Seismic Study of Diagrid Structure with Brace Frame Structure of Different Arrangement

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Abstract— In the current situation, population and industrialization are growing rapidly over time. Architects and engineers want to focus on the growth and vertical development of tall buildings and skyscrapers. However, increasing the height of the building is not easy. Several parameters play an important role in construction, including lateral loads. (Examples of wind and seismic loads). The next task of the designer is to design a type of building that will be more sustainable. In this paper study about 30m X 30m plan of diagrid structure and X-brace frame structure of different arrangement. Seismic zone III, soil type II, analysis done by the response spectrum method on ETAB'S 2017. Result in terms of time period, story drift, story displacement, story stiffness and base shear. After analysis diagrid structure is perform better then X-brace frame.
Keywords: Diagrid, X-Bracing, Lateral load, ETAB'S

I. Introduction

In the current situation, population and industrialization are growing rapidly over time. Architects and engineers want to focus on the growth and vertical development of tall buildings and skyscrapers. However, increasing the height of the building is not easy. Several parameters play an important role in construction, including lateral loads. (Examples of wind and seismic loads). The next task of the designer is to design a type of building that will be more sustainable. Diagrid is a construction made of steel, concrete and wooden blocks and is used diagonally in the construction of buildings and roofs. As the height of the building increases, the lateral drag mechanism from the gravitational system becomes more and more important. The physical stability of the diagonal structure has a triangular shape, which resists gravity and lateral loads due to the axial pressure of its elements. Some of these systems include pipe designs, gaskets, transverse joints, cantilever joints, transition walls, and diode structures. The diagrid system is used as a roof to create a large transparent area without columns. Use 20%-25% less building material in comparison to others.

Bracing are a method used to build seismic structures. Elements in a lattice frame are designed to work with skeletal or push structures. Braking maintains the lateral load of the seismic force by terminating the inclined elements. The brake frame is on the screen; They move along spiral axes and columns. Since the diagonal buffer operates under axial load, the amplifier is the most efficient, therefore, the minimum size of the element gives it greater rigidity and strength in the horizontal section. There are two types of bracing i.e. Concentric bracing and eccentric bracing.

II. Objective of Work

1) To study seismic behaviour of building for regular plan under seismic loads and load combinations as per IS 1893:2016.
2) To evaluate the response of diagrid and braced frame lateral resisting force system structure.
3) To determine seismic parameter that are time period, mode of vibration, base shear, story displacement, story drift and story stiffness.

III. Description of Building

Building type- Commercial
Plan area- 30m X 30m
Number of story- 44
Height of each story- 3m
Total height of building- 132m
Core thickness- 400mm
Size of steel square tube section used for Diagrid 385.6mm X 385.6mm X 11mm.
Steel section used for Beam- ISMB 600
Steel section used for Column- ISWB 600-2
Steel section used for brace- ISMB 300
Concrete grade used for core- M40
Concrete grade used for Deck slab- M25
Grade of steel- Fe345
Dead load self-weight of structure
Live load – 4kN/m^2 as per IS-875(Part 2)

IV. Seismic Data

Seismic zone-III
Zone factor (Z)=0.16(table3, clause 6.4.2)
Importance factor (I)=1.2(table8, clause 7.2.3)
Response reduction factor I=5 (SMRF) (table9, clause 7.2.6)
Soil type-II (Medium soil)
MODELLING
MODEL 1- DIAGRID STRUCTURE
MODEL 2- X-BRACEING (ALL FACES)
MODEL 3- X-BRACEING (At CORNER)
MODEL 4- X-BRACEING (At CENTER)
Modelling done by the help of ETAB'S 2017 software.

