COMPARATIVE ANALYSIS OF DIA GRID BUILDING IN DIFFERENT SEISMIC ZONES

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Abstract Now-a-days, there is rapid increase in development of tall buildings all over the world. Advances in construction technology, materials, structural systems and analytical methods for analysis and design facilitated the growth of high rise buildings. It is very important that the selected structural system is such that the structural elements are utilized effectively while satisfying design requirements. Recently dia grid structural system is adopted in tall buildings due to its structural efficiency and flexibility in architectural planning. Compared to closely spaced vertical columns in framed tube, diagrid structure consists of inclined columns on the exterior surface of building. Due to inclined columns lateral loads are resisted by axial action of the diagonal compared to bending of vertical columns in framed tube structure.

In the present study a10 stories building is analyzed by using ETABS software by using dia grids in different seismic zones. The results like story drift, story shear, story bending and time period, are compared with bare frame building model.

Key words: dia grid, ETABS, like story drift, story shear, story bending, time period,

1. INTRODUCTION

The contemporary architectural design trend has produced various complex shaped tall buildings such as twisted, tilted, tapered and freeform towers. As the height of building increase, the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. The lateral load resisting systems that are widely used are: rigid frame, shear wall, wall-frame, braced tube system, outrigger system and tubular system. Recently, the diagrid structural system is widely used for tall steel buildings due to its structural efficiency and aesthetic potential provided by the unique geometric configuration of the system.

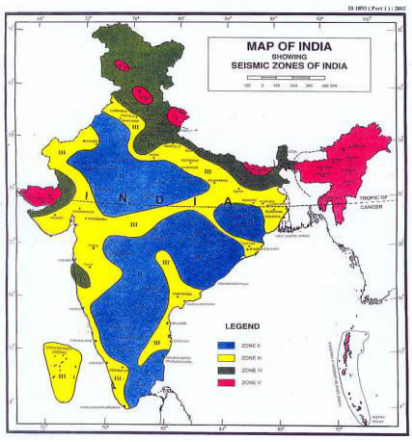
Diagrid is a particular form of space truss. It consists of perimeter grid made up of a series of triangulated truss system. Diagrid is formed by intersecting the diagonal and horizontal components. The famous examples of diagrid structure all around the world are the Swiss Re in London, Hearst Tower in New York, Cyclone Tower in Asan (Korea), Capital Gate Tower in Abu Dhabi and Jinling Tower in China. The new headquarter for Central China Television (CCTV) in Beijing is one of the examples of utilization of diagrid structural system to support the challenging shape. Diagrid has good appearance and it is easily recognized.

The configuration and efficiency of a diagrid system reduce the number of structural element required on the facade of the buildings, therefore less obstruction to the outside view. The structural efficiency of diagrid system also helps in avoiding interior and corner columns, therefore allowing significant flexibility with the floor plan. Perimeter diagrid system saves approximately 20 percent of the structural steel weight when compared to a conventional moment-frame structure.

Dia grid structure

Seismic zones in India

Every nation carries out mapping of its territory based on all natural disasters like earthquake, cyclone, flood and volcano etc.. This mapping is done on the basis of past history and factors responsible for such disaster of present in that area. This mapping helps people to design their home and other infrastructure so that they don't become the victim of such disaster and can withstand disasters with as minimum as possible loss of life and property. Code of practice of all nations for design of buildings and other structure recommended design guidelines based on such mapping or zoning.



Seismic zone map in India

Objectives of the study

The following are the main objectives of the project

1. To study the seismic behavior of building by using IS 1893:2002
2. To analyse the10 stories dia grid building in different seismic zones.
3. To compare the results of story drift, shear force, bending moment, building torsion of buildings.
4. To study the multi story buildings in ETABS in Response spectrum analysis.

2. LITERATURE REVIEWS

Khushbu Jani, et. al. studied comparison of analysis results in terms of time period, top storey displacement and inter-storey drift. ETABS software is used for modeling and analysis of structural members. All structural members are designed as per IS 800:2007 considering all load combinations. Dynamic along wind and across wind are considered for analysis and design of the structure. Load distribution in dia grid system is also studied for 36 storied building. Similarly, analysis and design of 50, 60, 70 and 80 storied dia grid structures is carried out.

