Parametric Study on Influence of DIAGRID Angles On Seismic Parameters Of Multi-Storey Circular Shaped Building

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Abstract*: Advanced structural elements, materials and methodology are considered for the analysis and design which leads to the development of tall buildings. Tall structures are raised due to lack of construction areas, which also provides the land for vegetation purposes. Tall structures are susceptible to failure under lateral loads like seismic loads and wind loads. Lateral load resistance of structure is provided by interior structural system or exterior structural system. Usually braced frame and shear wall and their combination refer to interior system. In the other hand Diagrid, framed tubes are provided at the periphery of the structure. In modern days Diagrid system is adopted in tall buildings due to its efficiency and flexibility. Provision of Diagrid to tall buildings, reduces the steel when compared to the conventional buildings. The present work is concerned with considering circular shape plan having 23 storey building, along with Diagrid are used. The Diagrid are provided with angles. In this work seismic analysis is carried out using ETABS v9.7 software to determine the structural parameters like storey displacement, storey drift, Time period and base shear.*

Keywords: **Diagrid, ETABS, Storey displacement, storey drift, Base shear, Time Period**

1. INTRODUCTION

Now a days the rapid growth of urban population, scarcity and high cost of available land influence the construction industries. So that the construction of high rise structures are preferable. Lateral stiffness is very much important for a tall building. Lateral load consideration is very much important when the height of the structure increases. For that reason lateral load resisting system has become much importance than structural system that resists the gravity loads. Now a day's Diagrid, diagonal grid system is used for high rise buildings due to its structural efficiency and aesthetic look provided by its geometric configuration. Here structural efficiency means, it decreases the number of interior columns. Therefore it provides more flexibility to the design. In recent days conventional framed structures are losing interest because of new and different aesthetic look provided by diagonal systems and also they gives good appearance and recognized very easily. The main objective of using Diagrid system is to remove the number of vertical columns. The vertical columns carry the gravity loads and are not capable of resisting lateral load. The Diagrids carry the gravity loads and it gives lateral stability due to its triangular configuration of the structure. The Diagrid system also saves 20% of the structural steel compared to conventional framed structure.

2. OBJECTIVE OF THE STUDY:

- Analysis of Diagrid structure for different angle of Diagrid by varying the Seismic zones.
- Study the Maximum storey displacement, storey drift, Base shear and Time period to show the behavior of the structure under Earthquake loading.

3. METHODOLOGY

3.1 Analysis of 23 storey Circular Diagrid building

Following data are considered in the modeling of the structure.

1) 23 storey building having circular shape with 40m diameter. The total height of the building is 82.8m with 3.6m height of each storey is taken.
2) Size of Diagrid is taken as 350mm pipe section with 25mm thickness.
3) The diagrid angle of 66.43^{o}, 73.78^{o} and 80.1^{o} will be taken.
4) ISMB 550 is taken for the size of beam, and 700mm circular column will be considered.
5) The characteristic strength of concrete is taken as 25N/mm^2 and characteristic strength of steel will be taken as 415N/mm^2.
6) The yield stress of steel is taken as 250N/mm^2 and ultimate tensile strength is taken as 420N/mm^2.
7) The dead load is taken as 5.5KN/m^2 on terrace level and 4KN/m^2 on floor level. The live load is taken as 1.5KN/m^2 on terrace level and 4KN/m^2 on floor level.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 05 | May -2017 www.irjet.net p-ISSN: 2395-0072

8) The earthquake load parameters are taken as zone factor 0.1, soil type II, Importance factor 1, Response reduction factor 5 as per IS-1893-2002.
9) The wind loads are taken based on location Lucknow , wind speed 47m/s, Terrain category 2, Structure class C, Risk coefficient 1, Topography factor 1.
10) Supports are taken fixed.
11) Modeling and analysis is carried out on ETABS v9.7 software.

