DIAGRID BASED MULTISTOREY BUILDING DESIGN AND DURABILITY FORECASTING

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Abstract –

Development of tall buildings have been rapidly increasing in number worldwide. The trends in tall building design is now towards the integration of optimal building form with the structure to produce an efficient design. Diagrid system is an innovative technology that is widely used now a days which promise better lateral load efficiency. Modelling and analysis of structural member is done using finite element software STAAD pro. Loads, load combinations and seismic data are provided according to IS 875:1987and IS 1893:2002 respectively. Analysis results with conventional system is done in terms storey displacement, storey shear, storey drift and time period Using ANOVA method.

Key Words: **Diagrid structural system, Hexagrid structural system, Lateral load resisting system, Storey displacement, Storey drift, Storey shear, Time period.**

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I.Introduction

The rapid growths of urban population and consequent pressure on limited space have considerably influenced the residential development of city. The high cost of land, the desire to avoid a continuous urban sprawl, and the need to preserve important agricultural production have all contributed to drive residential buildings upward. The rapid growths of urban population and consequent pressure on limited space have considerably influenced the residential development of city.

Over the past decade several research works have been carried out about diagrid buildings. Having established the importance of diagrid structures, researchers and practitioners have developed advanced design strategies to make diagrid structural systems efficient and economical. The structural efficiency and flexibility in architectural planning makes diagrid an innovative structural system for tall buildings. Several studies have pointed out the design methodology to be followed and researches have been carried out about the joint connections as well. Hence the purpose of this paper is to provide a systematic summary of the existing research achievements of the diagrid structural system for tall buildings. 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 façade 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] [2].

II. Research motivation

In the today's trend population has rapid growth and the space is limited for the building. Therefore there is need to develop tall buildings for development of city. Diagrid system is economical and has good lateral resisting system and carrying gravitational loads. Important point are taken into consideration while designing tall structure is lateral loads due to the wind and earthquake, diagrid system have better latter load resisting system due to inclined column located at the periphery of the structure [2]. Diagrid System and braced tube structure are as follows generally for tall structure braced tubes system is used for 11storeys John Hancock Center of 1970 in Chicago. But due to various structural problems in braced tube structure, diagrid performs better than conventional system [3]. In conventional system columns are spaced widely by diagonal braces and diagonal braces create wall like characteristics. The increase in the number of high-rise buildings is contributed mainly by the evolution of efficient structural system, advances in construction technology, scarcity and high cost of urban land and also the advancement in computational techniques which allows the analysis and design of complex structures less time consuming and easy. Along with gravitational loading lateral loads such as wind loads and seismic loads proves to be major governing factor in the design of high-rise buildings. In order to resist lateral loads in tall structures mainly interior structural systems and exterior structural systems are provided. The widely used internal lateral load resisting systems are: rigid frame, braced frame, shear wall and outrigger structure. The exterior systems are: tubular structure and diagrid structure. Out of many framed structures the uniqueness that differentiate diagrid is the ability to form wide range of nonrectilinear geometric structures which includes angles and curves. This makes diagrids as an excellent architectural choice in the creation of contemporary buildings.

III. Benefits

The diagrid system has a lot of benefits that can make it more favored be the designer against other systems. Some of those benefits are:

- Mostly column free exterior and interior
- Generous amounts of day lighting due to dearth of interior columns and structure
- Roughly 1/5th reduction in steel possible
- Simple construction techniques (although they need to be perfected yet)
- Full exploitation of the structural material
- Similar design/construction tolerances as a typical moment frame construct (for instance: a type. columnar element would be created 1/8th of an inch longer than called for to allown for compression in the final product in a M.F. project. The same can be said for a DiaGrid project.)
- Free and clear, unique floor plans are possible
- Aesthetically dominate and expressive.

IV. Diagrid structural behavior

The diagrid structures can be seen as the latest mutation of tube structures, which starting from the frame tube configuration, have increased structural efficiency thanks to the introduction of exterior mega-diagonals in the braced tube solution; in this case the significant improvement in terms of lateral stiffness and shear lag reduction also reflects in the building architecture, strongly connoted by the clear and disciplined structure, "the honesty of the structure", in the words of the architect Bruce Graham. The diagrid system can be considered as a further evolution of the braced tube structures, since the perimeter configuration still holds for preserving the maximum bending resistance and rigidity, while, with respect to the braced tube, the mega-diagonal members are diffusely spread over the façade, giving rise to closely spaced diagonal elements and allowing for the complete elimination of the vertical columns; thus the diagonal members in diagrid structures act both as inclined columns and as bracing elements, and carry gravity loads as well as lateral forces; due to their triangulated configuration, mainly internal forces arise in the members, thus minimizing shear racking effects.

