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Analysis of Tall Structure Project Considering Effect of Diagrid and Hybrid Diagrid Members : A Review

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ABSTRACT

Skyscraper development involves various complex factors such as economics, aesthetics look, technology, municipal regulations, and politics. Among these, economics has been the primary governing factor. For high rise building, the structural design is generally governed by its lateral stiffness. Diagrid structures carry lateral seismic loads much more efficiently by their diagonal member's axial action in comparing with conventional orthogonal structures for tall buildings such as framed tubes, A diagrid structure provides great structural efficiency without vertical columns have also opened the new aesthetic potential for tall building architecture. Diagrid has a good appearance and it is facilely apperceived. The configuration and efficiency of a diagrid system reduce the number of the structural element required on the façade of the buildings, therefore less obstruction to the outside view. The diagrid system structural efficiency also helps in avoiding interior and corner columns and therefore allowing significant flexibility with the floor plan. The magnitude and intensity of seismic forces are varying from region to region causing moderate to severe destructive energy on engineering properties as well as rising to great economic losses and threat to life. In this paper we are presenting the past development took place in the field of lateral load resisting members. We are presenting literature review of past researches related to diagrid technique.

Keywords : Skyscraper, Diagrid Structure, Destructive Energy, DIAGRID

I. INTRODUCTION

Earthquake has always been a threat to human civilization from the day of its existence, devastating human lives, property and man-made structures. The very recent earthquake that we faced in our neighbouring country Nepal has again shown nature's fury, causing such a massive destruction to the country and its people. It is such an unpredictable calamity that it is very necessary for survival to ensure the strength of the structures against seismic forces. Therefore there is continuous research work going on around the globe, revolving around development of new and better techniques that can be incorporated in structures for better seismic performance. Obviously, buildings designed with special techniques to resist damages during seismic activity have much higher cost of construction than normal buildings, but for safety against failures under seismic forces it is a prerequisite.

To provide a detailed review of the literature related to DIAGRID in its entirety would be difficult to address here. Although there has been a lot of work modeled as diagrid system in reinforced concrete structures ranging from analysis assumptions to design recommendations - none provide in-depth understanding of the seismic response of reinforced concrete (RC) buildings contributions related to diagrid in tall structure and past efforts most closely related to the needs of the present work. A brief review on diagrid technique and code provision of previous studies is presented here. This literature review focuses on diagrid system used in reinforced concrete structures and some code provisions will be addressed by area.

II. LITERATURE SURVEY

Ravi K Revankar et.al. (2014) analyzed a G+12 storey structure which consist of diagrid members, the geometry of structure consider in his study was 27 X 27 m in lateral dimensions and 48 m in height consist of 12 storey considering 4m each storey height. Modelled and analysed the structure using analysis tool SAP2000, considering dead, live and seismic loads as per Indian Standards and conducted non linear analysis (pushover analysis), designed the structure as per specifications, and concluded that structure with diagrid are more stable and resistable during collapse and found more durable to counteract forces in terms of displacement.

Kiran Kamath et. al. (2015) performed a comparative study on a circular plan with different angels of diagrid are considered as 64.00°, 72.00°, 76.30° and 90.00°. the geometry of circular plan is G+36 storey tall structure with 3.6 m each floor height and 36 m diameter of lateral dimensions are provided, considering wind load as per 875 part3 and seismic zone III as per 1893 part-1. Compared the structure in terms of base shear, top storey displacement, concluded that As the angle of diagrid increases, axial rigidity of the diagonal columns decreases, time period is minimum for 72° whereas top storey displacement is minimum for angle of 64.0°.

Moon et al., (2007) studied the behaviour of diagrid structure square in plan. Size of the plan is 36m x 36m. Braced core is also provided. Shear lag effect is compared between diagrid and tubular structure. They concluded that for a diagrid structure square in plan, the optimal angle lies between 65° to 75°. They also suggested member sizing methodology for preliminary design of diagrid structure so that structural and architectural decisions can be made at an early stage.

