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REVIEW ON COMPARATIVE STUDY OF DIAGRID STRUCTURE WITH CONVENTIONAL BUILDING HAVING DIFFERENT HEIGHT

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Abstract: Buildings in seismically active places should be constructed specially to withstand earthquakes of exceptional magnitude, taking into consideration their high structural stability. Moving in a landscape orientation is made easier by using diagonal columns, which assist to turn all of the effort that an axial force puts out. Buildings using Diagrid structural systems (a diagonal grid of columns) have more lateral stability than those with traditional structural systems. diagrid system is a popular option for many buildings across the globe because of its structural aesthetics and structural benefits, and it has been used in a great number of exceptional, tall structures created in recent years. In this study, we explored the nonlinear behavior and construction of medium and high steel diagrid structures, as well as the effects of temperature and humidity. Comparing the findings to matching time-drag frames and concentrically related frames is also done, as is doing so with date, running time, base length, fractional, and offset charts. A virtual work schedule-energy and nonlinear seismic analyzing ETABs, G+7 G+11 (G+16), is recommended for use in the design of potential high-seismic diagrid structures in the regions. The nonlinear behavior and increased collapse load of these structures are improved by using a virtual work schedule-energy and nonlinear seismic analyzing ETABs.
Keyword: *Diagrid building, Seismic, Response spectrum analysis.*

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I INTRODUCTION

The word earthquake may be used to define any kind of seismic phenomenon that produces seismic waves, whether normal or caused by humans. Earthquakes are usually induced by seismic fault rupture, although they may also be sparked by volcanic activities, mine explosions, landslides, and nuclear testing. Many structures have primary construction systems that do not fulfill existing seismic standards and are severely damaged during an earthquake. India is divided into four zones based on seismic operations, according to the Seismic Zoning Map of IS: 1893-2002. Zones II, III, IV, and V are the four zones. Some companies construct full-scale models and do extensive research before mass-producing thousands of similar systems that have been studied and engineered with test outcomes in mind. Unfortunately, the construction industry may not have this choice, making large-scale creation unfeasible. Many current structures in India are built according to Indian standard code 456:2000, but in order to render buildings earthquake prone, IS 1893-2002 should be included.

In certain cases, the only loads acting on these systems are gravity loads, resulting in elastomeric structural behavior. However, in the case of a strong earthquake, a system can be exposed to forces that exceed its elastic limit. After the last earthquake in the last four decades, in which several concrete structures were severely weakened or destroyed, it has been essential to assess the seismic suitability of existing or planned structures. As a result, the structure's susceptibility to harm must be calculated. Simplified linear elastic approaches are not ideal for achieving or achieving this goal. As a result, structural engineers have devised a novel modeling approach and seismic protocol that incorporates performance-based structures and nonlinear techniques.

A. Diagrid Concept

The diagrid (a portmanteau of diagonal grid) is a structure for building and roof design that consists of diagonally intersecting metal, concrete, or wooden beams. In comparison to a traditional steel frame, it uses less structural steel. Diagrid structural system that may be characterized as trim components, how the bed was generated from the transition, different materials such as metal, concrete, or wooden beams used in the construction of the structure, and the roof are all discussed. Using steel pieces to construct diagonal constructions, you may quickly improve the C-power and stiffness properties of a structure. Today, however, it is commonly employed in diagrids found in large-span and high-rise structures, particularly when the forms are complicated or curved in nature. However, it is also the diagrid's diagonal element that is responsible for the shift and for the instant. Consequently, the height of the structure has an effect on the ideal exit angle for the diagonals. The ideal angle allocated to the greatest bending strength of a normal structure is 90 degrees diagonally, while the ideal angle allocated to the maximum shear strength of a normal structure is 35 degrees. It is thought that the ideal angle of the diagrid is located somewhere in the center of these two possibilities. As a general rule, temperatures are supposed to be in the range of 60 to 70 degrees Celsius. A building's ideal angle grows in proportion to its height.