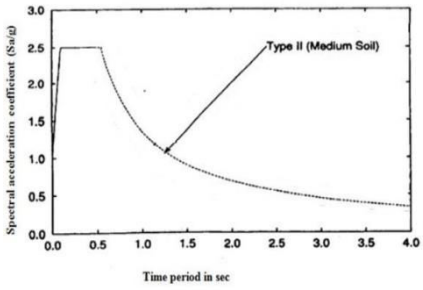
Femy Maria Thomas, et. al. studied the concept of steel diagrid structural system by conducting literature review, then optimum configuration for building and optimum angle for diagrid is found out comparing square, rectangular and circular building with same plan area using ETABS software. Square and circular Diagrid buildings perform almost equally better than rectangular diagrid buildings and circular Diagrid buildings perform better than square diagrid buildings.

Rohit Kumar Singh, et. al. studied comparison of analysis results in terms of storey drift, node to node displacement, bending moment, shear forces, area of reinforcement, and also the economical aspect is presented. Drift in Diagrid building is approximately half to that obtained in conventional building. In these steel reinforcement used in Diagrid structure is found to be 33% less compared to conventional building. It is observed that due to diagonal columns in periphery of the structures, the Diagrid structure is more effective in lateral load resistance. They concluded that the diagrid buildings show structural performance, material saving property, better resistance to lateral loads, aesthetic look.

3. METHODOLOGY AND TYPES OF LOADS

Response spectrum analysis

The representation of maximum response of idealized single degree freedom system having certain period and damping, during earthquake ground motions. This analysis is carried out according to the code IS 1893-2002 (part1). Here type of soil, seismic zone factor should be entered from IS 1893-2002 (part1). The standard response spectra for type of soil considered is applied to building for the analysis in ETABS 2013 software. Following diagram shows the standard response spectrum for medium soil type and that can be given in the form of time period versus spectral acceleration coefficient (Sa/g).



Response spectrum for medium soil type for 5% damping

This approach permits the multiple modes of response of a building to be taken in to account (in the frequency domain). This is required in many building codes for all except very simple or very complex structures. The response of a structure can be defined as a combination of many special shapes (modes) that in a vibrating string correspond to the "harmonic" computer analysis can be used to determine these modes for a structure. For each mode, a response is read from the design spectrum, based on the modal frequency and the modal mass, and they are then combined to provide an estimate of the total response of the structure. In this we have to calculate the magnitude of forces in all directions i.e. X, Y & Z and then see the effects on the building. Combination methods include the following:

- absolute - peak values are added together
- square root of the sum of the squares (SRSS)
- complete quadratic combination (CQC) - a method that is an improvement on SRSS for closely spaced modes

The result of a response spectrum analysis using the response spectrum from a ground motion is typically different from that which would be calculated directly from a linear dynamic analysis using that ground motion directly, since phase information is lost in the process of generating the response spectrum.

In cases where structures are either too irregular, too tall or of significance to a community in disaster response, the response spectrum approach is no longer appropriate, and more complex analysis is often required, such as non-linear static analysis or dynamic analysis.

Types of loads

Types of loads acting on the structure are:

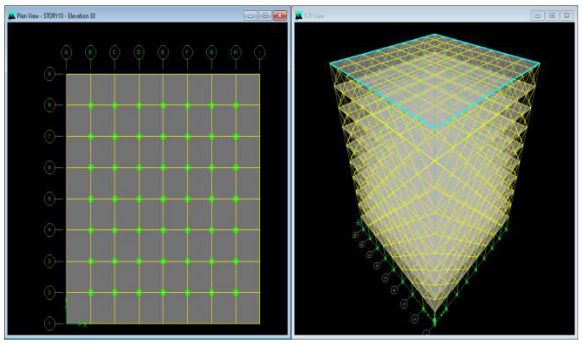
1. Dead loads
2. Imposed loads
3. Wind loads
4. Snow loads
5. Earthquake loads
6. Special loads

In the present study, analysis of G+9 stories building in various seismic zones is carried out in ETABS.

