame construction models with symmetrical and asymmetrical plans.

KEYWORDS: Bare Frame and Diagrid Frame, ETABS, like Story Drift, Story Shear, Story Bending, Time Period, Model Stiffness

I. INTRODUCTION

Modern architectural design has resulted in a variety of complexly shaped tall structures, including twisted, slanted, tapered, and freeform towers. As a building's height rises, the structural system that resists lateral loads takes precedence over the system that resists gravity stresses. The following lateral load-resisting systems are frequently used: tubular system, outrigger system, braced tube system, rigid frame, shear wall, and wall-frame. Due to its structural effectiveness and aesthetic potential made possible by the system's distinctive geometric configuration, the diagrid structural system has recently become frequently used for tall steel buildings.

A particular kind of space truss is called a diagrid. It is constructed up of a perimeter grid made of triangulated truss systems. By crossing the diagonal and horizontal elements, a diagrid is created. The Swiss Re building in London, the Hearst Tower in New York, the Cyclone Tower in Asan, Korea, the Capital Gate Tower in Abu Dhabi, and the Jingling Tower in China are prominent examples of diagrid structures. One example of using a diagrid structural system to sustain a difficult shape is the new Central China Television (CCTV) headquarters in Beijing. Diagrid looks good and is clearly identifiable.

DIAGRID STRUCTURE

A skyscraper's (tall building) structural system is made up of triangulated beams, either straight or curved, and a horizontal ring called a diagrid (diagonal grids) structure. In a nutshell, it is composed of diagonal and horizontal components that intersect. Compared to a typical steel frame, it uses less structural steel. Diagrid looks good and is clearly identifiable. A diagrid system's design and effectiveness result in fewer structural elements being needed on

building facades, which means less blockage to the outside view. The diagrid system's structural effectiveness also aids in avoiding interior and corner columns, providing for a great deal of freedom in the floor layout. Comparing a perimeter "diagrid" system to a typical moment-frame structure, one can save about 20% of the structural steel weight.

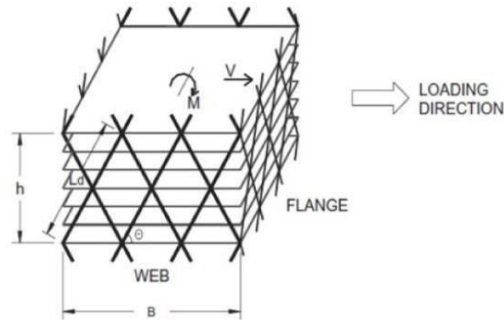


Fig3.1Diagrid Structure



Fig3.2 Hearst Tower, NewYork

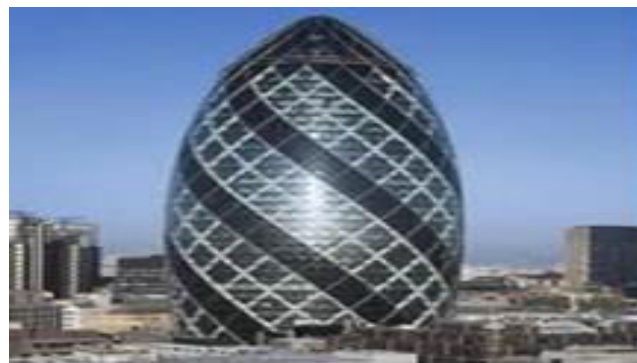


Fig3.3 Swiss Re, London, UK

MERITS AND DEMERITS OF DIAGRID STRUCTURAL SYSTEM

MERITS OF DIAGRID STRUCTURAL SYSTEM

1. Increased stability due to triangulation
2. Combination of the gravity and lateral load-bearing systems, potentially providing more efficiency.
3. Provision of alternate load paths (redundancy) in the event of a structural failure (which lacks in case of conventional framed building).
4. Reduced weight of the super structure can translate in to a reduced load on the foundations.
5. By adopting this system, we can save up to about 20% of structural steel in high rise buildings compared to frame structures.

DEMERITS OF DIAGRIDS

1. As of yet, the Diagrid Construction techniques are not thoroughly explored.
2. Lack of availability of skilled workers. Construction crews have little or no experience creating a Diagrid skyscraper.
3. The Diagrid can dominate aesthetically, which can be an issue depending up on design intent.
4. It is hard to design windows that are create angular language from floor to floor.
5. The Dia-grid is heavy-handed if not executed properly.

