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A Review of Study and Analysis of Time History Analysis of Multistory RCC/ Steel Buildings using Etabs Software

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ABSTRACT

It is necessary to understand the seismic behavior of buildings of similar design under different earthquake intensities. To determine seismic responses, it is necessary to perform a seismic analysis of the structure using the various methods available. Diagonal structures are extrinsic structures consisting of diagonal arcs, circumferential links, and an inner core. These diagonal members bear the gravity load and lateral load through axial movement of the member. Due to the structural efficiency of diagonal grids, interior columns and corner columns can be eliminated, providing flexibility in the floor plan. The concept of today's high-rise buildings is rooted in the architectural features of the building's geometry, combined with solidity and lightness. Therefore, the architectural concept and the structural concept must go hand in hand. On this basis, many lateral load resistance systems have been developed. The tubular system is the latest technology in this field. Recently, high-rise building technology is based on this system.

KEY WORD- Time Period, Steel Weight, ETABS Software

1. INTRODUCTION

This procedure does not require a dynamic analysis, but takes into account the building dynamics in an approximate manner. The static method is the simplest method - it requires less computational efforts and is based on the formula given in the Code of Practice. First, the design base shear for the entire building is calculated, and then distributed along the building height. Lateral forces are distributed at all floor levels to the elements resisting the lateral load. Diagrid is another, more recent invention in this field, which is a breakthrough in the tubular system. Diagrid is the best choice when a tubular system fails to meet requirements, especially in the case of complex geometries. In this work, diagonal and tubular buildings were compared to study the structural efficiency of both types of buildings [1]. For this purpose, a comparison is made between different building models with a diagonal grid and the respective tubular building models. The complex geometries of buildings, coupled with the high cost of land, emphasize the need to consider architectural ideas and structural concepts side by side. As the height of the building increases, the lateral load resisting system is more important than the gravity load resisting system. There are a number of lateral load resisting systems, such as moment-resistant frame system, braced frame system, shear wall system, and advanced structural systems with tubular shapes [2].

In high-rise buildings, as the height of the structure increases, consideration of lateral load becomes the most important factor. There are many lateral load resisting systems, such as steel frame system, shear wall, reinforced pipe system, anchorage system, and tubular system. Currently, the inclined structural system is widely used in high-rise buildings due to its unique geometric configuration. This system is a combination of triangular beams that can be straight or curved and horizontal loops. The Diagrid structure itself acts as inclined columns and strengthening elements, thus withstanding gravity and lateral loads. The purpose of using inclined structure in high-rise buildings is, firstly, to increase the stability of the structure due to its triangular configuration, and secondly, to provide an alternative loading path in case of structural failure [3].

This work deals with the comparative study of inclined structure with traditional building subjected to lateral loading. The construction of high-rise buildings or high-rise structures is more common in this era; Due to population increase and economic prosperity and also due to scarcity of land, skyscrapers are preferred. Height is the main criterion in this type of building, and the demand for high-rise buildings has increased due to increasing demand for commercial and residential spaces, advances in construction, high-strength structural elements and materials and also various programs such as ETABS [4]. These are the analysis and design programs that have enabled high-rise structures to grow. In the nineteenth century, high-rise buildings were constructed in the United States of America, but nowadays, due to the needs of people, high-rise buildings are being constructed everywhere, which leads to the sustainable development of society, which is “development that meets the expectations and needs of the current generation” without compromising the ability to future generations to meet their requirements.” According to studies and articles published in 1980, most of the high-rise buildings were located in America, and now recent studies show that the number of high-rise buildings and the construction process is higher in Asia.

The percentage in North America and Europe is about 32% and 24%, and in general High-rise building construction and use in commercial office buildings, apartments, etc. [5].

The construction of high-rise buildings is not as easy as ordinary conventional buildings due to the action of lateral loads, the lateral displacement will cause bending and the effects of shear lag will be more serious, which has led to the invention of new systems to resist lateral loads. , known to resist lateral load systems, some consider the tubular system more efficient in terms of weight reduction and better resistance to lateral load. They are made with a strong outer frame to resist lateral loads, allowing the inner frame to support gravity loads only. The space between the interior and exterior is bridged using beams or supports and intentionally left free of columns [6-7].

This increases the effectiveness of the circumferential tube by transferring some of the gravity loads within the structure to it and increasing its ability to resist tipping due to lateral loads. Diagrid or Exo is a new concept in resisting lateral loads in high-rise buildings. This is the latest breakthrough in tubular architecture, where tubes are arranged diagonally along the perimeter of the building. That is, the columns are placed in an inclined position to form a triangular structural configuration, such that all loads acting on the plan are distributed as axial forces; Instead of bending or shearing[8]. The tubular configuration uses the overall dimension of the building plan to counteract the overturning moment. But this potential bending efficiency cannot be fully achieved due to the shear deformation that arises in the building webs. On the other hand, diagonal grid systems, which provide shear strength and stiffness through axial movement in the diagonal bars, rather than bending moment in beams and columns, allow almost full exploitation of the theoretical flexural strength [9].