Basic parameters considered for the analysis are

1. Grade of concrete : M40
2. Grade of Reinforcing steel : HYSD Fe600
3. Dimensions of beam : 300mmX300mm, 230mmX500mm
4. Dimensions of column : 500mmX500mm
5. Thickness of slab : 120mm
6. Height of bottom story : 3m
7. Height of Remaining story : 3m
8. Live load : 3.5 KN/m^2
9. Floor load : 1.5 KN/m^2
10. Density of concrete : 25 KN/m^3
11. Seismic Zone : Zone 2, Zone 3, Zone 4, Zone 5
12. Site type : II
13. Importance factor : 1.5

14. Response reduction factor : 5
15. Damping Ratio : 5%
16. Structure class : B
17. Basic wind speed : 39m/s
18. Risk coefficient (K1) : 1.08
19. Terrain size coefficient (K2) : 1.14
20. Topography factor (K3) : 1.36
21. Wind design code : IS 875: 1987 (Part 3)
22. RCC design code : IS 456:2000
23. Steel design code : IS 800: 2007
24. Earth quake design code : IS 1893 : 2002 (Part 1)

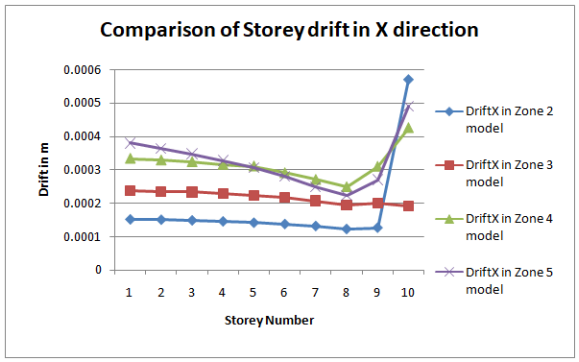


Dia grid structure

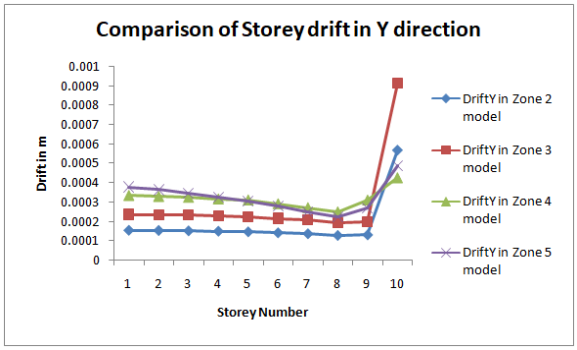
4. RESULTS AND ANALYSIS

Story drift

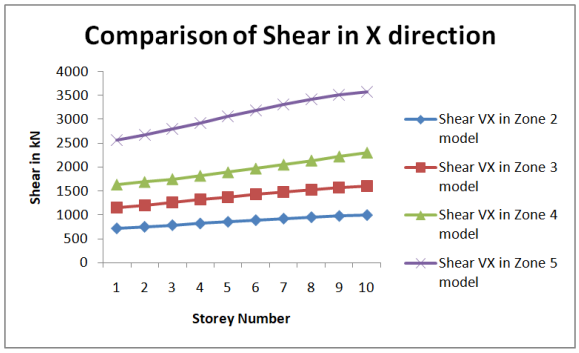
X direction



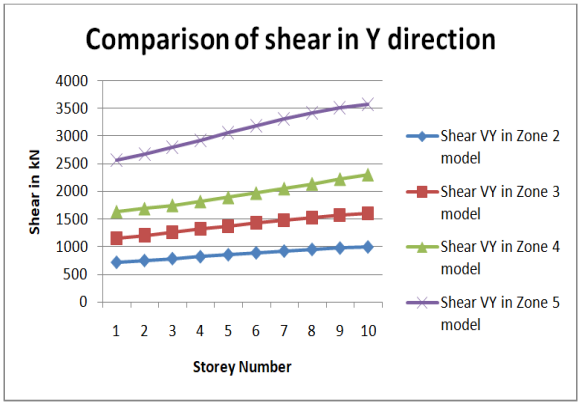
Graph 1: Comparison of storey drift in X direction



