

# Comparative Study of Performance of Conventional R.C Framed Structures and Diagrid Structures Subjected to Ground Motions

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**Abstract:** Diagrid members are more effective in carrying gravity loads and lateral forces as well, these members carry lateral forces on their axis which helps in minimizing shear deformations. Usually diagrids members are located in the periphery of the buildings due to which these buildings do not require shear walls or any other systems such as wall frame, braced tube, outrigger system to resist lateral shear. In this study a conventional 31 story R.C building and another three buildings with diagrids having inclination of 36.86°, 56.30° and 66.03° have been modeled as per IS 1893 (part 1) : 2002 provisions and analyzed using Nonlinear static analysis in ETABS 2015. The response parameters of conventional building and buildings with diagrids are studied in terms of story displacement, story drift, diaphragm drift, spectral acceleration, spectral displacement and base shear. It is found that the values of all these parameters are least at a diagrid angle of 66.03°. Hence this angle is regarded as an optimum angle of diagrid at which the building has shown its best performance.

**Key Words:** story displacement, story drift, diaphragm drift, spectral acceleration, spectral displacement, base shear, optimum diagrid angle, Pushover Analysis.

## I. INTRODUCTION

The rapid increase in urban population have lead to increase in land value and limited space in the metropolitan cities. To minimize this urban sprawl one of the option is to erect high rise buildings. High rise buildings are more susceptible to ground motions and heavy wind. Diagrids have good appearance. The efficiency and configuration of dia grid will reduce number of structural members required for a building the efficiency in structural system of a diagrids system minimizes the No. of columns and specially the corner columns, and hence provides significant flexibility in the floor plan. The conventional high rise buildings need lateral shear resisting systems such as wall frame systems, braced tube, outrigger system and shear walls etc. to resist lateral shear imposed on them. The diagrids are usually provided in the perimeter of the building which resists gravity and lateral loads effectively through it axis and they don't need any extra shear resisting systems. Diagrids can also save steel from 20%-30% of the steel as compared to the conventional buildings.

In this study an attempt is made to compare the conventional building with that of buildings with diagrids

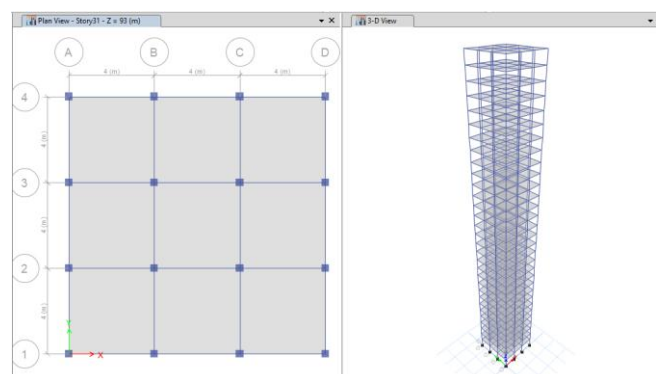
inclined at different angles. Various response parameters of both type of buildings are studied and the optimum angle at which the building's performance is best is determined.

## II. SCOPE OF THE STUDY

1. By studying various parameters of a conventional building subjected to nonlinear static analysis and comparing those with buildings with different diagrids angles the significance of using diagrids in the buildings can be known.
2. Diagrids when used in buildings it improves the aesthetic appearance of the building.
3. Diagrids reduces the total steel consumption in the building as compared to the conventional buildings.
4. Diagrids improves the ductility of the building, and less steel consumption results in achieving economy in designs without compromising the safety and stability of the buildings.

## III. OBJECTIVES

- To compare the performance of a conventional 31 story R.C building and buildings with diagrids angles 36.86°, 56.30° and 66.03°. Using static Nonlinear analysis in ETABS 2015.
- To study the behavior of the conventional building and buildings with diagrids having angles of inclinations 36.86°, 56.30° and 66.03° in terms of parameters such as story displacement, diaphragm drift, story acceleration, base shear and story displacement.
- To determine the optimum angle of diagrids at which the building performs its best under the influence of lateral forces imposed on it.



