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SEISMIC ANALYSIS OF DIAGRID STEEL STRUCTURES FOR MULTISTOREY BUILDINGS

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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. It is very important that the selected structural system is such that the structural elements are utilized effectively while satisfying design requirements. Recently diagrid structural system is adopted in tall buildings due to its structural efficiency and flexibility in architectural planning. diagrid structure consists of inclined columns on the exterior surface of building. Due to inclined columns lateral loads are resisted by axial action of the diagonal. lateral shear can be carried by the diagonals on the periphery of building. Analysis and design of 30 story diagrid steel building is presented. A regular floor plan of 36 m × 36m size is considered. ETABS software is used for modeling and analysis of structural members. All structural members are designed as per IS 800:2007 considering all load combinations. Earthquake is considered for analysis of the structure. Load distribution in diagrid system is also studied for 36 storey building. Similarly, analysis for the different diagrid pattern is carried out. Comparison of analysis results in terms of time period, top storey displacement and storey drift is presented in this paper.

KEYWORDS: Diagrid Structural System, High rise buildings, Structural design.

1. INTRODUCTION

In recent years new and emerging architectural designs have been put forward consisting of geometrical and structural system frame definitions consisting of triangulated sloped column and beam frame configuration called 'Diagrid'. The diagrid (Diagonal Grid) is a narrow grid of diagonal members. Diagrid is a particular form of space truss. It consists of perimeter grid made up of a series of triangulated truss system. Diagrid is formed by intersecting the diagonal and horizontal components.

A diagrid structure is modeled as vertical cantilever beam on the ground, subdivided longitudinally into modules according to the repetitive diagrid pattern. The configuration and efficiency of diagrid system reduce the number of structural elements required on the facade of buildings. The diagonal members in diagrid structural systems can carry gravity loads as well as lateral forces due to their triangulated configuration. Diagrid structures are more effective in minimizing shear deformation because they carry lateral shear by axial action of diagonal members. Diagrid structures generally do not need high shear rigidity cores because lateral shear can be carried by the diagonal members located on the periphery. The unique structural characteristics of diagrid provide great structural efficiency and aesthetic. Now days the residential development of the city is considerably affected by the rapid growth of the urban population and consequent pressure on limited space, the high cost of land. As the height of building increase, the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. Recently, the diagrid structural system is widely used for tall steel buildings due to its structural efficiency and aesthetic potential provided by the unique geometric configuration of the system. Also the diagrid requires less material than other tall building systems .The diagrid structural system has great potential to be developed as one of the most appropriate structural solutions for freeform towers.

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Configuration of Diagrid Structures

Diagrid structures are different from conventional structural frames. Diagrid structures are made of inclined columns at the periphery of structure having some angle. As the maximum number of columns is on the periphery of the structure, it is more flexible to plan interior space and facade of building.

