Analysis And Modeling Of Diagrid Structure Using Etabs

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Abstract- *Advances in construction technology, materials, structural systems and analytical methods for analysis and design facilitated the growth of high-rise buildings. Structural design of high-rise buildings is governed by lateral loads due to wind or earthquake. Lateral load resistance of structure is provided by interior structural system or exterior structural system. Recently diagrid structural system is adopted in tall buildings due to its structural efficiency and flexibility in architectural planning. Analysis and design of G+15 storey diagrid steel building is presented. A regular floor plan of 18 m × 18 m size is considered. ETABS software is used for modeling and analysis of structural members. All structural members are designed as per IS 800:200, considering all load combinations. Dynamic along wind and across wind are considered for analysis and design of the structure. Different models have been drawn by adopting different Story height and Optimum angle. Different parameters studied are Storey Displacement and Storey Drift. Based on these parameters, best model has been suggested.*

Keywords- Storey drift 1, Storey displacement 2, Diagrid structure 3, ETAB 4

I. INTRODUCTION

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 skyscraper (Tall Building). In short, it is made up of intersecting diagonal and horizontal components. It requires less structural steel than a conventional steel frame.

Diagrid has good appearance and it is easily recognized. The configuration and efficiency of a diagrid system reduce the number of structural elements 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% structural steel weight when compared to a conventional moment-frame structure.

As Diagrid Structure are efficient in providing solution both in terms of strength and stiffness. Therefore, nowadays widespread application of Diagrid is used in high rise building and skyscrapers, particularly when complex geometries and curved shapes are involved. As height of building rises, not only D.L and L.L are predominant forces but along with-it W.L and Seismic forces equally hold a share with it. In order to provide resistance against these forces, conventional design approach might be sufficient to counteract these loads but may lead to uneconomical design, lesser F.O.S, greater stability requirement and aesthetics part may not be up to the mark. Diagrid takes into account above mentioned limitation which conventional building faces and proves to be one of the solutions for getting optimum structure skyscrapers, particularly when complex geometries and curved shapes are involved.

II. MATERIALS AND METHODS

In this quantitative study, the structural performance of a diagrid structure and a conventional moment-resisting frame structure will be investigated to determine the structural benefits of a diagrid system.

A regular G+15 storey steel building with a plan size of 18 m x 18 m, using the provisions of the National Structural Code of the India (ISI), will be analyzed and will be designed using an ETABS. Software considering a diagrid structural system and a conventional moment-resisting frame structural system.

The results will then be compared in terms of structural performance and cost-effectiveness of the design to determine the structural advantages of the diagrid structure.

The methodology to be employed will be presented in this section, which will be organized into four sections: (a) Sources of Data, (b) Instrumentation, (c) Data Collection, and (d) Data Analysis.

III. SOURCES OF DATA

The design parameters and loadings, including seismic design forces to be used in the study will be based on the prevailing National Structural Code of the India (IS) provision for earthquake resistant design of structures.

All structural member sizes to be used in the design of the structures will be based on the commercially available standard steel sections as listed in the ASEP Steel Handbook.

The geometric parameters of the conventional moment-resisting frame structure and diagrid structure to be used in the study are shown in Table below.

Table -1: Geometric parameters of Conventional and Diagrid Building

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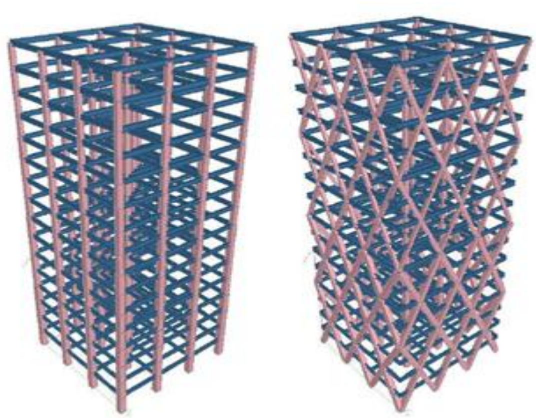
S.No.	Description	Data/Values
1	Number of Storey	G+15
2	Plan Size	18m x 18m
3	Storey Height	3.0m
4	Number of Bays along X and Z direction	3
5	Length of each bay	6m
6	Dead Load: a) Floor load b) Wall Interior (i) Parapet wall	 3.4 kN/m^2 2.11 kN/m^2 3.276 kN/m
7	Live Load: a) At roof and Residential Areas b) Parking and Commercial Areas	 1.9kN/m^2 2.4 kN/m^2
8	Seismic Zone as per NSCP Vol. 1, 6th edition 2010	IV
9	Response Reduction Factor	5
10	Importance Factor	1
11	Soil Type	Hard
12	Structure Type	Steel frame
13	Diagrid Angle	63.43°
14	Diagrid Module	4



