

Comparative Study of Different shapes of Diagrid Structure System with Conventional System using Response Spectrum Analysis: A Conceptual Review

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Abstract— The diagrid structural system may be outlined as a diagonal member shaped as a framework created by the intersection of various materials like metals, concrete or wood beams that are used in the construction of buildings and roofs. Diagrid structures of the steel members are efficient in providing a solution both in term of strength and stiffness. But these days a widespread application of diagrid is employed within the giant span and high-rise buildings, significantly after they area unit complicated geometries and shapes. Diagrid structure consists of inclined columns on the exterior surface of the 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. Diagrid structures typically, don't need core because of lateral shear may be carried by the diagonals on the outer boundary of a building.

Keywords— Diagrid buildings, Seismic Analysis, Wind Analysis

I. INTRODUCTION

Construction of the multi-storey building is quickly increasing throughout the globe. Advances in construction technology, materials, structural systems, analysis, and design software package expedited the expansion of those buildings. Diagrid buildings square measure rising as structurally economical furthermore as architecturally important assemblies for tall buildings. Recently the diagrid structural system has been wide used for tall buildings because of the structural potency and aesthetic potential provided by the distinctive geometric configuration of the system. Generally, for tall building diagrid structure steel is employed. In present work, concrete diagrid structure with completely different shapes is analyzed and compared with a conventional concrete building. The structural design of high-rise buildings is ruled by lateral loads because of wind or earthquake. Lateral load resistance of the structure is provided by the inside structural system or exterior structural system. because of inclined columns, lateral loads are resisted by axial action of the diagonal in diagrid structure compared to bending of vertical columns within the typical building.

II. CONTRIBUTION OF RESEARCHERS IN FIELD OF DIAGRID STRUCTURE

Table 2.1 present the contribution of Different researchers in the field of Diagrid structure

S. No	Research (year)	Contribution
1	Irfan Saleem (2018)	The objective of this work is aimed to Study the different parametric behavior of asymmetric buildings by analysis and modeling of different story buildings using three linear analysis (Response Spectrum Method) procedure using ETABS Software. For this study, a Circular Diagrid structure which is Asymmetric in shape With and Without core Shear Walls is modeled and analyzed. All the models/buildings are analyzed and compared for the outcomes such as maximum story drifts, story displacements, Storey Shear and the conclusions are presented at the end of the paper.
2.	Akshat et.al (2018)	In this paper, the study is created on the idea of lateral load because of earthquake. There square measure varied structural systems for resisting the lateral load however the diagrid structural system is in trends these days and adopted for analysis work. In this paper, a 60-storey tall building of height 216 m is analysed. The arrange dimension of the building is forty-eight m by forty-eight m. The building is analysed for lateral load due to earthquake in seismic zone IV. Various patterns of the diagrid were employed in the dynamic analysis by variable the angles of the diagonal components. The analysis is performed by using ETABS software. Response Spectrum technique is adopted for the dynamic analysis of the structure. The number of diagonal elements is also varied on the façade of the structure for the assessment of the economy. At last, secondary bracing system was also added to it. The results of research square measure mentioned in terms of most level displacement, most level drift and most level shear.