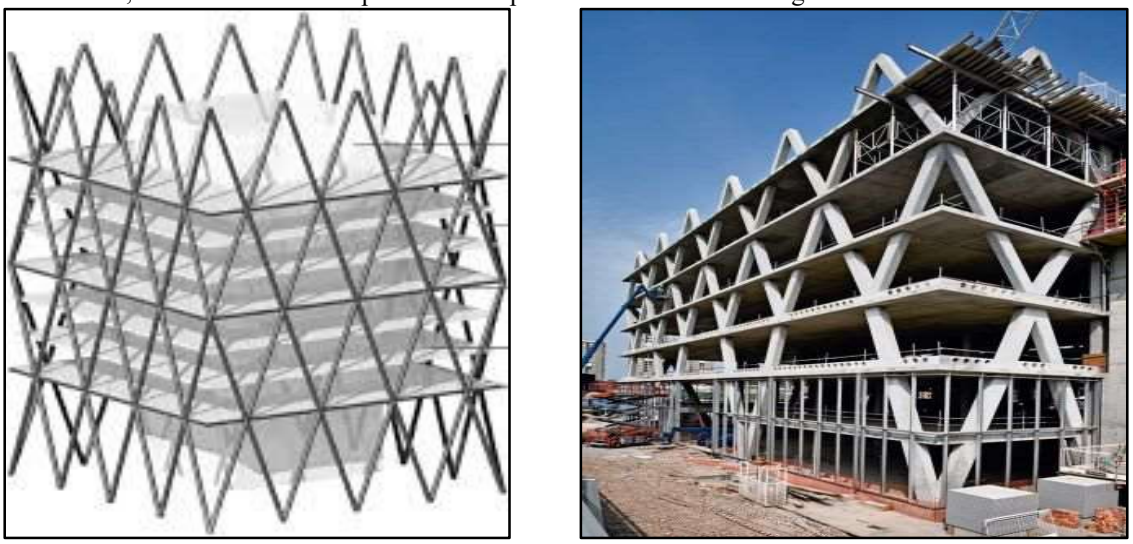

Figure1: Diagrid Structure

2. MATERIALS AND METHODS

Materials

Steel (Specified as per IS 800:2007)

Methodology

The following study consists of the seismic analysis of the steel structure having diagrid structural system. In this work five different geometrical patterns are taken into consideration for seismic analysis of diagrid steel structure. The modeling of diagrid steel structure is made for five different diagrid patterns. The plan dimensions, section properties and material properties are same for all structures. The modeling and analysis is carried out by using ETABS software.

Table 1: Details of Diagrid Model

Type of Structure	Steel
No of stories	G+30
Size of Plan	36Mx36M
Number of bays along X &Y	12
Each bay Length	3m
Height of each Storey	3.5m
Grade of Steel	Fe 250
Grade of Concrete	M 30
Thickness of Slab	150 mm (concrete slab)
Column size	1200X1200X50 mm (Hollow Square Column)
Diagrid size	700X700X30 mm (Hollow Square Column)
Primary Beam size	ISWB 600-2
Secondary Beam size	ISMB 500
Seismic Zone	III
Soil Type	Medium
Response Reduction Factor	1.5
Importance Factor	1

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Plan and Elevation of ETABS Models