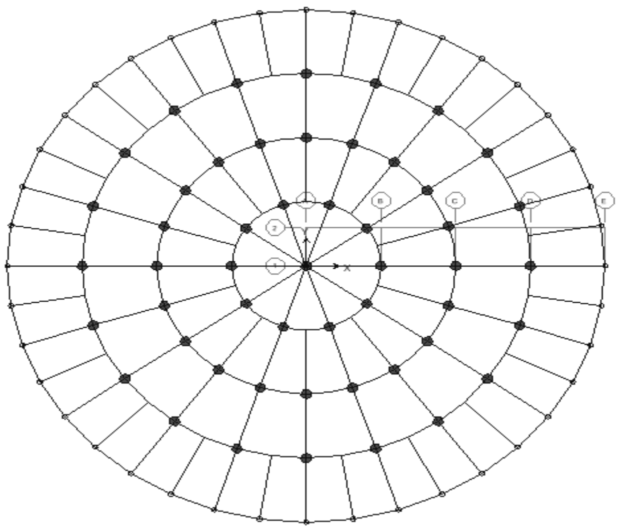

Fig -1: Plan of the model

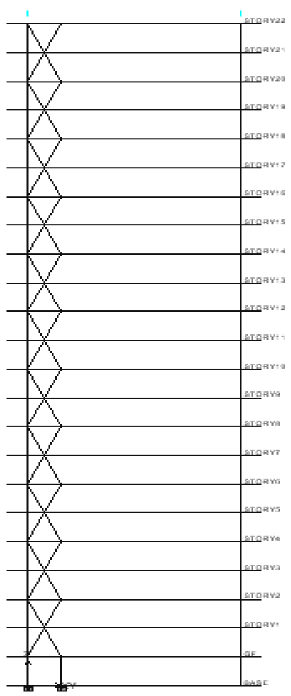

Fig -2: Elevation of 66.43° Diagrid angle

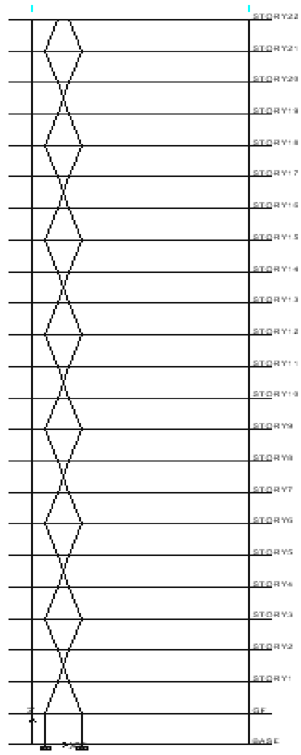

Fig -3: Elevation of 73.78° Diagrid angle

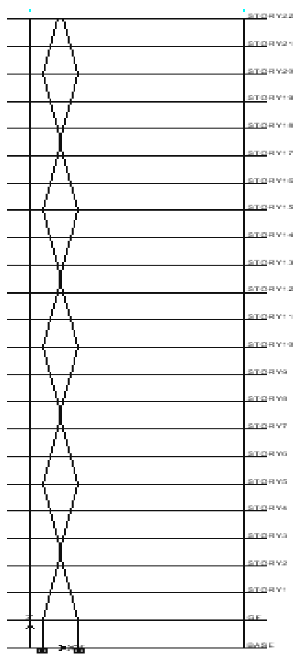

Fig -4: Elevation of diagrid angle 80.1°

3.2 Modeling

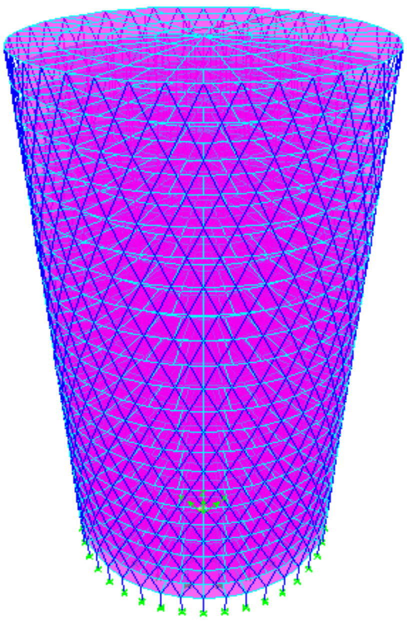

Fig -5: 3D view of 66.43° diagrid angle building

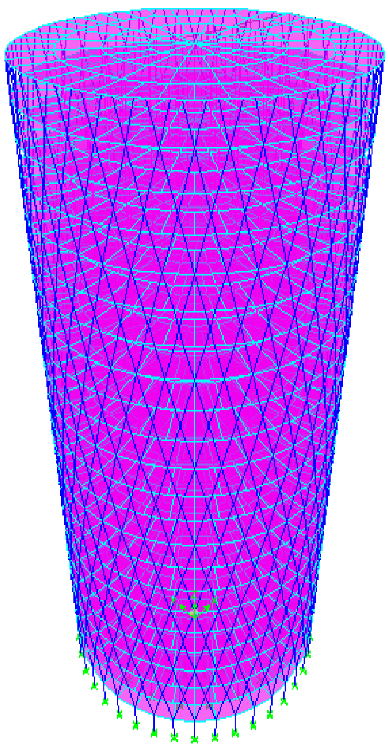

Fig -6: 3D view of 73.78° diagrid angle building

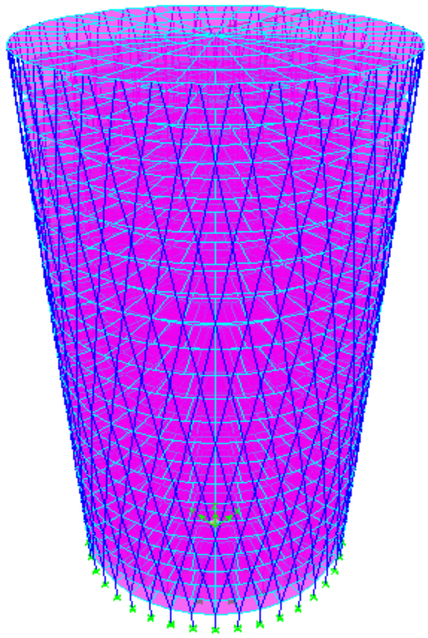

Fig -7: 3D view of 80.1° Diagrid angle building

4. ANALYSIS RESULTS

In this chapter, the results of models are presented and discussed in detail. The results are included for all different building models. The analysis of the different building models is performed to zone II, zone III, zone IV and zone V by using ETABS software.

In this present study the behavior of each model is studied and the results are tabulated in the form of storey displacement, storey drift, Base shear and Time period in static and dynamic analysis.

4.1 Storey displacement

Table -1: Comparison of Storey Displacement along X-direction for various seismic zones

TOP STOREY DISPLACEMENT IN X- DIRECTION (mm)				
	Seismic Zones			
Diagrid angle in degree	2	3	4	5
66.43	13.1	20	27.9	42.9
73.78	11.3	18.1	27.1	40.7
80.1	16.8	26.8	40.2	60.2

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 04 Issue: 05 | May -2017 www.irjet.net p-ISSN: 2395-0072