NEED OF STUDY

Tall building 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 a very tall building, its structural design is generally governed by its lateral stiffness. Comparing with conventional orthogonal structures for tall buildings such as framed tubes, diagrid structures carry lateral wind loads much more efficiently by their diagonal member's axial action. A Diagrid structure provides great structural efficiency without vertical columns have also opened new aesthetic potential for tall building architecture. Diagrid has a good appearance and it is easily recognized. The configuration and efficiency of a diagrid system reduces the number of structural element required on the façade of the buildings, therefore less obstruction to the outside view. The structural efficiency of diagrid system also helps in avoiding interior and corner columns, and therefore allowing significant flexibility with the floor plan.

V. Objectives of study

1. To study the concept of diagrid structural system on a high rise structure.
2. To determine the optimum configuration for buildings using STAAD.pro software.
3. To determine the variation in forces due to diagrid structure under seismic forces.
4. Results obtained forecasting in terms of Max story drift, max story displacement, base shear in seismic case using ANOVA method [5,6,7].

VI. Proposed methodology

In this paper comparison of diagrid and conventional building under seismic load is observed. Here G+ 11storey is taken and same live load, dead load and slab load is applied in both the buildings for its behavior and comparison. The framed buildings are subjected to vibrations because of earthquake. Seismic analysis is essential for these building frames. The fixed base system is analyzed for both building frames in seismic zone V by using staad software [8-15].

The G+11-storey building is having 18m x 18m plan dimension and 21m total height of building. The storeyheight is 21m. The typical elevation shown in figure 1. There are two models for comparative study, one is for simple frame building and another is for diagrid structure. The building data is kept same for both models.

Interior Column Analysis: The analysis of the interior column is carried out at each floor in terms of axial force, bending moment in y and z direction. The plan of the selected location for analysis is shown in fig.3. The behavior of the rest of interior column is shown by symmetry. The selected location of the column to be analyzed. From graph in fig.7 it is cleared that axial force is increases from conventional to angle 45˚but after increasing diagrid angle axial force decreases as compared to conventional. This depends on number of floors.

Analysis of variances

Analysis of variances (ANOVA) statistical models were initially introduced in a scientific paper written by Ronald Fisher, a British mathematician, in the early 20th century. He is credited with first introducing the term variance.

ANOVA testing does not just examine the differences, it also looks at the degree of variance, or the difference between them, in variable means. It is a way of analyzing the statistical significance of the variables. ANOVA analysis is sometimes considered to be more accurate than t-testing because it is more flexible and requires fewer observations. It is also better suited for use in more complex analyses than those that can be assessed by conducting tests.

Additionally, ANOVA testing allows researchers to uncover relationships among variables, while a t-test does not. Variations of ANOVA testing include One-Way ANOVA (used to search for statistically significant differences between two or more independent variables), Two-Way ANOVA (to uncover potential interaction of two independent variables on one dependent variable) and Factorial ANOVA, which typically involves assessing two or more factors or variables with two levels.

VII. Result and simulation

Aanalysis of results in terms of moments, displacements, shear force, axial force, drift and economy has been made. Following steps are adopted in this study:-

Step-1 Selection of building geometry and Seismic zone: The behaviour of both the models is studied for Zone V of Seismic zones of India as per IS code 1893 (Part 1): 2002 for which zone factor (Z) is 0.36. Five storey building is taken. Each storey is of 3m height. Depth of foundation is taken as m.

Step-2 Formation of load combination: Six primary load case and thirteen load combination is considered for analysis and design.

Step-3 Modelling of building frames using STADD.Pro software

Step-4 Analysis of both the building frames is done under seismic zone v and each load combination.

Step-5 Comparative study of results in terms of maximum moments in columns and beams, storey displacement, shear force, axial force, drift and economy.

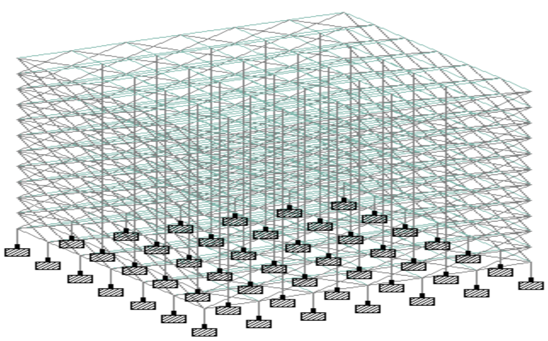

Fig.1.Diagrid design Staad pro.