ETABS SOFTWARE

ETABS, which stands for Extended Three-Dimensional Analysis of Building System, is a piece of software. It is a piece of building software that considers the analysis and design of multi-story buildings. The network-like geometry that is unique to the current class of structure is used to coordinate all of the demonstrating tools and formats, code-based burden remedies, examination procedures, and arrangement techniques. ETABS is currently the market's dominant structural programming. This product is used by many configuration organizations for task configuration purposes. In light of the foregoing, the main focus of this study is the close evaluation of the findings from the physical dissection and use of ETABS software for the investigation of a widely recognized structure. The fundamental response to tremor depends on the dynamic properties of the structures and the strength, length, and recurrence content of the current ground movement. Auxiliary research entails assurance of the overall design and all individual components of a given structure in order for it to perform the function for which it is intended and will soundly survive the impacts that will befall it throughout its valuable life.

We have chosen ETABS due to the subsequent advantages:

- Easy to use interface
- Confirmation with the Indian Standard Codes
- Versatile nature of solving any sort of problem
- Accuracy of the solution.

The software ETABS also offers a cutting-edge user interface, visualization tools, strong analysis and design engines, as well as the ability to do complex finite element and dynamic analysis. Model generation, analysis, and design, as well as result verification, are all provided by this software. The professionals choose ETABS to design low and high-rise buildings, culverts, petrochemical facilities, tunnels, bridges, piles, and a variety of other structures out of steel, concrete, timber, aluminum, and cold-formed steel.

OBJECTIVES OF THE STUDY

The following are the main objectives of the project

1. To study the seismic behavior of building by using IS 1893:2016 (part-1).
2. To analyze the 13stories diagrid building in high seismic zone i.e., zone-V.
3. To compare the results of story drift, shear force, bending moment, building torsion of buildings.
4. To study the multistory buildings in ETABS V20.0.0 in Dynamic Analysis.

SCOPE OF THE STUDY

"Diagrid" refers to the collection of triangles that are created when different materials, such as concrete, steel, or wood, are brought together to form a framework. Diagrids can withstand lateral loads operating on the building as well as gravity. The use of diagonal elements improves the structure's stiffness and strength. By employing response spectrum analysis and wind loading analysis, the current study compares the performance of dia-grid buildings under seismic and wind loading conditions.

I. LITERATURE REVIEW

Ashwini. D, Abdul Quddus Suhaib (2020) In their study they had been put effort towards analysis of the ordinary moment resisting building located over a medium soil considered. The building is constructed with earthquake design stipulations of Indian standards with high seismic zone condition by using Etabs with bare frame and diagrid frame building structures of both comparing symmetric and asymmetric plan. The outcomes of their study parameters like lateral story displacement, story drift, story shear, base shear and modal period. The diagrid structural system has become a more effective lateral load resisting system in terms of lateral displacement, according to the project's conclusion. Additionally, they claim that the diagrid provides greater member stiffness than traditional braced constructions. Because there are fewer columns in diagrid constructions, the inner space is larger, and the façade of the building can be planned more effectively as a result of these findings.

Khushbu Jani, et. al. (2013) compared analysis results over time, in terms of top storey displacement, and in terms of inter-story drift. For the modelling and analysis of structural members, Staad Pro software is employed. According to IS 800:2007, all structural components are created taking into account all load combinations. For the structure's study and design, both dynamic along wind and across wind are taken into account. For a 36-story skyscraper, the load distribution in a grid system is also investigated. Similar research and design work is done for grid buildings with 50, 60, 70, and 80 stories.

Rohit Kumar Singh, et. al. (2014) Storey drift, node to node displacement, bending moment, shear pressures, area of reinforcement, and even the economical side of the analysis are all compared in detail. The amount of drift achieved in Diagrid buildings is around half that of conventional buildings. When compared to a normal building, the steel reinforcement utilized in Diagrid structures is shown to be 33% less. It has been shown that the Diagrid construction is more successful at resisting lateral loads since it has diagonal columns throughout its perimeter. They came to the conclusion that diagrid buildings had greater lateral load resistance, aesthetic appeal, and structural performance.

