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Comparative Performance of Octagrid and Hexagrid Lateral Load Resisting Systems For Tall Building Structure

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ABSTRACT
The construction of high rise structure is quite common in this era. There are a number of high rise structures constructed all over the world and are being constructed. The analysis and design of high rise structure is quite different from that of low rise structures because of lateral forces due to wind and earthquake. In high rise structures the resistance to lateral loading (wind and earthquake loads) will be the dominant criteria that have to be considered in the analysis and design and an efficient lateral load resisting system will define the efficiency of tall structures.

In the present paper it is aimed to study different lateral load resisting systems like octagrid and hexagrid bracing systems for tall building. Not much information is available in the literature on such systems. It is intended to study such lateral load resisting systems.

The two types of bracing systems including octagrid and hexagrid bracings are modeled and analyzed. Behavior under lateral loads of hexagrid and octagridsystem is compared with that and the commonly employed shear wall systems. The key parameter for comparision is the top story displacement under wind and seismic loading, the maximum storey drift ratio and also quantity of concrete consumed. It is found that the hexagrid and octagrid systems are best with respect to the above parameter. Although there is a marginal increase in the quantity of concrete consumed.
Key words: octagrids, hexagrids, drift, Time history

I. INTRODUCTION

Loading on tall buildings is different from that of low-rise buildings in many ways such as large accumulation of gravity loads on the bottom floor is more than top floors. Thus, multi-storied structures need proper evaluation of loads for safe and economical design. Except dead loads, the evaluation of loads cannot be done accurately. Live loads can be predicted approximately from a combination of experience and the previous field observations. Wind loads and earthquake loads are random in nature and it is difficult to predict them. They are evaluated based on a probabilistic approach.

Bracing is a highly efficient and economical method of resisting horizontal forces in a framed structure. Braced bent consists of columns and girders, whose purpose is to support gravity loading and diagonal bracings to resist horizontal loading. Bracing is efficient because the diagonals work in axial stress, which provide stiffness and strength against horizontal shear.

II. SALIENT FEATURES AND IMPORTANT DIMENSIONS

30 storied tall building with centre shear wall is considered for the analysis purpose. Height of the building is 118m. The Plan area of the Structure is 42 x 42m with columns spaced at 6m from center to center. The height of each storey is 4.00m and all the floors are similar. The location of the building is assumed to be at Bangalore, which is zone II as per code, IS 1893. An elevation and plan view of the structure is given in fig.1 and 2.
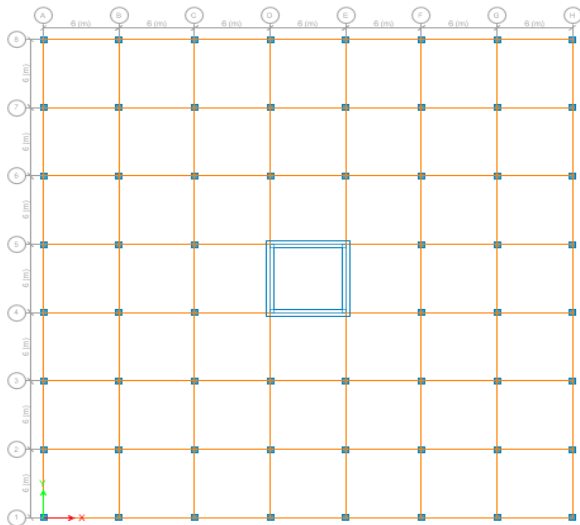
Fig.1 Building Plan dimensions and column centre spacing
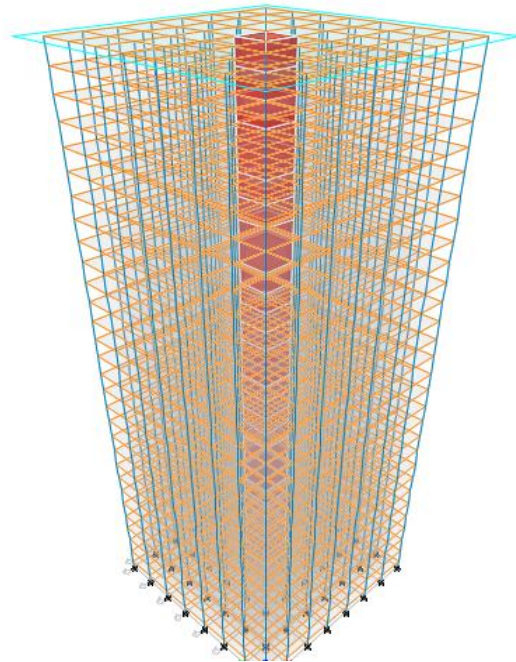