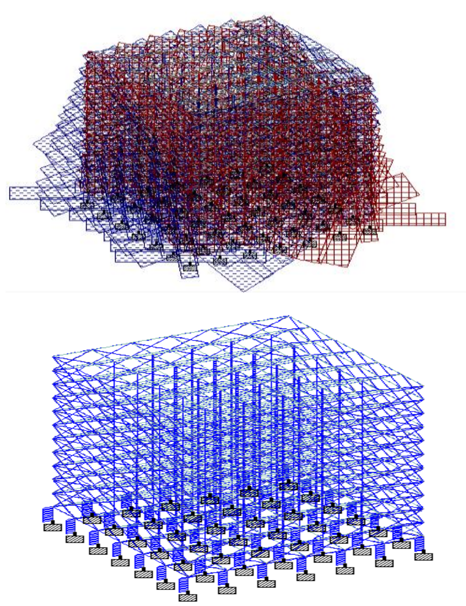

Fig.2. Fy and Fz direction deflection Occur.

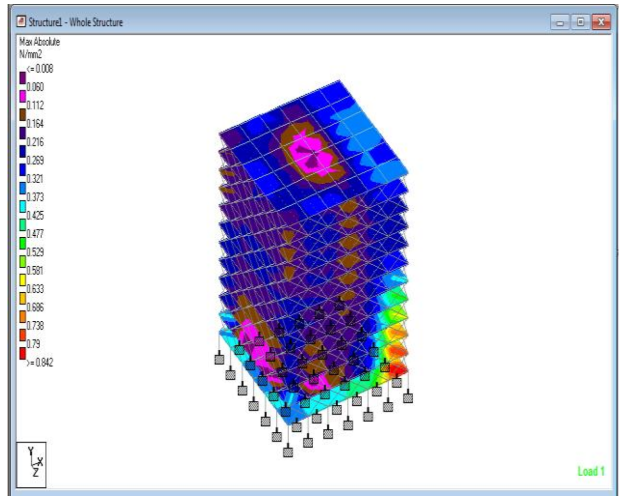

Fig.3. Earthquake effect.

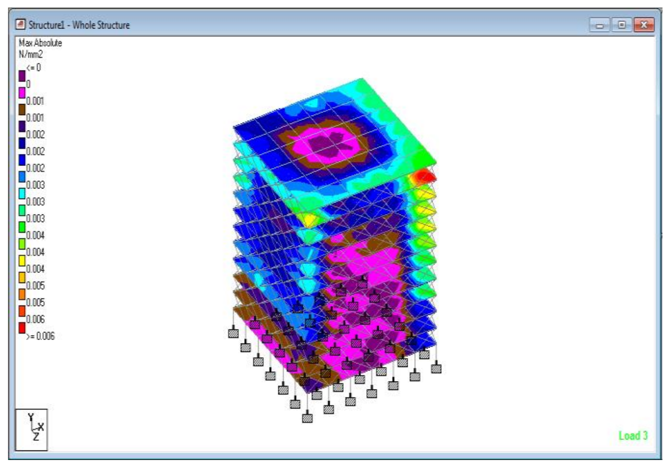

Fig.4. Wind Load Effect.

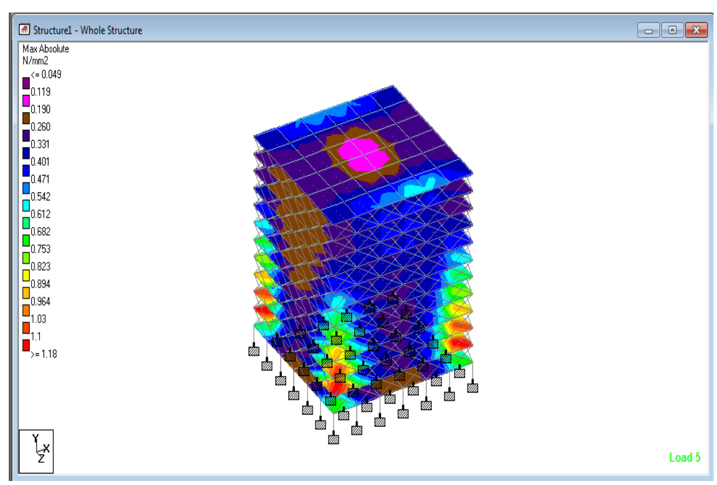

Fig.5.Dead Load Effect.

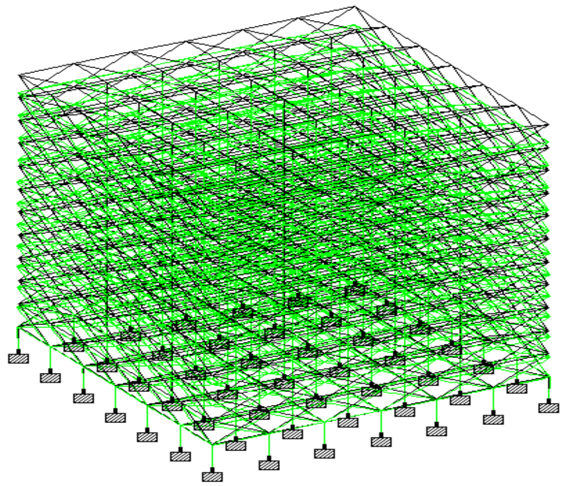

Fig.6 Bending Movement Occur.

