# Analytical Study of Vertical Geometric Irregular Diagrid Structure And Comparison With Braced Tube Structure

**Arpi V. Patel[1], Ronak S. Gajjar[2], Javal J. Patel[3]**
[2, 3] Asst. Prof
[1, 3]Merchant Institute of Technology, Piludara
[2]Sakalchand Patel College of Engineering, Visnagar

***Abstract***- *The rapid growth of high rise buildings leads to the evolution of new structural concepts. Structural systems nowadays are becoming stiffer and lighter. 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. Structural design of high rise buildings is governed by lateral loads due to wind or earthquake. 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. In most of situations, buildings become vertically irregular at the planning stage itself due to some architectural and functional reasons. This paper presents analysis of diagrid structure and braced tube structure for irregular vertical geometry using ETABS software. Comparison of storey drift and storey displacement results by using non-linear dynamic time history analysis.*

***Keywords***- Diagrid, Braced tube, ETABS, Storey displacement, Storey Drift

## I. INTRODUCTION

The rapid growth of urban population and limitation of available land leads to the evolution of taller structures. As the height of building increase, the lateral load resisting system becomes more important than the structural system that resists the gravitational loads. The lateral load resisting systems that are widely used are rigid frame, shear wall, wall frame, braced tube system, outrigger system and tubular system. Recently, the diagrid structural system is widely used for tall buildings due to its structural efficiency and aesthetic potential provided by the unique geometric configuration of the system. The diagrid systems can be called the evolution of braced tube structures because both systems are able to carry lateral loads due to the axial action of structural members. In case of braced tube structures, the bending rigidity is provided primarily by vertical perimeter columns whereas in diagrid structures, bending rigidity is provided by diagonal members which are also provide shear rigidity.

## II. OBJECTIVE OF STUDY

- Comparative analysis of diagrid structures with braced tube structures based on vertical geometric irregularity.
- Study the parameters like storey displacement and storey drift to predict the behaviour of structures under seismic loading.

## III. MODELING AND MATERIAL SPECIFICATIONS

The modelling and analysis of a G+29 storey diagrid and braced tube model is analysed by using ETABS 2017 (30 days trial version) software. The modelling data is listed below. Typical floor plan of size 24m x 24m, 16m x 16m and 8m x 8m are used as shown in figure1, figure2 and figure3. Storey height is taken 3.6m.

The characteristics compressive strength of concrete is 40 N/mm2 for columns and 30 N/mm2 for slab. The yield strength of main reinforcement is 415 N/mm2 in columns and slabs. The yield strength of steel is 250 N/mm2 and the ultimate tensile strength is 420 N/mm2.

Three models are considered for both structures as per described below. This is shown in Figure.

1) Model 1: 75% of total height (H) having regular plan of 24mx 24m as shown in Figure 1 and remaining portion having plan dimension 16m x 16m as shown in Figure 2.
2) Model 2: 50% of total height (H) having regular plan of 24mx 24m as shown in Figure 1, another 25% of total height having plan dimension 16m x 16m as shown in Figure 2 and remaining portion having plan dimension 8m x 8m as shown in Figure 3.

3) Model 3: 25% of total height (H) having regular plan of 24mx 24m as shown in Figure 1, another 50% of total height having plan dimension 16m x 16m as shown in Figure 2 and remaining portion having plan dimension 8m x 8m as shown in Figure 3.

