Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 7, Issue 2; April-June 2020, pp. 158-163
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http://www.krishisanskriti.org/Publication.html

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 i.e. seismic or wind force. The next task of the designer is to design a type of building that will be more sustainable. In this study structural analysis of G+44 story steel frame, diagrid structure with grid angle 67.32. And X-bracing at all faces, at corner, at centre. The plan considered for all models was 30m X 30m and the method use for analysis was Response spectrum analysis method. All the member was designed as per IS456:2000, IS800:2007 and load combination for seismic force were considered as per IS1893(Part-1):2016. ETABSv17 software has been used for modelling and analysis. Latest 2017 version has been used for analysis. The performance was evaluated from various. The result was expressed in forms of graphs, tables and figures while comparison was done with the limitation as per IS1893(Part-1):2016.*

It was found that maximum story displacement and story drift lies within the permissible value as per IS1893(Part-1):2016. Comparing the specified parameters, it was found that the diagrid frame structure performing better than the x-bracing and damper frame structure thus can be consider to be more effective for high rise construction. From all the six-models diagrid gives less value of story displacement and story stiffness compare to other models. Hence, the diagrid can be considered as the sustainable solution in terms of high-rise construction.

Keyword: *Diagrid, X-Bracing, Lateral load, ETAB'S.*

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. The next task of the designer is to design a type of building that will be more sustainable. Recently diagrid structure are more popular due to aesthetics. They have very attractive look. 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. Concentric bracing and eccentric bracing are being used here. Bracing system are very efficient in resisting lateral load as they provide strength in lateral direction.

There is recent revision of earthquake code 1893:2016. This code has been revised after 14 year. In this code some strict norm has been added in design of earthquake resistance structure. The definition of soft storey and weak storey have been revised and importance factor have also been increased for some structures. This code has altered the value of Sa/g. In this paper the study has been done using latest code.

OBJECTIVE OF WORK

1. Study of seismic behaviour of buildings for regular plan under seismic loads and combinations according to IS 1893: 2016.

2. To assess the report of diagrid and braced frame lateral resisting force system structure.

3. To stimulate seismic parameter that are base shear, modes of vibration, time period,story deracination, story drop off and story constrain.

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 counterweight of structure
Live load – 4kN/m^2

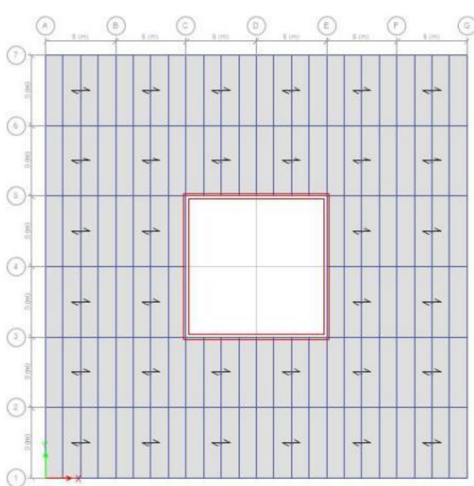
EARTHQUAKE DATA

Zone-III
Zone factor = 0.16
Importance factor =1.2
Response reduction factor =5
Soil type-II

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.

Plan, Elevation and 3D



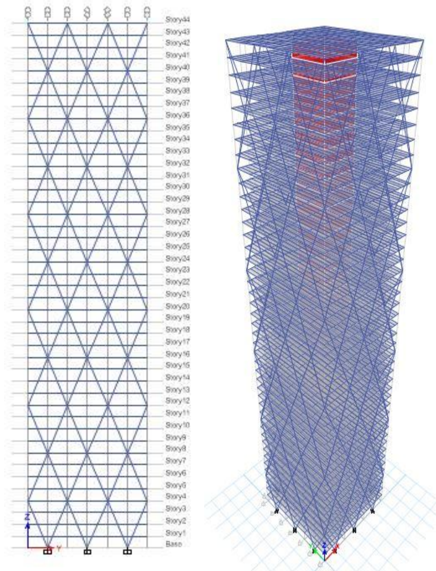
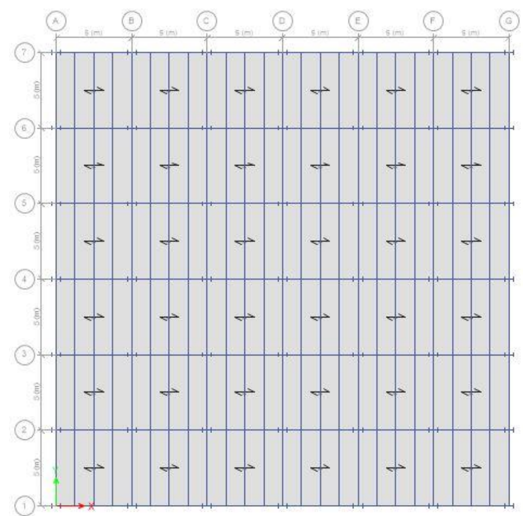