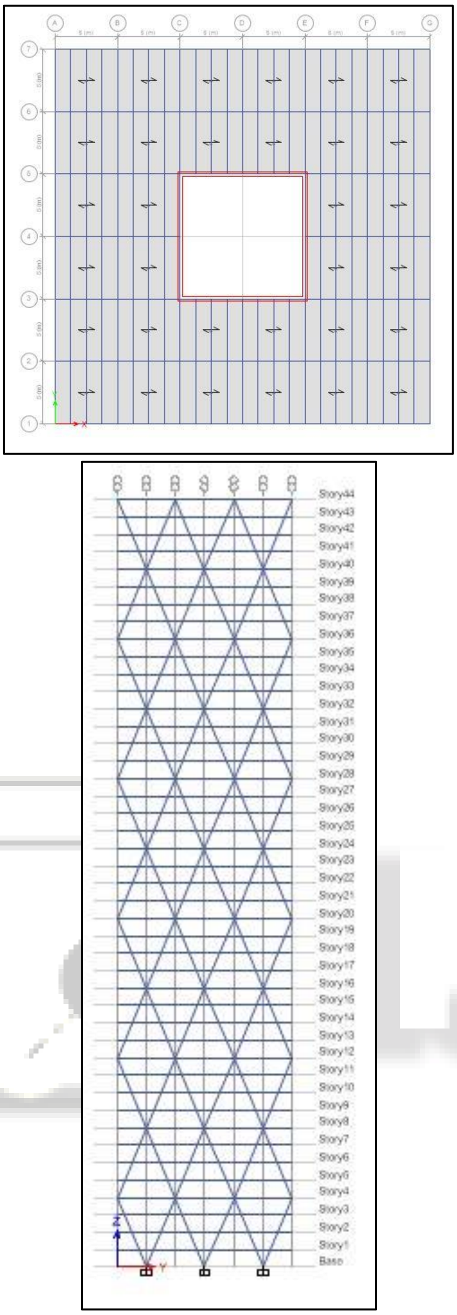
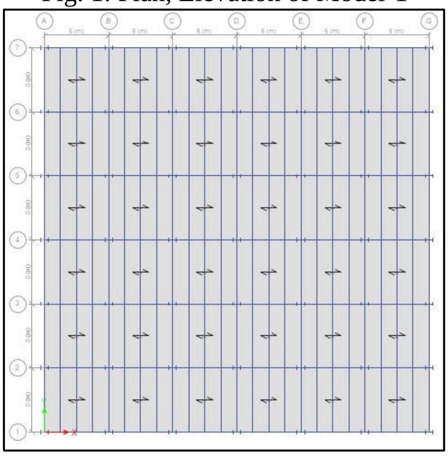


Fig. 1: Plan, Elevation of Model-1



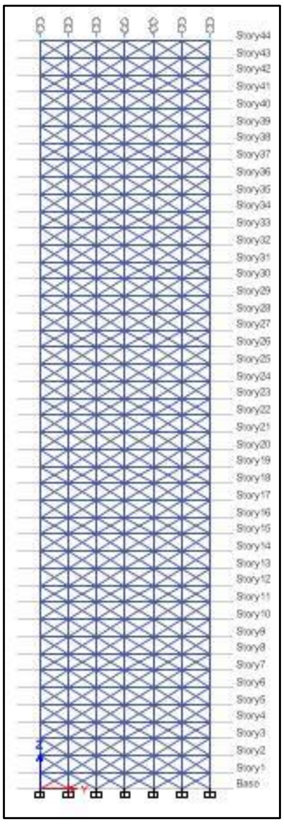
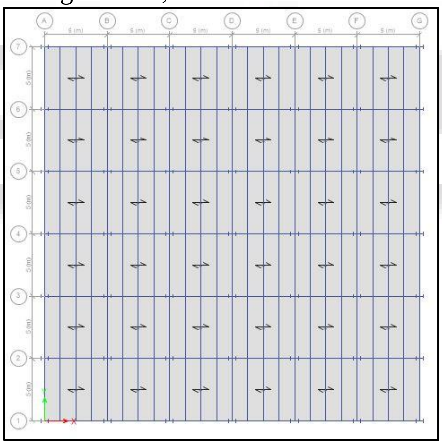