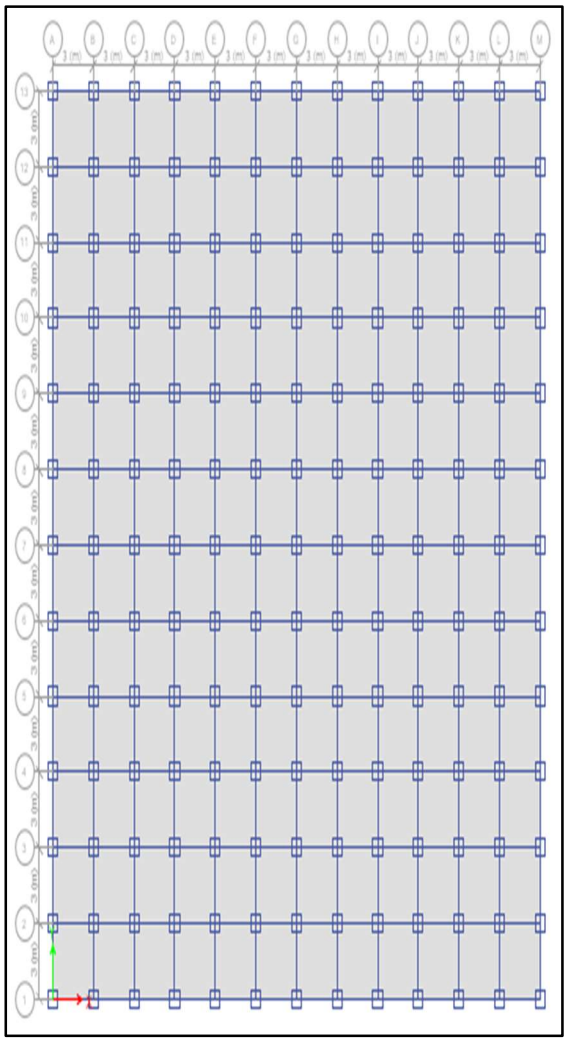

Figure 2: Plan of Diagrid Model

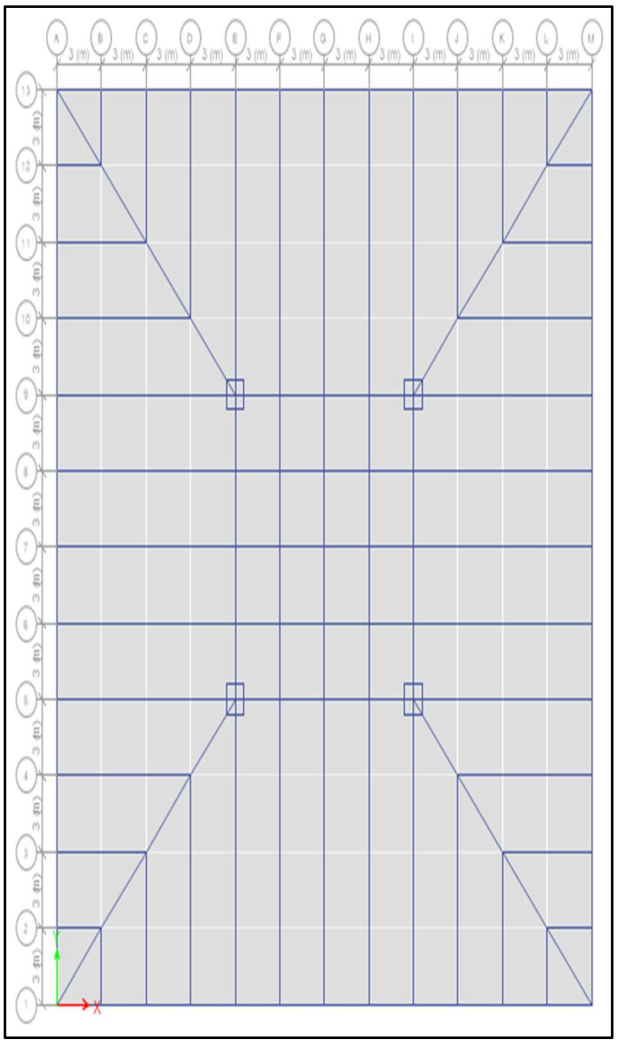

Figure 3: Plan of Diagrid Model

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ETABS Models of Different Diagrid Patterns (Elevation)

