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A Review Study of Conventional and Diagrid Building in Seismic Loading

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Abstract: India is a country where many big projects are still being built, because even an undeveloped city needs to be developed for many years. In the current century, a large number of projects are being built in the world, which will have to be given time, which will greatly improve the planning process. It is necessary to understand the seismic behavior of buildings of the same configuration under different earthquake intensities. A seismic analysis of the structure should be carried out using the various methods available to determine the seismic response. Diagonal structures are external structures with diagonal stresses, peripheral connections and an internal core. These diagonal members carry gravity loads and lateral loads through the axial movement of the member. Thanks to the structural efficiency of the diagonal grid, internal columns and corner columns can be eliminated, providing flexibility in the floor plan. The concept of today's high-rise buildings lies in the architectural features of the building's geometry, which combine rigidity and lightness, and therefore the architectural concept and the structural concept must go hand in hand. On this basis, many lateral load resistance systems have been developed. Tubular systems are the latest technology in this area.

Keyword: Diagrid Building, Conventional Frame Building, Time Period, ETABS Software

I. INTRODUCTION

In order to give time and to oppose the development of the cause, it is necessary to adopt the method of building a house. To make the structure a house, advanced construction technology must be used. For special important systems, structural modifications are required, it must be built deeply. In many metropolitan cities, the base is being developed very much, because it is in the context of either subsidence development or high-rise development. The population in the metropolitan cities of Delhi, Bangalore and Mumbai is increasing and the problem of land availability will increase a lot in the coming years, which will change the overall development of the cities very much, so the industries give priority to high-rise development by most of the builders. There are. For example, we increase the number of floors or the height, which increases the cost of the project in terms of steel concrete and other financial developments. Therefore, advanced technologies are generally adopted to create structural facilities. The speed of computers and advanced software devices has made possible new and different approaches to design. The revision study is starting from the architectural stage. The structural design by the grid dimension does not generally result in the most economical member sizes and aesthetic language. The general revision involves the consideration of the entire structure in a series of sub-frames with slabs, beams, columns and footings. This method does not require dynamic analysis, but considers the dynamics of the structure in a limited way. The static method is the simplest method - it requires minimal computational effort and is based on the formulas given in the Code of Practice. First, the design base shear is calculated for the entire structure, and then it is distributed along the height of the structure. The lateral forces are distributed to the structures that resist the lateral load at all lower levels. Diagrid is another recent development in this field, which is a result of tubular systems. Diagrid is the best choice when the tubular system fails to meet the requirements, especially in the case of complex geometries. In this work, diagonal and cylindrical structures are compared to study the structural efficiency of both types of structures [1]. For this purpose, a comparison is made between different building models with diagonal grids and corresponding cylindrical building models. The complex geometry of the structures, combined with the high land costs, emphasizes the need to consider structural concepts and structural concepts side by side. As the height of a building increases, the lateral load-resisting system becomes more important than the gravity load-resisting system. There are several lateral load-resisting systems, such as moment-resisting frame systems, rigid frame systems, shear wall systems, and advanced tubular structural systems [2]. In very tall buildings, lateral load becomes a more important factor to consider as the height of the building increases. There are many lateral load-resisting systems, such as steel frame systems, shear walls, reinforced pipe systems, cable-stayed systems, and tubular systems.

Currently, the inclined structural system is widely used in tall buildings due to its unique geometric configuration. This system is a combination of triangular beams that can be straight or curved and horizontal. The diagrid structure itself acts as a curved column and a stiffening element, thus resisting gravity and lateral loads. The purpose of using curved structures in tall buildings is, firstly, to increase the stability of the structure due to the triangular configuration and, secondly, to provide an alternative load-bearing mechanism in the event of structural failure [3].

This work deals with a comparative study of inclined structures and traditional structures subjected to lateral loading. The construction of tall buildings or high-rise buildings is very common in this era; due to the increase in population and economic prosperity and the scarcity of land, tall buildings are preferred. Height is a major criterion for such buildings, along with the need for commercial and residential space, developments in construction, high-strength structural elements and materials, and various programs such as ETABS [4]. These are analysis and design programs that have facilitated the growth of tall buildings. In the nineteenth century, the tallest buildings were built in the United States, but nowadays, due to human needs, tall buildings are being built everywhere, leading to sustainable development of society, which is "development". that meets the expectations and needs of the present generation "without compromising the ability to meet the needs of future generations." According to research and articles published in 1980, most of the tall buildings were in America, and now recent research shows that the number of tall buildings and the construction process are higher in Asia. The percentages in North America and Europe are about 32% and 24%, and they are mainly used in the construction of tall buildings and commercial office buildings, apartments, etc. [5].