Fig.2 Building 3D view with central core portion

III. MODELING AND ANALYSIS

For the analysis the structure is assumed to be fixed at the base. The various types analyzed are (1) only shear wall at centre (2) one octagrids at the outer periphery of the building, and (3) one hexagrids at the outer periphery of the building.

Columns of varying sizes, which are given below:

      Storey 1,2,3-1000x500mm
      Storey 4,5-900x500mm
      Storey 6,7,8-800x500mm
      Storey 9,10,11,12-700x500mm
      Storey 13,14,15,16-600x500mm
      Storey 17 and above-500x500mm

Beams-600x500mm
Shear wall-600x600mm
Octagrid-280x280mm
Hexagrid-300x300mm

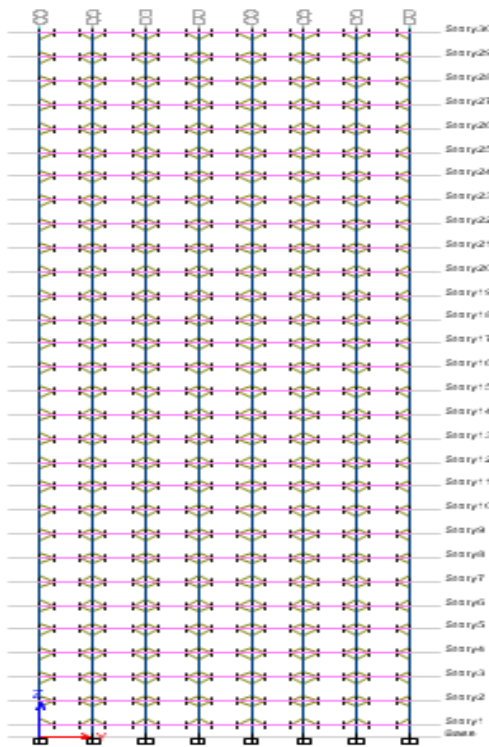**Octagrid and hexagrid models**
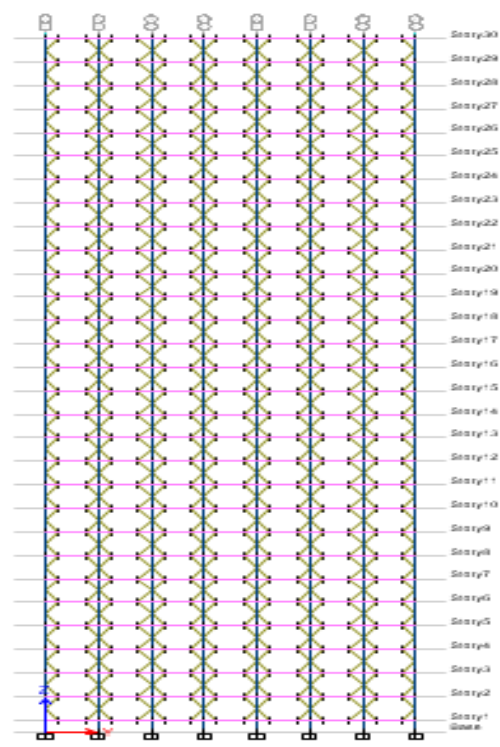
Fig.3 Frame with Octagrid 1 elevation
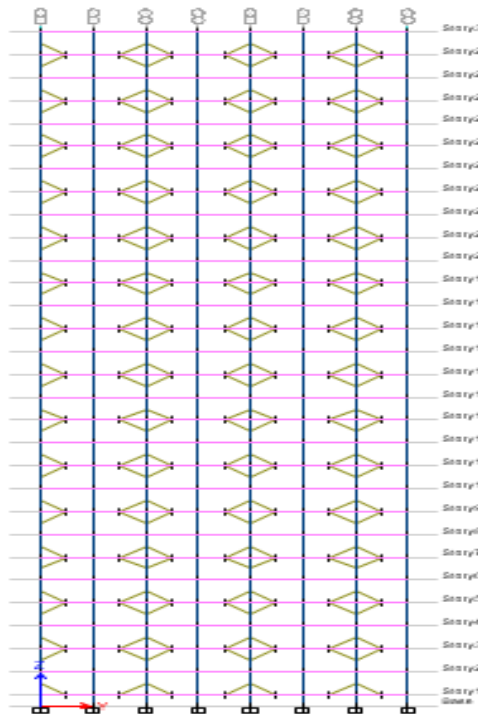

