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A Review Paper on Comparative Seismic Analysis of RCC Frame Structure and Diagrid Structure

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ABSTRACT
Multistory buildings are playing a very important role in development of any country in all around the world. High-rise building in large earthquake areas must be design with special consideration for lateral stability in extreme earthquake. A new technique of adjusting the vertical columns orientation to Diagrid columns aid in the transforming all the forces in the Axial forces. Diagrid structure means diagonal Griding system of Column is a modern technique design to increase a structure's stability against the lateral load. A Diagrid structural system has architectural and structural design benefits make it a popular option for many buildings all over the World, including so many prominent high-rise structures constructed in recent years. Many researchers investigate the structural performance of diagrid structure. Some of the noteworthy contributions of researchers in the field of diagrid structure are discussed in this review. The behavior of the diagrid structures with respect to different parameters such as floor displacement, Base shear is observed. The results are compared to corresponding RCC frame structure as well as Diagrid Structure in the form of Base Shear and Storey Displacement.

Keywords: High-rise building, Earthquake force, Diagrid structure, Base shear, Story displacement

I. INTRODUCTION

The growing world population is actively promoting the development of building construction everywhere. High-rise buildings are favored these days due to lack of available land andrapid urban population growth. Today, tall buildings can be seen in every country, especially in developing countries. High-rise buildings perform a very important role in development of any country in the world. India has faced many disasters such as earthquakes and tsunamis. Earthquakes are becoming more frequent in our country. Earthquakes are natural disasters and cannot be predicted, but damage can be minimized by installing various lateral load-bearing systems in buildings. Structural framing systems are one of the most used structural systems. Early 20th century building structural system were designed primarily to absorb vertical loads only. However, with the increase of high-rise buildings, the lateral loads from Wind and earthquakes have become more dominant loads, and the increasing height of buildings is causing more significant loads than before. The concept Seismic, it is used to define any type of seismic phenomenon that produces seismic action or waves, whether it is normal or man-made. The main structural systems of many structures cannot meet existing seismic standards and are severely damaged during an earthquake. As per IS code, India is divided into four Seismic zones based on seismic survey, according to the seismic zone map of IS: 1893-2016. Zones II, III, IV, and V are the four zones. As a result, it is becoming increasingly difficult for structural engineers to provide the strength required to withstand the lateral loads of tall buildings when designing new tall structural systems.

Building in extreme seismic areas must be designed with special consideration for lateral stability during extreme earthquakes. In recent years, the diagonal grid or diagrid structural system has been widely used for construction of high-rise buildings due to its efficiency and aesthetic possibilities due to its different geometric configuration. This diagrid structural system made more interest towards architects and structural engineers of high-rise building. Buildings with Diagrid systems include Swiss Re London, IBM Building, Hearst Tower in New York, China and Lego's Ribskind Freedom Tower. Several studies have been conducted to examine the efficiency of the Diagrid system when applied to tall buildings, and the introduction of the diagrid system into tall

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buildings results in a higher lateral displacement of the building top than using a single simple frame system. has been demonstrated to decrease. This shows that the diagrid system is an effective system for tall buildings.

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Fig 1 – Daigrid Structural Building

II. LITERATURE REVIEW

- **S.S.Tabaeeet.al.(2015)** In this paper, the diagrid system is studied which is a combination of diagrid system and moment frame system. Due to the possibility of comparison between the behavior ofthe proposed system andthe diagrid and moment frame systems, analytical models with similar dominant periods and therelativelateralplacechangingofthefloorsandth edistributionofthemomentanchorin the components were studied. The hybrid diagrid system, despite having less weight, has less relative lateral place changing compared to the moment frame and moment diagrid. Also, it has a more proper distribution of moment anchor than the other two systems.
- **Kamil A shraf Bhat, Peerzada Danish (2020)** This paper investigates the different configuration of thevariableangle diagridsystemandcomparesther esultsbasedontheefficiencyfactorcalculated for each configuration of the models selected for the study. Selecting the suitable configuration of the variable angle diagrid system can help in further reducing cost and material used for construction. In this paper, the study on the various configurations of the variable angle diagrid structures is done. For that, the angle of inclination of diagrids with height and the ratio of the heights for which angle of diagrids is constant is varied and the various configuration of diagrids are obtained. In this paper, diagrid structures with two different in clinations of diagonal members and diagrid structures with three different inclinations of diagonal members are studied and the evaluation of these patterns of the diagrid structures is done based on the structural steel used and the performance. The building was first designed using load combinations as per Indian Standards, then the maximum drift, maximum displacement, and the weight of the steel in diagrids are obtained. After that the models were optimized and the new maximum drift, maximum displacement, and the weight of the steel in diagrids are obtained.
- **KYOUNG SUN MOONa (2011)** This paper presented structural performance and construct ability issues of diagrid structures employed for complex-shaped tall buildings such as twisted, tilted and freeform towers. For each complex form category, tall buildings are designed with diagrid systems, and their structural efficiency is studied in conjunction with building forms. In order to investigate the impacts of variation of important geometric configurations of complex-shaped tall buildings, such as the rate of twisting and angle of tilting, parametric structural models are used for this study. The unique compositional characteristics of diagrids provide great structural efficiency and aesthetic potential as an accentuating element in any existing urban context generally composed of buildings of orthogonal components. This paper presented structural performance and constructability issues of diagrid structures employed for complex-shaped tall buildings such as twisted, tilted and freeform towers.