Kyoung (2011) studied the behaviour of diagrid structure with floor twisting at different rates. He found that twisted tower perform better than straight tower under across wind loading. Optimal angle of twist is though not established.

Montuori et al., (2014) varied the diagrid density and angle of diagonal columns along the height for square plan. The models are compared in terms of structural weight and performances. The efficiency potentials of different models are discussed.

Giulia Milana et. al. (2015) analyzed a G+40 tall structure with Different diagrid structures were considered, namely, three geometric configurations with inclination of diagonal members of 42°, 60°and 75°, and geometry considered is 36 x 36 m in lateral dimensions, and 160 m tall structure with circular shape. In this work the consider seismic Zone IV and did pushover analysis and concluded that providing diagrid is not only making economical building but also much stable in terms of safety.

k. moon (2009) compared different stories tall structure of 60 and 80 storey heights with same lateral geometric aspects and loadings with considering diagrids of 63°, 69° and 73 ° and determine that The structural efficiency of dia-grids for tall buildings can be maximized by configuring them to have optimum grid geometries. Though the construction of a diagrid structure is challenging due to its complicated nodes, its con-structability can be enhanced by appropriate prefabrication methods.

KYOUNG-SUN MOON (2007) presented a comparative study on tall structures ranging from 20 to 60 stories. And compare bracings and diagrid works in terms of forces and economical sections, presenting diagrid range from 65 to 75 degrees and concluded that diagrid structure is more economical and resisting as also removing the requirement vertical columns at the outer side.

Khushbu jani et. al. (2013) Observed tall structure of G+36, G+50, G+60 and G+70 storey tall structure of lateral geometry 36 x 36 m. structures are modelled and analysed in csi etab software. Considering diagrid structures and designed as per I.S. 800:2007. And concluded 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 peripherial diagonal columns. So, internal columns need to be designed for vertical load only. Due to increase in lever arm of peripherial 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.

Harshita Tripathi et. al. (2016) Deteremined the effect of dynamic analysis on tall structures of different storey G+24, G+36 and G+ 48, with same dimesions in length and width directions as 36 m x 36 m. and work is done on csi Etab, an analyzing and designing tool with considering lateral forces both seismic as per 1893 part-1 and wind forces as per 875 part-3 and conluded that storey displacement and storey drift values are within the permissible limit and stiffness to the diagrid structural system which reflects the less top storey displacement.

J. Kim et. al. (2010) proposed a comparative study between a diagrid structure with different angles as 50.2°, 61.0°, 67.4°, 71.6°, 74.5°, and 79.5°. with a tubularsection without using diagrids, on a tall structure of 36 storey with plan of 36 m in both directions. Considering non linear analysis and determined that as the slope/angle of braces increased the shear lag effect increased and the lateral strength decreased. The diagrid structures with the brace angle between 60° to 70° seemed to be most efficient in resisting lateral as well as gravity loads.

Ravish Khan et. al. (2015) proposed a comparative study between bracing system and diagrid system in at building fram with same geometry as G+20 tall structure with floor height 3.6m and lateral dimensions as 18m x 18m. considering rigid diaphragm with slab thickness 120mm and seismic zone and wind pressure is applied as per code specification for Aurangabad city. And 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 Also, less amount of storey shear is seen in diagrid structure than to the braced frame structure.

Rafael Sabelli et al (2003) studied on Seismic Demands on Steel Braced Frame Buildings with Buckling-Restrained braces. This paper highlighted on the research being conducted in identifying ground motion and structural aspect, that control the feedback of concentrically braced frames, also identified the improved design procedures and code provisions. In this study the author was keened on the seismic response of three and six story concentrically braced frames utilizing buckling-restrained braces. The examined results of the nonlinear dynamic analyses for specific cases as well as statistically for several suites of ground motions to characterize the effect on key response parameters of various structural configurations and proportions.