Fig 1 Diagrid Structure

II. STATE OF DEVELOPMENT

Giulia Milana et al. (2015) The aim of this research is to evaluate the robustness of a tall diagrid structure. The aim is to determine whether gains in terms of sustainability have a detrimental effect on the structure's structural robustness. Different failure conditions are compared numerically and the results are presented. The diagrid (diagonal grid) structural structure is one of the most evocative designs for tall buildings. Because of its aesthetics and structural efficiency, diagrid (with perimeter structural configurations) has emerged as a new design trend for tall-shaped complex structures. It is a more sustainable structure since it uses less structural steel than a traditional steel frame.[1]

Seyed Saeid Tabaee et al. (2015) The rising urban population and its demand on limited urban space has affected the construction of city dwellings, according to this paper. The high cost of property, as well as plans to discourage the construction of short buildings and modern architecture, has resulted in an increase in the number of tall buildings in urban areas. In comparison to the gravity load bearing mechanism, the resisting system against lateral forces becomes more critical as a structure rises. Moment frame, braced frame, dual frame, shear wall, outrigger system, and other lateral force resisting mechanisms are all commonly used. In recent years, designing engineers have embraced diagrid diagonal networks - as a structural framework for tall buildings, owing to the structural efficiency and aesthetic architectural potential provided by the geometric configuration of the components. The diagrid system is a type of space truss that is unique. This structural framework is made up of triangular space trusses that form peripheral networks.[2]

Kiran Kamath et al. (2016) In the case of diagrid structures, for example, nonlinear static analysis may be used to minimize their size, assess their efficiency, and examine their efficiency qualities. With a circular layout and an aspect ratio of (H/B) ranging from 2.67 to 4.26 (where H is the overall height and (B) is the design of the radiation room), this model is suitable for use in radiation rooms. While the outside of the stick (angle between 78° and 59° and 71°F) determines the height of your structure, its breadth is governed by the foundation, which will stay constant during construction. Since coupling is unbalanced, as previously stated, FEMA rules 356 are meant to describe "non-linear" behavior and are used for strain computation. Using nonlinear static analysis, the seismic response of the system is calculated in terms of the basis, lkdn, and roof displacement, which are all measured in the final step of the process. As a consequence, there are glaring inconsistencies. According to the findings of the research, the 71° angle rod source model, which is the greatest driving force, preparation, and processing, is being used more often in all areas of accountancy. The efficacy of angular adjustment has an influence on the proportions as well as the angles.[3]

Deepak Nathuji Kakade et al. (2017) This paper presents an analysis of a 32-story diagrid structural structure without a vertical column across the periphery building. Here is a comparison of the study results in terms of storey displacement and storey drifts for them. Tall buildings have traditionally served as industrial office buildings. Since then, other uses such as retail, mixed-use, and hotel tower projects have exploded. Economic considerations, aesthetics, infrastructure, urban legislation, and politics all play a role in tall building growth. The most important governing principle has been economics. The structural architecture of a very tall building is normally controlled by its lateral stiffness.[4]

Roham Afghani Khoraskani et al. (2018) The lower and upper floor plans' various geometries and dimensions, as well as the method of shape generation that determines the building's ascending development from base to top, resulted in 49 architectural schematic forms. The produced architectural forms are later mapped with diagrid members of identical steel tubular section as the framework of the tall buildings. The structure is then subjected to lateral loads that reflect analogous static behavior, and a static linear analysis is performed. Finally, the findings show that the structural behavior of initial models is largely determined by the base floor plan rather than other parameters, and that architectural models with a higher side count have a higher structural performance.[5]

U. A. Nawale et al. (2018) In this article, Etabs and SAP software are used to compare storey drift and base shear of 32-story diagrid structural framework with or without vertical column around periphery building and simple frame building. Here is a comparison of the results of the study in terms of storey drift (as per IS 1893-2000) and base shear. The lateral loads caused by earthquakes and wind force have an effect on the design of high-rise buildings. Wall frame, shear wall, braced tube system, and outrigger system are examples of lateral load resistance systems. Because of its structural strength, the diagonal grid design is commonly used in steel buildings or tall buildings. It's a vertical bracing device with a triangulation configuration that transfers load. As far as the construction of a tall building is concerned, storey drift and displacement are the most significant factors. [6]