Fig.4 Frame with Hexagrid 1 elevation
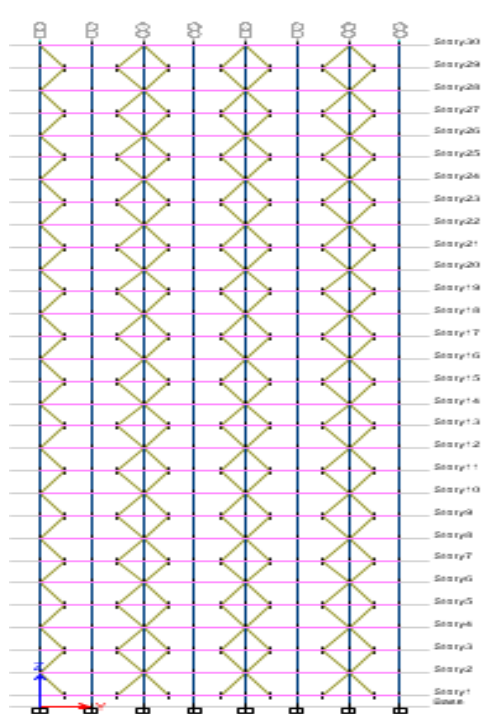

Fig.5 Frame with Octagrid 2 elevation

Fig.6 Frame with Hexagrid 2 elevation

IV. ANALYSIS

Fig 3 to 6 shows different bracing systems, they are octagrid 1and 2, hexagrid 1 and 2. They are

- ➢ Octagrid 1-One grid for each story
- ➢ Octagrid 2-One grid for every two stories
- ➢ Hexagrid 1-One grid for each story
- ➢ Hexagrid 2-One grid for every two stories

V. 1.4 MATERIAL

The material used for building is M40 grade concrete whose weight density as 25 KN/m^3, Young's modulus (E) 3.1×10^7 kN/m^2, poisons ratio (U) as 0.2.

VI. 1.5 RESULTS AND DISCUSSION

1.5.1 DRIFT

The most significant basic parameter monitored throughout the whole analysis process is drift at various levels of the building. The following plots show the variation of drift in different grid systems.