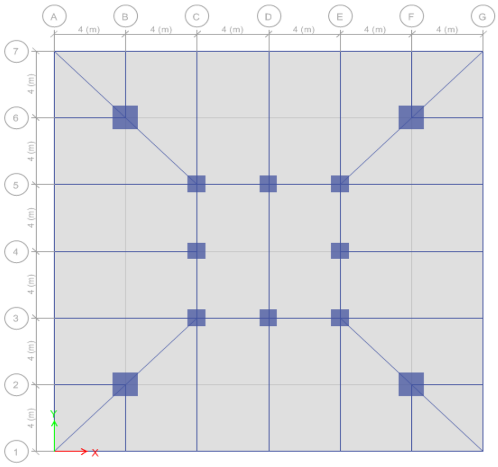

Figure 1: Typical floor plan 24m x 24m

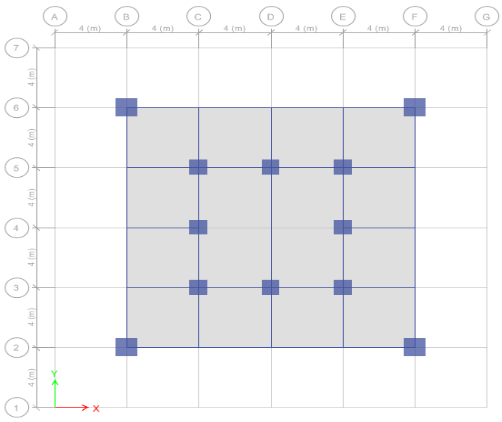

Figure 2: Typical floor plan 16m x 16m

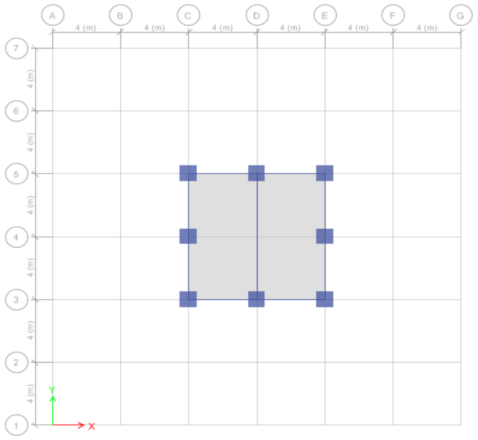

Figure 3: Typical floor plan 8m x 8m

Table 1: Structural member specifications and design data

| Member | Diagrid Structure | Braced Tube Structure | Properties |
|---|---|---|---|
| Beams | ISMB550 | ISMB550 | Steel |
| Interior Columns | 1m x 1m<br>1.2m x1.2m | 1m x 1m<br>1.2m x 1.2m | Concrete |
| Exterior Columns | | 0.4m x 0.4m | Concrete |
| Slab | 0.12 m, thickness with 20mm cover | 0.12 m, thickness with 20mm cover | Concrete |
| Bracings | | 2-ISA 200X200X25 | Steel |
| Diagrid | 450mm pipe 25mm thick, $\theta$=60.56° | | Steel |

The dead load is taken 4kN/m2 on floor level. Wall load at floor level beams is 5KN/m and a terrace level beam is 2KN/m. The live load is taken 2KN/m2 on terrace level and 4kN/m2 on floor level for all models. Earthquake inputs are taken as Zone factor 0.36, Soil type II, Importance factor 1, Response reduction factor 5 as per IS: 1893-2016. The Supports are taken fixed. Hinged condition is applied to diagrids only. Nonlinear dynamic time history analysis carried out by using India-Burma border earthquake data.

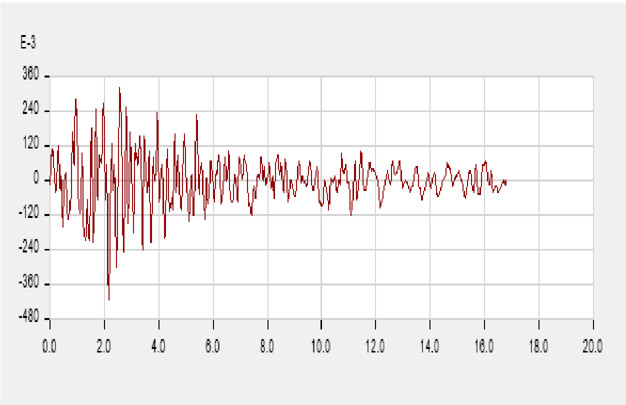


Figure 4: Graph showing time history input – India-Burma border earthquake

## IV. RESULTS AND DISCUSSION

### 1. Analysis result of Model-1 diagrid structure and braced tube structure

The storey displacement and storey drift due to seismic load is shown in figure 5 and figure 6 respectively.

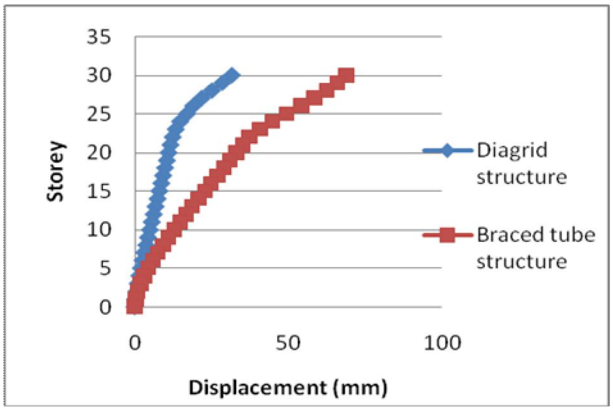

Figure 5: Storey displacement of Model-1

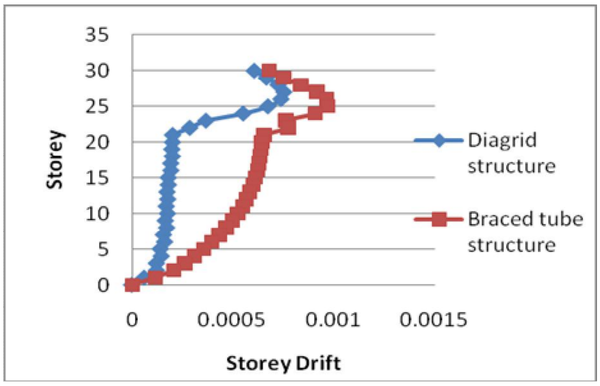

Figure 6: Storey drift of Model-1

It is observe that the top storey displacement for diagrid structure and braced tube structure is 31.45mm and 69.06mm respectively. Inter storey drift of top storey for diagrid and braced tube structure is 0.00060 and 0.00068 respectively. Maximum storey drift for diagrid structure is 0.00075 and for braced tube structure is 0.00097.