3.	Trupti A. Kinjawadekar et. al (2018)	Diagrid structural system has crystal rectifier to important innovations in study and structural ideas. In case of high-rise structures, the lateral load resistance is sometimes provided by interior or exterior structural systems. Adoption of diagrid structural system in high rise construction provides higher structural potency in resisting lateral load together with flexibility in study coming up with. Such system consists of inclined columns on the outside surface of buildings rather than closely spaced vertical columns in framed structures. This paper presents a comparative study of seismic characteristics of diagrid structural systems for multi-storey structures. The results supported numerical models indicate that these structures will address most of the current style needs. The study aims to explore the pertinence of diagrid structures in high rise structures, over the normal construction systems. Numerical models and seismic characteristics of diagrid members are studied mistreatment software system SAP-2016.
4.	Chetan S.Pattar (2018)	In modern era, construction of high-rise buildings is rapidly increasing throughout the world. Due to decrease of available free land and due to wide spread urban area, the architects and the engineers have started developing cities vertically. Recently, the diagrid structural system has been wide used for tall buildings thanks to structural potency and aesthetic potential provided by triangulation of the system. Compared to the standard frame buildings having exterior vertical column, diagrid structure resists the lateral masses a lot of expeditiously thanks to presence of inclined columns. In diagrid system the lateral loads are resisted by the axial action of the inclined columns that are placed at the exterior periphery of the buildings. In the present study a 16-story square plan structure is considered along with C-Type and L-Type structure which have plan irregularity in them. The structures are analyzed by dynamic linear method that is response spectrum method. The results obtained are compared using various parameters like base shear, top story shear, top story displacement, time, storey drift, quantity of material consumed.t. The behaviour of plan irregular structure is compared with regular structure.
5.	Avnish Kumar Rai (2017)	in this paper we studied about The diagrid system now a days wide used for prime rise buildings thanks to its structural potency. In gift analysis work, steel diagrid structure at AN outer portion of the building at sixty degrees having AN inner core of R.C.C columns with R.C.C beam and the slab is analysed and compared with a conventional concrete building. The diagonal member of diagrid structure transferred the lateral masses by axial action compared to bending of vertical columns within the typical building system. A regular eleven level RCC building with arrange size sixteen m × sixteen m settled in seismic zone V & III is considered for analysis. STAAD.Pro software package is employed for modelling and analysis of structural. Seismic zone is considered as per IS 1893(Part 1): 2002. The Comparison between the diagrid and standard building analysis results bestowed in terms of a node to node displacement, bending moment, level drift, shear forces, a neighbourhood of reinforcement, and additionally the economical aspect.
6.	Shubhangi V. Pawar (2017)	This analysis paper consists of earthquake and wind analysis of Steel Diagrid Structure with completely different shapes in set up. The Indian normal code of apply IS- 1893 (Part I: 2002), IS- 875:1987(Part III), IS-800-2007 tips and methodology are used to analyse and design building. Etab2015 structural analysis software system is employed to analyse buildings below the impact of wind and earthquake forces in zone III. Equal space of 1296 money supply used for Circular, Square, Rectangular plans. Seismic and Wind analysis done by Linear Static technique. The behaviour of building parts was examined and compared on the idea of displacement, story drift, and base shear.
7.	Snehal S. Mali (2017)	In the recent years, because of lack of land the development of high-rise buildings wide will increase. And these buildings are littered with lateral hundreds because of wind or earthquake. To resist these lateral hundreds variant construction strategies ar obtainable. Diagrid structural system is one in every of the foremost effective systems because of its potency and suppleness in subject coming up with. In this system peripheral columns of the building ar eliminated, and this constructs the most distinction between diagrid and orthogonal structure. The present work is formed for finding out the response of high rise building with completely different diagrid structural system. To this aim response of 4 completely different diagrid structures of (G+30) level ar disbursed to get optimized position of diagrid. And response of this diagrid building is compared with typical building by providing same parameters to each the buildings. The analysis of the building is disbursed by victimisation ETABS software package. The results obtained in terms storey displacement.

