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# Analysis of Diagrid Steel Structure on Multi-Storey Building

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**ABSTRACT:** Diagrid steel structures, a revolutionary technology that has changed the face of modern architecture. Diagrid steel structure is a type of structural system that utilizes diagonal members to create a grid-like pattern. Unlike traditional steel structures, which typically use vertical and horizontal beams, diagrid structures distribute loads more efficiently and provide greater strength and stability. One of the key benefits of diagrid steel structures is their ability to resist lateral forces such as wind and earthquakes. The diagonals act like a truss system, providing additional strength and stiffness to the building. In addition, the use of diagonals allows for greater flexibility in building design, as the structure can be shaped to fit the desired form. Overall, diagrid steel structures offer a combination of strength, because of the way they are designed, diagrid steel structures can support much heavier loads than traditional steel structures. This makes them ideal for use in high-rise buildings and other large structures. Diagrid steel structures also have a unique aesthetic appeal. Because of their intricate design, they can create stunning visual effects that are not possible with traditional steel structures. The use of diagonal members also allows for more open and flexible floor plans, as well as improved aesthetics. Diagrid structures are often used in high-rise buildings, bridges, and stadiums, where their unique properties can be leveraged to great effect. Compared to traditional steel structures, diagrid structures require less material to achieve the same level of strength and stability, resulting in cost savings and a reduced environmental impact. In this study, the seismic performance of typical diagrid structures was investigated. The response spectrum, base shear, storey drift (wind and seismic analysis) of steel diagrid structure was analysed with the help of Staad Pro V8i. Staad Pro V8i stands for structural analysis and design, and the software is widely used to develop & analyse various structure designs like steel structures, skyscrapers, tunnels, bridges, dams, culverts, or petrochemical plants. Indian standard codes is used for the calculations i.e. is: 800, is 1893, and is 875.

**KEYWORDS:** Diagrid Steel Structures, Modern Architecture, High-Rise Buildings.

## I. INTRODUCTION

In recent decades, the evolution of architectural and engineering innovations has propelled the construction industry toward novel and visually striking solutions to meet the demands of urbanization and population growth. One such transformative development is the adoption of diagrid steel structures, a revolutionary approach that redefines the aesthetics and efficiency of tall building design. The term "diagrid" is derived from the combination of "diagonal" and "grid," encapsulating the defining characteristic of this structural system. Unlike traditional building frameworks, diagrid structures employ a network of diagonal steel members that form an intricate lattice pattern on the exterior of the building. This unique design not only contributes to the iconic appearance of the structure but also serves as a fundamental component in optimizing both its structural stability and architectural flexibility. The increasing global trend towards taller buildings, driven by the scarcity of urban space, has underscored the need for structural systems that can efficiently bear the load of height while offering visually compelling designs. Diagrid steel structures have emerged as a preferred solution due to their inherent advantages, including a high strength-to-weight ratio, ease of assembly, and the ability to efficiently resist both gravity and lateral loads. This project aims to explore the intricacies of diagrid steel structures, shedding light on their architectural significance, structural efficiency, and the technological advancements that have propelled their widespread adoption. Through a comprehensive examination of iconic examples, engineering principles, and advancements in construction technologies, this exploration seeks to provide a deeper understanding of the role and impact of diagrid structures in shaping the skyline of modern cities.

## II. METHODOLOGY

- To study the analysis of diagrid steel structure and typical steel structure with different parameters.
- To go through the different literature reviews related to diagrid steel structure and typical steel structure.
- It is the study on lateral forces applied on the tall structures.

## III. MODELING AND ANALYSIS

The 10 storey structure of dimension 30m x 30m plan dimensions, consisting with six bays in horizontal direction and six bays in lateral direction is taken and analysed it by response spectrum analysis. The storey height is 3 meters and the horizontal spacing between bays is 5 meters and lateral spacing of bays is 5 meters. The height of the building is 30m.