II. 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 asymmetric structure with diagrid in seismic zone 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

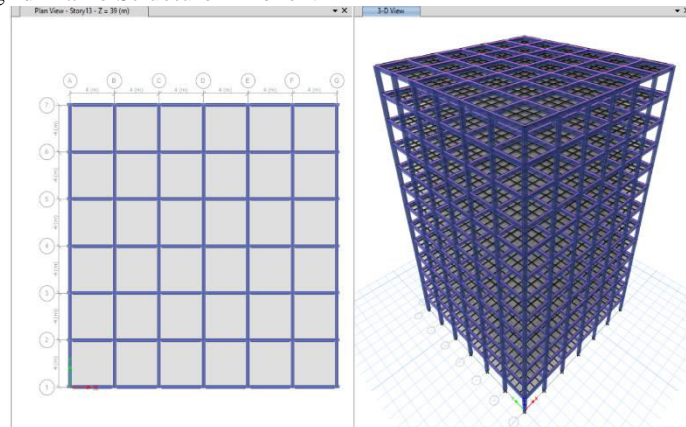


Fig3.1 Showing plan and 3D view of Symmetric Bare Frame in Etabs

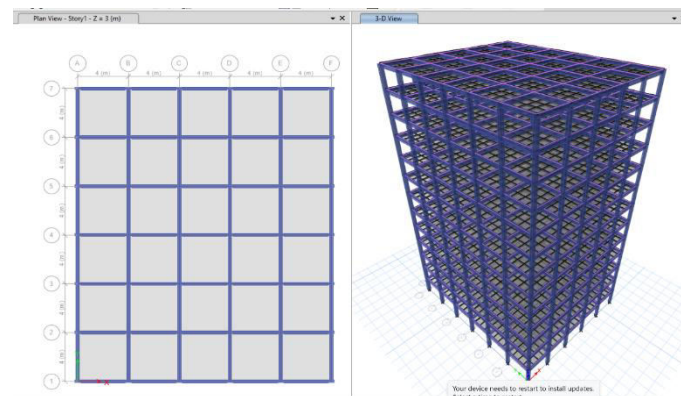


Fig3.2 Showing plan and 3D view of Asymmetric Bare Frame in Etabs

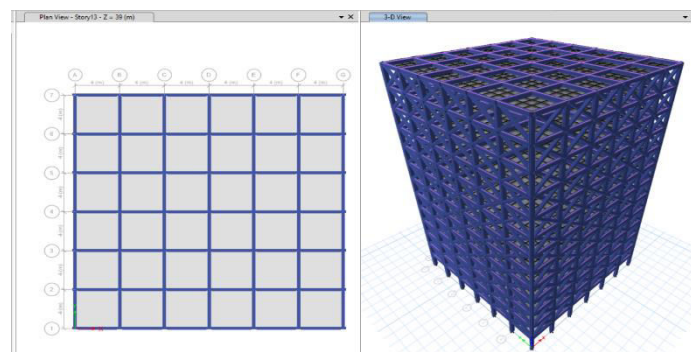


Fig3.3 Showing plan and 3D view of Symmetric Diagrid Frame in Etabs

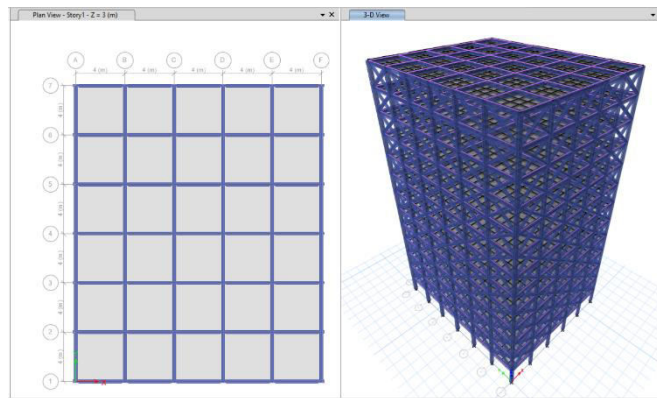


Fig3.4 Showing plan and 3D view of Asymmetric Diagrid Frame in Etabs

III. MODELLING OF BUILDING SYSTEM

Problem Statement:

