Structural System in Resisting the Effect of Lateral Load in High Rise Building

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ABSTRACT

In the structural systems of high-rise buildings there are a multitude of structural systems forms, such as twisted, tilted, tapered and free forms. The article describes the characteristics of the diagrid system and its applicability in the construction of tall buildings in relation to other modern construction systems: braced-tube. This is an attempt to evaluate the effectiveness of this system for G +30 Steel structure.. The characteristics of buildings with very complex geometry and that use the diagrid system are presented.

KEYWORDS: *Diagrid system, Geometrical forms, High-rise buildings, Storey stiffness, Storey Drift, Base Shear.*

1. INTRODUCTION

There hav been numerous innovations being carried out by architects in order to plan a good looking and an unconventional building which will be regarded as more than ordinary. In order to plan a good looking and an unconventional building, architects are trying many new challenging models and are giving them a distinct feature both internally as well as on its facade. Now it's the duty of a structural engineer to design such models safely and also consider economical nature of the same.

The design of tall buildings starts with the shaping of their spatial rigidity to gravity and horizontal forces (wind, seismic and para-seismic forces). As the height of building increases, the importance of horizontal forces also increases in the process of selecting its load-bearing structure. The main problem here is the choice of a suitable construction solution that would meet the requirements for ultimate limit states (determined by the strength criterion) and serviceability limit state (determined by the stiffness criterion). The selected type of load-bearing structure of a high-rise building must have sufficient strength to transfer all loads and impacts and also have appropriate rigidity, which is determined by the admissible amount of inclination of the top of the building subjected to the lateral load. Contemporary high-rise buildings consist of one or several basic support structures: rigid frame, shear wall, core or tube.

High-rise buildings with mixed constructions (shear-wall, braced-tube, tube-in-tube) are formed with the combination of several load-bearing structures. The application of particular types of load-bearing systems is determined by the height and geometric form of the building. Due to very complex geometric forms of tall buildings, it has recently been very popular to use the diagrid system for both steel and reinforced concrete.

Diagrid is formed by intersecting the diagonal and horizontal components. Diagrid has good appearance and it is easily recognized. The configuration and efficiency of a diagrid system reduce the number of structural element required on the facade of the buildings, therefore less obstruction to the outside view. The structural efficiency of diagrid system also helps in avoiding interior and corner columns, therefore allowing significant flexibility with the floor plan. Perimeter "diagrid" system saves approximately 20 percent of the structural steel weight when compared to a conventional moment-frame structure.

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.

2. LITERATURE REVIEW

Khalid K Shadhan et.al, [1]: The aim was to find optimal angle and to lessen the lateral drifts. Five dissimilar diagrid angled configuration such as 27, 45, 56, 72 and 81 degree had been considered for 48, 24 and 72 storeyed steel models. ETABS software was used for analysis and results were for lateral displacement & storey drift. Finally, after the analysis it is determined that the diagrid angle has a critical influence on the lateral behaviour of the high rise building models under lateral load. The optimal kind of diagrids angle is reduced as a building aspect ratio increases.

Jatin B Tank et.al,[2]: Here a symmetric plan of 40mx40m was considered with different storeyed diagrid models with different angle variation along the width are measured. Modeling and analysis is carried in ETABS software. The results are compared for displacements, time period and steel mass. An optimal angle is found to be 67.37º, Uniform angled diagrid structures found to be more economical than varying angle diagrid structures in terms of steel mass. It was observed that as the height increased max displacement in steeper angle towards corner diagrid structure reduced considerably.

3. OBJECTIVES :
1. Understand the behaviour of tubular steel structures with angled diagrid in comparison with tubular steel structure.
2. Study has been carried out for Steel tubular structure and Steel tubular structure provided with 60º angle diagrid.
3. Modelling and analysis are carried out in ETABS with high seismic zone and dynamic time history analysis.
4. The behaviour of the building on implementation of diagrids to tubular buildings will be summarized based on the obtained results.
5. Efficiency of tubular steel buildings with respect to base shear, displacement, drift are found out for the respective geometric configurations.