### Load Parameters:-

1. SEISMIC LOAD :-
  - Zone : 2
  - Response Reduction Factor : 5
  - Importance Factor : 1
  - Soil type : Medium Soil
  - Structure type : Steel Frame Building
  - Damping ratio : 5 Percent
  - Self-weight : 1
  - Member weight : Uniform load – 3kN/m
  - EQ X : Seismic Load – X-Direction – Factor – 1
  - EQ Z : Seismic Load – Z-Direction – Factor – 1
2. WIND LOAD :-
  - Wind Type : 1
  - ASCE – 7 – 2010
  - Building Classification Category : 2
  - Basic Wind Speed : 7 kmph
  - Exposure Category : Exposure B
  - Structure Type : Building Structures
  - Building Natural Frequency : 2 Hz
  - Enclosure Classification : Partially Enclosed
  - Building Damping Ratio : 1 Percent
  - Building Wall To Generate Wind Load On : Windward
  - Exposures : 1
  - WX : Wind Load – X(Windward Face) – Factor- ‘1’ & ‘-1’
  - WZ : Wind Load – Z(Windward Face) – Factor- ‘1’ & ‘-1’
3. DEAD LOAD :-
  - Self-weight :- 1
4. LIVE LOAD :-
  - Floor load :- Y-Range ‘3-30’
  - Pressure- ‘-9.812 kN/m<sup>2</sup>’

### Calculation of Lateral Forces (Base Shear)

$$V_B = A_h W \quad \dots (7.2.1, IS 1893 PART 1 2016) \text{ Page no.21}$$

Where

$A_h$  = design horizontal acceleration coefficient value, using approximate fundamental natural period  $T_a$  along the considered direction of shaking.

W = seismic weight of the building

$$A_h = \frac{Z}{2} \times \frac{I}{R} \times \frac{S_a}{g} \quad \dots (6.4.2, IS 1893 PART-1:2016) \text{ Page no. 9}$$

Where

Z = seismic zone factor

I = importance factor

R = response reduction factor

$\frac{S_a}{g}$  = design acceleration coefficient for different soil types

$$Z = 0.10 \quad \dots (\text{Table 3, IS 1893 Part-1:2016}) \text{ Page no. 10}$$

$$I = 1 \quad \dots (\text{Table 8, IS 1893 Part-1:2016}) \text{ Page no. 19}$$

$$R = 5 \quad \dots (\text{Table 9, IS 1893 Part-1:2016}) \text{ Page no. 20}$$

$$\frac{S_a}{g} = \frac{1.36}{T} \quad (\text{for medium stiffness soil}) \quad \dots (6.4.2, IS 1893 PART-1:2016) \text{ Page no. 9}$$

$$T_a = 0.085h^{0.75} \quad (\text{for steel MRF building}) \quad \dots (7.6.2, IS 1893 PART-1:2016) \text{ Page no. 21}$$