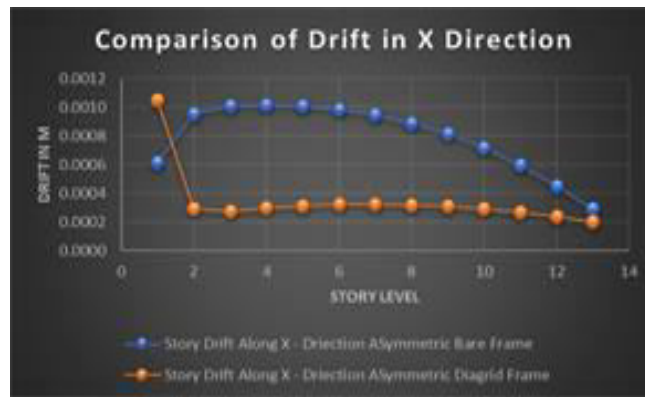
In this present study, analysis of G+12 stories building in Zone V seismic zone is carried out in ETABS

Basic parameters considered for the analysis are

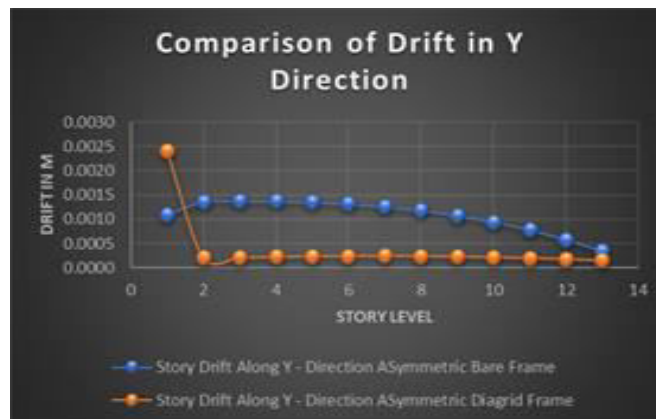
1. Grade of concrete :M40
2. Grade of Reinforcing steel : HYSD Fe500
3. Dimension of Plan:
 - Bare Frame :24mX24m
 - X-Direction 6 spans : Each 4m
 - Y-Direction 6 spans : Each 4m
 - Diagrid Frame :20mX24m
 - X-Direction 5 spans : Each 4m
 - Y-Direction 6 spans : Each 4m
4. Dimension of Beam :0.25mX0.40m
5. Dimension of Column :0.25mX0.50m
6. Dimension of Diagrid Beam :0.25mX0.25m
7. Thickness of Slab : 0.15m
8. Height of Bottom Story : 3m
9. Height of Remaining Story : 3m
10. Live Load : 3 KN/m²
11. Dead Load : 2 KN/m²
12. Floor Finish Load : 2 KN/m²
13. Density of Concrete : 40 KN/m³
14. Seismic Zone : Zone V
15. Seismic coefficient factor for Zone V: 0.36
16. Site Type : II
17. Importance Factor : 1
18. Response Reduction Factor : 5
19. Damping Ratio : 5%
20. Structure class : B
21. Basic wind speed : 44 m/s
22. Risk size coefficient(K1) : 1
23. Terrain size coefficient (K2) : 1.1
24. Topography factor (K3) : 1
25. Wind design code : IS 875:2015 (part3)
26. RCC design code : IS 456:2000
27. Earthquake design code: IS 1893:2016 (part1)

IV. RESULT AND ANALYSIS

Zone V: Comparison Tabulated Values and Graphs for Bare and Diagrid Frame Buildings



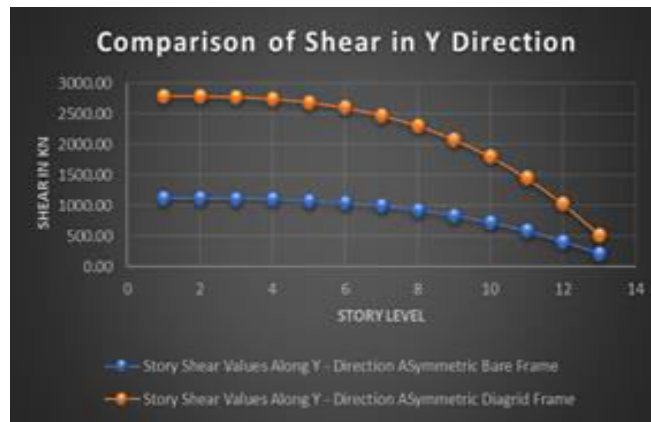
Graph 5.1 Showing comparison of story drift in X direction Z-V