The construction of high-rise buildings is not as easy as that of 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 development of new manufacturing systems. Resist lateral loads. Known as lateral load resisters, some consider the tubular system to be more efficient in terms of reducing weight and better resisting lateral loads. They are constructed with a rigid outer frame to resist lateral loads, allowing the inner frame to support only the gravity load. The space between the inner and outer frames is enclosed using beams or supports and is intentionally left without columns [6-7]. This increases the effectiveness of the circular tube by transferring some of the gravity load inside the building and increasing its ability to resist deflection due to lateral loads. Diagrid or exo is a new concept to resist lateral loads in high-rise buildings. It is a recent development in tubular construction, in which the tubes are arranged diagonally around the perimeter of the building. That is, the columns are placed in an inclined position to create a triangular structural configuration, so that all the loads acting on the system are distributed as axial forces; instead of bending or shearing forces [8]. The tubular configuration uses the mass of the building plan to resist the overturning moment. However, this strong bending effect cannot be fully achieved due to the shear deformation caused by the building web. On the other hand, the diagonal grid system, which provides shear and stiffness by using axial movement in the diagonal bars instead of bending moments in the beams and columns, allows for the full absorption of the theoretical bending strength [9]. Modern construction technology favors the tubular concept for very tall buildings. However, the diagonal grid is an important system for resisting lateral loads, which can be used in complex structural engineering. Therefore, in this study, in order to enhance the importance of diagonal grid as a system to resist lateral loads, diagonal structures and tubular structures are compared to reveal the structural advantages, if any, of diagonal structures over tubular structures. . For comparison, the eight-grid structure model and the eight-tube structure model were created in ETABS software. The lower value is taken as the model selection method.

II. LETERATURE REVIEW

J.P. Anne Sweetlin (2015): The current scenario witnesses a series of natural disasters like earthquakes, tsunamis, floods etc. The most damaging and frequent event among these is earthquakes. Effective design and construction of earthquake resistant structures have gained increasing importance across the world. This paper analyses the seismic resistance of a G+20 multi-storey building using the equivalent static method with the help of ETABS 9.7.4 software. The method includes the seismic coefficient method recommended by IS 1893:2002. The parameters studied are displacement, floor flow and floor shear. The seismic analysis was carried out using E-TABS software and was successfully verified manually as per IS 1893:2002. Complete guidelines for using E-TABS 9.7.4 for seismic coefficient analysis are provided by this paper.

Panchal D.R. and Marathi P.M. (2015) This paper includes comparative study of RCC, steel and composite (G+30) story structures under seismic effects. Equivalent static method has been used for analysis and the structure has been modeled by ETABS. From this study they concluded that steel structures are better than RCC structures for low-rise buildings, but for high-rise buildings composite option is most suitable among the three options. Moreover, self-weight loss of steel structures is 32% less than RCC structures and self-weight loss of composite structures is 30% less than RCC structures. And they also suggest that, bending moment of secondary beams increases by 83.3% on average in steel structures and reduces by 48% in composite structures compared to RCC.

Abhay Guleria (2016) Abhay Guleria presented the analysis of multi-storey building using ETABS and found that floor overturning moment varies inversely with floor height. Moreover, L-shape, I-shape type buildings give almost similar response to overturning moment. With increase in height up to 6 floors the floor drift displacement reaches maximum value and then starts decreasing. From the dynamic analysis, mode shapes are generated and it can be concluded that asymmetric plans undergo more deformation as compared to symmetric plans. Asymmetric plans should be adopted keeping in view the gap

Meer and Moon 2017, Diagrid structures have emerged as a new aesthetic approach for high-rise buildings in the modern architectural era as a flexible structural system that is a special type of spatial truss. Kyung-sun Moon (2017) introduced a robust design approach applied to a set of diagonal-line buildings of 40, 50, 60, 70 and 80 stories in height. For each story, the diagonal structure is constructed with diagonals placed at different angles that gradually change along the length of the building, to determine the same horizontal angle for each building. Fazlur Khan proposed the concept of a "height premium". As buildings become taller, there is a "height premium" due to the lateral loads and the demand for structural systems increasing significantly, leading to a significant increase in the overall use of building materials (Mair and Moon 2017). When a rigid frame is used for a very tall building, the column sizes increase gradually due to the gravity load accumulated at the base and the amount of material required to resist the lateral bearings increases significantly with height. Khan also noted that a design concept based on strength rather than a strength-based approach dominates the design when the height of the building exceeds 10 stories.

Nishith B. Panchal et al. (2018),This work includes modeling of diagonal buildings with 24, 36, 48, and 60 stories. The diagonal building was designed with the height of each story set at different angles, and gradually changing the angle along the height of the building, to determine the same suitable angle at different heights of each building and the possibility of the building. diagonals can be studied. A grid with different angles. In this work, a comparative study of diagonal structural systems 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 is conducted. A comparative analysis of the results in terms of top floor displacement, floor drift, area length, diagonal grid angle, steel and concrete costs is included in this article.