- **AidaMirniazmandanet.al. (2018**) In this paper, the optimization procedure is applied totall buildings with different angles of diagrid and various configurations of the base and to pgeometries. The most efficient models must employ the least amount of steel for the same load bearing. With reference to the analysis results diagrid structure with the angle of 63° provides the least amount of lateral top story displacement that shows the more stiffness for the building in comparison to other diagrid angles. Therefore, it can provide less structural weight by approaching the amount of lateral displacement to its maximum allow able limit (Height/500) and considerable amount of material can be saved. The results of the analyses performed in this paper show, among all the best solutions that have the diagrid angle of 63°, the building forms with circular cross-section for the base plan and 12-10-8 sided polygon in addition to circle for the top plan are the best average solutions to achieve the architecturally and structurally efficient buildings. Based on the above considerations, it is concluded that if the number of polygonal cross-sections goes up, the efficiency of the building with diagrid system increases.
- **DengjiaFang, Chengqing Liu.(2021)**In this paper, the vertical stiffness and lateral stiffness of diagrid structure with arbitrary polygon plane under vertical load and horizontal load are derived respectively. The vertical stiffness, lateral shear stiffness, lateral bending stiffness and displacement calculation equations proposed in the paper can be used for the diagrid structure from low to high rise. Only the equivalent lateral stiffness equation is limited to the application of high-rise diagrid structure. The corresponding laboratory test and numerical simulation analysis are carried out for a reduced scale steel diagrid structure model with octagonal plane. The results showthat the proposed stiffness equations are in good agreement with the experimental results.
- **Amruta K.Potdar, G.R.Patil (2017)** In this paper, a comparative study of 20-storey simple frame building and with same configuration, a diagrid structural system building is presented. A regular floor plan of 15m x 15m size is considered. Different models for different diagrid angle (45, 63, 71, 75 and conventional) are made. Analysis results are presented as Axial load on internal column is less in diagrid building as compared to conventional building. Shear force of interior beam is less in diagrid as compared to conventional building. For 20 storey diagrid structure, the optimal range of diagrid angle is from about 60º to 70º.
- **Vimlesh V. Agrawal, Vishalkumar Bhaskarbhai Patel (2019)** In this paper, Parametric study of diagrid structure has been carried out by analyzing and designing 40 storey diagrid structure having variation in parameters like angle of diagrid, cross sectional shape of diagrid and column placed at different position. The plan area considered was 24m * 24m. The parameters nominated for evaluation are 3 different angles i.e., 45degree, 63.4 degree and 78.69 degree. The second parameter considered was 4 different cross-sectional shape i.e. I section, box section, tube section and composite section made up of tube section having concrete as an infill material. The Conclusion of this paper are- Most efficient section: - I section Optimum angle: - 63 degree Most efficient column position: Corner.
- **D. N.Kakade, U.A.Nawale (2018)** In this paper, E-TAB and SAP software are used to compare Storey Drift and Base Shear of 32-story digrid 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 influence 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.
- **Snehal S. Mali, D.M.Joshi (2017)** In this paper, the seismic response of a diagrid building and a conventional frame structure has been analyzed in seismic zone IV with hard soil type. The model possesses identical parameters to both diagrid and conventional frame structures. The positioning of the diagrid has been determined for the opposing face, three faces, and all faces within the model. The ETABS software is utilized to perform Equivalent Static Analysis, Response Spectrum Analysis, and Wind Analysis. The output is expressed in terms of displacement. The findings suggest that the lateral displacement of diagrid structures is notably lower than that of conventional structures in both the X and Y directions, by 45.48% and 41.71%, 45.92%, and 42.17%, respectively, when subjected to response spectrum analysis under equivalent static

conditions.