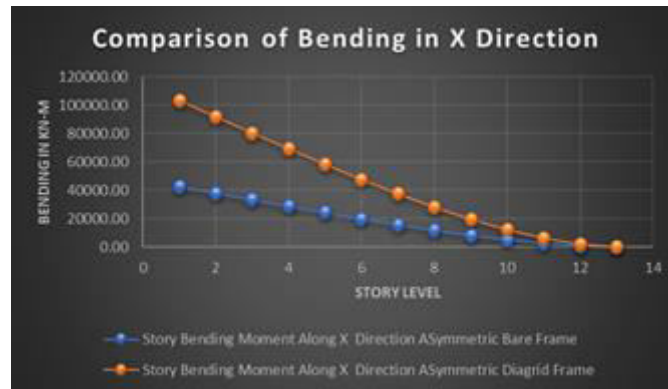
Graph 5.2 Showing comparison of story drift in Y direction Z-V



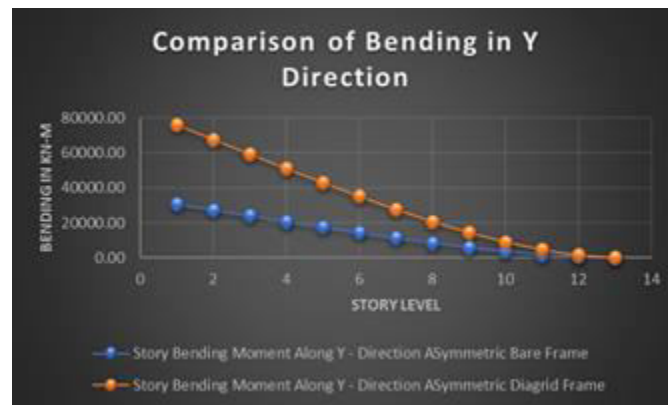
Graph 5.3 Showing comparison of story shear in X direction Z-V



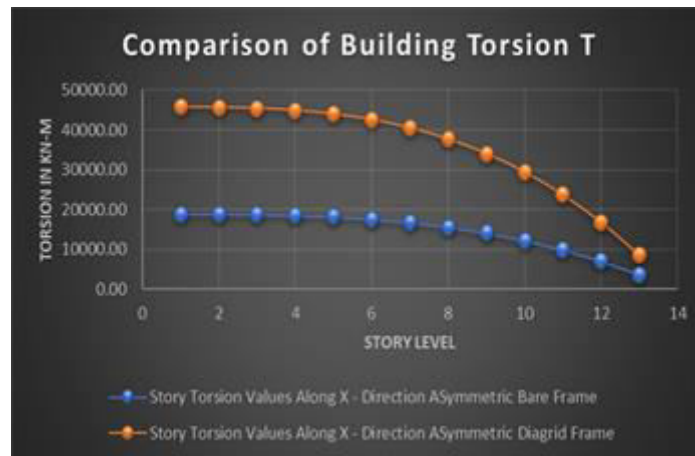
Graph 5.4 Showing comparison of story shear in Y direction Z-V



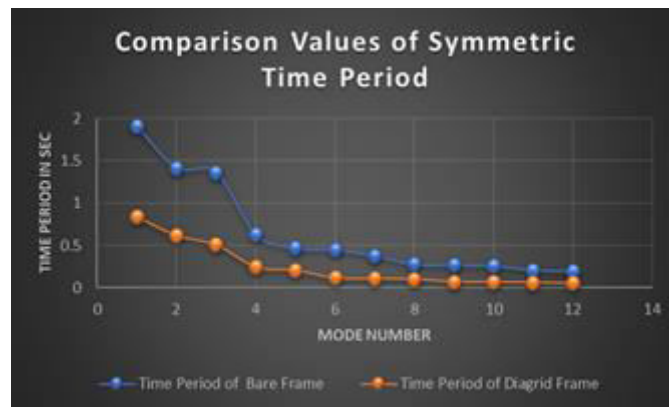
Graph 5.5 Showing comparison of story bending in X direction Z-V



