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ANAYSIS OF DIAGRID STRUCTURE BY USING E-TABS SOFTWARE

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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 diagrid 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.

Keyword: Conventional building, diagrid structure, twisted tall buildings, tilted tall buildings, tapered tall building.

I. 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.

1.1 Diagrid Structure

Diagrid (diagonal grids) structure is a system of triangulated beams, straight or curved and horizontal ring that together make up a structural system for a skyscrapers (Tall Building).In short, it is made up of intersecting diagonal and horizontal components. It requires less structural steel than a conventional steel frame.

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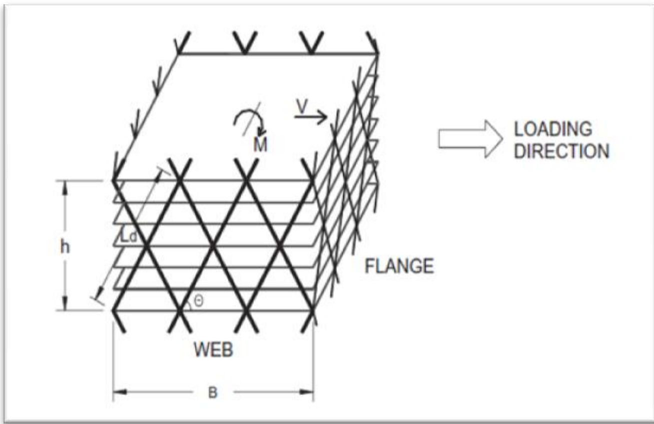

Fig.1.1.1. Diagrid structure

There are so many diagrid structures constructed all over the world as shown in the images below:-

Fig.1.1.2.Hearst Tower, New York.

Fig.1.1.3. SwissRe, London, UK

1.2 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 superstructure can translate into 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.

1.3 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 upon design intent.
4. It is hard to design windows that create a regular language from floor to floor.
5. The Diagrid is heavy-handed if not executed properly.

II. LITERATURE REVIEW

2.1 General

The diagrid structure is suitable for constructing large building with both regular and irregular forms. They are more effective in minimizing shear deformation and do not needs high shear rigidity cores. Below papers show above mentioned properties.

2.2 Study of Research Papers

Kyoung Sun Moon et. al.[1] studied comparison between lateral performance of diagrids, braced tubes and outrigger structures, employed of twisted, tilted, tapered and free form tall buildings. Parametric structural models are generated to investigate the impacts of varying various important geometric configurations of complex shaped tall buildings, such as the rate of twist, angle of tilt, angle of taper and degree of fluctuation of free form. The parametric models are exported to structural engineering software for analysis, design and comparative studies. Lateral stiffness of tilted diagrid and braced tubes is not substantially by angle of tilt ranging from 0 to 13 degrees studied in this paper. Lateral stiffness of diagrids, braced tubes and outrigger structures is reduced when they are employed for twisted tall buildings. As the rate of twist is increased, the rate of stiffness reduction is also increased. Lateral stiffness of outrigger structures is somewhat increased as they are tilted because of the triangulation of the major components of the lateral load resisting system – the braced core, mega-columns and outrigger trusses. Tilted tall buildings are laterally deformed by not only wind loads but also eccentric distribution of gravity loads. The gravity-induced lateral displacements can be substantially managed through careful construction planning. Tapered form is typically advantageous for tall building structures. As the angle of taper is increased, the lateral stiffness of the structural system is increased and the wind loads applied to the structure is decreased. Consequently, the lateral displacements of tapered tall buildings are substantially decreased compared to comparable prismatic tall buildings. Tapered form also works well architecturally for tall buildings with commercial office functions on the lower levels and residential functions on the higher levels. For freeform tall buildings, the diagrid structural system has great potential to be developed as one of the most appropriate structural solutions because triangular structural geometric units naturally defined by diagrids can specify any irregular freeform tower more accurately without distortion. Lateral stiffness of diagrid structural systems employed for freeform tall buildings is decreased. As the degree of fluctuation of free form is increased, the rate of lateral stiffness reduction is also increased.

Khushbu Jani, et. al.[2] 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 diagrid system is also studied for 36 storied building. Similarly, analysis and design of 50, 60, 70 and 80 storied diagrid structures is carried out.

Raghunath D. Deshpande, et. al.[3] compared conventional and diagrid structural systems. ETABS software is used for modeling and analysis of structural members. Dynamic along wind and across wind are considered for analysis and design of the structure. Diagrid performs better across all the criterions of performance evaluation, such as, efficiency, expressiveness and sustainability. Structure has comparatively less deflection; structural weight is reduced to greater extent, due to this structure has more resistance to lateral forces, cost effective and eco-friendly, diagrid uses 11247 tonnes of steel which is 28% less compared to the conventional orthogonal building which uses 15255 tonnes. Compared to Conventional Structure, Diagrid Structure has more opening area, less deflection, 28% less steel usage.

Femy Maria Thomas, et. al.[4] 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.[5] 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.

Kyoung Sun Moon et. al.[6] studied structural system design option for tilted tall building and their performances. Tilted tall buildings are designed with various structural system, such as braced tubes, diagrid and outrigger system, and their structural performances are studied. Structural design of today's tall buildings built with higher strength material is generally governed by lateral stiffness. Tilted towers are deformed laterally not only by lateral loads but also by dead load and live load due to their eccentricity. The impact of tilting tall building on the gravity and lateral load resisting systems is studied. Comparative evaluation of structural system for titled tall building is presented.

Sree Harsha J, et. al.[7] studied the comparison of 24-storied diagrid structural system with different uniform angles. The 24 storied diagrid structural systems with different angles are modeled and analyzed by using ETABS Software. Now a day the nonlinear analysis is essential for a tall building, in this present study the nonlinear analysis is carried out for the considered diagrid structural system. The comparison of analyzed results is in terms of top storey displacement, time period, storey shears and mode shapes is presented here.

Nishith B. Panchal, et. al.[8] studied the comparison of 20-storey simple frame building and diagrid structural system building. The comparison of analysis of results in terms of top storey displacement, storey drift, steel and concrete consumption is presented here. ETABS 9.7.4 software is used for modeling and analysis of structure. Analysis results like displacement, storey drift and storey shear are presented here. Also design of both structures is done and optimum member sizes are decided to satisfy the code criteria.

Ravish Khan, et. al.[9] studied 20 storey diagrid structures in comparison with exterior braced frame structure. Analysis results and design of both the models are presented in terms of storey shear, displacement, drift and summary of lateral and gravity forces. From the study, it is concluded that the diagrid structure resists approximately the same amount of lateral loads as compared to the exterior braced structure; despite all the vertical columns being eliminated in the periphery of the diagrid structure. Diagrid structure provides more efficiency than braced structure. Also, less amount of storey shear is seen in diagrid structure than to the braced frame structure. The top storey drift of diagrid structure is less by 30.7% than in the exterior frame structure. The top storey displacement of diagrid structure is less by 46.7% than in the exterior frame structure. All these factors make the diagrid structure more resistant than the braced frame structure. Diagrid structure gives more aesthetic look and gives more of interior space due to less columns and façade of the building can also be planned more efficiently.

III. CONCLUSION

From the study it is observed that most of the lateral load is resisted by diagrid columns on the periphery, while gravity load is resisted by both the internal columns and peripheral diagonal columns. 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. 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.

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