(a) Conventional building (b) Diagrid building

Fig – 1: Isometric view of Conventional building and Diagrid building

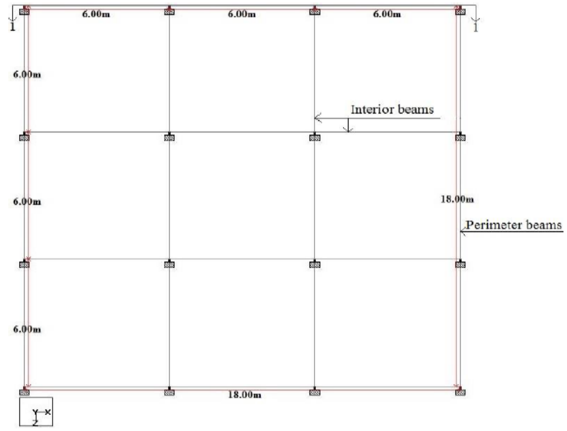
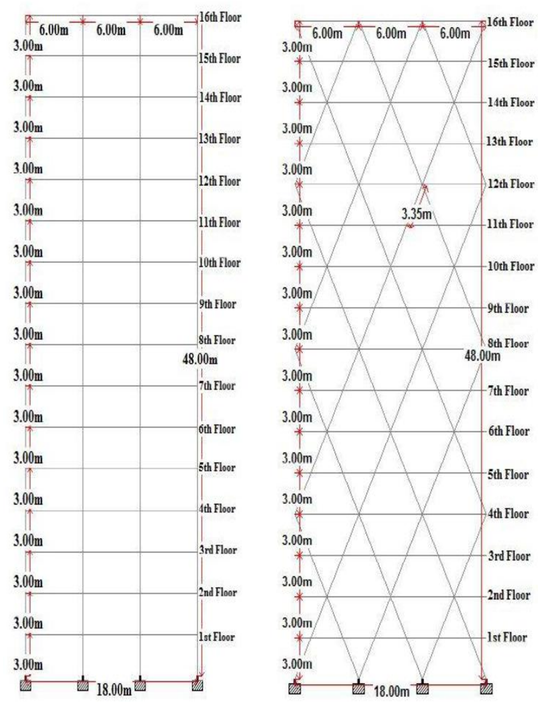


Fig - 2: Plan of Conventional/Diagrid building



(a) Conventional building (b) Diagrid building

Fig - 3: View of conventional and diagrid building at section 1-1

IV. INSTRUMENTATION

A regular G+15 storey steel building with a plan size of 18 m x 18 m will be analyzed and will be designed using aEtabs 2017. Software considering a diagrid structural system and a conventional moment-resisting frame structural system

Etabs is originally developed by Ashraf Habibullah in 1987.

Late it is bought by CSI America. Now we will be going to use the latest version of Etabs 18.1 it is mainly used by structural engineers.

Indian Standard Codes IS: 875-1987; minimum design loads for building and other structures deals with design loads for structure

IS 456 – Concrete Design (Columns, Beams, Foundation, Pile Cap, Mat)
IS 800 – Steel Design
IS 802 – Steel Transmission Tower Design
IS 1893-2002 – Seismic Analysis
IS 875(part i)-1987 DEAD LOADS
IS 875(part ii)-1987 LIVE LOADS
IS 875(part iii)-1987 WIND LOADS etc.…….
Steel - more than 37 codes from around the world.

Concrete – more than 25 codes batch processed within the interactive RC Design modes it is capable of analyzing and designing civil engineering structures such as building, bridge, ware house, plane and space trusses etc.…

V. DATA COLLECTION

Using the geometric parameters shown in Table 1, load case details shown in Table 2, and the corresponding isometric view, plan and section of the conventional and diagrid buildings shown in Figure 1 to Figure 3, the deflections at various floors of the conventional moment-resisting frame structure and the diagrid structure will be obtained. These results will then be compared to determine which structural system has a better performance when subjected to seismic loads.