The drift ratio is defined as the ratio of difference in displacement between any two stories to the story height. Fig 7, 8, 9 show variation of drift ratio over the height of the frame for various systems. The earthquake response is obtained by equivalent static method as well as dynamic analysis.
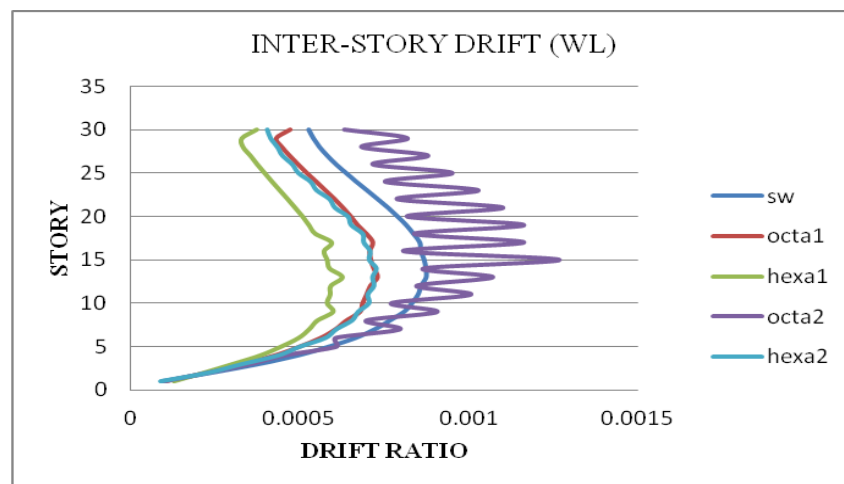

Fig.7 Interstory drifts for various grid systems for wind load
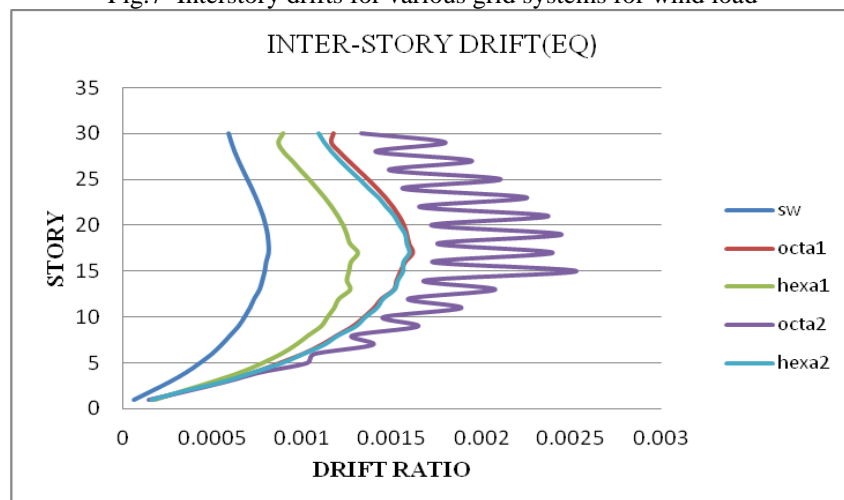

Fig.8 Interstory drifts for various grid systems for earthquake load (Equivalent static method)
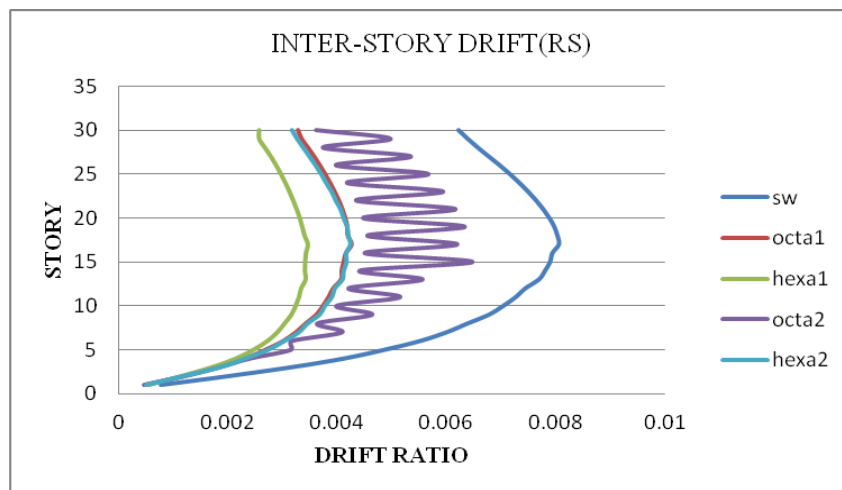
Fig.9 Interstory drifts for various grid systems for eathquake load (dynamic analysis)