Fig. 2: Plan, Elevation of Model-2



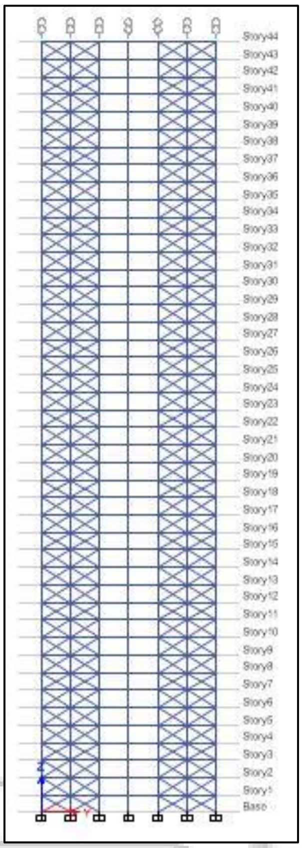
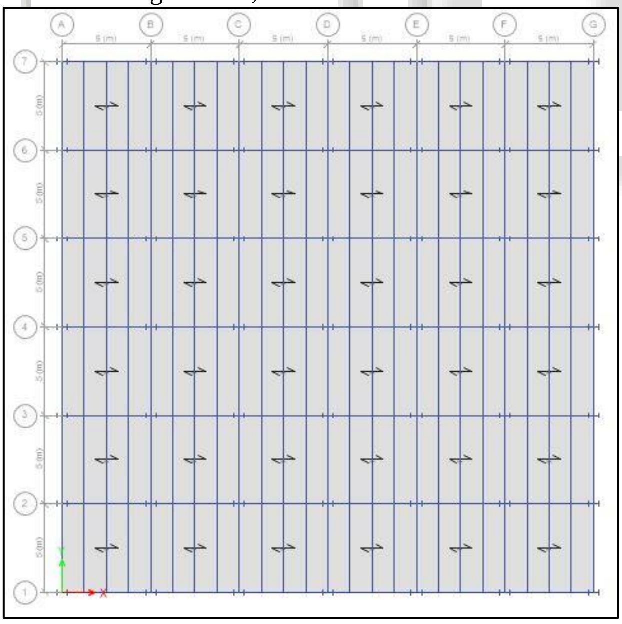


Fig. 3: Plan, Elevation of Model-3



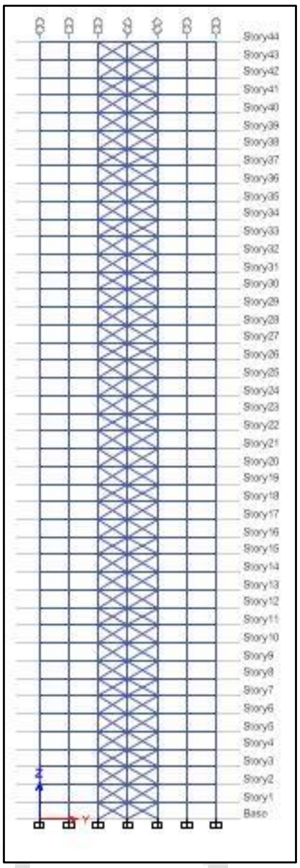


Fig. 4: Plan, Elevation of Model-4

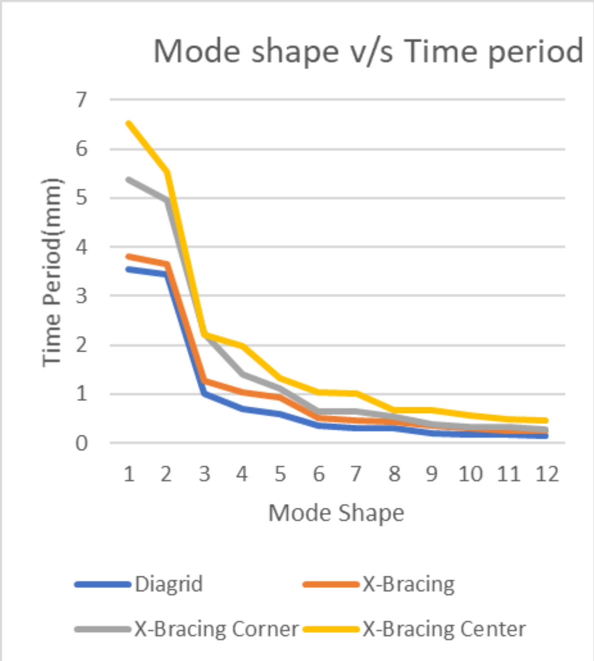
V. ANALYSIS AND RESULTS

A. Time Period

The natural period (Tn) of a building is the time it takes to go through a complete vibration cycle. This is the inherent nature of the building controlled by its mass "m" and stiffness "k". These three astrological signs are interconnected.

$$T_n = 2\pi\sqrt{m/k}$$

Its unit is second. Building that are heavy and flexible have more natural time period than light and stiff building.