Today's building technology favors the tubular concept for high-rise buildings. But the diagonal grid is also an important system for resisting lateral loads, which can be used in complex building engineering. Thus, in this study, the diagonal building and the tubular building are compared in order to reveal the structural advantages, if any, of the diagonal building over the tubular building, so as to add the importance of the diagonal grid as a system for resisting lateral loads. For comparison, eight radial grid building models and eight tubular building models were created in ETABS software. The number of floors is taken as a criterion for choosing the model. Models of 24, 30, 36, 42, 48, 54, 60 and 66 floors were used for the study [10].

2. LETERATURE REVIEW

Meer and Moon 2007, Diagrid structures emerge as a new aesthetic trend for high-rise buildings in the modern era of architecture as a more versatile structural system that is a special form of spatial truss. **Kyung Sun Moon (2007)** presents a stiffness design methodology applied to a set of diagonal-line structures 40, 50, 60, 70, and 80 storeys high. The diagonal structure for each floor height is designed with diagonals placed at different angles that gradually change along the building height, to determine the optimal uniform angle for each structure. **Fazlur Khan** proposed the concept of "height award". As buildings become taller, there is a “height premium” due to lateral loads and the demand on the structural system increases dramatically and as a result the total consumption of structural materials increases significantly **(Mair and Moon 2007).** If a rigid frame is used for a very tall building, the column sizes gradually increase towards the base due to the gravitational load accumulated at the base, and the amount of material needed to resist the lateral bearings increases dramatically with height. Khan also realized that a stiffness-based design concept governs the design rather than a strength-based approach when a building is more than 10 storeys in height.

Nishith B. Panchal et.al. This work includes modeling of diagonal structures with 24, 36, 48 and 60 floors. The diagonal structure was designed for each floor height with diagonals placed at different uniform angles, as well as gradually changing angles along the building height, in order to determine the ideal uniform angle for each structure with different heights and to study the structural potential of diagonal grids with varying angles. In this work, a comparative study of the diagonal structural system consisting of 24 floors, 36 floors, 48 floors and 60 floors with diagonal angles of 50.2 degrees, 67.4 degrees, 74.5 degrees and 82.1 degrees was presented. Comparison analysis of the results in terms of upper floor displacement, floor drift, span, diagonal grid angle, steel and concrete consumption are included in this article.

Through the study it was observed that the angle of the diagonal grid in the region of 65° to 75° provides greater rigidity to the diagonal structural system which reflects less displacement of the upper floor, floor deflection, span and floor shear. It also indicates savings in steel and concrete consumption. **Khushboo Jani and Paresh,** The analysis and design of a 36-storey steel building is presented in this article. A regular plan with an area of 36 m x 36 m was considered for the study. Structural element modeling and analysis were performed using ETABS software.

All structural members are designed as per IS 800:2007 considering all load combinations. Wind direction and crosswind dynamics are taken into account when analyzing and designing the structure. The load distribution in the diagonal grid system of a 36-storey building was also studied. Likewise, analysis and design of diagonal structures of 50, 60, 70 and 80 floors are also being carried out.

The results of the analysis were compared in terms of time period, upper displacement, and inter-floor deviation. It was observed from the study that most of the lateral load is resisted by the diagonal columns at the ends, while the gravity load is resisted by the internal columns and the peripheral diagonal columns. Therefore, interior columns should be designed for vertical loading only. Lateral loads and gravity are resisted by the axial force acting on the diagonal members at the perimeter of the structure, making the system more effective.

They concluded that for taldiagrid structures, whose aspect ratios range from about 4 to 9, the ideal angle range is about 60 to 70 degrees. **Nishith B. Panchal (2014)** presents a comparative study of 24 storeys, 36 storeys, 48 storeys and 60 storeys of inclined structural system with diagonal angle of 50.2°, 67.4°, 74.5° and 82.1°. Using ETABs, a comparative analysis of the results in terms of top deck displacement, floor drift, span, diameter angle, and steel and concrete consumption is presented. They concluded that the ideal diameter angle is observed in the region from 65° to 75°.

Harish Varsani (2015) presents a comparative study of a 24 storey building with a 36m x 36m floor plan of a lean-to structural system and a conventional structural steel construction system using ETABS. They compared the analysis results of the floor shear in the form of a graph, indicating that the floor shear of the inclined structure due to earthquake load is higher compared to the traditional structure.