Graph 5.6 Showing comparison of story bending in Y direction Z-V



Graph 5.7 Showing comparison of building torsion in Z-V



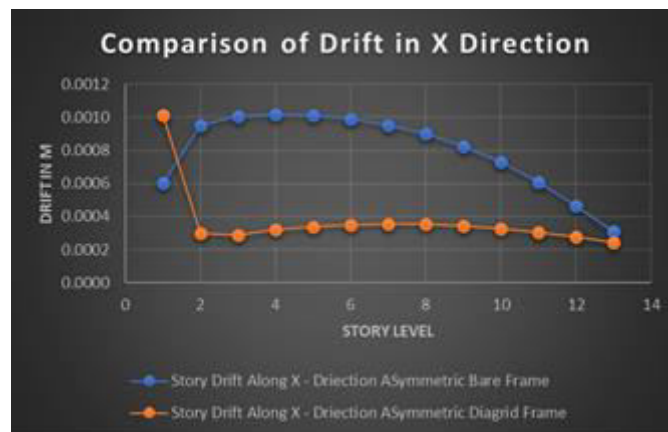
Graph 5.8 Showing comparison values of time period in Z-V



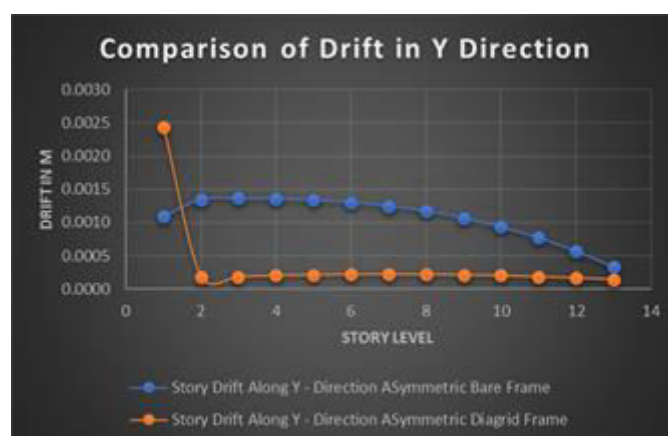
Graph 5.9 Showing comparison of model stiffness in X Direction Z-V



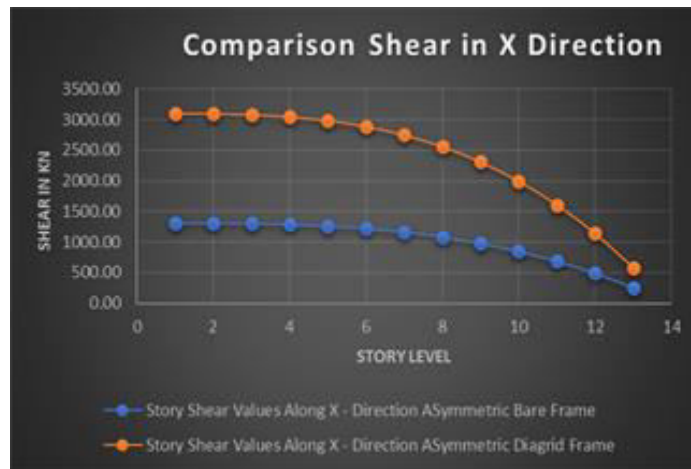
Graph 5.10 Showing comparison of model stiffness in Y Direction Z-V