Esmaeel Asadi et al. (2018) These works are discussed in 12 details, and the research capabilities of steel diagrid design are appraised for the aim of constructing a seismic energy core 13 while taking operational factors into mind are also provided. There are three distinct forms of dynamics: nonlinear statics and dynamics, when-history, dynamic, and progressive, dynamic, and when-history, dynamic and progressive, dynamic. High-level 14-analysis is performed on the 15 seismic zone (EEZ) in order to determine the processes of diagrid, egress, and decay. To quantify the elements of the seismic energy period, such as the correction factor, response plasticity coefficient, element power, and deflection gain, four distinct approaches are utilized. The four reflecting diagonal structures with heights ranging from four to thirty floors, which invigorate the working class, have been extensively examined. To find the ideal angles along the diagonal, steel diagonal ranging from 4 to 19.5 if an extra 20 study is conducted. It is suggested that an R-factor of at least 3.5-4 be used for low-rise diagrids above the 21st level (8th level). It is also advised to use strength and ductility in the 2.5-2-too-strong formulation. Steel, diagrids, and the rules established in the text are the most often encountered materials. [7]

Aida Mirniazmandan et al. (2018) These are academic research papers. The structure of the diagrid system is now very widespread among engineers and architects, thanks to its structure, efficiency and versatility of architectural planning and design. Because architects and engineers can use architectural and structural parameters in order to create more productive buildings, the goal of these studies is how changing the geometry of the base and upper plane configurations of high-rise buildings, as well as the angle of diagrid makes, affects the overall weight of structural elements-territorial unit and horizontal movement on the top floor, while at the same time to develop efficiently, tall buildings (which is how to minimize). To achieve this goal, the number of sides of the base and tip plans is not coincidentally increasing, resulting in 64 parametric models with different cross-sectional shapes having a height of 180 meters. Different angles of the crossbars, they created a model to work out. Modeling is performed using the software, Rhino and its Grasshopper plug-in, and structural analysis is performed using the Grasshopper Karamba plug-in. Optimization A genetic algorithm is used to find the best available models. Finally, the optimal diagonal angle limit lies between 53° and 70°, and the performance of building diagrids of optimal diagonal angles increases with the number of polygonal cross-sections.[8]

Yue Li et al. (2018) Using static, time-history reactive, and gradual dynamic studies, this paper provides a thorough inquiry into the nonlinear performance of steel diagrid frameworks. The ASCE/SEI 41-13 and FEMA P-58 performance-based assessment approaches are used to establish a system for seismic performance assessment and loss estimation of steel diagrid buildings. The seismic failure of archetype diagrid buildings is estimated using illustrative and quantitative criteria for diagrid frame efficiency and damage assessment. The diagrids are found to have a high degree of lateral stiffness and collapse capability. However, the non-structural loss caused by stiff diagrid frames' high maximum absolute floor acceleration can have an adverse effect on the estimated total loss. The corner diagonal members are the main elements in their action due to the shear lag effect. Building height, diagonal angle, and incomplete diagrid modules are also investigated for their impact on efficiency and loss.[9]

Esmaeel Asadi et al. (2018) The nonlinear behavior and architecture of mid-to-high-rise steel diagrid structures was investigated in this article. Steel diagrids are analyzed and compared to corresponding moment resisting frames and concentrically braced frames in terms of weight, storey drift, fundamental time, lateral stiffness, and sequence of plastic hinge forming. Practical architecture recommendations are suggested utilizing simulated work/energy diagrams and nonlinear static analysis to enhance the nonlinear behaviour and increase the failure load potential of diagrid structures in high seismic regions. The diagrid method has mostly been used in the construction of tall buildings with a height of 20 to 100 meters. The diagrid system may also be a powerful and cost-effective structural system for mid-rise buildings in the 8-15-story range, according to the findings of this study.[10]