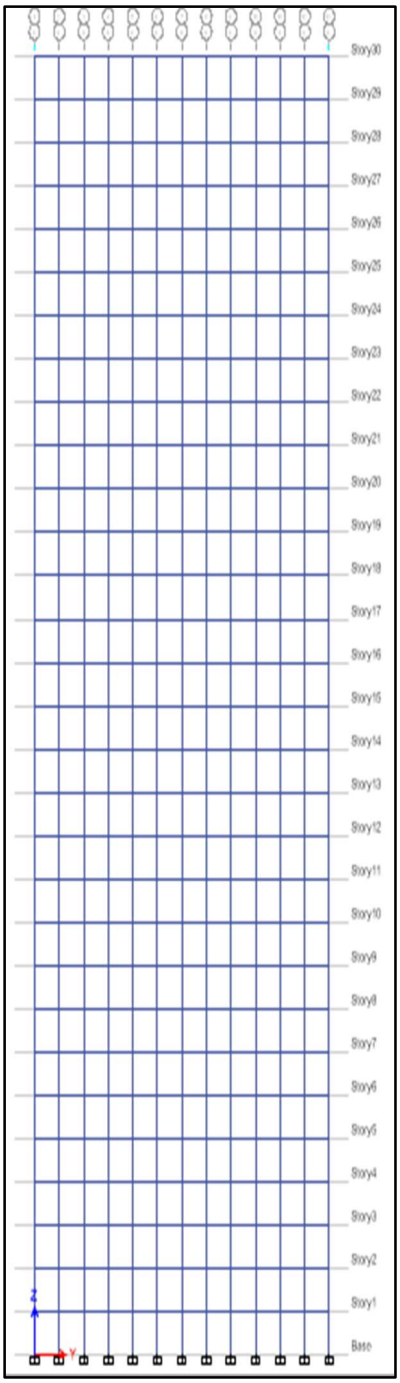

Figure 4.1 Model P

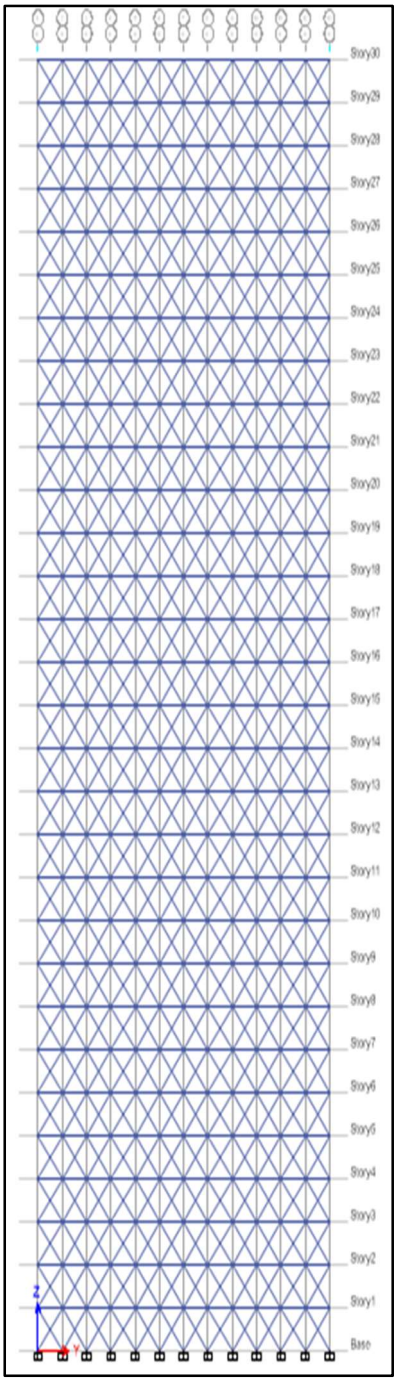

Figure 4.2 Model P1