#### IV. ANALYTICAL WORK

This analytical work is carried out by using ETABS 2015 considering four types of symmetric buildings such as.

Model 1: A conventional 31 storied building as shown in Fig 4.1.

Model 2: A 31 storied Building with diaphragms inclined at  $36.86^\circ$  as shown in Fig 4.2.

Model 3: A 31 storied building with diaphragms inclined at  $56.30^\circ$  as shown in Fig 4.3.

Model 4: A 31 storied building with diaphragms inclined at  $66.03^\circ$  as Shown in Fig 4.4.

Fig 4.1: plan and 3-D elevation of a 31 storied conventional building.

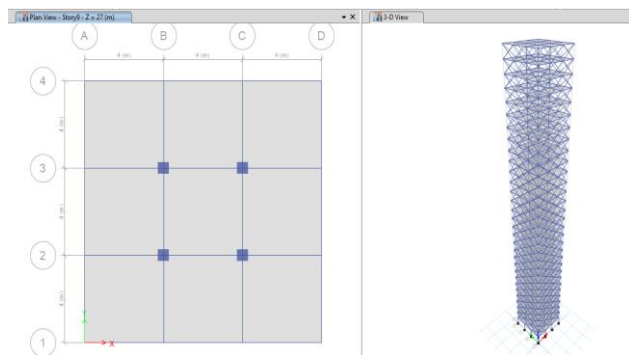


Fig 4.2: plan and 3-D elevation of a 31 storied building with diaphragms angle  $36.86^\circ$

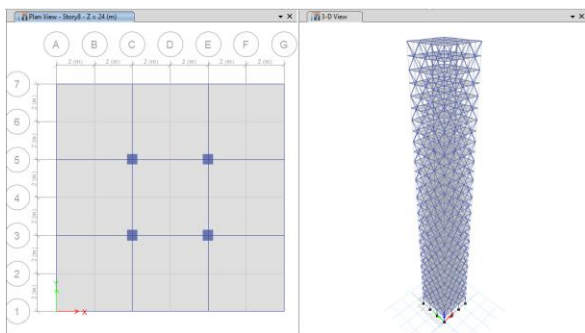


Fig 4.3: plan and 3-D elevation of a 31 storied building with diaphragms angle  $56.30^\circ$

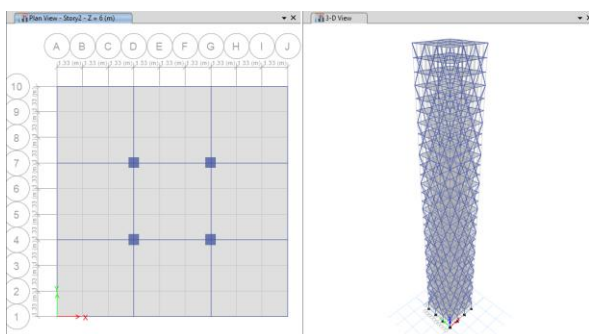
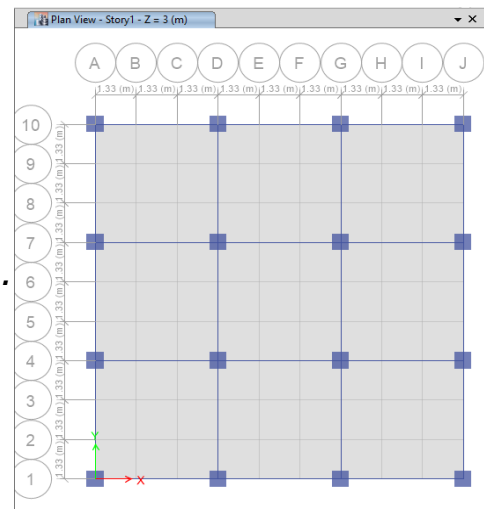


Fig 4.4: plan and 3-D elevation of a 31 storied building with diaphragms angle  $66.03^\circ$



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Fig 4.5: Typical bottom story plan of a 31 storied building with diaphragms at different angles.

