



Analysis of Diagrids Using Symmetric and Asymmetric Plan Geometry

¹Ravish Khan, ²Sangeeta Shinde

^{1,2}Civil Engineering Department, Jawaharlal Nehru Engineering College, Aurangabad, Maharashtra

Abstract— These days the latest trend of technology in diagrid structures is evolving. The diagrid structures are buildings with diagonal grids in the periphery at a particular angle and in modules across the height of the building. Diagrid structure uses triangulated grids which are in place of vertical columns in the periphery. The latest trends in diagrid structures are making the scope in new strategies to reduce the earthquake and wind responses in the structure. The triangulated configuration of diagrids takes the lateral as well as gravity loads and passes them through axial action into the ground. The use of diagrid structures has proved to be more efficient than a regular framed structure. Also, the vertical columns in the periphery are also eliminated, giving efficient utilization of the space. In this paper, two models of diagrid structures with different symmetric and asymmetric plan geometries are analyzed by linear static method and designed for the same. The analysis results are shown in terms of storey shear, storey drift and storey displacement in all the two models.

Index Terms—Diagrid structure, shear, drift, displacement.

I. INTRODUCTION

Any high rise building is judged by its ability to withstand the lateral forces. Diagrid structures are evolving because of its ability to efficiently withstand lateral forces, with them being lighter and stiffer. The diagonal members in diagrid structural systems can carry gravity loads as well as lateral forces due to their triangulated configuration in a distributive and uniform manner.

As the trends in analyzing high rise building is increasing, it is very necessary to find strategies which can reduce the response of lateral forces on the building. There are strategies in diagrid structures in which the amount of forces can be reduced and dissipated in to the ground. In the diagrids, all the heavy columns in the periphery are eliminated and hence, less amount of material is used as compared to other structures. Also, the interior space can be planned efficiently.

A diagrid's module has a diamond shape which contains a number of stories. Modules are classified into 4 different groups including small modules (2-4 stories), mid-size modules (6-8 stories), large modules (more than 10 stories) and irregular modules. Moreover, diagrid's angle

is the angle of diagonal members.

In this study, two structural plans of the diagrid are taken with symmetric and asymmetric plan configurations. These two models are analyzed and then design with suitable safe sections. So in all aspects, the diagrids have emerged to be efficient in planning the interior space as well as façade of the building and also them being lighter and stiffer.

II. CONFIGURATION OF THE MODELS

A. Model Types

In this study, two structural models are used. They are:

I. Symmetric form (Model -1)

II. Asymmetric form (Model -2)

These models are illustrated below.