Fig. Plan, Elevation and 3D (Model 1)



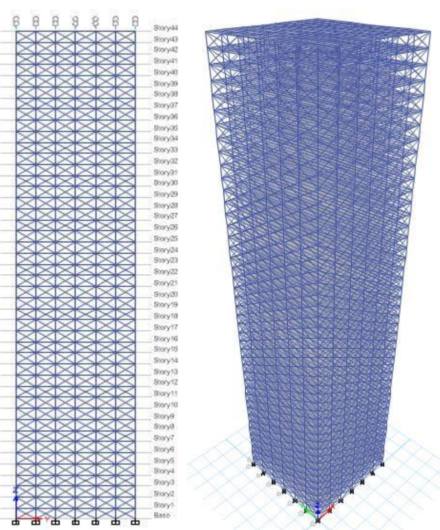


Fig. Plan, Elevation and 3D (Model 2)

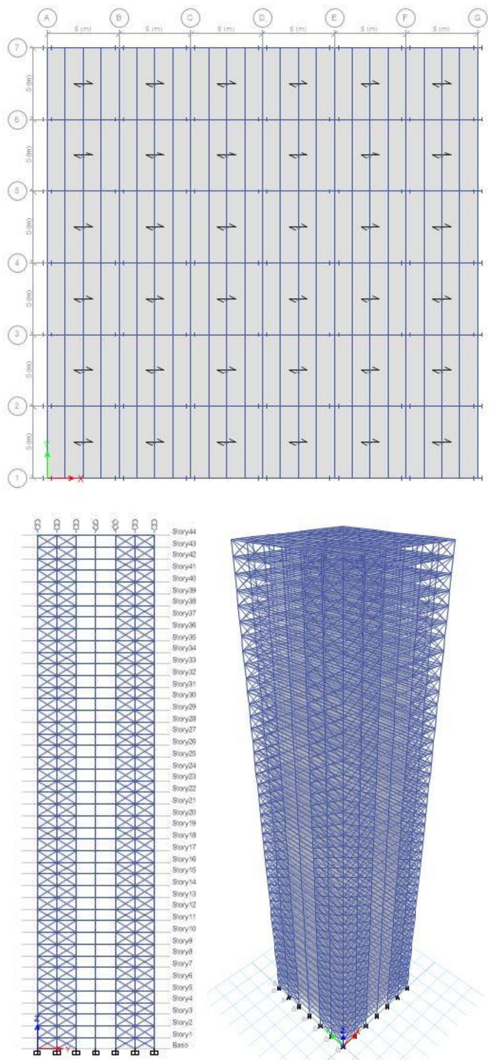
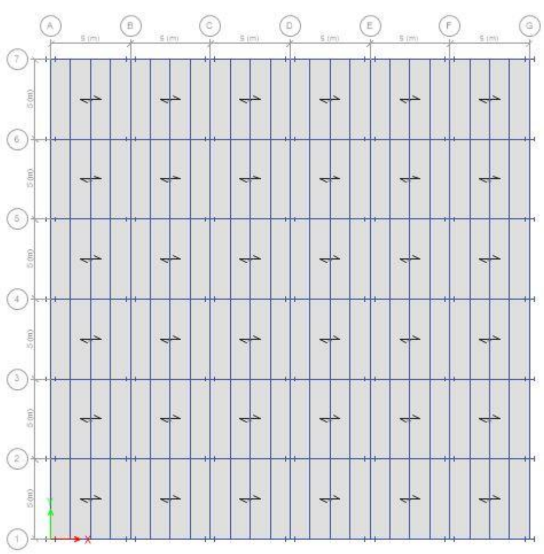


Fig. Plan, Elevation and 3D (Model3)