#### V. RESULTS AND DISCUSSION

Here we have discussed about conventional building, building with diaphragms inclined at different angles. The results are obtained in terms of diaphragm drift, spectral acceleration, spectral displacement, base shear vs. monitored displacement and max story displacement.

#### Diaphragm drifts for the force in push-X direction

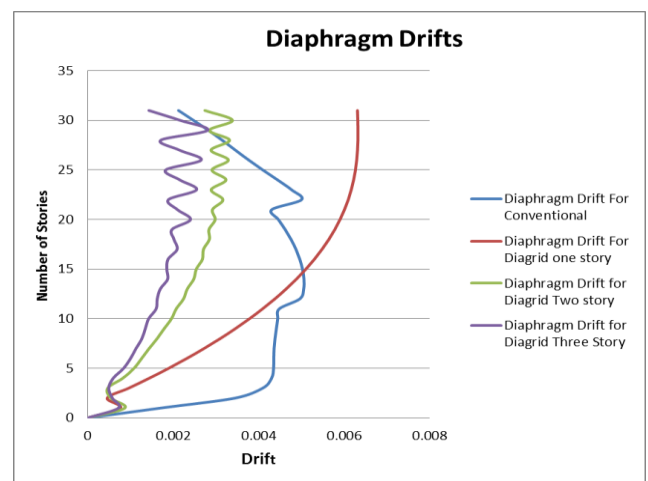


Fig 5.1: Graph showing diaphragm drifts. It can be seen that the diaphragm drift is least when the angle of inclination of the diaphragms is  $66.03^\circ$ . ie, when the diaphragm is spanning in three stories.

**Spectral acceleration and spectral displacement for the force in push-X direction.**

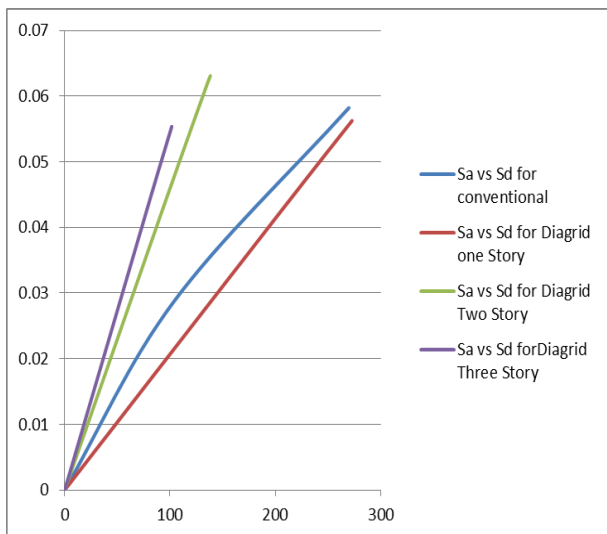


Fig 5.2: Graph showing spectral displacement vs spectral acceleration values. It can be seen that sd and sa are least when the angle of inclination of the diagrids is 66.03° ie, when the diagrid is spanning in three stories.

**Base Shear vs Monitored Displacement for the force in push-X direction.**

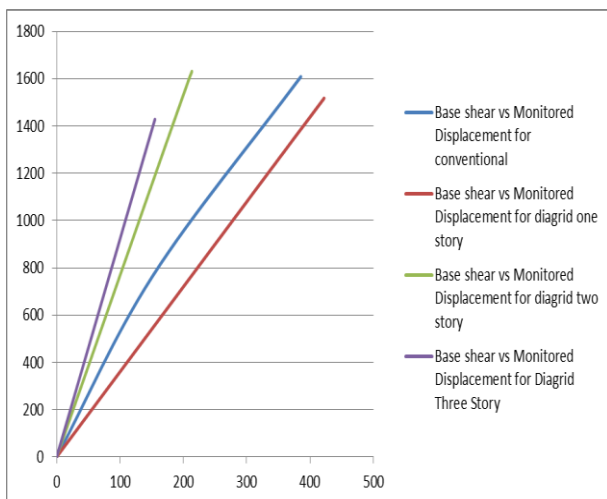


Fig 5.3: Graph showing Base shear vs Monitored displacement values. It can be seen that Base shear and displacement values are least when the angle of inclination of the diagrids is 66.03° ie, when the diagrid is spanning in three stories.