The study showed that a diagonal grid angle in the region of 65° to 75° provides maximum rigidity in the diagonal structural system showing less top floor displacement, floor deflection, span and floor shear. It also shows savings in steel and concrete costs. Khushboo Johnny and Paresh, Analysis and design of a 36-storey steel structure is presented in this article. A typical system with an area of 36 m x 36 m was considered in the study. Modeling and analysis of the structural elements were carried out using ETABS software.

All the structural members were designed considering all load combinations as per IS 800:2007. Wind direction and crosswind variations were considered while analyzing and designing the structure. The load distribution in the diagonal grid system of a 36-storey building was also studied. Similarly, analysis and design of diagonal buildings of 50, 60, 70 and 80 storeys were also carried out.

The analysis results were compared in terms of duration, maximum displacement and inter-storey deflection. The study showed that most of the lateral load is resisted by the end diagonal columns, while the gravity load is resisted by the inner and peripheral diagonal columns. Therefore, the interior columns should be designed to carry only vertical loads. The lateral load and gravity forces are counteracted by axial forces acting on the diagonal members at the ends of the structure, making the system efficient.

They concluded that for talldiagrid buildings, with aspect ratios ranging from about 4 to 9, the optimum angle is around 60 to 70 degrees. Nishith B. Panchal (2019) presented a comparative study of 24-storey, 36-storey, 48-storey and 60-storey curved structural systems with diagonal angles of 50.2°, 67.4°, 74.5° and 82.1°. Using ETABs, a comparative analysis of the effects on top deck displacement, ground drift, site length, span angle and steel and concrete usage is presented. They concluded that the optimum span angle is observed in the region of 65° to 75°.

Harish Varsani (2020) presented a comparative study of a 24-storey building with a 36m x 36m floor plan with a sloping system and a conventional steel structure using ETABS. They compared the results of the shear floor analysis graphically, which showed that the floor shear of the sloping system due to seismic loading is higher than that of the conventional structure. Manthan Shah (2020) presented a comparative study between a 18m x 18m floor plan with 4, 8, 12, 16, 20, 40 and 48 floors and a conventional steel structure using ETABS. They compared the results of the analysis with the base shear, where the base shear will be the same in both directions, as it is known that the diagonal grid system is stiffer than the regular frame, it attracts more lateral forces and thus has a base shear. . up to 12 stories. After 12 stories, the static wind loading takes over and becomes the dominant force and the base shear is controlled by the static wind load. Thus, after 12 stories, it is seen that the base shear of both the systems is the same.

Deepika R. (2021) conducted a comparative study of 30 stories with 30 m × 30 m layout of Diagrid and Hexagrid structural systems using ETABS. They arrived at the result by comparing the first mode time of the diagonal structure as 3.268 seconds, while in the hexagonal frame structure it is 3.69 seconds. Deepika R. (2022) present the comparative results of the slope under load in the form of a graph, which shows that the lower slope is much less in the diagonal grid structure. Compared to the diagonal structure. Rohit Kumar Singh (2022) presents the comparative results of the upper storey displacement in the curved structure of 18.8 mm, while in the conventional structure it is 34.7 mm. Harish Varsani (2023) observes that the diagonal columns resist the lateral loads of the structure and the displacement of the upper storey is much less in the diagonal structure as compared to the conventional structure. The maximum displacement of the conventional frame is 172.7 mm whereas the maximum displacement of the curved frame is only 31.6 mm.

Raghunath Deshpande (2023) presented a comparative study of a 24m x 24m floor plan with a inclined structural system and a conventional structural system with a central wall using ETABS. They presented the results of comparing the stock of each floor in both the systems. The deflection in the high conventional system is 84.90 mm, while the deflection in the diagonal system is only 75.00 mm.

III. METHODOLOGY

Structural response analysis is designed using ETABS software specifying all dimensional and material parameters. Different time histories should be analyzed to detect specific failures. In summary:

1) A model is built for different types of direct failures.
2) Time history analysis is performed on ETABS models.
3) The results are plotted and compared with the time history and other anomalies.

The deflection of the structure can be reduced if the end points are considered. Most building structures consist of structural elements such as beams, columns, arches, shear walls and floor slabs. Floor slabs in multi-story buildings, which usually transmit gravity loads to the building system, are required to transmit lateral forces to the building system.