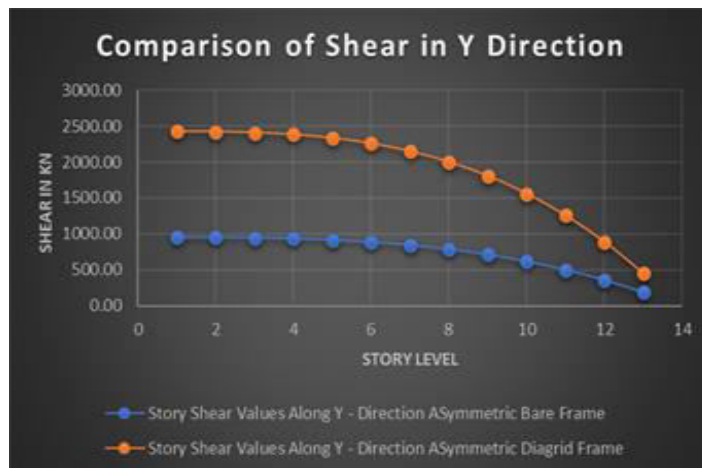
Graph 5.11 Showing comparison of story drift in X direction Z-V



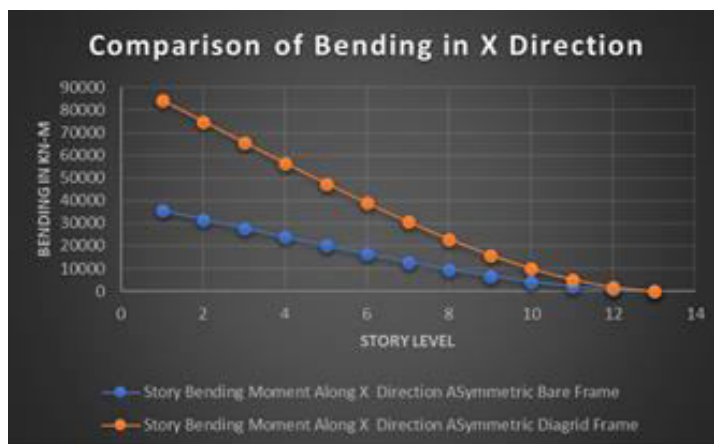
Graph 5.12 Showing comparison of story drift in Y direction Z-V



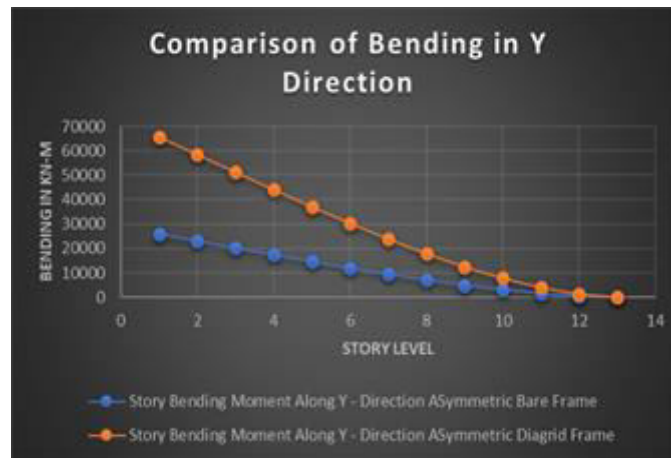
Graph 5.13 Showing comparison of story shear in X direction Z-V



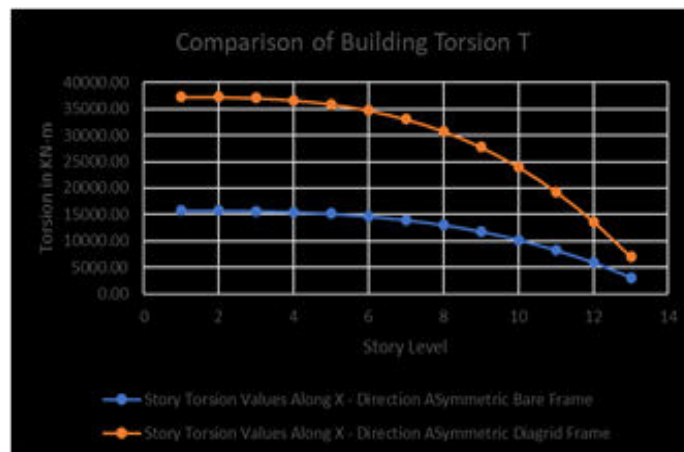
Graph 5.14 Showing comparison of story shear in Y direction Z-V