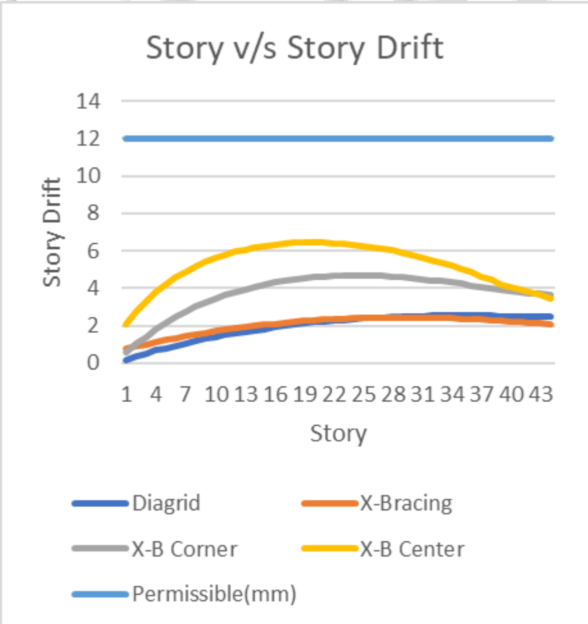


Graph 1: Fundamental natural time period

B. *Story Drift*

It is the displacement of one story relative to the other story above or below. The story drift in any story due to the minimum specified design lateral force, with partial load factor of 1, shall not exceed 0.004 times the story height or (h/250).

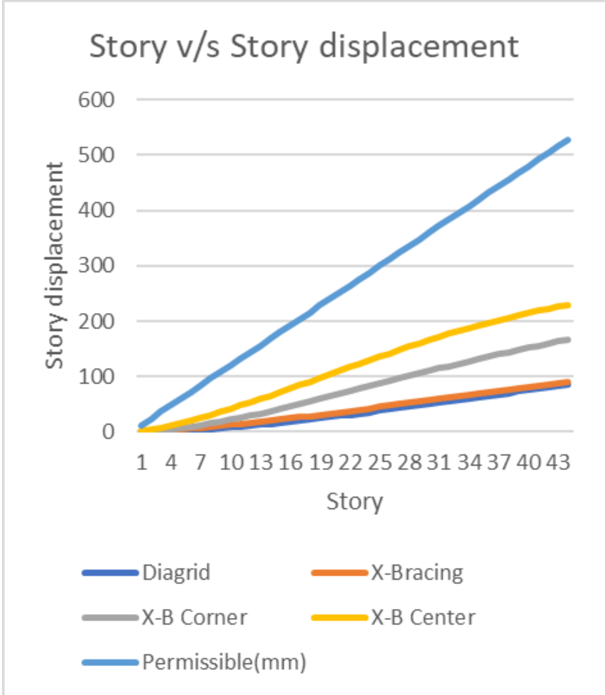
In Eurocode 8:2004 Part 1 specifies allowable maximum story drift is 1% of story height therefore as per Eurocode permissible limit of drift will be 0.01 X 3000 = 30 mm.



Graph 2: Story v/s Story drift

C. *Story Displacement*

It is total displacement of the story with respect to ground. According to IS 1893:2016 deformations, the maximum allowable deflection is calculated as H/250, where h is the height of the story from the ground level. In Eurocode 8:2004 specifies allowable maximum story displacement is H/100.



Graph 3: Story v/s Story displacement

D. *Base Shear*

IS 1893:2016 (Part I) Auto Seismic Load Calculation:
This calculation presents the automatically generated lateral seismic loads for load pattern EQ-X and EQ-Y according to IS 1893:2016.

$$V_b = A_h \text{ x } W$$

Where, Ah= Design horizontal seismic coefficient for structure

W= Seismic weight of the building.