4. MODELLING AND ANALYSIS

To study the behaviour of diagrid buildings, a building with G+30 storeys is been modelled. The diagrid steel structure with the diagrid angle being 60º and conventional steel structure is examined. The modelling and analysis is carried out using ETABS with Bhuj Time history data.
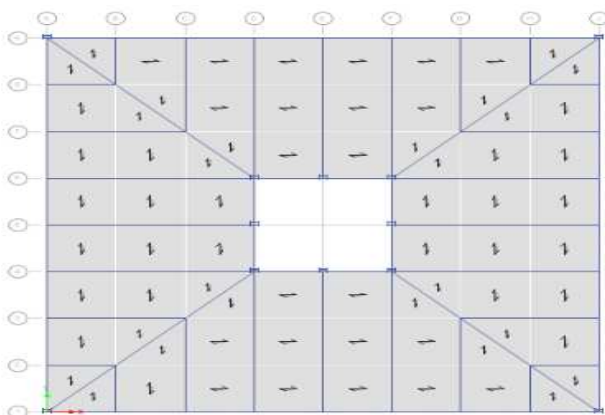
Plan of Tubular Diagrid building with 60º Angle

No of Storeys	G+30
Building Type	Tubular & Diagrid Steel Structure
Building Dimension	40mx40m
Typical Storey Height	3m
Seismic Zone	Zone V
Soil Type	Type 2
Response Reduction Factor	5
Importance Factor	1

Description of Analytical Model
The general geometric details and structural details such as dimensions of the structural members, material properties, load intensities and seismic data considered in the modeling are as follow

General details of the buildings

Structural members of the buildings

Thickness of Deck	0.2m
Beam	ISMB
Column	ISWB
Wall Thickness	Glazing load is considered

Material properties of the buildings

Grade of concrete	M30
Grade of Steel	Fe350
Density of Concrete	25 kN/m^2
Young's modulus of concrete	27386x10^{3}kN/m^2
Poisson's ratio	0.2

Assumed load intensities

Slab live load	4kN/m^2
Floor finish	1.5kN/m^2
Glazing load	1kN/m^2

Defining Nonlinear Load Cases
Time history analysis is a nonlinear dynamic analysis. Diaphragms to all slabs at respective storey levels are to be assigned before going to time history analysis. Here, Bhuj quake data is considered. First we have to define a time history function as Bhuj and then we have to define time history cases in both the direction as THX and THY with scale factor as 1.

5. RESULTS AND DISCUSSION
This chapter deals with results and discussion of a structure with and without diagrid system.

Discussions are made based on following parameters
1. Storey Displacement
2. Storey drift
3. Storey acceleration
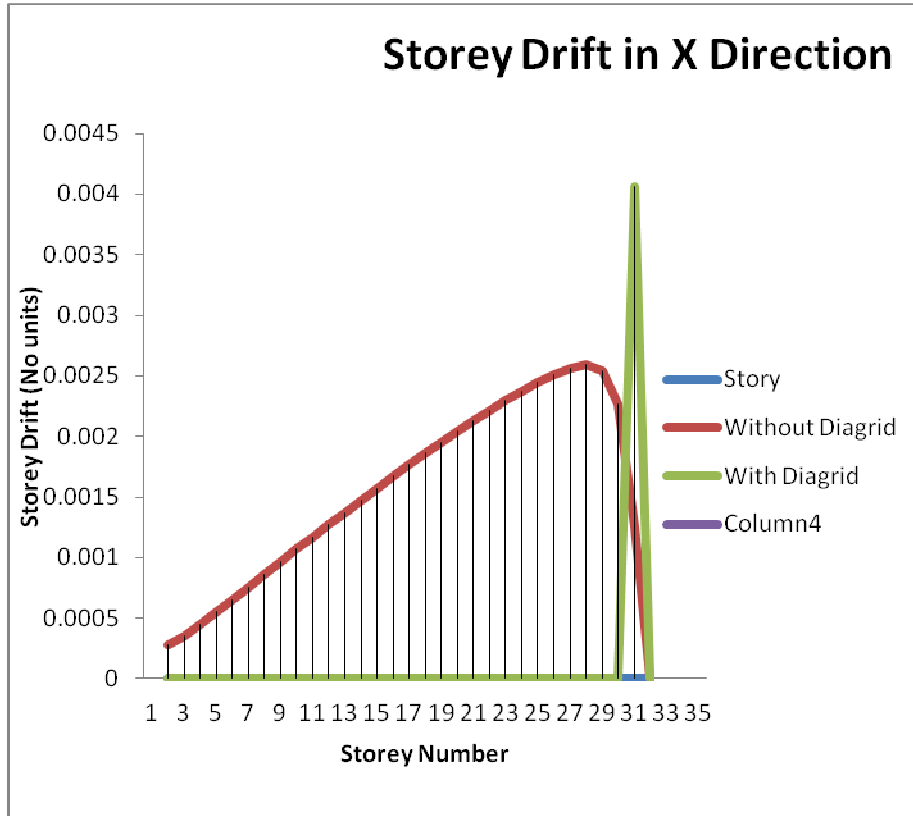4. Storey forces
5. Storey Stiffness
6. Base Shear