The total steel weights of the conventional moment-resisting frame structure and the diagrid structure will then be obtained and will be compared to determine which structural system is more economical in terms of design

VI. DATA ANALYSIS

A three-dimensional space frame computer models of the conventional moment-resisting frame structure and diagrid structure will be performed to determine the spatial behavior of each structural element. The buildings will be idealized as an assemblage of column and beam elements interconnected by a horizontal rigid floor diaphragm. The three-dimensional computer models enable full interaction between directly loaded elements and those elements in the vicinity, which greatly assists in load distribution. These models mathematically will represent the actual behavior of the structures when required loads are applied. Structural analysis will be carried out to determine the behavior of the structures and to check on the structures' deflections. Stresses for each structural member will be obtained and the design for the member sizes of each structural member will be determined for both the conventional and diagrid buildings.

The structural analysis will consider the design of the conventional and diagrid structures in different loading conditions using service load cases and ultimate load combinations. Dead loads, live loads and seismic loads will be based from the provisions of the local governing code, National Structural Code of the India. The primary load cases and load combinations to be considered in the analysis are shown in Table 2 above.

A comparison of analysis results between the conventional and diagrid structures will be made to evaluate the structural advantages of a diagrid structure. This will include comparing the deflections at various floors of both buildings. Finally, the total steel weights of both buildings in terms of economy in the design will be compared.

VII. PRESENTATION OF EXPERIMENTAL OR ANALYTICAL RESULTS

Based from the structural analysis performed using the data provided for the study, the resulting deflections at various floors for both the conventional structure and the diagrid structure are shown in Figures 3 and 4 respectively. A comparison of the resulting deflections at various floors for both the conventional structure and the diagrid structure are shown in Figure 5.

Fig - 3: Graph showing Conventional Building deflection at various floors

Figure 5 suggests that the conventional structure had a maximum deflection of 120mm at the top of the building while the diagrid structure only had a maximum deflection of 15mm at the top of the building. Thus, the diagrid structure tends to show significantly less deflection than the conventional structure.

After performing the design of the member sizes and computing for the steel weight for both the conventional structure and the diagrid structure, the resulting total steel weights are shown in Figure 5.

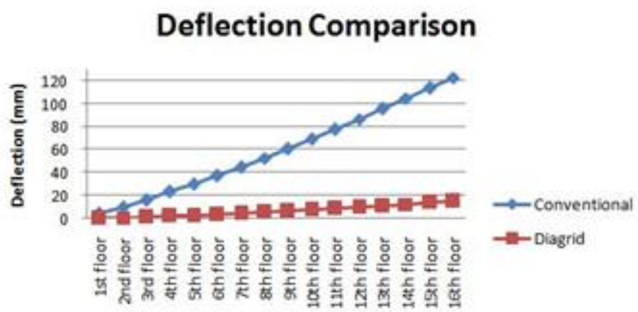


Fig - 5: Graph comparing deflection of both buildings at various floors

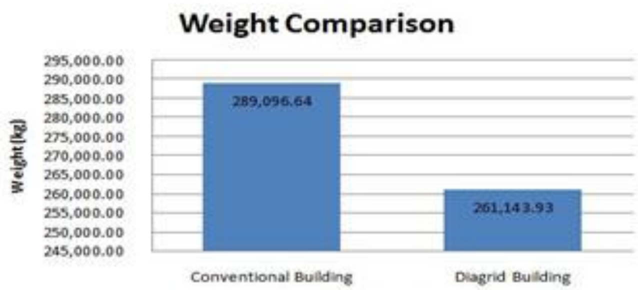


Fig - 6: Comparison of total steel weight of both buildings

The results indicate that the diagrid structure has a total steel weight of 261,143.93kgs while the conventional structure has a total steel weight of 289,096.64 kgs. Thus, the diagrid structure tends to show a 9.7% decrease in total steel weight than the conventional structure.

VIII. CONCLUSIONS

- The following are drawn from the results of the study and evaluation undertaken:
- Similar to the previous studies conducted, the diagrid structure indicates a significantly less deflection than a conventional structure and thus has more resistance to lateral forces.
- As revealed in the previous studies conducted, the total steel weight of the diagrid structure tends to show 9.7% less than the conventional structure.
- Thus, it can be concluded that the diagrid structure shows a favorable structural performance and is a more cost-effective structural system compared to a conventional structure.

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