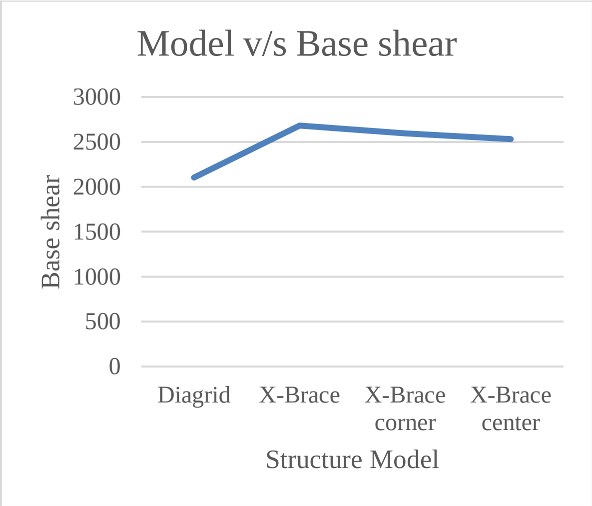
Where, R=response reduction factor.

Z= zone factor.

I= importance factor.

Sa/g=average acceleration response coefficient.

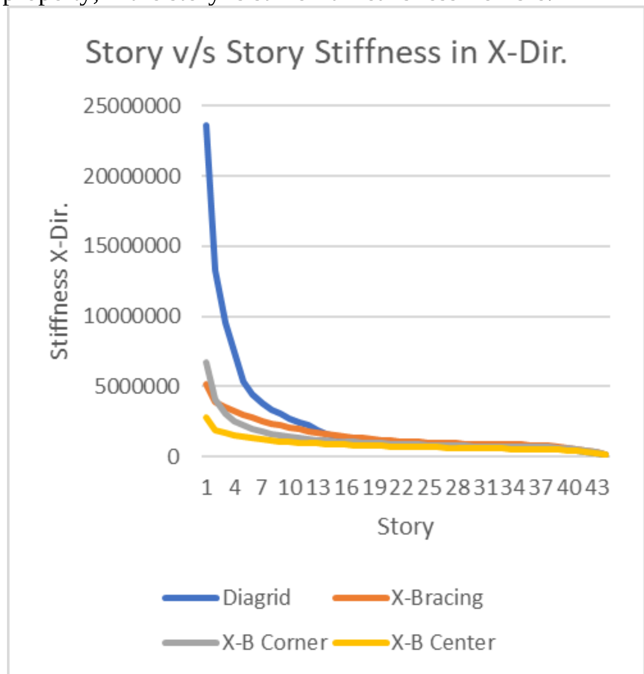
Model	Base Shear (kN)
Diagrid	2103.8416
X-Brace	2682.3112
X-Brace corner	2593.8597
X-Brace centre	2529.938



Graph 4: Model v/s Base shear

E. Story Stiffness

The term story stiffness is defined as capability of resisting force/load acting on any story. It is depending on material property, if the story is stiffer it means less flexible.



Graph 4: Story v/s Stiffness

VI. Conclusion

1) Time taken in first mode is minimum in diagrid structure and in other all with respect to diagrid structure, 10.66% more in X-bracing in all faces, 55.46% more in X-bracing at corner, 89.27% more in X-bracing in centre.
2) Drift is minimum in X-bracing in all faces after 27 story before 27 story Diagrid structure having minimum vale but overall comparisons shows with respect to diagrid structure, maximum value of drift is 5.16% less in X-bracing in all faces, 81.5% more in X-bracing at corner, 150.5% more in X-bracing in centre.
3) Displacement is minimum in diagrid structure and in other all with respect to diagrid structure, 4.49% more in X-bracing in all faces, 95.69% more in X-bracing at corner, 169.75% more in X-bracing in centre.
4) Base shear is minimum in diagrid structure cause of less weight of structure and in other all with respect to diagrid structure, 27.49% more in X-bracing in all faces, 23.29% more in X-bracing at corner, 20.25% more in X-bracing in centre.
5) Story stiffness is maximum for Diagrid structure from all four models.
6) In all four models, model 1 perform best.

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