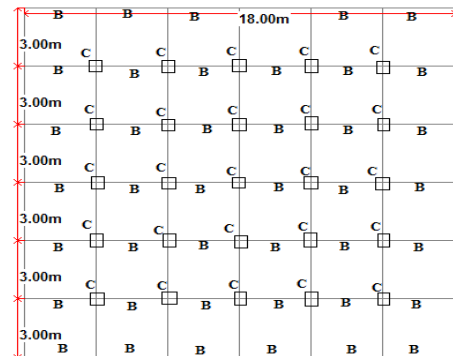


Fig.-1. Plan for Model-1

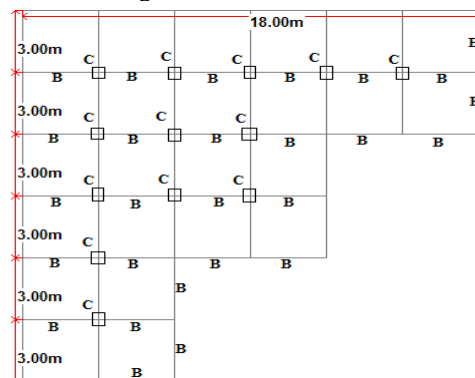


Fig.-2. Plan for Model-2

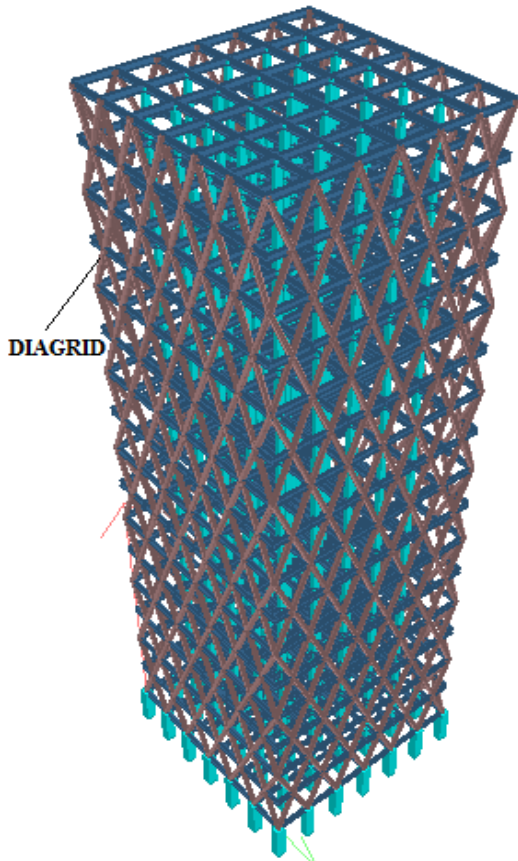


Fig.-3. 3-D view for Model-1

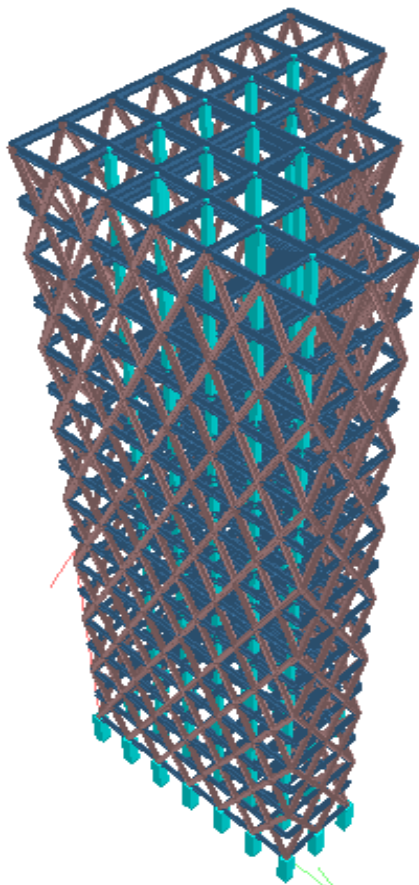


Fig.-4. 3-D view for Model-2

B. Geometry and structural data

The configuration of both the models is as follows:

1. Symmetric form – Model-1

Asymmetric form – Model-2

2. Plan dimensions- 18m x18m

3. Storey height- 3.6m

No. of stories- 16

4. Angle of diagrid- 67.4°

5. Module of diagrid- 2 storey module

6. Beams and diagrid- steel

7. Columns- concrete

8. The slab thickness is taken 120mm

9. The dead load is taken 5.5kN/m² on terrace level and 4kN/m² on floor level. The live load is taken 1.5kN/m² on terrace level and 4kN/m² on floor level of both the models.

10. The earthquake load parameters are taken as zone factor 0.1, soil type II, Importance factor 1, Response Reduction 5 as per IS-1893-2002.

11. The wind loads are computed based on location Aurangabad, Wind speed 39 m/s, Terrain category 2, Structure class B, Risk Coefficient 1, Topography Factor 1 as per IS: 875(Part- III)

12. Supports are taken fixed. Hinged condition is applied to diagrids.

13. Modeling, analysis and design is carried out on STAAD.Pro V8i software and the design of columns is done by IS-456-2000 and that of beams and diagrids are done by IS 800-2007.

III. ANALYSIS AND RESULTS

The results of analysis are in terms of displacement of the stories, storey drift, storey shear and are presented in this paper. A building when subjected to lateral loads, it deflects. Two principle directions, X and Z are considered. In connection with the lateral displacements of the building, storey drift is also found out.

The results of storey displacement of the models are given in the table-I.

Table-I: Storey Displacement results

Storey (m)	Displacement (mm)		% Increase in Model-2
	Model-1	Model-2	
1	5.6	6.1	4.3
2	10.1	10.8	3.3
3	13.2	15.6	8.3
4	17.8	21.3	9.0
5	20.2	26.7	13.9
6	24.9	33	14.0
7	26.5	38.4	18.3
8	31.2	44.8	17.9
9	32.4	49.9	21.3
10	37	56.1	20.5
11	37.5	60.7	23.6
12	41.9	66.6	22.8
13	42	70.6	25.4
14	46.2	76.2	24.5
15	45.8	79.6	27.0
16	49.5	84.5	26.1

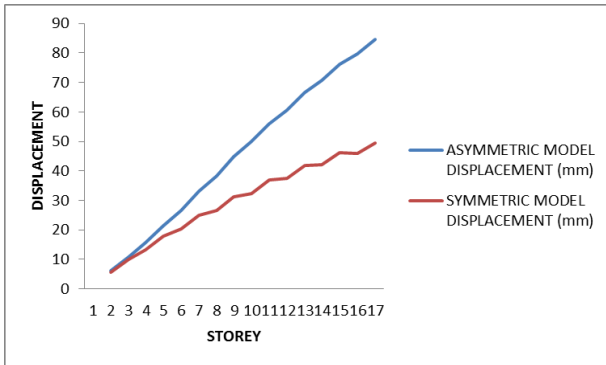


Fig.-5. Storey displacement v/s storey

It is seen that the displacement of model-2 is more than that of model-1. Also, it is noted in the fig.-5 that the displacement in symmetric model increases moderately as the stories increases, whereas in asymmetric model, it increases with much higher values with each story.