**Maximum story displacement for push in X-direction**

Fig 5.4: Graph Maximum displacement values. It can be seen that Maximum displacement values are least when the angle of inclination of the diagrids is 66.03° ie, when the diagrid is spanning in three stories.

**Story Acceleration for push in X direction**

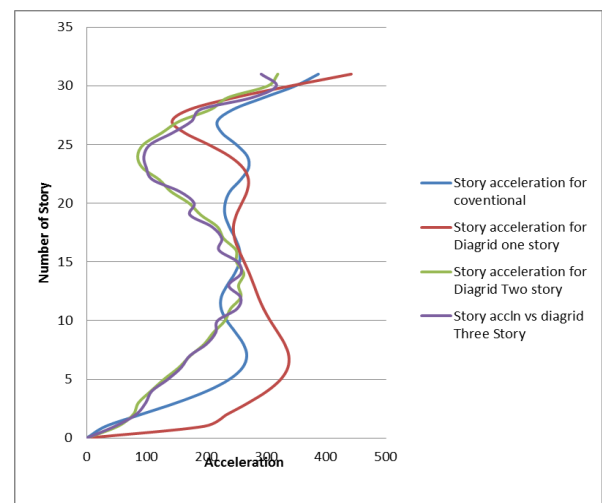
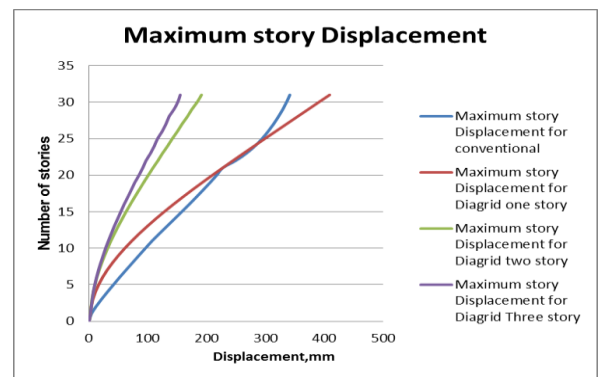


Fig 5.5: Graph story acceleration values. Its can be seen that story acceleration values are least when the angle of inclination of the diagrids is 66.03° ie, when the diagrid is spanning in three stories.



**Diaphragm drifts for the force in push-Y direction**

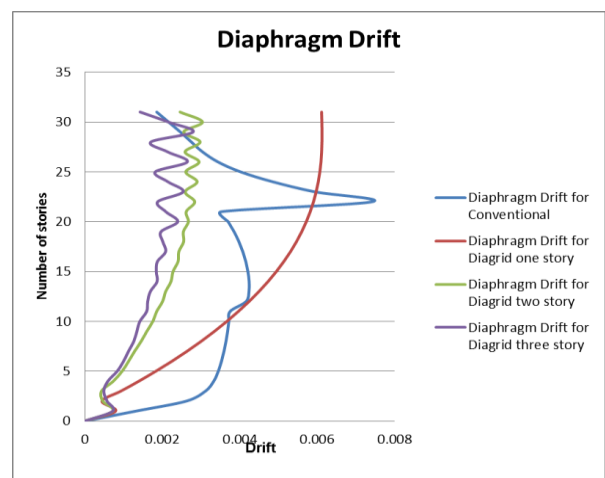
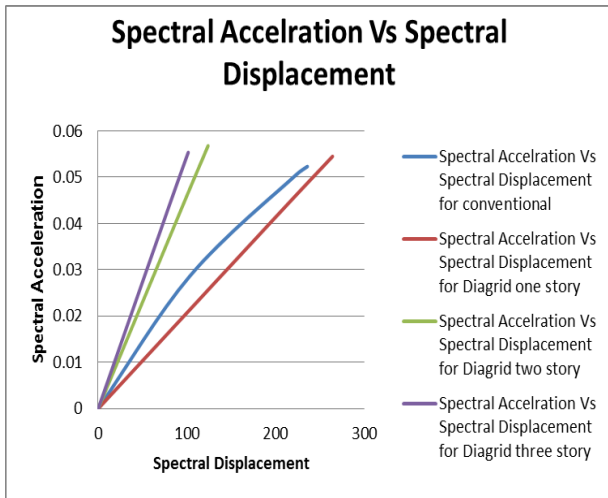