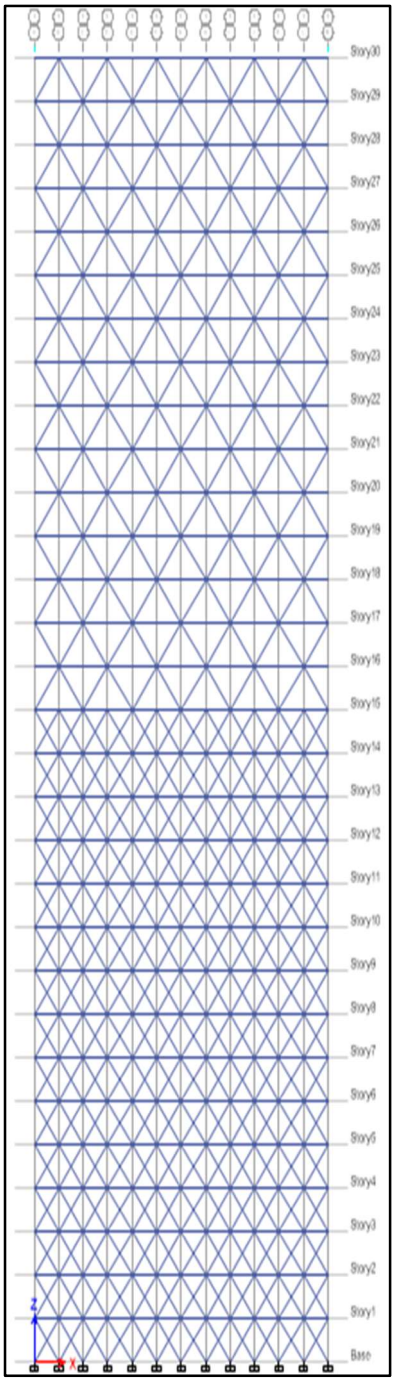

Figure 4.3 Model P2

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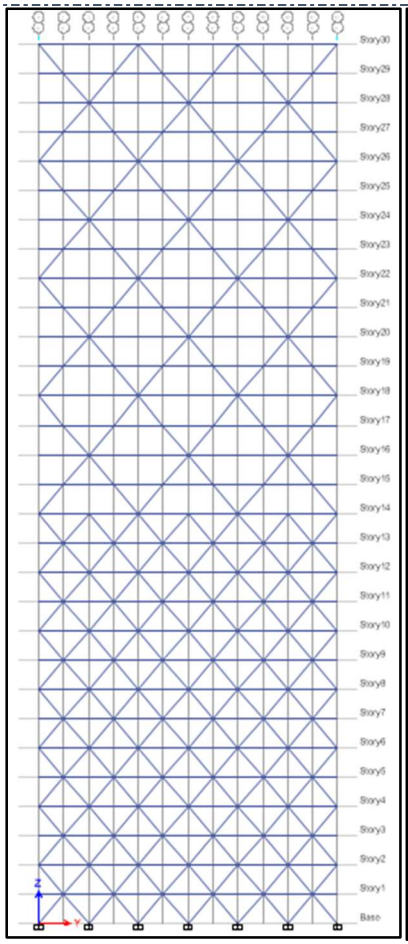