Table 1.Ground Floor Bending Occur.

DISTANCE	FY	MZ
0	-5.442	-8.82
0.25	-5.442	-7.459
0.5	-5.442	-6.099
0.75	-5.442	-4.738
1	-5.442	-3.378
1.25	-5.442	-2.018
1.5	-5.442	-0.657
1.75	-5.442	0.703
2	-5.442	2.064
2.25	-5.442	3.424
2.5	-5.442	4.785
2.75	-5.442	6.145
3	-5.442	7.505

Table 1.Top Floor Bending Occur.

DISTANCE	FY	MZ
0	-0.673	-1.253
0.25	-0.673	-1.085
0.5	-0.673	-0.917
0.75	-0.673	-0.749
1	-0.673	-0.58
1.25	-0.673	-0.412
1.5	-0.673	-0.244
1.75	-0.673	-0.076
2	-0.673	0.093
2.25	-0.673	0.261
2.5	-0.673	0.429
2.75	-0.673	0.597
3	-0.673	0.766

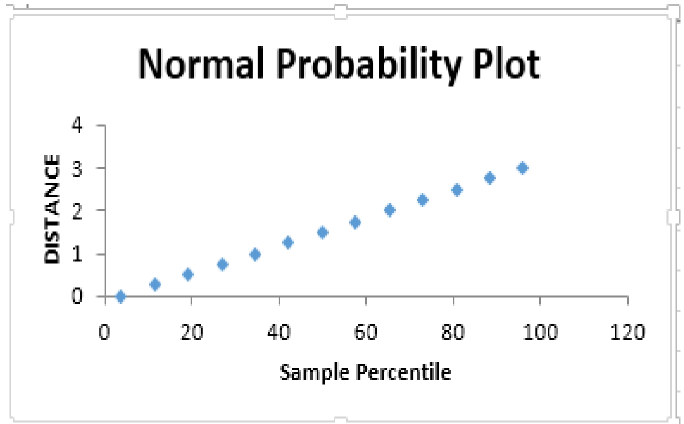

Fig.7 Probability of Ground Floor Bending Occur.

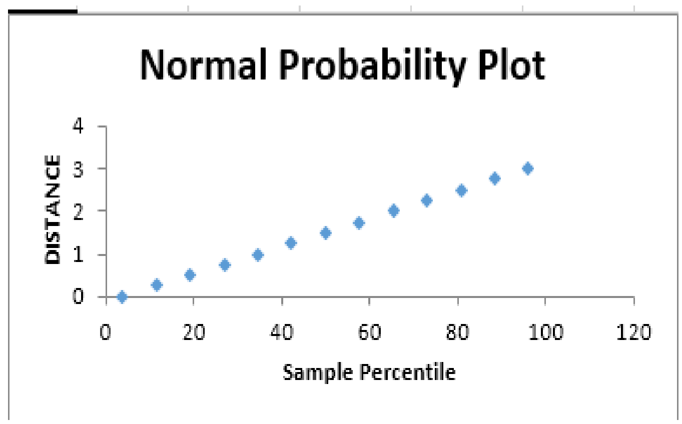

Fig.8 Probability of top Floor Bending Occur.

VIII. Conclusions

In this study, it is observed that due to diagonal columns in periphery of the structures, the diagrid structure is more effective in lateral load resistance. Due to this property of diagrid structure, interior column is used of smaller size for gravity load resistance and only small quantity of lateral load is considered for it. While in case of conventional frame building, both gravity and lateral load is resisted by exterior as well as interior column. The following points are concluded from above study about diagrid structure:

- Structural performance: Diagrid building shows less lateral displacement and drift in comparison to conventional building.
- Material saving property: Although volume of concrete used in both building is approx. same, but diagrid shows more economical in terms of steel used.
- Better resistance to lateral loads: Due to diagonal columns on its periphery, diagrid shows better resistance to lateral loads and due to this, inner columns get relaxed and carry only gravity loads. While in conventional building both inner and outer column are designed for both gravity and lateral loads.
- Aesthetic look: In comparison to conventional building, diagrid buildings are more aesthetic in look and it becomes important for high rise buildings. So from results and comparison with conventional building, one can adopt diagrid structure for better lateral load resistance and this becomes important for seismic zone.

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