Fig 5.6: Graph showing diaphragm drifts values. Its can be seen that the diaphragm drift is least when the angle of inclination of the diagrids is 66.03° ie, when the diagrid is spanning in three stories.

**Spectral acceleration and spectral displacement for the force in push-Y direction.**



5.7: Graph showing spectral displacement vs spectral acceleration values. It can be seen that sd and sa are least when the angle of inclination of the diagrids is 66.03° ie, when the diagrid is spanning in three stories.

**Story Acceleration for push in Y direction**

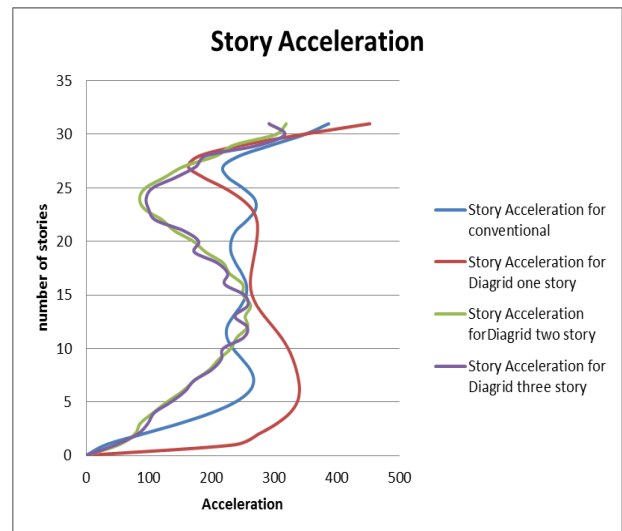
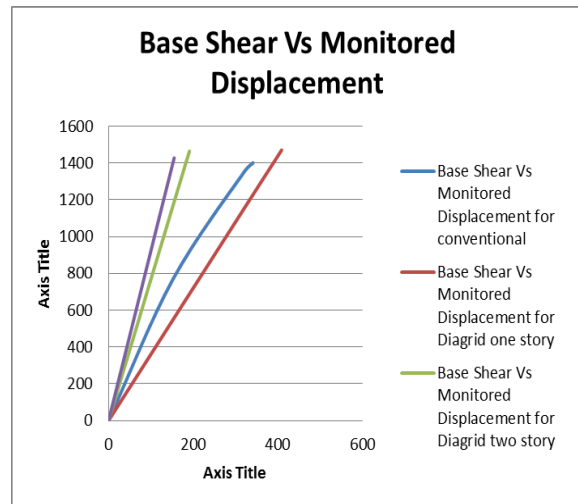
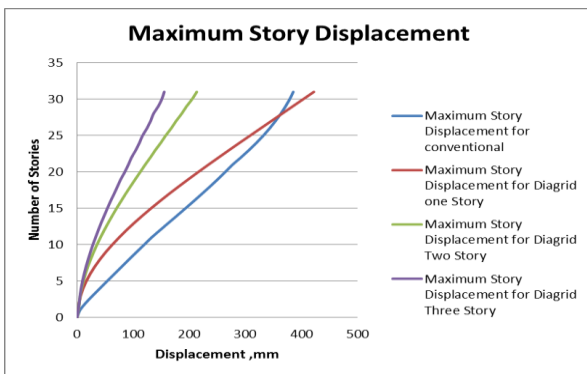


Fig 5.10: Graph story acceleration values. It can be seen that story acceleration values are least when the angle of inclination of the diagrids is 66.03° ie, when the diagrid is spanning in three stories.