Luigi DI SARNO et al (2004) studied on Bracing systems for seismic retrofitting of steel frames. The seismic performance of steel moment resisting frames (MRFs) retrofitted with different bracing systems were assessed in this study. The three types of braces which have been utilized in this study are special concentrically braces (SCBFs), buckling-restrained braces (BRBFs) and mega-braces (MBFs). The author designed a 9-storey steel perimeter MRF with lateral stiffness insufficient to satisfy code drift limitations in zones with high seismic hazards. The SCBFs, BRBFs and MBFs were been retrofitted with the frame. The executed inelastic analyses demonstrated that MBFs were the most cost persuasive. On an average the reduction of inter story drifts was equal to 70% when compared to original MRF. The author showed that moment resisting frames (MRFs) with insufficient lateral stiffness can be retrofitted with diagonal braces in the present analytical work.

Nauman Mohammed et al (2013) studied on Behavior of Multistory RCC Structure with Different Type of Bracing System (A Software Approach). This paper was to evaluate the response of braced and unbraced structure subjected to seismic loads and to identify the suitable bracing system for resisting the seismic load efficiently was its objective. A G+14 floors building were analyzed using STAAD V8i software for special moment resisting frame situated in zone 4.The RCC G+14 structure was analyzed for both without bracings and with different types of bracings system. For all type of structural systems i.e. braced and unbraced structural system bending moments, shear forces, storey shears, story drifts and axial forces was compared. The author has been concluded that the displacement of the structure decreased after the application of the bracing system. After the application of cross bracing system the maximum reduction in the lateral displacement occurs. In the columns bracing system reduces bending moments and shear forces. The author achieve that the execution of cross bracing system was better than the other specified bracing systems. To retrofit the existing structure steel bracings were used. Significantly after the application of the bracings, total weight of the existing structure will not be changed.

Mussa Mahmoudi et al (2013) studied on Determination the Response Modification Factors of Buckling Restrained Braced Frames. The author evaluated the response modification factors of buckling restrained braced frames (BRBFs) utilized for rehabilitation of steel frames. The response modification factor which depended on ductility and over strength, the constant nonlinear analysis has been performed on building models including both the single and double bracing arms, multiples of floors and different brace composition (chevron V, invert V). For all the buildings assessment of the BRBFs values for factors such as ductility, over strength, force reduction due to ductility and response modification has been done. The response modification factors for BRBFs have high values in accordance with the result. The number of bracing arms and height of buildings have had greater effect on the response modification factor which has been founded out.

Shrikant Harle (2014) studied on Analysis and Design of Earthquake Resistant Multi-Storied Braced R.C.C. Building using NISA Software. In the authors work the construction of multistoried reinforced concrete building with the help of NISA software was analyzed and designed with steel braces .The behavior of the Reinforced concrete buildings which was subjected to earthquake forces has been obtained. For the better performance of building during and after earthquake has been carried out using the IS 1893:2000 (Part I) for R.C.C. building in zone III. The results have been obtained for the three different cases i.e. normal loading, earthquake loading and earthquake loading applied to braced and unbraced building. The author concluded that in comparison to unbraced building for earthquake loading soft drift decrease by 26.3% for braced building. The distortion of frames was reduced by bracings which lead to reduction in the drift. As compared to unbraced building distortion for braced building is found to be lesser and hence moments were also founded to be less.

Karoly A. Zalka (2014) studied on Maximum deflection of asymmetric wall-frame buildings under horizontal load. The author presented a new analytical procedure for the determination of the maximum deflection of asymmetrical multi-story buildings braced by frameworks, shear walls and cores. The lateral deflection and rotation were the two phenomenon's which separated the complex response of the building. The results of over one hundred test structures of different bracing system preparations, various stiffness characteristics and different heights ranging from four story's to eighty stories was used to determine the accuracy of the proposed method was demonstrated.

III. CONCLUSION

The researchers have tried to find the variation in forces which occurs due to bracing system and shear link, following are the outcomes of literature review:

- Determine that frame with diagrid results in less lateral forces in beam and columns.
- Structure with diagrid at approximately 60 ° diagrids become more stable.
- Determine that diagrids in tall structures reduces the effect of storey drift.

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