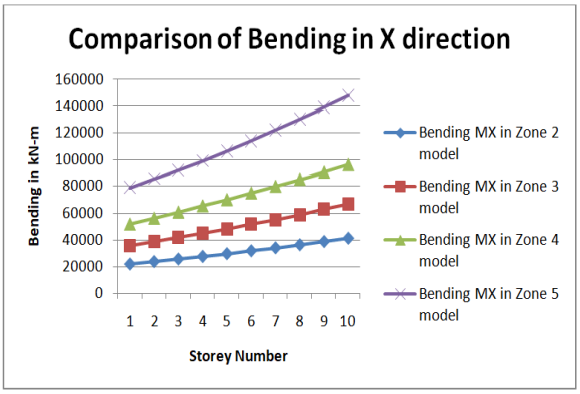
Graph 2: Comparison of storey drift in Y direction



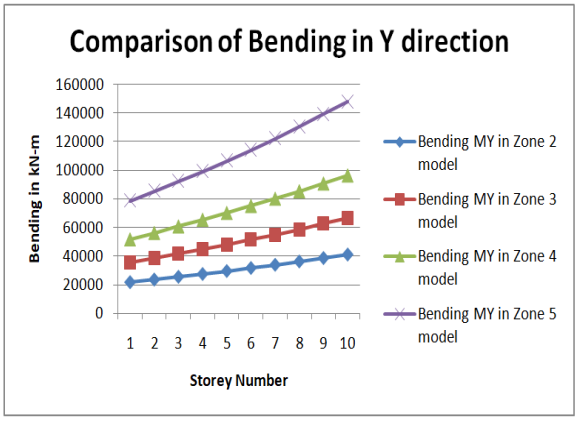
Graph 3: Comparison of storey shear in X direction



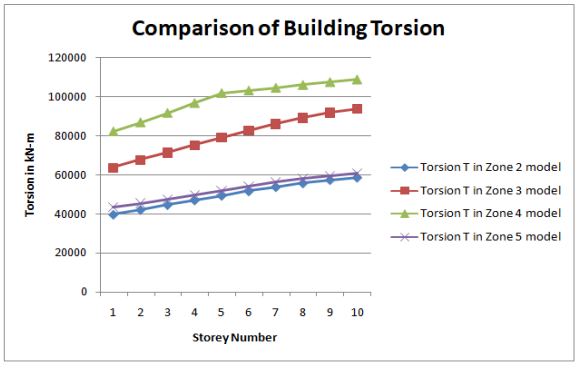
Graph 4: Comparison of storey shear in Y direction



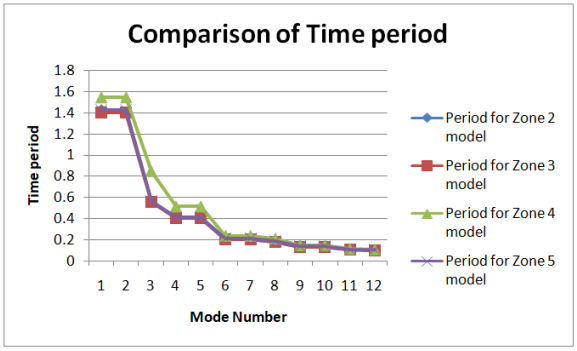
Graph 5: Comparison of bending in X direction



Graph 6: Comparison of bending in Y direction



Graph 7: Comparison of building torsion



Graph 8: Comparison of time period

CONCLUSIONS

1. From the study it is observed that most of the lateral load is resisted by dia grid columns on the periphery, while gravity load is resisted by both the internal columns and peripheral diagonal columns.
2. So, internal columns need to be designed for vertical load only. Due to increase in lever arm of peripheral diagonal columns, diagrid structural system is more effective in lateral load resistance.
3. Lateral and gravity load are resisted by axial force in diagonal members on periphery of structure, which make system more effective. Diagrid structural system provides more flexibility in planning interior space and façade of the building.
4. The values of story drift in X direction and Y direction has higher values for bare frame building model than dia grid models.
5. The values of shear, bending in X direction and Y direction has higher values for dia grid building in Zone 5 condition than remaining models.
6. The torsion has higher intensities for bare frame models than the dia grid building structures.
7. The time period has higher values in case of bare frame model than remaining building structures.
8. Model stiffness has higher values for dia grid building models than bare frame structure.

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