$$h = 30\text{m} \quad (\text{height of building})$$

$$T_a = 0.085 \times 30^{0.75}$$

$$= 1.08958 \text{ sec}$$

$$\frac{S_a}{g} = \frac{1.36}{T}$$

$$= \frac{1.36}{1.08958}$$

$$= 1.248$$

$$A_h = \frac{Z}{2} \times \frac{I}{R} \times \frac{S_a}{g}$$

$$= \frac{0.1}{2} \times \frac{1}{5} \times 1.248$$

$$= 0.0125$$

$$V_B = A_h W$$

$$= 0.0125 \times 48886.58$$

$$= 610.20 \text{ KN}$$

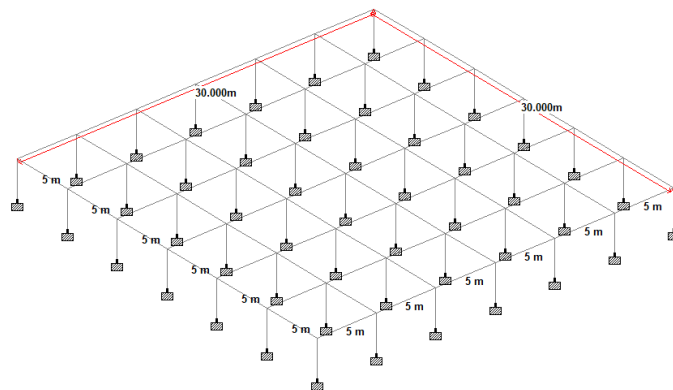


Figure 1: Dimensions of a structure along x & z axis

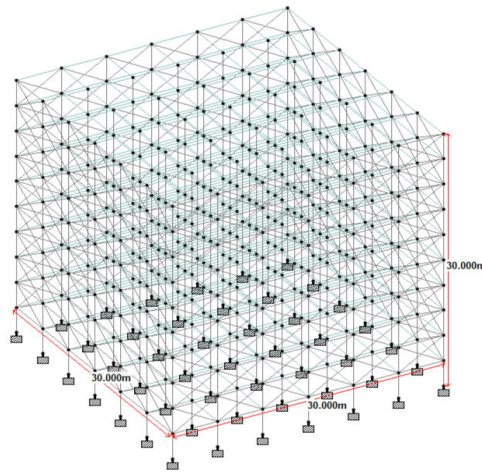


Figure 2: Height of a structure

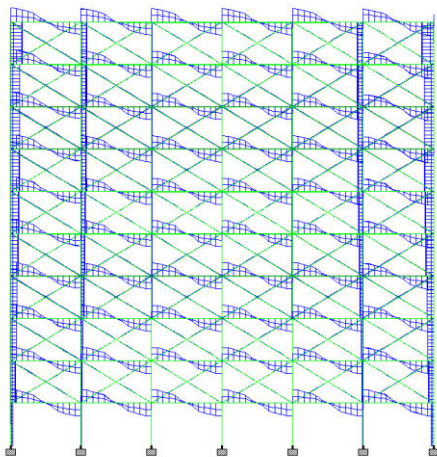


Figure 3: Shear Force with external diagrid steel structure.

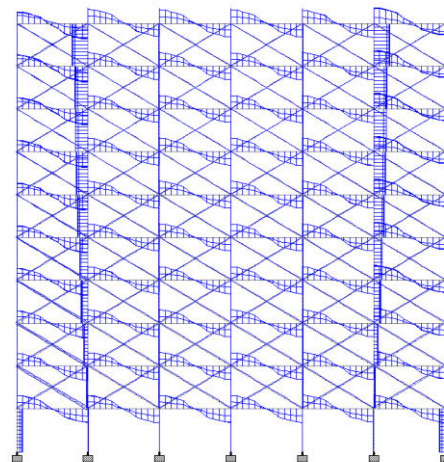


Figure 4: Shear Force without external diagrid steel Structure.

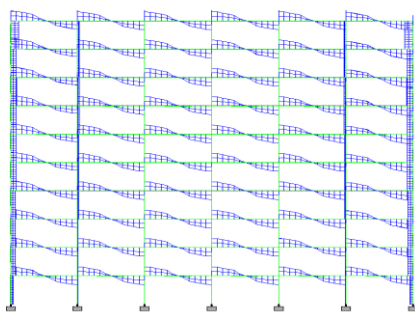


Figure 5: Shear Force for Typical steel structure

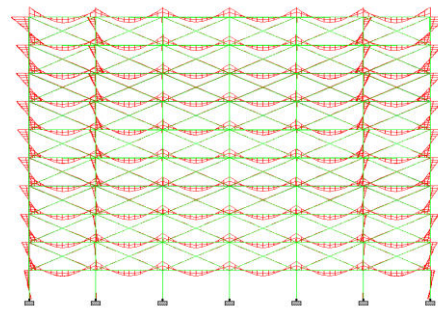


Figure 6: Bending Moment with external column diagrid steel structure

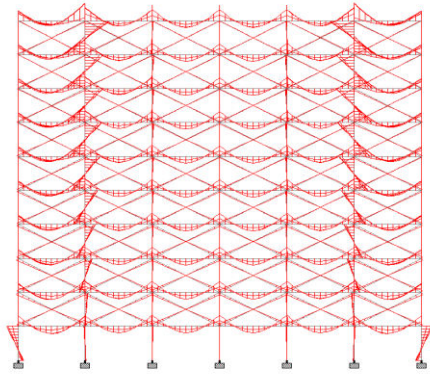


Figure 7: Bending Moment without external diagrid steel structure

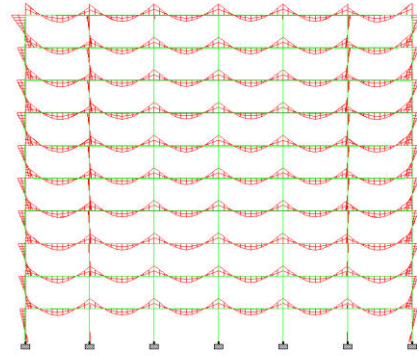


Figure 8: Bending Moment without external diagrid steel structure

#### IV. RESULTS AND DISCUSSION

It is the study of comparison between Typical steel structure, Diagrid steel structure without external columns & Diagrid Steel Structure with external columns. As we have analyzed Base shear and storey drift as shown below in the table and in graph.