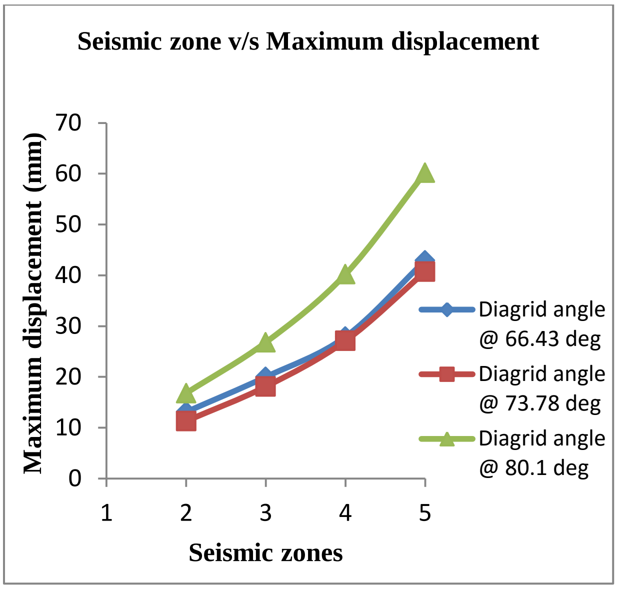

Chart -1: Graph showing seismic zones v/s maximum displacement along X-direction

From the table 1 it can be seen that, the Diagrid angle decreases the angle decreases the Displacement of the building decreases upto certain angle then increases. The displacement of the building will be less nearly 32.7%, 32.5%, 32.6%, and 32.4% for zone II, III, IV and V. hence the Diagrid angle 73.78º is having less displacement. Therefore this angle is more preferable.

4.2 Storey drift

Table -2: Comparison of Storey Drift along X-direction with different angles for seismic zone II

STOREY DRIFT IN X-DIRECTION (ZONE II)			
STORIES	DIAGRID ANGLES IN DEGREES		
	66.43	73.78	80.1
1	0.224	0.234	0.255
2	0.112	0.146	0.238
3	0.132	0.131	0.223
4	0.138	0.138	0.241
5	0.159	0.139	0.236
6	0.160	0.148	0.239
7	0.175	0.149	0.238
8	0.177	0.154	0.237
9	0.185	0.152	0.249
10	0.191	0.151	0.238
11	0.188	0.153	0.235
12	0.189	0.148	0.231
13	0.186	0.146	0.223
14	0.183	0.143	0.227
15	0.179	0.135	0.209
16	0.172	0.132	0.198
17	0.167	0.124	0.191
18	0.158	0.112	0.172
19	0.151	0.113	0.161
20	0.139	0.108	0.139
21	0.131	0.093	0.115
22	0.118	0.079	0.104
23	0.116	0.074	0.072

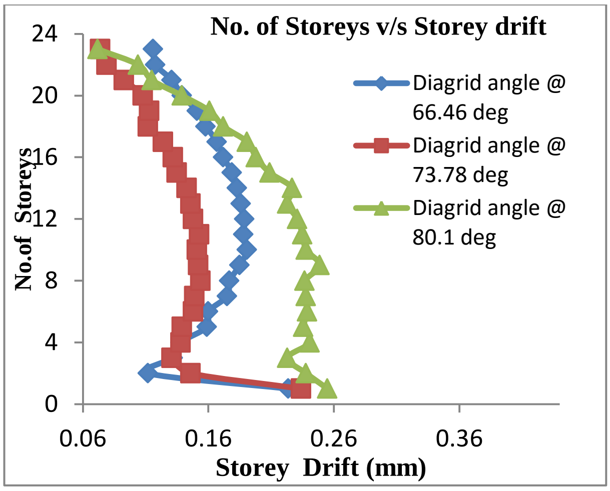

Chart -2: Graph showing Storey drift along X-direction v/s No of storeys for zone II

From the table 2 it can be observed that, as the Diagrid angle decreases storey drift of the building decreases. Displacement of one floor with respect to floor is called storey drift. It means lesser is the flexibility lesser will be the displacement. And also lesser will be the storey drift.

4.3 Base shear

Table -3: Comparison of Base shear along Y-direction for various seismic zones

BASE SHEAR IN EQy DIRECTION (KN)				
	Seismic Zones			
Diagrid angle in degree	II	III	IV	V
66.43	2344.83	3741.51	5636.62	8441.36
73.78	2349.85	3759.76	5639.64	8459.46
80.1	2352.80	3764.49	5646.73	8470.10