Storey Displacements

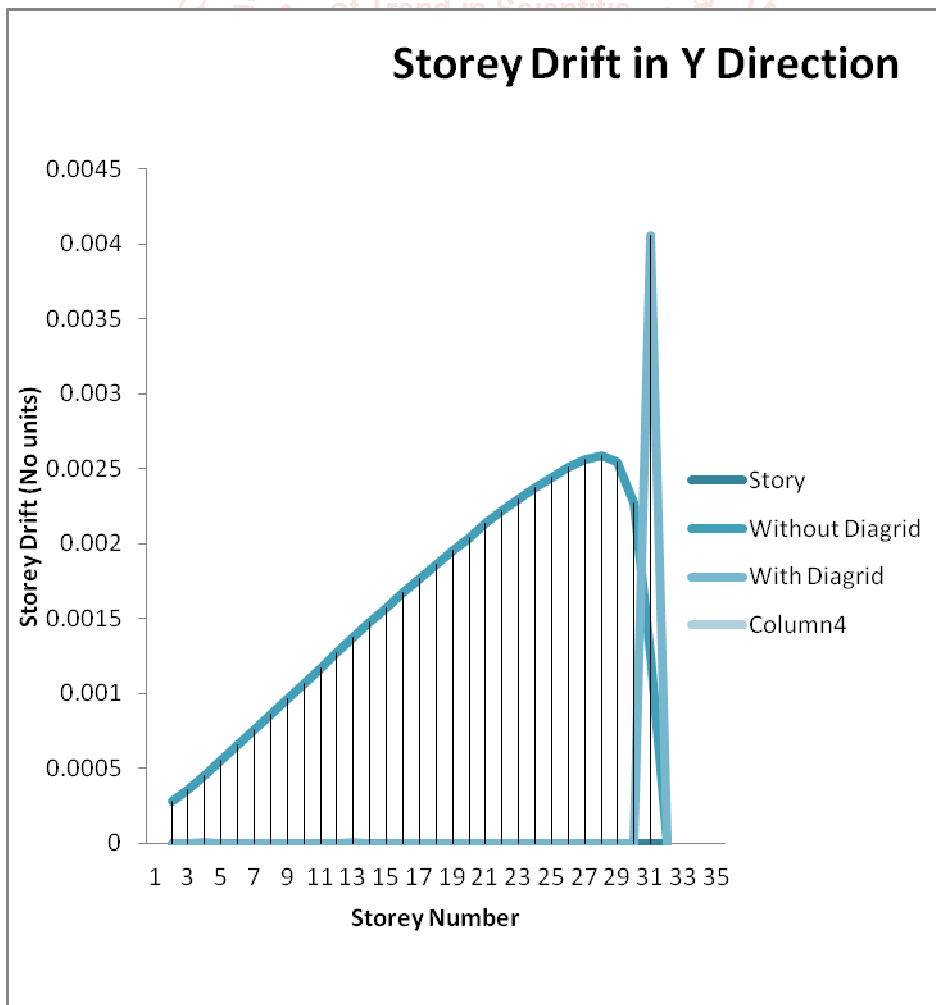It is defined as total displacement of its storey with