Manthan Shah (2016) presents a comparative study between 4, 8, 12, 16, 20, 40 and 48 storeys with floor plan of 18 m x 18 m tilted structural system and conventional structural system using ETABS. They compared the analysis result to the base shear, where the base shear would be the same in both directions, since it is known that the diagonal grid system is more rigid than the conventional frame, it attracts more lateral force and thus has a base shear up to 12 storeys. After 12 storeys, the static wind loads take over and become the governing forces and the base shear is governed by the static wind loads. Thus, after 12 floors, it is observed that the base shear for both systems is similar.

Deepika R. (2016) Comparative study of 30 storeys with 30 m × 30 m layout of Diagrid structural system and Hexagrid structural system using ETABS. They reached a result by comparing the time period for the first mode in the diagonal structure is 3.268 seconds, while in the hexagonal frame structure it is 3.69 seconds. Harish Varsani (2015) shows the result of comparing the time period of the first mode in the diagonal structure is 2.74 seconds, while in the simple frame structure it is 6.96 seconds. **Manthan Shah (2016)** presents the comparison result of the time period in the form of a graph, which indicates that the time period of the diagonal structure is less than the traditional structure.

Rohit kumar Singh (2014) presents the result of the maximum comparison. The deflection resulting from the load in the inclined structure is 4.4 mm, while the deflection in the traditional structure is 8.8 mm. **Harish Varsani (2015), Manthan Shah (2016), and Deepika R. (2016)** present the comparison result of the floor drift under load in the form of a graph, which indicates that the floor drift is much smaller for the diagonal grid structure compared to the diagonal structure.

Rohit kumar Singh (2014) presents the result of comparing the top floor in inclined construction as 18.8 mm, while in conventional construction it is 34.7 mm. Harish Varsani (2015) observed that diagonal columns resist the lateral loads of the structure, and the displacement of the upper floor is much smaller in a diagonal structure compared to conventional construction. The maximum displacement of the conventional structure is 172.7 mm while the maximum displacement of the inclined structure is only 31.6 mm. **Manthan Shah (2016)** presents the comparison result of top floor displacement in the form of a graph. They note that the drawing pattern is similar, but the overall displacement values are much higher for conventional frames, even though they are designed for excessive column sizes. Thus, it proves the effectiveness of country structures.

Raghunath Deshpande (2015) presents a comparative study of a 60 storey 24m x 24m floor plan with a central wall of inclined structural system and conventional structural system using ETABS. They have presented a stock comparison result for each floor for both systems. the above. The deviation in the traditional system is 84.90 mm, while the deviation in the diagonal system is only 75.00 mm.

3. MODELLING

In diagonal models, the end diagonals are spaced 8 m apart. The diagonal angle is kept uniform for each model. It is assumed that the final conditions of the diagonals are constant and the support conditions are assumed to be constant. The 6-storey diagonal grid unit is used for modeling. Based on the 6-layer module, the specified diagonal angle is 70.6°. In tubular construction models, the distance between columns is less than 4 meters on the outer perimeter of the building. To model these buildings, member departments are kept in the same diagonal grid building for comparison purposes.

4. DIAGRID AND CONVENTIONAL FRAME

For parametric comparison, a symmetrical building is chosen. Seven steel buildings of different heights were designed, analyzed and designed using ETABS software for two structural systems; Diagrid and traditional frame. Analysis and design are performed for permanent loads, live loads, lateral seismic loads and lateral wind loads.

For earthquake loads, static spectrum and response spectrum analyzes are performed. In order to take into account the extreme conditions of lateral loads, the buildings are considered to be in Zone V. The specific parameters for comparison are the base span, maximum lateral displacement of the upper floor, maximum base shear, steel weight and weight difference ratio, maximum floor displacement and maximum floor deflection. In addition, the governing lateral force is also determined.

4.1 Diagrid Buildings

Structural elements such as columns, beams and drop nets are mapped to structural steel properties while panels are CCR. All sections in buildings are optimized for design sections. That is why all buildings of 12 floors and above are divided into three parts along the height of the buildings. For designing diameter grids and columns, built-up box sections are used, and for designing beams, Indian standard I-sections are used.

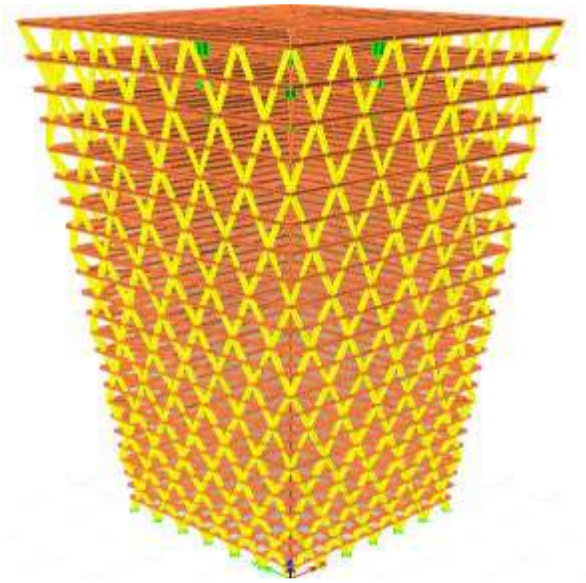

Figure 1 3D View of Storey Diagrid Building

4.2 Conventional Frame Buildings

In the case of conventional frame, as the height increases, stiffness-based design criteria become dominant, and even if the column sections meet the strength criteria, the maximum lateral displacement exceeds 1/500 of the building height. . To overcome these excessive organ sizes, increased height is needed