Table-II: Top Storey Displacement and Drift results

	Model-1	Model-2	Permissible value
Top storey displacement	50mm	85mm	115mm
Top storey drift	3.6mm	4.9mm	11.5mm

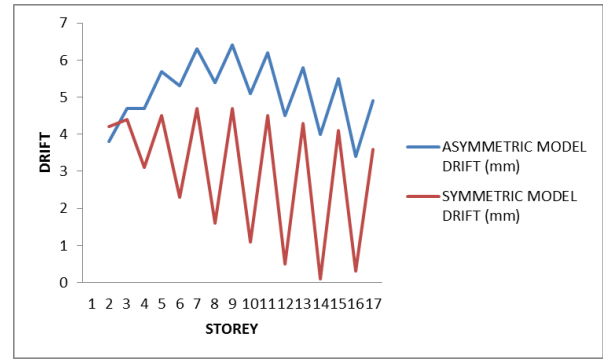


Fig.-6. Storey drift v/s storey

The results of storey drift of both the models are shown in the table-II. It is seen in fig.-6 that the drifts in both models vary in each storey. This variation in the drifts is much more fluctuating in the model-1 as compared to model-2.

In the model-1, storey shear is much more than in model-2. It is shown in the fig.-7 and in table-III.

Table-III: Storey Shear

Storey (m)	Storey Shear (V) (KN)	
	Model-1	Model-2
Top storey	88.2	60.8

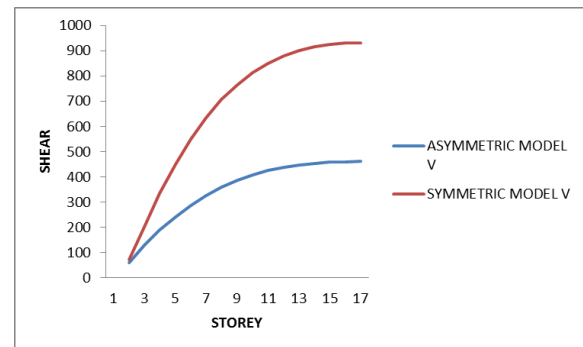


Fig.-7. Storey shear v/s storey

IV. DESIGN OF THE MODELS

The design of both the structural models is carried out using STAAD.Pro V8i software. The dead, live, earthquake and wind load and all load combinations are applied to the models. The design of diagrid members and all beams are designed as per IS 800-2007 and all the columns are designed as per IS 456-2000. The characteristic compressive strength of concrete is taken 30 N/mm² and for steel is 415 N/mm². The yield stress of steel is taken 250 N/mm² and the ultimate tensile strength is 420 N/mm². The final sizes of members which are obtained from the analysis for both the structures are given in the table-IV

Table-IV: Member sizes

Member	Member No.	Model-1	Model-2	Property
Beam	B	ISMB500	ISMB500	Steel
Column	C	350X350mm m	350X350mm m	Concrete
Diagrid	D	350mm pipe with 12mm thickness	350mm pipe with 12mm thickness	Steel

V. CONCLUSION

By performing this study, the state of the structure in symmetric geometry and asymmetric geometry is observed.

1. It is observed that the top storey displacement of symmetrical model is less than asymmetrical model by 26%.
2. The top storey drift is also less in the first model by 15% than in the second model.
3. This is because the stiffness of the members provided in model-1 is more than that of the model-2.
4. Also, the symmetric shape allows equal number of members to displace when subjected to lateral forces.
5. Hence, due to symmetry of plan, the response of the building along with diagrids is more efficient than the one with asymmetrical form when subjected to wind loads.
6. Top storey shear in model-2 is less than model-1 by 18%.
7. The response of asymmetric model proves more efficient in terms of storey shear as compared to symmetric one.
8. By providing diagrids to both the models, the symmetrical model comes out as more efficient than the asymmetrical one in terms of storey displacement and storey drift.
9. All these differences in both structures are observed for the same height and plan area.

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