respect to ground.
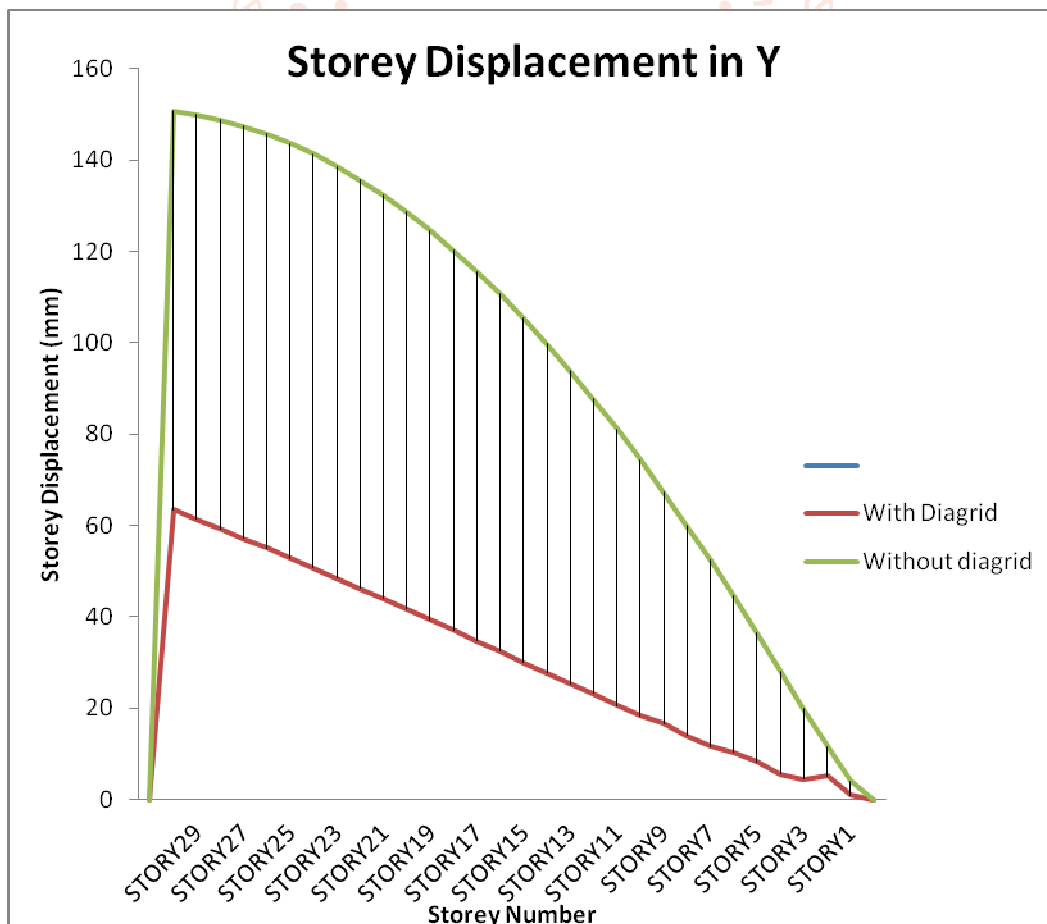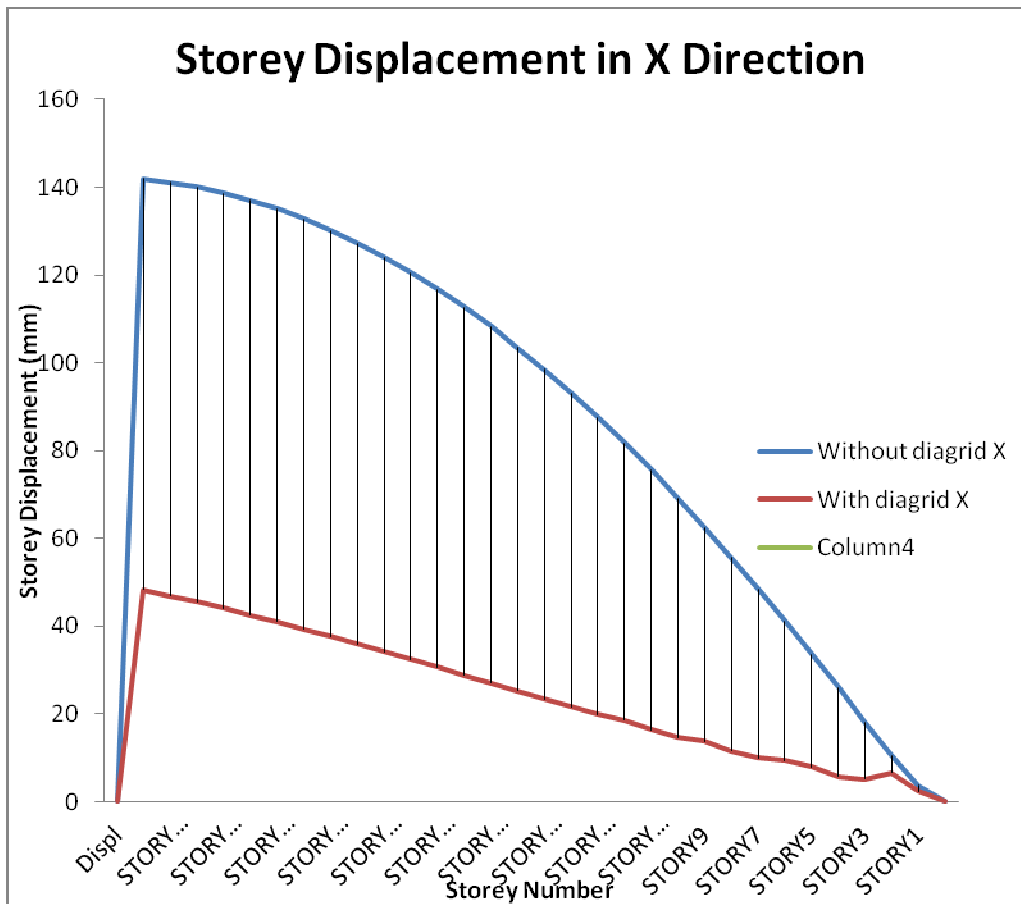
Storey Drift