8.	Deep Bajoria (2017)	One of the redolent of structural style solutions for tall buildings is recently embraced by the diagrid (diagonal grid) structural system. In tall buildings, the main problem that governs the design is lateral loads, instead of the gravitational loads in shorter building. Thus, systems that are a lot of economical in achieving stiffness against lateral hundreds ar thought-about higher choices in planning tall buildings. The diagrid system is one amongst the foremost economical lateral resisting systems, and this feature is caused by its triangular configurations. The diagrid structural system has been wide used for recent tall buildings thanks to the structural potency and aesthetic potential provided by the distinctive geometric configuration of the system. This paper presents a stiffness-based design methodology for determining preliminary member sizes of R.C.C. diagrid structures for a G+36 story building. The methodology is applied to the diagrid to determine the optimal grid configuration of the diagrid structure and further its comparison with conventional R.C.C structure. A regular floor plan of 36 m × 36 m size is considered for the structures. ETABS 9.7.4 software is used for modelling, analysis and design of structural members. All structural members are designed as per IS 456:2000 and cargo mixtures of seismic forces are thought-about as per IS 1893(Part1):2002 considering all load mixtures. Dynamic load along wind and across wind are considered for analysis for the structure as per IS 875-1987 (part 3). Analysis of G+36 story building with perimeter diagrid is carried out by Response spectrum method. The comparison of analysis of results in terms of top story displacement, story drift, story shear, time, steel and concrete consumption, base reactions for seismic and wind forces is done.
9.	Ravi Sorathiya (2017)	Construction of multi- storey building is speedily increasing throughout the globe. Recently the diagrid structural system has been widely used for tall buildings due to the structural efficiency and aesthetic potential provided by the unique geometric configuration of the system. These days the latest trend of technology in diagrid structures is evolving. The diagrid structures are buildings with diagonal grids in the periphery at a angle and in modules across the height of the building. Diagrid structure uses triangulated grids which are in place of vertical columns in the periphery. Thus, systems that square measure a lot of economical in achieving stiffness against lateral hundreds square measure thought of higher choices in planning tall buildings. This paper presents a stiffness-based style methodology for deciding preliminary member sizes of r.c.c diagrid structures for tall buildings. A G+24, G+36, G+48,G+60 storey RCC building with plan size 18 m × 18 m located in surat wind and seismic is considered for analysis. STAAD.Pro software package is employed for modelling and analysis of structural members. All structural members square measure designed as per IS 456:2000 and cargo mixtures of unstable forces square measure thought of as per IS 1893(Part 1): 2002. Comparison of analysis results in terms of beam displacement, Storey Drift, Bending Moment. This cause economical design of diagrid structure compared to conventional structure.
10.	Ravish Khan (2016)	These days the latest trend of technology in diagrid structures is evolving. The diagrid structures are buildings with diagonal grids in the periphery at a angle and in modules across the height of the building. Diagrid structure uses triangulated grids which are in place of vertical columns in the periphery. The latest trends in diagrid structures are making the scope in new strategies to reduce the earthquake and wind responses in the structure. The triangulated configuration of diagrids takes the lateral as well as gravity loads and passes them through axial action into the ground. The use of diagrid structures has proved to be more efficient than a regular framed structure. Also, the vertical columns in the periphery are also eliminated, giving efficient utilization of the space. In this paper, two models of diagrid structures with different symmetric and asymmetric plan geometries are analysed by linear static method and designed for the same. The analysis results are shown in terms of storey shear, storey drift and storey displacement in all the two models.
11.	Kamath, K (2016)	In this study, an effort has been created to review the performance characteristics of diagrid structures mistreatment nonlinear static pushover analysis. The models studied are circular in plan with aspect ratio H/B, (where H is total height and B is the base width of structure) varying from 2.67 to 4.26. The 3 completely different angles of external brace thought of square measure 59°, 71° and 78°. The dimension of the bottom is unbroken constant at 12m and height of the structure is varied consequently. The nonlinear behaviour of the weather is modelled mistreatment plastic hinges supported moment-curvature relationship as represented in Federal Emergency Management Agency 356 pointers. Seismic response of structure in terms of base shear and roof displacement equivalent to performance purpose were evaluated mistreatment nonlinear static analysis

		and the results square measure compared. For 71° brace angle model base shear at performance shows a rise altogether the ratio thought of within the study. The performance of the structure is influenced by brace angle and ratio.
12.	Manthan I. Shah (2016)	In modern age, the decrease of available free land and increase of land prices along with the wide spread of urban area has made architects and engineers to develop the cities vertically. For vertical growth, the sole possibility is to construct the buildings as high as attainable. It is a task of a structural designer to form the required building stand and stable throughout its life. There are a unit varied structural systems for tall buildings, among them diagrid system is chosen for this work. Diagrid is associate degree exterior structural system that resists the lateral forces by axial actions of diagonals provided in boundary. Statistical analysis of tall buildings in Asian country is applied and bestowed for buildings having height over a hundred and fifty m or forty storeys. Parametric study and careful comparison of diagrid structural system with relevance standard frame is applied for symmetrical buildings. In this study seven steel buildings of identical base space and loadings with completely different heights area unit designed for optimum sections for each structural systems diagrid and traditional enclose ETABS. Various parameters like elementary period, most high structure lateral displacement, most base shear, steel weight, share variations in modification of steel weight, most structure displacement and most structure drift are considered in this study. A Diagrid structure performs well than standard frame structures and increase in steel weight with increase tall of building is significantly less in diagrid structures.
13.	Arpitha L M (2016)	In this era increasing within the population limiting within the land house and high within the price of land, to save lots of agricultural land we tend to opt for tall buildings. When height of the building will increase, the lateral masses are going to be will increase this cause failure of structure. To resist this lateral mass resisting systems are introduced. Some of lateral resisting systems area unit of diagrid and Braced tubes area unit taken for this study. The setup of sq. and polygon area unit sculpturesque for each Diagrid and Braced tube structures. The models are compared for different plans of the structure, such as square and hexagonal, the maximum storey displacement, storey drift, base shear, and time period, the structure is analysed for seismic zone III and zone V and medium soil condition as per IS 1893:2002 victimization ETABSV15 software package. From the model braced structures is stiffer than the diagrid structures, since the columns are provided in periphery. Diagrid structures can be made effective by providing additional columns near periphery of the structurur. Bharath Reddy (2015) The vulnerability of seismic forces onto a high-rise structure leads to a collapse which is unpredictable. It can even be understood from the provisions of Indian Standards that, it is desired to allow the damage of the structure to certain extent for sudden earthquakes by safeguarding the livelihood. In the present study, a five storied RC building has been modelled and then analysed considering the combination of gravity and seismic forces. The performance of the same structure has been investigated for different types of bracing system such as cross and diagonal bracings using a concrete section and steel sections respectively. The performance of constant building has been evaluated in terms of lateral displacement of members, storey drift, axial force and bending moment in columns at different critical. The effectiveness of various bracing systems on the structure has also been investigated. More significantly, the reduction in lateral displacement has been found out for different types of bracing system in comparison to building with no bracing for zone-3 and zone-4. From this study, it's been found that the crossed 'X' bracing reduces additional lateral displacement and therefore considerably contributes to bigger structural stiffness to the structure
14.	Prashant T G (2015)	Diagonalized grid structures – “diagrids” - have emerged collectively of the foremost innovative and elastic approaches to structuring buildings during this millennium. Diagrid could be a specific variety of area truss, it consists of perimeter grid created from a series of triangulated truss system. Diagrid is made by across the diagonal and horizontal elements. Construction of multi- storey building is chop-chop increasing throughout the globe. Advance in construction technology, materials, structural systems, various analysis and design software have facilitated the growth of various kinds of buildings. Diagrid buildings square measure rising as structurally economical further as architecturally and aesthetically vital assemblies for tall buildings. Recently these diagrid structural systems are wide used for tall buildings thanks to the structural potency and aesthetic potential provided by the distinctive geometric configuration of the system. This paper presents a 12-storey steel diagrid structure which is 36m in height. Symmetric and uneven structural configurations of diagrid structures were modelled and analysed exploitation SAP 2000 by