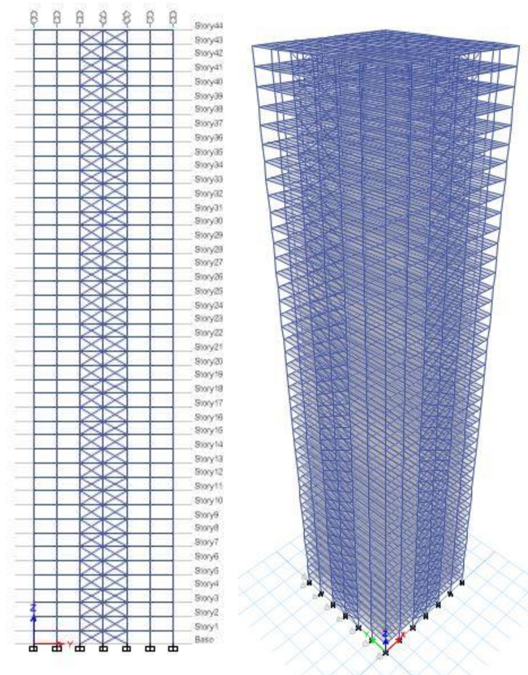


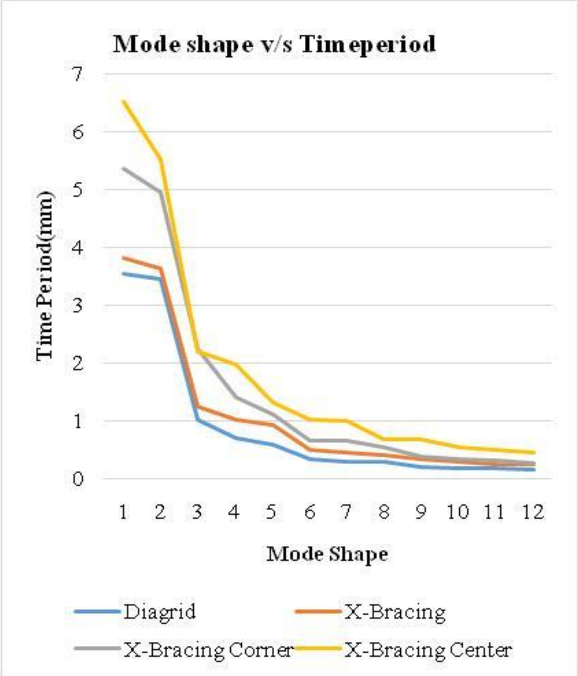
Fig. Plan, Elevation and 3D (Model 4)

ANALYSIS AND RESULTS

Time period

When the structure is considered for analysis, it is considered as lumped mass. General building act as inverted pendulum. With increase in the storey one lumped mass get increased. When earthquake occur building start vibrating under forced vibration. General earthquake lasts for few minutes. After completion of earthquake building vibrated as free vibration and it vibrate at natural frequency. Natural time period is the time required to complete one cycle of oscillation when it was disturbed and left free i.e. no external force is applied. Natural time period is inverse of natural frequency. It depends mass and stiffness of the building.

