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SEISMIC STUDY OF DIAGRID STRUCTURE WITH BRACE FRAME AND DAMPER FRAME SYSTEM 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. wind or seismic 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. In other two frame using x-bracing at all faces, at corner, at centre and damper 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. The procedure of modelling also analysis was done on ETABSv17.0.1 software. 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, Damper; Lateral load; Response spectrum analysis; ETABs software.*

1 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. (i.e. wind or seismic force). 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 arranged diagonally at the time of constructions of buildings, 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.

The damper uses lateral force to hold the structure in place. A damper is a power distribution device that limits evacuation from a home during an earthquake. This helps the structure to reduce the bending of columns and supports and increase the rigidity of the structure.

2: OBJECTIVES 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.

3: DESCRIPTION OF BUILDING

S. No.	Structural Part	Dimension
1.	Type of building	Commercial(G+44)
2.	Type of structure	Steel structure
3.	Length in X-Dir	30m
4.	Length in Y-Dir	30m
5.	No of bays in X-Dir.	7No@5m
6.	No of bays in Y-Dir.	7No@5m
7.	Floor to floor height	3.m
8.	Total height of buildings	132 m
9.	Slab thickness	150mm
10.	Column	ISHB 600-2
11.	Beam	ISMB 600
12.	Diagrid (Tube section)	385.6mm X 385.6mm X 11mm
13.	Grid Angle	67.32
14.	Secondary Beam	ISLB 400
15.	Bracing	ISMB 300
16.	Fluid Viscous Damper	500kN, 98Kg.
17.	Thickness of core	400mm

Table 3(a) Geometrical Properties

S. No.	Material	Grade
1.	Concrete (slab)	M25
2.	Concrete (Core)	M40
3.	Steel section (I-shape)	Fe345
4.	Re-bar	HYSD550
5.	Density of Steel	7850 kg/m^3
6.	Young Modulus E	2.1 X 10^5 N/mm^2
7.	Shear Modulus	80000 N/mm^2
8.	Poisson's Ratio	0.3

Table 3(b) Material Properties (IS 456:2000 & IS 800:2007)

1.	Earthquake Zone	III
2.	Zone factor (Z)	0.16 (Table 3, clause 6.4.2)
3.	Damping Ratio	5% (clause 7.2.4)
4.	Important Factor(I)	1.2 (Table 8, clause 7.2.3)
5.	Type of soil	Medium soil (clause 6.4.2.1)
6.	Response Reduction Factor (R)	5(SMRF) (Table-9, clause 7.2.6)

Table 3(c) Seismic Data (IS 1893:2016 (part 1)

4: STRUCTURAL MODELLING

Model-1 Diagrid Structure

Model-2 X-Bracing Structure (All faces)

Model-3 X-Bracing Structure (Corner)

Model-4 X-Bracing Structure (Centre)

Model-5 Damper Structure (Corner)

Model-6 Damper Structure (Centre)

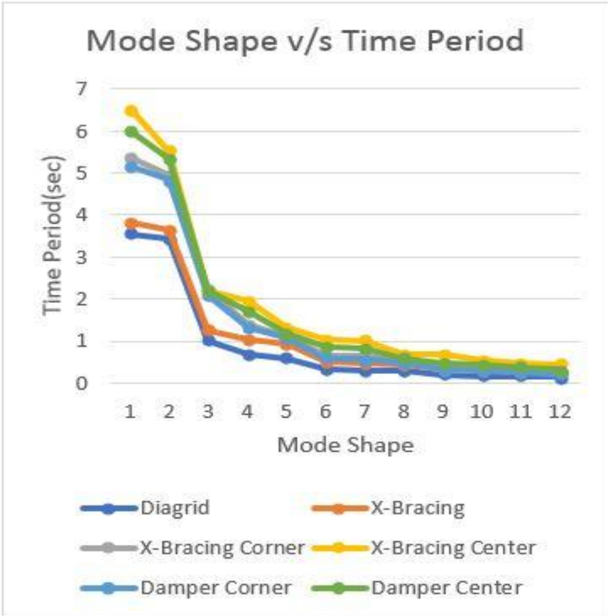
Modelling done by the help of ETAB'S 2017 software.

5: 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.

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



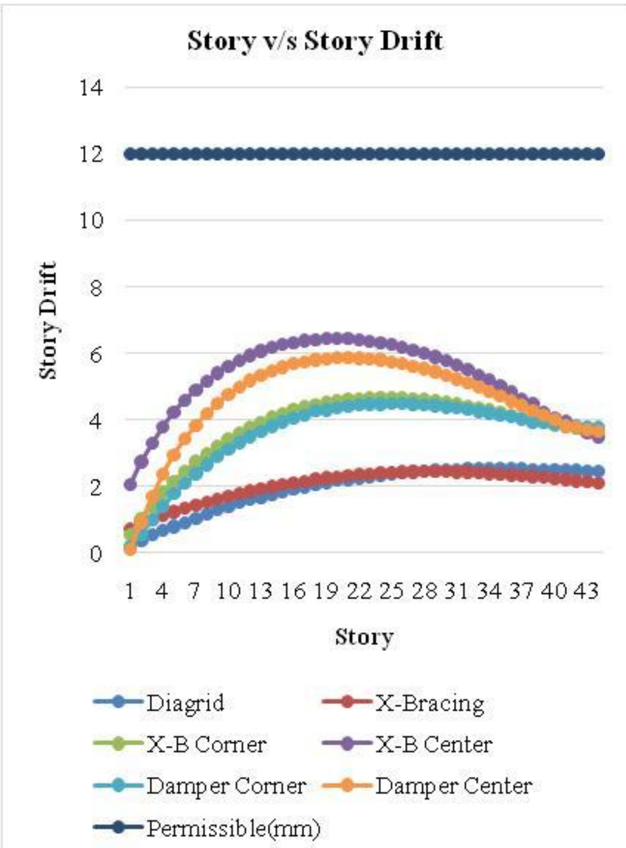
Graph 5. Mode v/s Time Period of All Models

From the above table and graph, we can see that Diagrid structure having less time period value then X-Bracing at all faces and maximum value of time period in all model having X-Bracing at centre. We can say that Diagrid structure is more efficient in all six models.