		considering burden, Live load and Seismic Loads (IS 1893-Part-1, 2002). Then independent agency 356 hinges (auto hinges) square measure assigned to an equivalent structure and nonlinear Static (Pushover) analysis is dispensed by exploitation unstable load because the pushover load case to find out the performance points that's Immediate Occupancy, Life Safety, and Collapse Prevention of diagrid elements using static pushover curve. At an equivalent time, spectral displacement demand & spectral displacement capability further as, spectral acceleration demand and spectral acceleration capability is compared to grasp the adequacy of the design by using ATC capacity spectrum method.
15.	Deepa Varkey (2015)	Diagrid structures for tall buildings area unit very talked-about among engineers and designers. One of the evocative structural design solutions for sustainable tall buildings is embraced by the diagrid structural scheme. This study focusses on the concept of diagrid structural system, structural performance of a steel tall building and compare the complex shape of high rise building for diagrid system using SAP2000. The ensuing diagrid structures were assessed underneath gravity, wind and seismic hundreds and varied performance parameters were evaluated on the idea of the analysis results. The comparisons are in terms of lateral displacement, base shear and inter storey drift.
16.	Andre R. Barbosa (2014)	The steel diagrid structural gadget is a recent load bearing and lateral resisting structural gadget for tall constructing systems that is exceptionally unexplored inside the western United States. One feasible motive for the little use of diagrid systems in earthquake inclined regions is the shortage of recommendations and application examples illustrating the design and evaluation of these structures. In this work, a 72-tale prototype constructing is used as an instance for which the layout and evaluation of the diagrid gadget is performed. To mitigate the feasible huge displacement and base shear needs that those structures can also go through below seismic occasions, new design answers consisting of 1 or two friction tuned mass damper (TMD) units are explored. In the first answer, a TMD is located on the pinnacle four memories of the building and is tuned to reduce the contribution of the essential mode of vibration of the structure, in each horizontal instruction. In the second one answer, a double TMD machine is added at mid-height of the constructing, in which a 2nd TMD unit in tuned to the second period of the shape. Using a nonlinear finite detail model of the tuned mass damper, the effectiveness of the friction mass damper design is studied. The mass damper gadget includes a concrete tank containing sand or water. The tank is positioned in between the constructing reinforced concrete structural center and the exterior steel diagrid machine. This mass damper is connected to the shape the usage of friction pendulum isolators which might be selected due to their capability to undergo big deformations. The fashions are then subjected to accelerograms from ancient shallow crustal earthquakes and subduction area earthquakes. Parametric studies are accomplished to understand the effect of various parameters of the mass damper design in improving the seismic performance of the constructing. Improvement of the seismic overall performance is classed in terms of minimization of inter-story flow ratios, base shear forces, in addition to ground absolute accelerations. The outcomes show that the unmarried TMD machine can reduce extensively the peak base reaction and inter-tale drift envelopes. Addition of the second TMD presents similarly improvements in phrases of reducing the height base reactions, at the same time as also generating super reductions in peak absolute floor accelerations, which are not found when best one TMD unit is used.
17.	Rohit Kumar Singh (2015)	Construction of multi- storey constructing is hastily increasing at some point of the sector. Advances in production generation, substances, structural systems, evaluation and design software facilitated the increase of those homes. Diagrid buildings are emerging as structurally efficient as well as architecturally full-size assemblies for tall buildings. Recently the diagrid structural system has been broadly used for tall homes because of the structural efficiency and aesthetic capacity supplied by way of the precise geometric configuration of the gadget. Generally, for tall building diagrid shape steel is used. In gift work, concrete diagrid structure is analysed and as compared with traditional concrete building. Structural layout of high-rise homes is governed by means of lateral hundreds due to wind or earthquake. Lateral load resistance of the shape is supplied by indoors structural machine or outdoors structural gadget. Due to willing columns lateral masses are resisted by using axial action of the diagonal in diagrid shape as compared to bending of vertical columns in conventional constructing. A regular five storey RCC constructing with plan length 15 m × 15 m located in seismic area V is considered for evaluation. STAAD.Pro software program is used for modelling and evaluation of structural