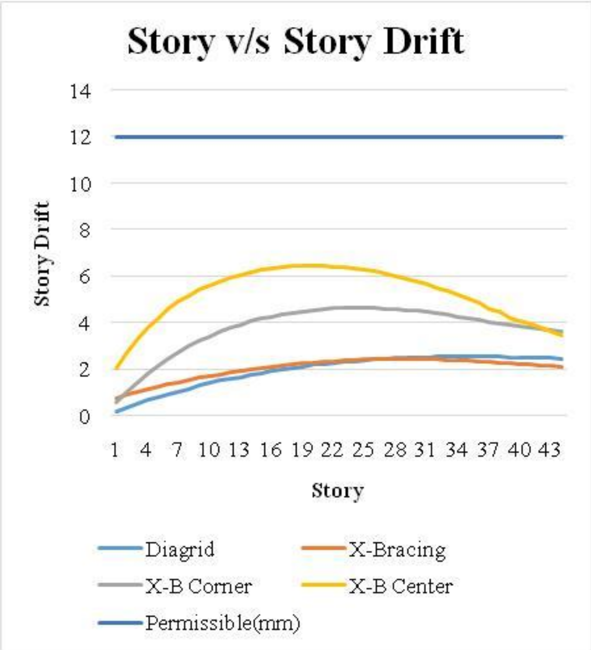
$$Tn = 2\pi\sqrt{m/k}$$



Graph: Fundamental natural time period

STORY DRIFT

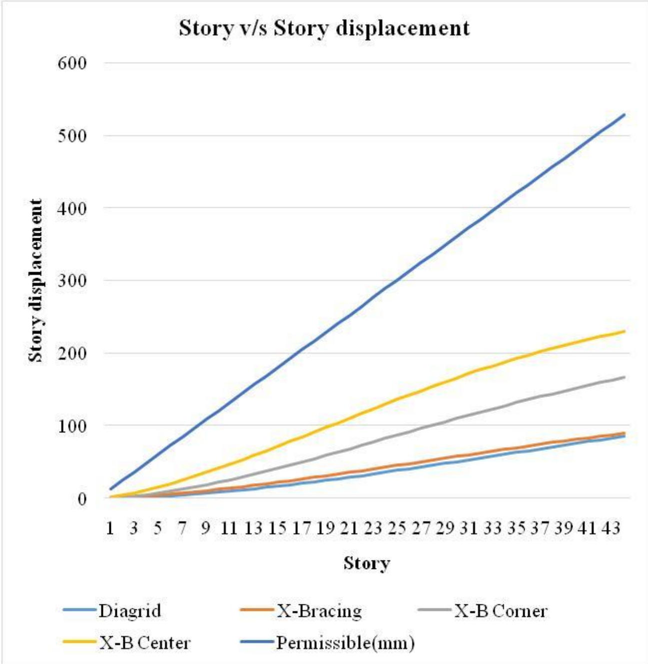
As mentioned before building act as spring mass system. Every storey's slab part act as mass and column part provide stiffness. When building subjected to seismic load each mass vibrated differently according to its location and value. The relative displacement between adjacent storey has been termed as storey drift. Codes have prescribed its value H/250. Where H represent storey height.



Graph: Story v/s Story drift

STORY DISPLACEMENT

When the building is excited with lateral force, it tends to move from its original position. This displacement with reference to fixed point that is base is termed as storey displacement. As per Indian standard code, the storey displacement is restricted to H/250 where H is storey height form base. Eurocodes have higher allowable value of storey displacement i.e. H/100.



Graph: Story v/s Story displacement

BASE SHEAR

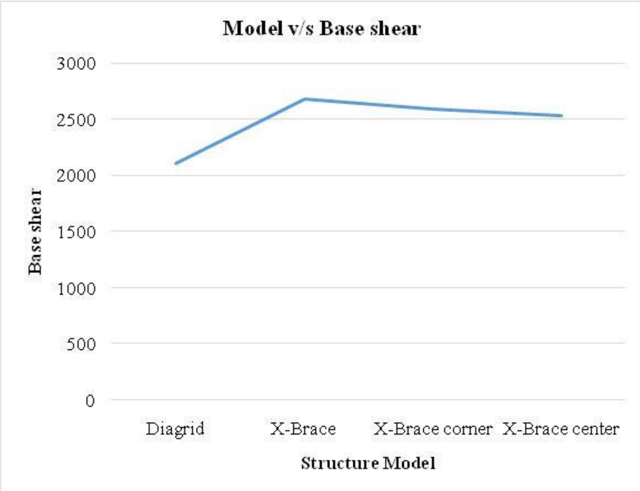
Base shear is the sum of all storey shear acting in lateral direction. Base shear plays important role in deciding the type of foundation used. High base shear required strong foundation as compared to lower value of base shear. Base shear can be calculated used given formula.

$$V_b = A_h \times W$$

Where, Ah= Design horizontal seismic coefficient for structure.

W= Seismic weight of the building

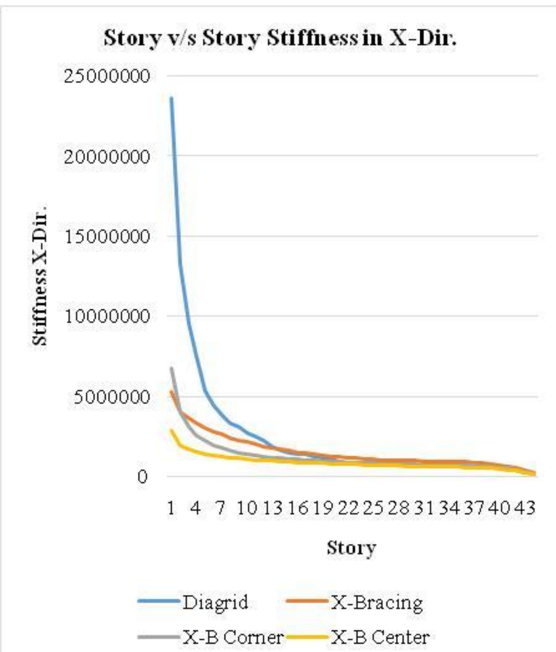
Model	Base Shear (kN)
Diagrid	2103.8416
X-Brace	2682.3112
X-Brace corner	2593.8597
X-Brace centre	2529.938



Graph: Model v/s Base shear

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: Story v/s Stiffness

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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