Table 1. Comparison of Base Shear of all 3 cases

SN.	Model Type	Base Shear	Seismic Zone
1	Conventional steel structure with shear wall on both axis with diagrid connecting every floor.	666.44	2
2	Diagrid steel structure with external columns with shear wall on both axis with diagrid connecting every floor.	670.23	2
3	Diagrid steel structure without external columns with shear wall on both axis with diagrid connecting every floor.	673.88	2
4	Diagrid steel structure without external column with shear wall on both axis with diagrid connecting every two floor.	610.20	2
5	Diagrid steel structure without external column with shear wall on both axis with diagrid connecting to every 3 floor.	609.92	2

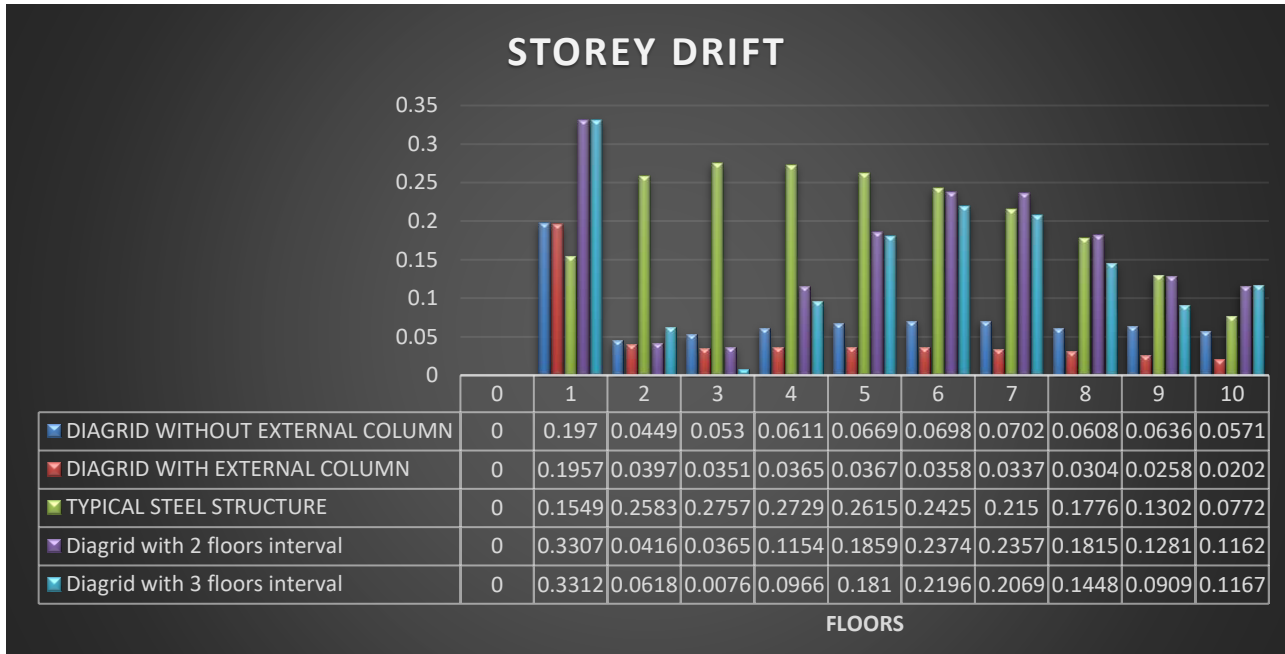


Figure 9: Graph of storey drift

### V. CONCLUSION

In this report, the study of diagrid steel structure with or without external columns & typical steel structures. The analysis of a steel structure having sizes 30m x 30m is carried out. Lateral forces and self-weight have applied on the structure. The base shear and storey drift is analyzed. Shear wall is also applied to structures. The results is as shown in the table given above.

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