		members. All structural participants are designed as in line with IS 456:2000 and load combinations of seismic forces are taken into consideration as consistent with IS 1893(Part 1): 2002. Comparison of analysis results in phrases of storey float, node to node displacement, bending second, shear forces, location of reinforcement, and additionally the in your price range element is provided. In diagrid shape, the important portion of lateral load is taken by means of outside diagonal members which in turn release the lateral load in internal columns. This causes within your means layout of diagrid shape in comparison to traditional shape. Drift in diagrid constructing is approx. 1/2 to that obtained in conventional building. In this have a look at, metal reinforcement utilized in diagrid shape is located to be 33% less as compared to standard constructing.
18.	Ravii K Revankar (2014)	Diagrid is a selected form of space truss. It includes perimeter grid made of a series of triangulated truss gadget. Diagrid is shaped through intersecting the diagonal and horizontal components. The diagonal members in diagrid structural systems can bring gravity hundreds as well as lateral forces due to their triangulated configuration. Diagrid structures are extra powerful in minimizing shear deformation due to the fact they carry lateral shear by using axial motion of diagonal participants. Diagrid systems usually do not need high shear pressure cores because lateral shear may be carried by way of the diagonal participants placed on outer edge. In this paper look at of diagrid system which is modelled with 12 storey diagrid building is analysed the use of SAP 2000 by means of considering Dead, Live and Seismic Loads (IS 1893-Part-1, 2002) and designed the use of IS-800. Afterwards the FEMA 356 hinges are assigned to the same building and performed Nonlinear Static (Pushover) to find out the overall performance points that is Immediate Occupancy, Life Safety, and Collapse Prevention of diagrid factors. At the identical time Base Shear and Displacements are studied and Spectral Displacement Demand & Spectral Displacement Capacity is compared to understand the adequacy of layout. And it's far glaring that the designed 12 storey diagrid constructing doesn't require redesign.
20.	Kyoung Sun Moona (2011)	Diagrid structures are prevalently used for these days's tall homes because of their structural efficiency and architectural aesthetic potentials. This paper studies structural performance of diagrid systems hired for complicated-fashioned tall homes such as twisted, tilted and freeform towers. For each complex form category, tall buildings are designed with diagrid structures, and their structural performance is studied along with constructing bureaucracy. To analyse the effects of version of vital geometric configurations of complicated-formed tall buildings, including the rate of twisting and angle of tilting, parametric structural models are used for this look at. Based on the observe results, layout concerns are mentioned for the efficient use of diagrid systems for complex-fashioned tall buildings.

III. GAP IN RESEARCH REVIEW AND OBJECTIVE OF NEW RESEARCH

Based on survey of available literature following gaps in the research are being identify.

1. There is very limited research which focuses on comparison of RC diagonals with different shapes of building.
2. There is almost Nil research available for triangular shape of diagrid structure.

Based on above mentioned gaps following objectives of the research are being investigated

1. To evaluate the performance of RC diagonal in high rise multistory building.
2. To compare conventional building with different shape of RC diagrid building, Comparison will be done between Square, Circular and Triangular building with Convention building.

IV CONCLUSION

Present research tells about the contribution of different researches in the field of the diagrid structure system, a gap in the research and objective of the research to be conducted. These contributions help to visualize the problem faced by RC diagonals from a new perspective. By evaluating the performance of different shape of diagrid structure with conventional structure its enhanced performance may be achieved, which shall lead to the direction of the lateral load resisting system stronger and more economical.

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