**Maximum story displacement for push in Y-direction**

Fig 5.8: Graph Maximum displacement values. It can be seen that Maximum displacement values are least when the angle of inclination of the diagrids is 66.03° ie, when the diagrid is spanning in three stories

**Base Shear vs Monitored Displacement for the force in push-Y direction.**

Fig 5.9: Graph showing Base shear vs Monitored displacement values. It can be seen that Base shear and displacement values are least when the angle of inclination of the diagrids is 66.03° ie, when the diagrid is spanning in three stories

**Table Given below Shows the Difference in shear force (Fy) and bending movement (Mz) between conventional building and building with diagrids**

Column No	Conventional Building		Diagrid Building		Ratio	
	Fy(kN)(1)	Mz(kN-m)(2)	Fy(kN)(3)	Mz(kN-m)(4)	(3/1)	(4/2)
1	21.7	69.5	23.78	53.36	1.095853	0.76777
2	27.66	75.17	23.78	53.36	0.859725	0.709858
3	27.66	75.17	24.24	53.8	0.876356	0.715711
4	21.7	69.5	24.24	53.8	1.117051	0.774101
5	22.65	70.4	28.54	57.89	1.260044	0.822301
6	29.23	76.66	28.54	57.89	0.976394	0.755153
7	29.23	76.66	23.78	53.36	0.813548	0.696061
8	22.65	70.4	24.24	53.8	1.070199	0.764205
9	22.65	70.4	24.24	53.8	1.070199	0.764205
10	29.23	76.66	23.78	53.36	0.813548	0.696061
11	29.23	74.91	28.54	57.89	0.976394	0.772794
12	22.65	69.04	28.54	57.89	1.260044	0.838499
13	21.7	68.2	29.84	59.13	1.375115	0.867009
14	27.66	73.51	29.84	59.13	1.078814	0.80438
15	27.66	73.51	29.84	59.13	1.078814	0.80438
16	21.7	69.5	29.84	59.13	1.375115	0.850791

**TABLE NO 1**

From this table it can be observed that building with diagrids at optimum angle has shown less shear force and bending moments, as compared to conventional buildings

**VI. CONCLUSIONS**

The following are the important conclusions drawn from this study.

1. The optimum angle of inclination of diagrids at which the building's performance is best is found to be 66.03°.
2. The diaphragm drift is found to be minimum in push-x and push-y directions when the angle of inclination of the diagrid is 66.03° as compared to conventional building and buildings with other angles of inclination.
3. At an optimized angle of 66.03° the Base shear and displacement are found to be least in both push-x and push-y directions as compared to other angles of inclination and conventional building.
4. The spectral acceleration and spectral displacement of the building with diagrid angle of inclination 66.03° is found to be less than conventional building and the buildings with other angles of inclination in both push-x and push-y directions.
5. Building having diagrid angle of inclination of 66.03° has shown less story displacement in push-x and push-y directions than the conventional building and buildings with other angles of inclination.

6. The story acceleration is minimum in push-x and push-y directions when the angle of inclination of the diagrid is 66.03°.
7. Hence it can also be concluded that the buildings with diagrids having certain optimized angle can resist more lateral forces and can perform much better than conventional buildings.

**VII. SCOPE OF FURTHER STUDY**

- This work can be further carried out by using nonlinear dynamic analysis.
- This study can be further done by considering the base as isolated instead of fixed base.
- In this study push over analysis is done for X and Y direction, further it can be done by taking into consideration various modes of the building.

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