- **Dr. Gopisiddappa et. al. (2017)** A comparative analysis was conducted on a 30-story linear building and diagrid systems with varying diagonal angles of 45°, 63°, 73°, 75°, 78°, and 81°. A comparative analysis is conducted between linear and diagrid construction methodologies. The ETABS software is utilized for the purpose of structural modeling and analysis. The presented data includes analysis results such as storey displacement and inter-storey drift. The study yielded the following conclusions. The absence of a load resisting system in a framing building result in greater drift and displacement values when compared to a diagrid system. The diagonal bracing system with an angle of 63 degrees results in reduced displacement of the top storey.In the angular region of 63 to 75 degrees, the diagrid system exhibits superior stiffness, with reduced storey drift and storey displacement.
- **Rohit kumar Singh et al. (2016)** In this paper, A regular five storey RCC building with plan size 15 m × 15 m located in seismic zone V is considered for analysis. STAAD.Pro software is used for modelling and analysis of structural members. All structural members are designed as per IS 456:2000 and load combinations of seismic forces are considered as per IS 1893(Part 1): 2002. Comparison of analysis results in terms of storey drift, node to node displacement, bending moment, shear forces, area of reinforcement, and the economical aspect is presented. In diagrid structure, the major portion of lateral load is taken by external diagonal members which in turn release the lateral load in inner columns. This causes economical design of diagrid structure compared to conventional structure. Drift in diagrid building is approx. half to that obtained in conventional building. In this study, steel reinforcement used in diagrid structure is found to be 33% less compared to conventional building.
- **Nishith B. Panchal VinubhaiR.Patel (2014)** In this paper, the comparison study of 20-storey simple frame building and diagrid structural system building is presented here. The comparison of analysis of results in terms of top storey displacement, storey drift, steel and concrete consumption is presented. Conclusions of the paper are as the lateral loads are resisted by diagonal columns; the top storey displacement is very much less in diagrid structure as compared to the simple frame building. The storey drift and storey shear are very much less for diagrid structural system. Diagrid provide more resistance in the building which makes system more effective.
- **Shahana E., Aswathy S Kumar (2016)** In this study comparison of diagrids with and without corner columns under seismic forces is done. Here G+ 4 storey is taken and same live load is applied in both the buildings for its behavior and comparison. The framed buildings are subjected to vibrations because of earthquake and therefore seismic analysis is essential for these building frames. The fixed base system is analyzed by employing in both building frames in seismic zone V by means of Staad.Pro software. The response of both the building frames is studied for useful interpretation of results. A comparison of results in terms of moments, displacements, shear force, axial force and drift has been made. The main conclusions obtained from the analysis of building in this paper are –
  The values of shear force, bending moment, lateral displacement and storey drift are approximately same for the diagrids with and without corner columns. When considering axial forces in the interior columns, the value for diagrid with corner column is two times more than the diagrid without corner columns. The axial force carried by the diagonal member get reduced due to the presence of corner column. Hence, the interior column must take more axial force. Thus, the study can be concluded as the behavior of structure without corner column is more effective than with corner columns.
- **Ravish Khan, S.B. Shinde (2016)** Two structural models are taken in account for analysis of diagrid structure, which is diagrid model and braced frame model. The design of both the structural models is carried out using STAAD.Pro V8i software. The dead, live, earth quake and wind load and all load combinations are applied to the models. The results of analysis are in terms of displacement of the stories, inter storey drift, storey shear and are presented in this paper. The distribution of storey shear in diagrid structure is less than braced frame structure.It is observed that top strorey displacement and drift of braced structure is more than diagrid 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.

- **Gurudath C. et.al. (2019)** In this study, an analysis of G+14 storey ordinary moment resisting building structure over a medium soil is considered. The number of bays will be kept as 6 along both direction and the bay size will be kept as 4m with the storey height being 3m. The building will be analysed considering zone III by static equilibrium method using ETABS 2015 software. it is observed that the storey displacement is reduced to greater extent for the diagrid building at an angle 63 degree, while displacement is maximum in RC bare frame building compare to all the RC diagrid building at an angle 63-, 66- and 69-degree Theses patterns are observed due to increased stiffness in diagrid building while compared to RC bare frame building. The top roof displacement for RC diagrid building with different diagrid angle such as (63 66 and 69) degree is reduced by 83.32%, 81.499% and 79.11% respectively when compared to without diagrid (bare frame) building. This paper concluded that, The Storey displacement and story drift is maximum for RC bare frame and minimum for RC frame with diagrid. Top storey displacement, storey drift and storey overturning moment is less for diagrid system with diagonal angle 63 degree. RC diagrid frame has the displacement which is 78%-84% less as compared to RC bare frames.

III. CONCLUSION

- The results come from the literatures are studied in this paper, A seismic analysis of RCC frame building and Diagrid building structure performed and it shows that the Diagrid building structure can help to reduce the storey displacement as compare to RCC frame building structure.
- The top storey displacement is very much less in diagrid structure as compared to the simple frame building. The storey drift and storey shear are very much less for diagrid structural system. Diagrid provide more resistance in the building which makes system more effective.
- Top storey displacement, storey drift is less for diagrid system with diagonal angle 63 degree.
- The top storey displacement of diagrid structure is less by 46.7% than in the exterior frame structure. This makes the diagrid structure more resistant than the RCC frame structure.

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