Vishalkumar Bhaskarbhai Patel et al. (2019) The comparison of various forms of lateral load resisting systems is discussed in this article. The thesis is primarily concerned with evaluating the most efficient and cost-effective systems for resisting lateral loads such as wind and seismic loads. Conduct a comparative analysis of different lateral load resisting structures such as Shear wall, Belt Truss, Outrigger, Belt Truss + Outrigger, Diagrid, Staggered Truss, and Tube in Tube framework of a 10-story building with a plan size of 18m X 18m based on a literature examination. Static earthquake forces, dynamic earthquake forces (Response Spectrum analysis as per guidelines of IS: 1893-(Part 1) 2016), static wind forces as per IS: 875 (Part-3)-2015, and design based on IS: 800-2000 were all analyzed using ETABs-2017. It was discovered that storey displacements and storey drifts are less in diagrid systems in X direction.[11]

Vimlesh V. Agrawal et al. (2020) In this article, land scarcity stifled horizontal progress, leading to the evolution of the town's vertical growth, which culminated in the construction of tall buildings. Fazlur Khan pioneered the design of tall buildings in the early 1960s. Tall buildings were able to get off the ground thanks to various structural systems, although advancements in material and building technology hastened their progress. The major force that influences the construction of tall buildings is the lateral load caused by wind and earthquakes, which is primarily resisted by either an exterior or an internal structural framework.[12]

Alejandro Palacio Betancur et al. (2020) The creation of various structural structures to ensure protection and serviceability against natural hazards has resulted from the study of high-rise buildings. Thanks to their high lateral stiffness and architectural potential, diagrid structures are a new trend in tubular high-rise buildings. Since the system's geometric flexibility allows for a wide range of element layouts that result in variations in the stiffness of each storey, determining an optimum configuration is critical for the design of these structures. Existing design codes and provisions do not provide precise guidance for diagrid structural structures, but there are many studies in the literature that use simplified calculation methods to provide design aids to engineers working with preliminary designs.[13]

Vishalkumar Bhaskarbhai Patel et al. (2020) The thesis is primarily concerned with evaluating the most efficient and cost-effective method for resisting lateral loads such as wind and seismic loads. Conduct a comparative analysis of different lateral load resisting structures such as Shear wall, Belt Truss, Outrigger, Belt Truss + Outrigger, Diagrid, Staggered Truss, and Tube in Tube framework of a 10-story building with a plan size of 18m X 18m based on a literature examination. Static earthquake forces, dynamic earthquake forces (Response Spectrum analysis as per IS: 1893-) and static wind forces as per a nd design based on IS: 800-2000 were all analysed using ETABS-2017. It was discovered that storey displacements and storey drifts are less in Diagrid systems in the X Direction as compared to other lateral directions.[14]

Snehal V. Mevada et al. (2020) The main topics covered in this paper are the design of Core and Outrigger structural systems using ETABS tools, link design between RCC core and steel framework, seismic analysis compared with standard moment resisting framed RCC building, and cost efficiency analysis comparison with framed RCC building. This structure is built in such a way that more forces are drawn to the building's central core and fewer forces are borne by the building's perimeter. This device was often used for a building of medium height, in addition to tall structures.[15]

III. CONCLUSION

This paper focuses only on the literature review of previously published studies. The gap findings of this study different geometric base and top plan configurations of tall buildings, as well as the angle of the diagrid framework, affect the total weight of structural elements per unit area and the horizontal displacement of the top floor in order to design efficient tall buildings. The optimum bound for diagrid angle is found to be between 53° and 70°, and the performance of buildings with diagrids that have the optimum diagonal angles increases as the number of polygonal cross-sections increases. If the number of polygonal cross-sections goes up, the efficiency of the building with diagrid system increases. There are numerous possibilities for future work in this issue such as; the variation of steel sections can be studied. Concrete can be used for diagrid cross sections.

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