It is nothing but the difference between storey displacements of one storey with respect to the other storey. As per codes it should not exceed 0.004 times height of the storey.
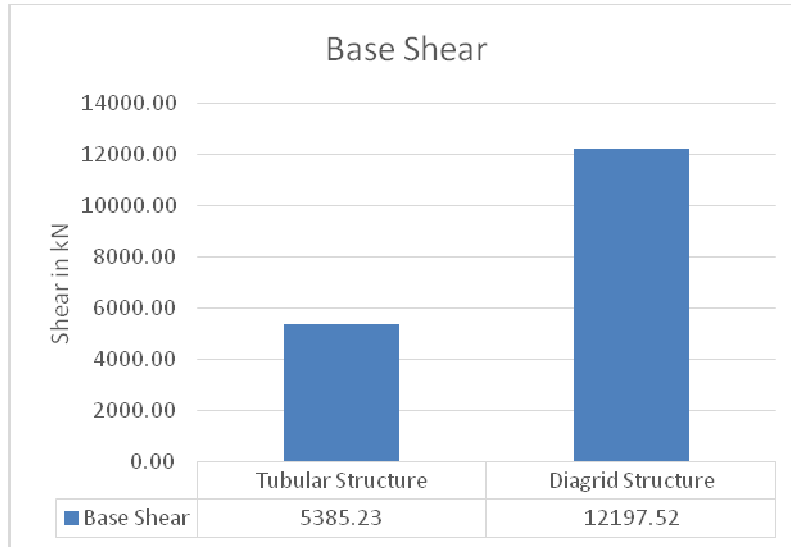

: Storey Drift

7Base Shear

Base Shear is an estimate of the maximum expected lateral force that will occur due to seismic ground motion at the base of a structure. It mainly depends on the soil conditions at the site.

Graph 5.6: Base Shear

6. CONCLUSION

From the obtained results the following conclusions are made,

1. Storey Displacement was found less in diagrid structure than that in structure without diagrid system.

2. The diagrids provided proper stiffness to structure that in turn result in decreasing the storey displacement.

3. In terms of utilization of steel and concrete, the diagrid structure is found to be more economical.

4. The base shear for the diagrid model is found to be more than the tubular steel structure, which imply higher stiffness to the structure that in turn offer higher resistance against overturning, higher stability and assure safety to the occupants.

5. The comparative study on tubular steel structure and tubular diagrid steel structure give a clear view that diagrid structures are much effective in reducing the response of the structure and is compatible.

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