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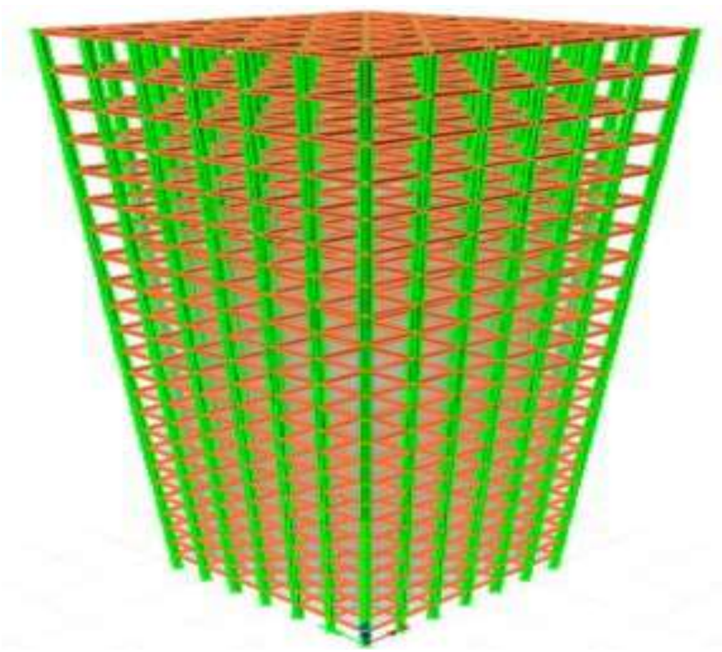

Figure 2 3D View of 24-Storey Conventional Frame Building

5. SEISMIC ANALYSIS

It is necessary to perform a seismic analysis of the structure to determine seismic responses. The analysis can be performed depending on the external action, structure or behavior of the structural material and the type of structural model selected.

5.1 Dynamic Analysis

For a regular structure with finite height, linear static analysis or the equivalent static method can be used. Linear dynamic analysis can be performed by the response spectrum method. The main difference between linear static analysis and linear dynamic analysis is the level of forces and their distribution along the height of the structure. Nonlinear static analysis is an improvement over linear or dynamic static analysis because it allows for nonlinear structure behavior. Nonlinear dynamic analysis is the only way to describe the real behavior of a structure during an earthquake. The method is based on direct numerical integration of the differential equations of motion taking into account elastic deformation of the structural element.

5.2 Equivalent Static Analysis

But this process does not require a dynamic analysis, because it takes into account the building dynamics roughly. The static method is the simplest - it requires less computational effort and relies on the formula provided in the exercise code. First, the basic design shear of the entire building is calculated and then distributed along the building height. At each floor level obtained, the lateral forces are distributed over the individuals on the elements resisting the lateral loads.

5.3 Nonlinear Static Analysis

It is a practical method to estimate the deformation and damage pattern of the structure under permanent vertical load and gradually increasing lateral load.

5.4 Linear Dynamic Analysis

The response spectrum method is a linear dynamic analysis method. In this method, the peak response of the structure during an earthquake is derived directly from the earthquake response, but is accurate enough for structural design applications.

5.5 Nonlinear Dynamic Analysis

This is known as time history analysis. It is an important technique for structural seismic analysis, especially when the estimated structural response is nonlinear.

5.6 Time history analysis

Time history analysis is a step-by-step analysis of the dynamic response of a structure to a specific load that may vary with time. Time history analysis is used to determine the seismic response of a structure.

6. CONCLUSIONS

The variance in the analysis results for Diagrid and Tubular decreases as you move up the models. This indicates that these lateral load resisting systems are more suitable for high-rise buildings. Therefore, the study of the selected models indicates that a building built in a diagonal shape is more structurally efficient than a tubular building. Diagrid structural system emerged as the best solution for lateral load resisting system in terms of lateral displacements, steel weight and stiffness. It is solid enough to withstand wind forces up to higher altitudes. Diagrid construction provides high steel weight efficiency combined with aesthetic appeal. For a 24-storey building, the weight of a conventional structure is 100% greater than that of a building with a diagonal grid. Displacements at each floor and floor deflections are smaller in the diameter grid.

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