6: 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.

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 6 Story v/s Story Drift of All Models

From the above table and graph, we can see that in begging Diagrid structure having less story drift value but after 28 story X-Bracing at all faces having less value from the Diagrid structure. And maximum value of story drift is X-Bracing at centre.

7: 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.

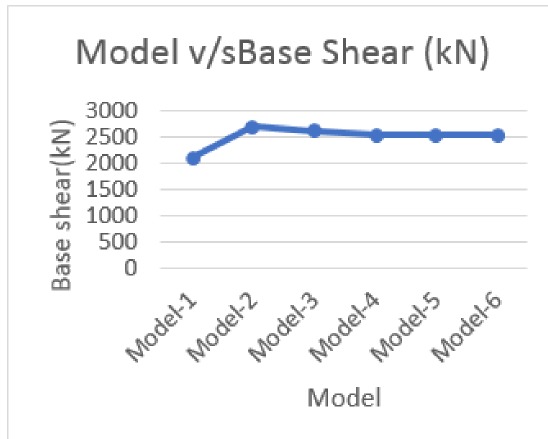
$V_b = A_h x W$

Where, Ah= Design horizontal seismic coefficient for structure.

W= Seismic weight of the building

Model	Base Shear (kN)
Model-1	2103.8416
Model-2	2682.3112
Model-3	2593.8597
Model-4	2529.938
Model-5	2523.47
Model-6	2520.6485

Table 8 base shear of all models

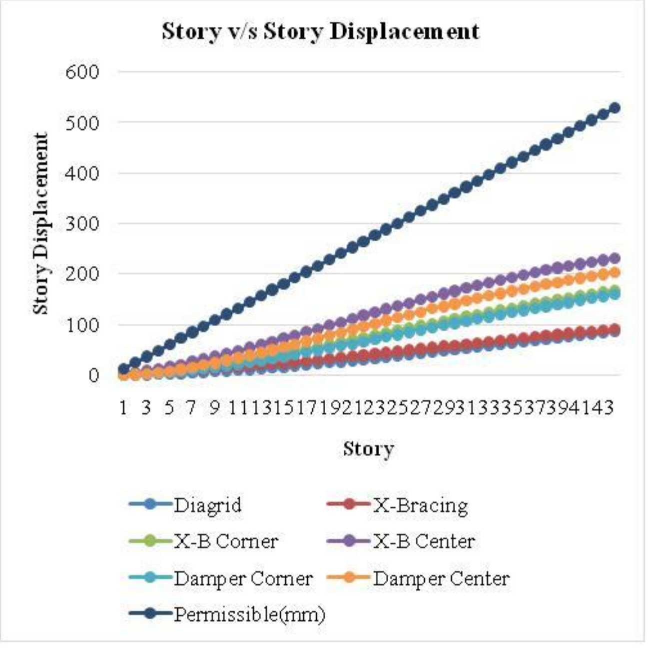


Graph 8 Model v/s Base Shear

From the above table and graph, we can see that Diagrid structure having less base shear value and maximum value of base shear in all model having X-Bracing at all faces. We can say that Diagrid structure is more efficient in all six models.

8: 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.

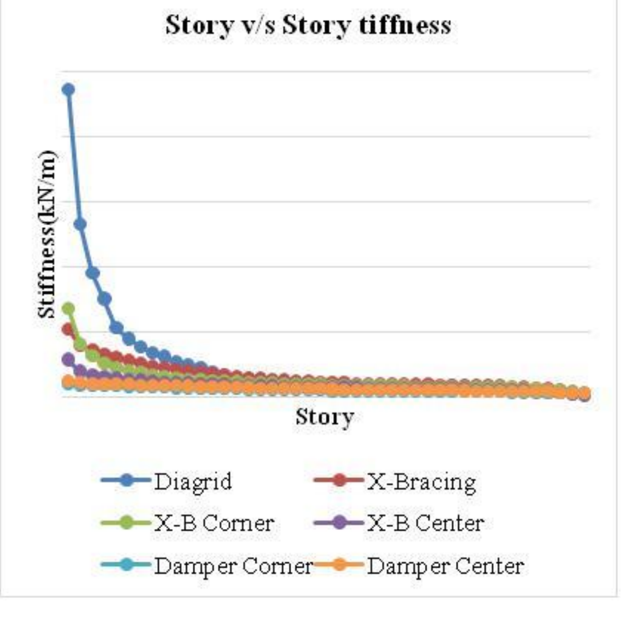


Graph 5.4 Story Displacement of All Models

From the above table and graph, we can see that Diagrid structure having less Story Drift value then X-Bracing at all faces and maximum value of Story Drift in all model having X-Bracing at centre. We can say that Diagrid structure is more efficient in all six models.

9: 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 9 Story v/s Story stiffness

From the above table and graph, we can see that Diagrid structure having maximum Story stiffness value then X-Bracing at all faces in all models. We can say that Diagrid structure is more efficient in Y-dir. from all six models.

10: CONCLUSION93

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.

From above all I can say, Diagrid structure is much better than other all considered models. And also, in diagrid structure using 20-25% less building material by which weight of building is reduces. For seismic effect one of the major factors is weight of building.

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