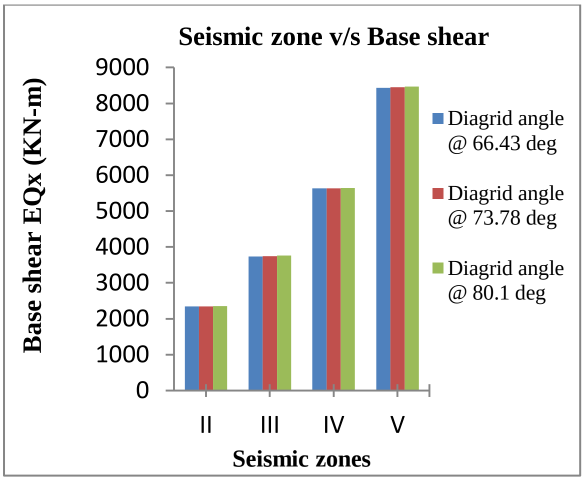

Chart -3: Graph showing seismic zones v/s No Base shear along X-direction

From the table 1 it is observed that, when the Diagrid angle decreases the base shear also decreases. It can be seen that the decrease in base shear was nearly 0.25%, 0.48% for zone II, 0.3%, 0.75% for zone III, 0.03%, 0.26% for zone IV and 0.25%, 0.48% for zone V. For the Diagrid angle 80.1°, the base shear is more compared to 66.43°.

4.4 Time period

Table -1: Comparison of Natural Time period with different angles for seismic zone V

Natural Time period in Seconds (Zone II)			
Mode	**Diagrid angle in degrees**		
	66.43	73.78	80.10
1	2.133	1.990	2.459
2	1.804	1.988	2.456
3	1.038	1.132	1.479
4	0.662	0.653	0.813
5	0.579	0.652	0.810
6	0.349	0.364	0.492
7	0.330	0.364	0.470
8	0.302	0.363	0.469
9	0.235	0.260	0.337
10	0.207	0.260	0.337
11	0.177	0.211	0.296
12	0.174	0.203	0.264

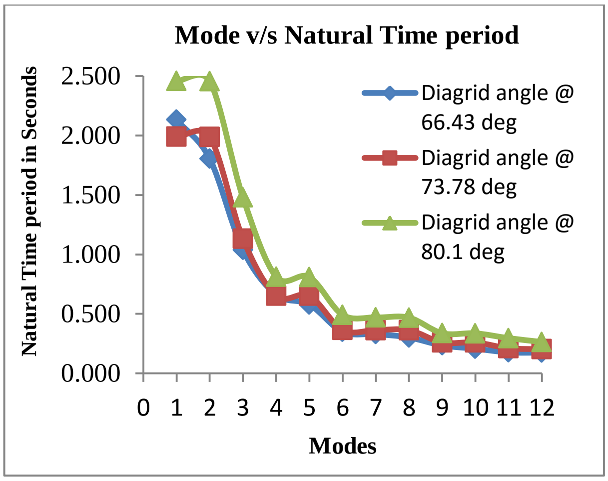

Chart -4: Graph showing modes v/s Time period

From table 4 it is observed that, as the Diagrid angle decreases the time period value decreases at certain angle and then increases. It means that the Diagrid angle 80.1° is having more flexibility. It is seen that time period value increases nearly 6.7%, 19.1% for 66.43° and 80.1°. Hence the Diagrid angle 73.78° is having lesser time period. So the stiffness of this angle is more compared to other angles. Therefore this angle is more preferable.

4. CONCLUSIONS

In this study an attempt has been made to compare the different Diagrid angle for different Seismic zones with twelve models. Totally twelve models of 23 storey are considered for Seismic analysis carried out using ETABS v.9.7 software. From the comparison of results below conclusion are drawn.

4.1 Conclusions

- The storey drift, Storey displacement is less in 73.78° Diagrid angle compared to 80.1°. Hence this angle is more optimum.
- The Base shear decrease as the Diagrid angle decreases, so we can conclude that 73.78° angle is better than the other Diagrid angle.
- The Natural Time period increases as the Diagrid angle increases, Natural Time period for 73.78° angle is less compared to 80.1°.
- As the height of the building increases Diagrid angle also increases it gives better results of Top storey displacement, storey shear and Time period.
- By providing Diagrid system to High Rise structures act as a good lateral resisting system against Earthquake loads.

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