## 2. Analysis result of Model-2 diagrid structure and braced tube structure

The storey displacement and storey drift due to seismic load is shown in figure 7 and figure 8 respectively.

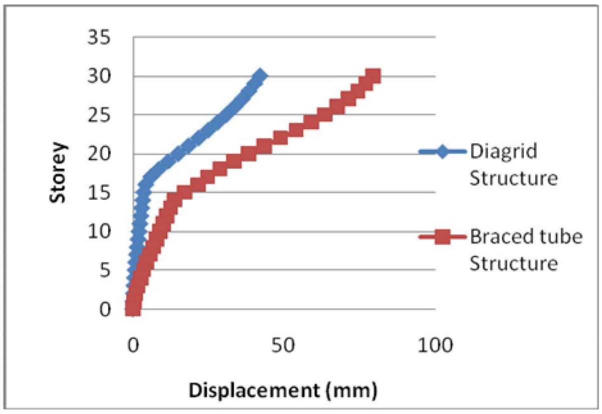

Figure 7: Storey displacement of Model-2

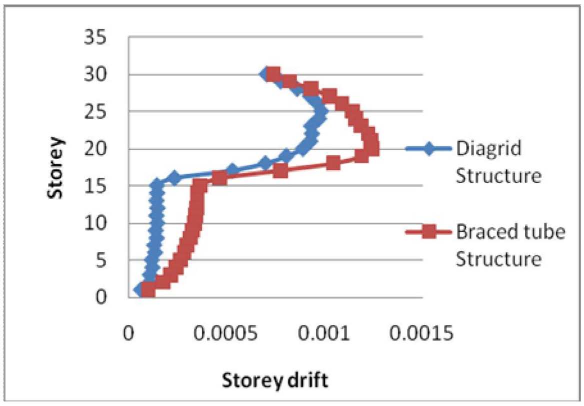

Figure 8: Storey drift of Model-2

It is observe that the top storey displacement for diagrid structure and braced tube structure is 42.04mm and 79.43mm respectively. Inter storey drift of top storey for diagrid and braced tube structure is 0.00071 and 0.00074 respectively. Maximum storey drift for diagrid structure is 0.00098 and for braced tube structure is 0.0012

## 3. Analysis result of Model-3 diagrid structure and braced tube structure

The storey displacement and storey drift due to seismic load is shown in figure 9 and figure 10 respectively.

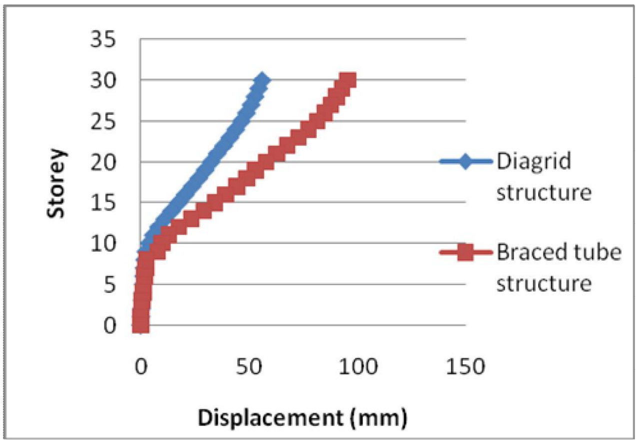

Figure 9: Storey displacement of Model-3

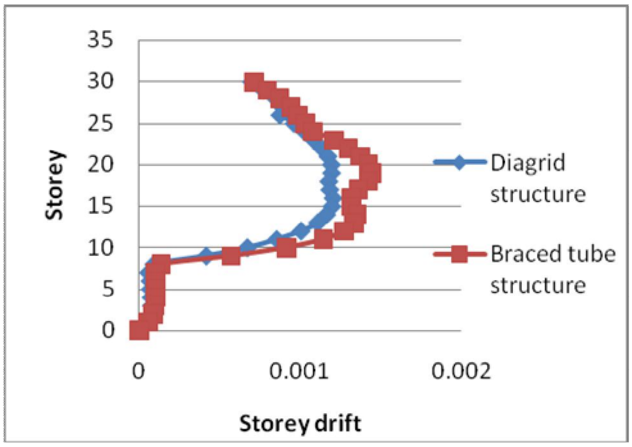

Figure 10: Storey drift of Model-3

It is observe that the top storey displacement for diagrid structure and braced tube structure is 56.03mm and 95.49mm respectively. Inter storey drift of top storey for diagrid and braced tube structure is 0.00071 and 0.00072 respectively. Maximum storey drift for diagrid structure is 0.0012 and for braced tube structure is 0.0014.

## V. CONCLUSIONS

1) Diagrid structure system having vertical geometric irregularity shows less top storey displacement and inter-storey drift than that of vertically irregular braced tube structure.
2) Diagrid structure gives more aesthetic look and gives more of interior space due to less columns and façade of the building can also be planned more efficiently.
3) Diagrid structure provides more efficiency than braced tube structure.

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