Figure 4.4 Model P3

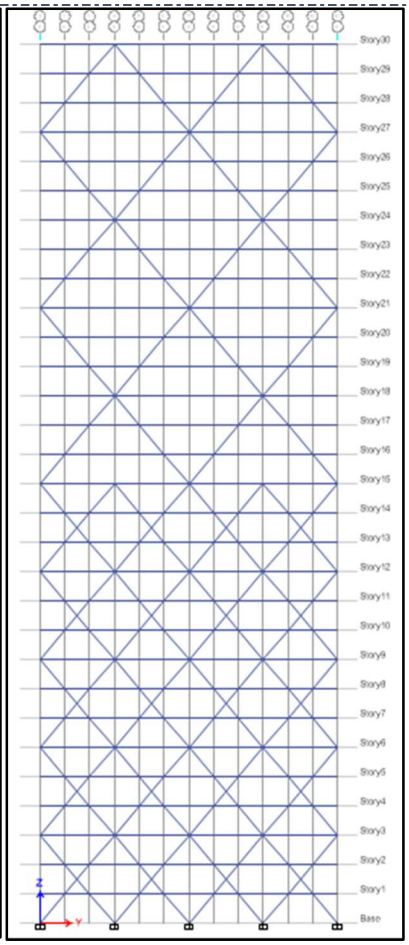

Figure 4.5 Model P4

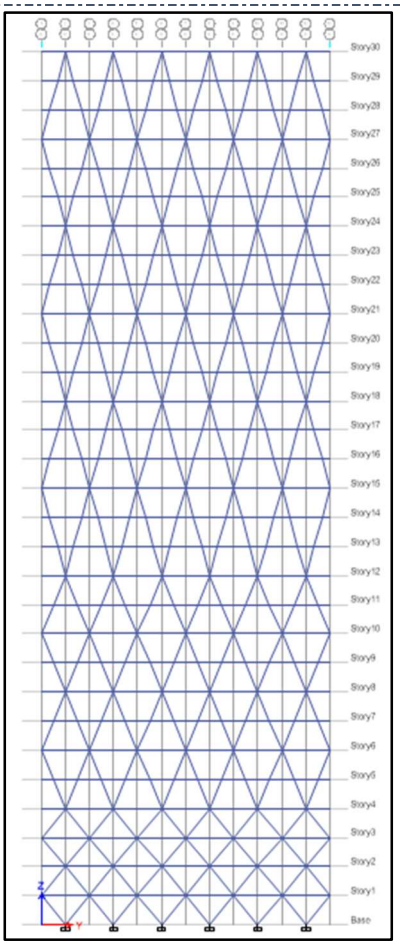

Figure 4.6 Model P5

ETABS Software Results of Different Diagrid Patterns

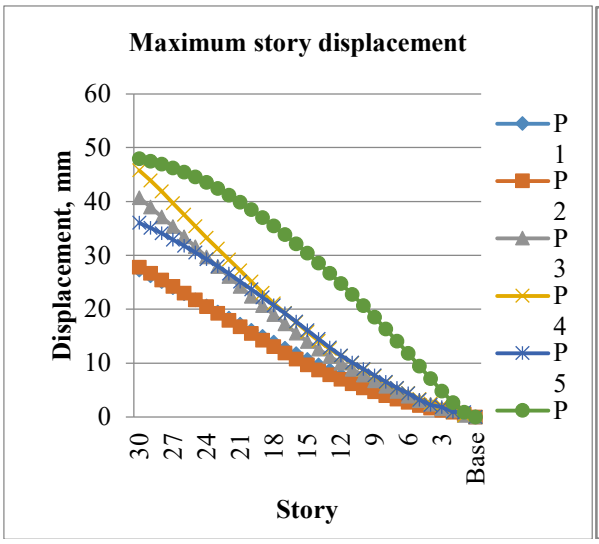

Figure 5.1: Story level Vs Displacement

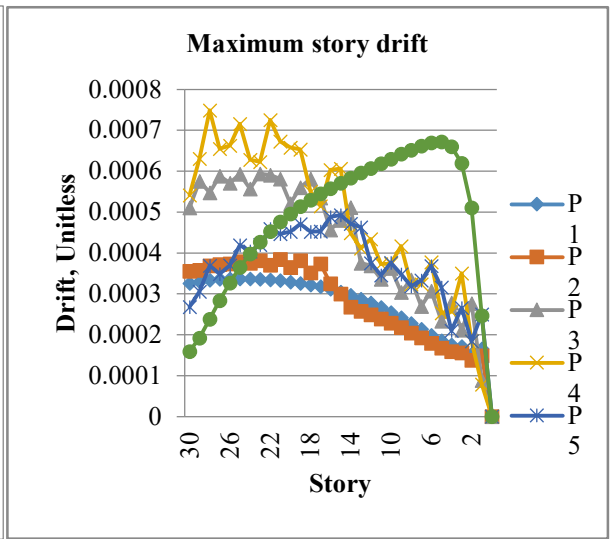

Figure 5.2: Story level Vs Displacement

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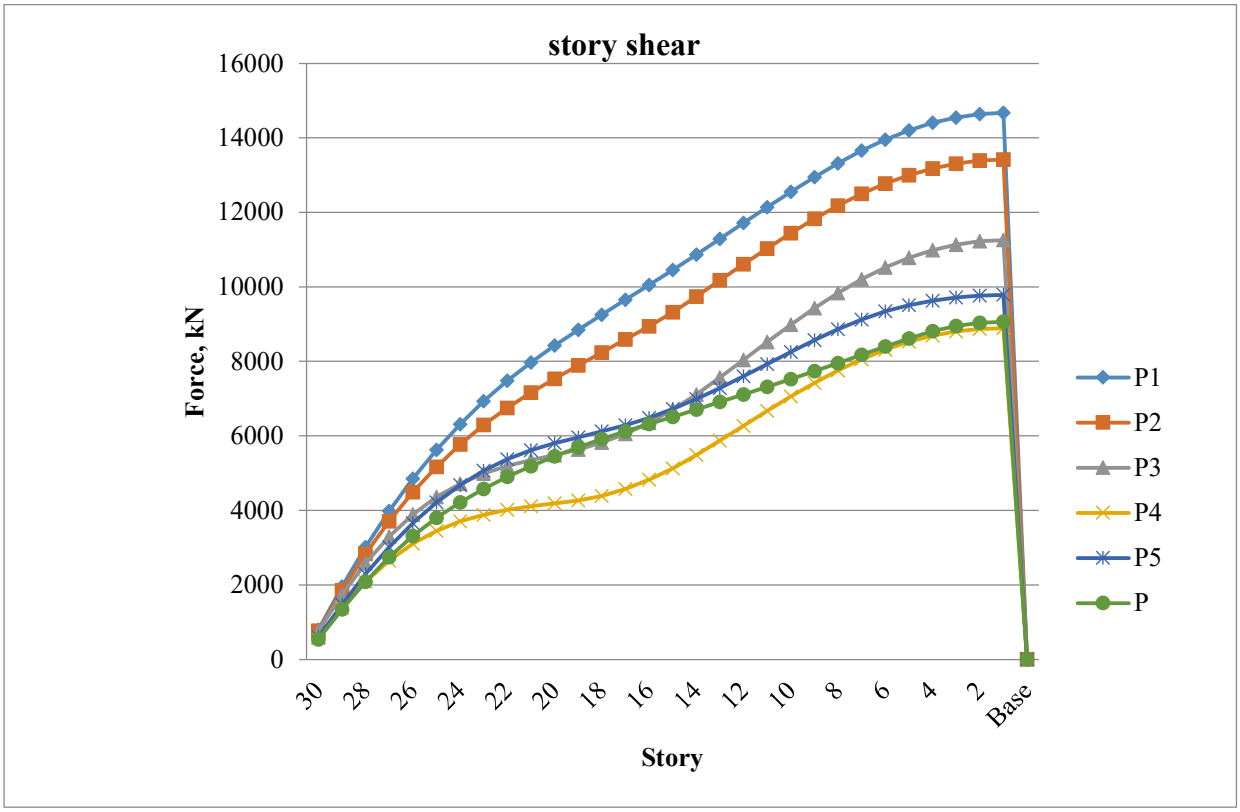

Figure 6: Story shear graph

3. RESULTS AND DISCUSSION

In this chapter the results of response spectrum analysis of diagrid structures having different diagrid patterns is presented. The comparison of seismic parameters; storey displacement, story drifts and story shears obtained from ETABS software is done.

Table 2: Comparison of software results of all diagrid patterns (Story Response)

Story	Elevation(m)		
30	105		
	Displacement	Drifts	Shears
	(mm)	(Unit less)	(kN)
P	47.964	0.000159	534.7868
P1	27.283	0.000326	792.8204
P2	27.818	0.000356	766.1734
P3	40.704	0.000511	762.2412
P4	45.78	0.000541	580.6162
P5	36.057	0.000268	596.4341

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4. CONCLUSION

The seismic response of conventional frame building structure and Diagrid frame structure has been studied Followings are the conclusion drawn from this study.

- In the seismic event of the building provided with the Diagrid elements shows better performance over the conventional type building
- Diagrid frame structure reduces the story displacement, story drift of the building and provide STABILITY to the building
- Diagrid frame structure buildings reduces usage of steel about 20% over conventional frame structure building
- Due to the reduction of steel usage in the construction of Diagrid type of structure, ultimately the cost gets reduced
- Above result shows that model P2 and P5 give better results in displacement, drift than conventional and all other diagrid patterns.

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