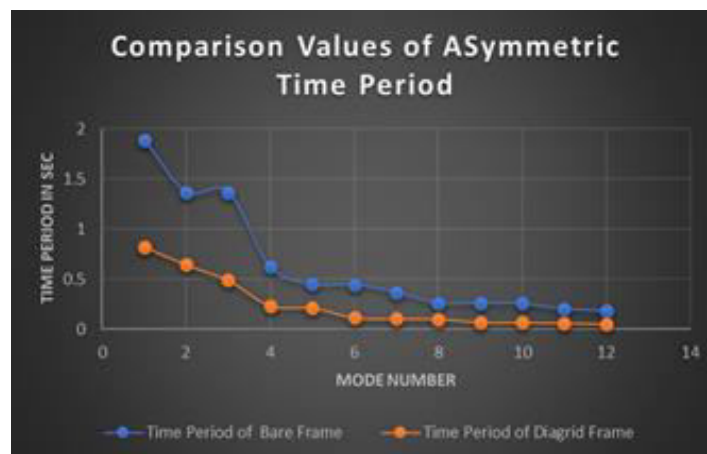
Graph 5.15 Showing comparison of story bending in X direction Z-V



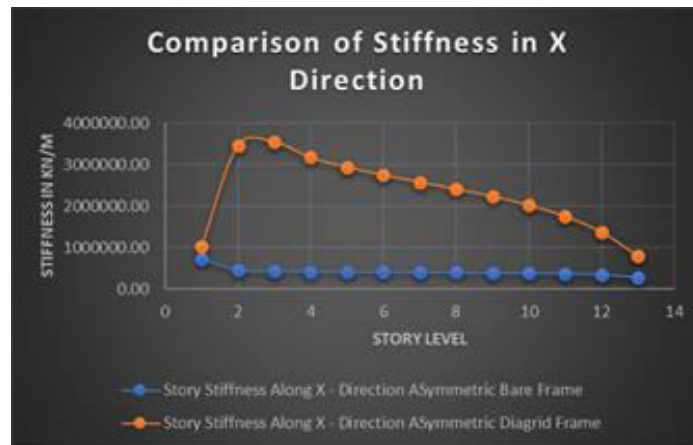
Graph 5.16 Showing comparison of story bending in Y direction Z-V



Graph 5.17 Showing comparison of building torsion in Z-V



Graph 5.18 Showing comparison values of time period in Z-V



Graph 5.19 Showing comparison of model stiffness in X Direction Z-V



Graph 5.20 Showing comparison of model stiffness in Y Direction Z-V

V. CONCLUSIONS

In this present project report seismic analysis of a G+12 building with bare frame and diagrid frame structures with symmetric and asymmetric plan carried out. Building is modeled as 3D frame using ETABS software which is analyzed by dynamic analysis. Following conclusions have been drawn from the seismic analysis of the building.

1. The story drift values by comparing both bare and diagrid frame structures is varying from story 1 to story 13 for seismic zone V. The story drift values for symmetric and asymmetric bare frame are higher than the diagrid frame along X and Y direction.
2. The story shear values by comparing both bare and diagrid frame structures is varying from story 1 to story 13 for seismic zone V. The story drift values for symmetric and asymmetric diagrid frame are higher than the bare frame along X and Y direction.
3. The story bending values by comparing both bare and diagrid frame structures is varying from story 1 to story 13 for seismic zone V. The story drift values for symmetric and asymmetric bare frame are higher than the diagrid frame along X and Y direction.
4. The story torsion values by comparing both bare and diagrid frame structures is varying from story 1 to story 13 for seismic zone V. The story drift values for symmetric and asymmetric bare frame are higher than the diagrid frame along X and Y direction.
5. From the results of time period and frequency it is clearly shows that the bare frame time period values are higher than the diagrid frame and the values are decreasing from mode 1 to mode 12.

6. The story stiffness values by comparing both bare and diagrid frame structures is varying from story 1 to story 13 for seismic zone V. The story drift values for symmetric and asymmetric diagrid frame are higher than the bare frame along X and Y direction.
7. In this project by comparing two models, the diagrid frame structure having more resistance against later loads by analysis when compared with bare frame structure.
8. In this project the models are considered symmetric and asymmetric plan with bare and diagrid frame structures to know the severity seismic action on the building in zone-v. Thus, thereby we can consider the plan of the building with less effect.

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