Failure patterns can be made ductile rather than brittle. If the tensile strength is ensured, the dissipation of the generated forces will show minimal deformation.

a) Bending shear will not fail first.
b) Column failure occurs after the failure of the package.
c) Joints must be stronger than joints
d) Structural dynamic analysis using the response spectrum method

IV. CONVENTIONAL FRAME BUILDING

Recent trends in high-rise commercial construction have led to a variety of unusual configurations, new building systems, and functional elements that challenge current design practices. One of the design goals of this model is to ensure that the models represent the characteristics of a residential building. Nowadays, high-rise buildings vary in size, height, and functionality. This is what makes each building unique from the others. There are specific standards for each type of high-rise building, such as residential, official, and commercial buildings.

The seismic design of modern high-rise buildings, which are defined as buildings with a height greater than its height, presents a series of challenges that must be addressed by considering specific aspects of scientific, engineering, and modeling, analysis, and appropriate processes for adopting this unique design. There are important design elements such as floor orientation, grid spacing, floor height, columns, and beams.

In the case of a conventional frame, as the length increases, the design criteria based on strength become stronger and even if the column sections meet the strength criteria, the maximum lateral displacement exceeds 1/500 of the length of the structure. . To overcome these large-sized members, increased height is required.

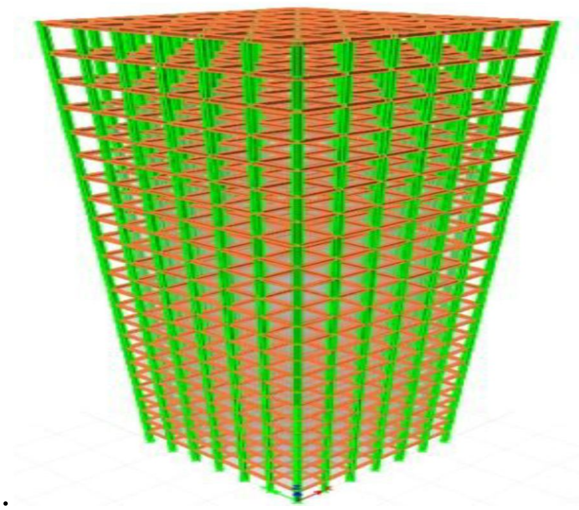

Figure 1. 3D View of 24-Storey Conventional Frame Building

V. DIAGRID BUILDING

Structural elements such as columns, beams and drop nets are drawn on the structural steel map of the building. All structural parts are designed for the design phase. That is why all buildings from G+10 and above are divided into three phases along the length of the building. To design the width grids and columns, the structural box sections are used along with the design of beams.

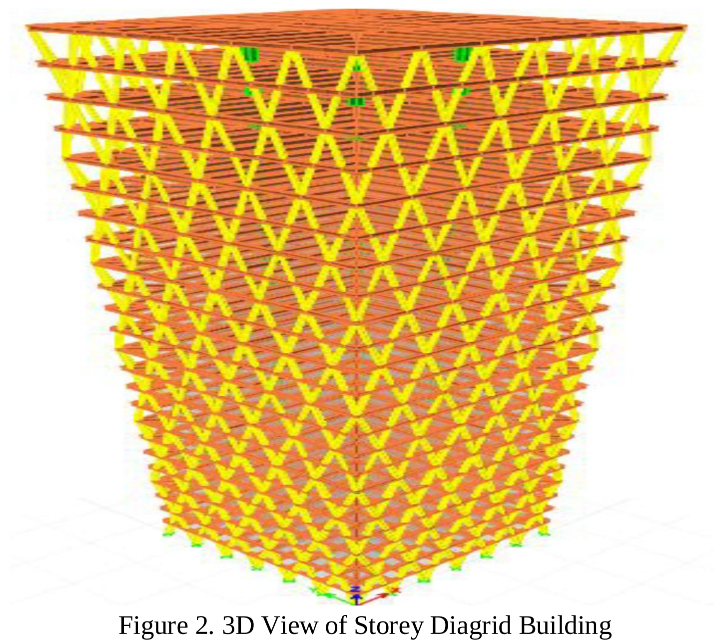

Figure 2. 3D View of Storey Diagrid Building

VI. CONCLUSIONS

Diagrid structural system has emerged as the best solution for lateral load resisting system in terms of lateral displacement, steel weight and stiffness. It is strong enough to withstand wind pressure up to high height. Diagrid construction provides high steel weight efficiency with aesthetic appeal. It is clear that the displacement of the building model increases with the increase in seismic zone. The displacement is very high at the roof and very low at the base. The displacement is 87.969 mm at a wind speed of 33 m/s and 183.17 mm at a wind speed of 50 m/s. This means that the displacement increases by more than 200% from a wind speed of 33 m/s to 50 m/s. The displacement of the building model increases with the increase in seismic zone. The displacement is very high at the roof and very low at the base. The displacement is 102.492 mm at a wind speed of 33 m/s and 226.609 mm at a wind speed of 50 m/s.

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