In all the systems the drift ratio is increased from very low value at the lowest story to a large value approximately at the middle level, ie.,at 15th story level here and later it decreases again.In all the cases it was found that in frames with hexagrids drift ratio is quite less. Compared to ordinary frame with shear wall, octagrid system shows the lowest drift ratio. Difference of drift ratios between hexagrid and octagrid 1 is very small, ie., 0.001 difference.
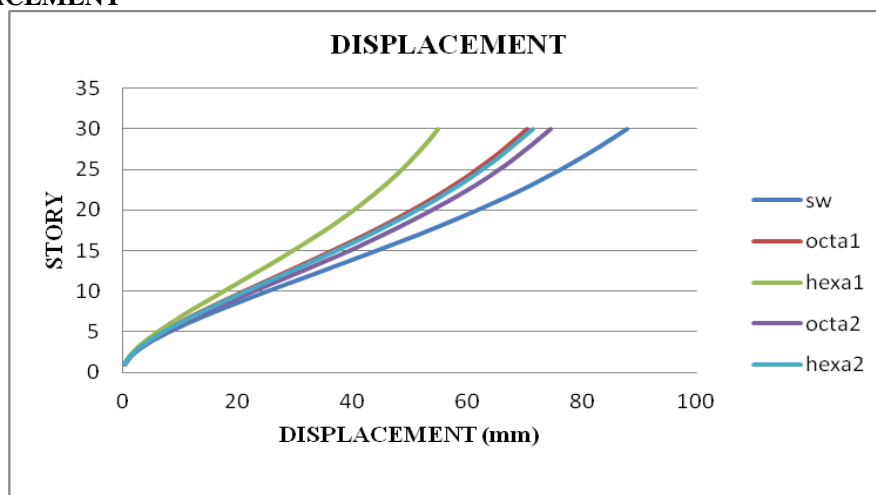
1.5.2 DISPLACEMENT

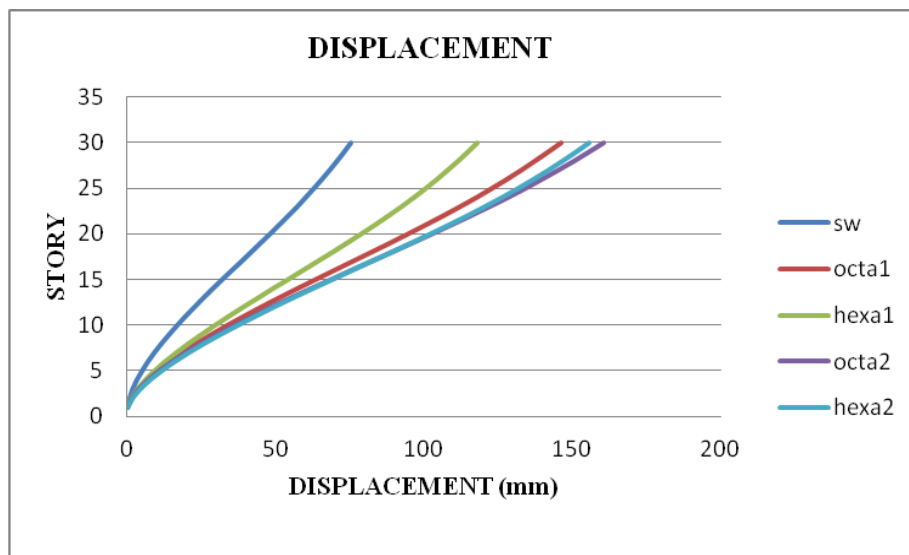Fig. 10 Story displacement for various grid systems for wind load

Fig. 11 Story displacement for various grid systems for earthquake load (Equivalent static method)
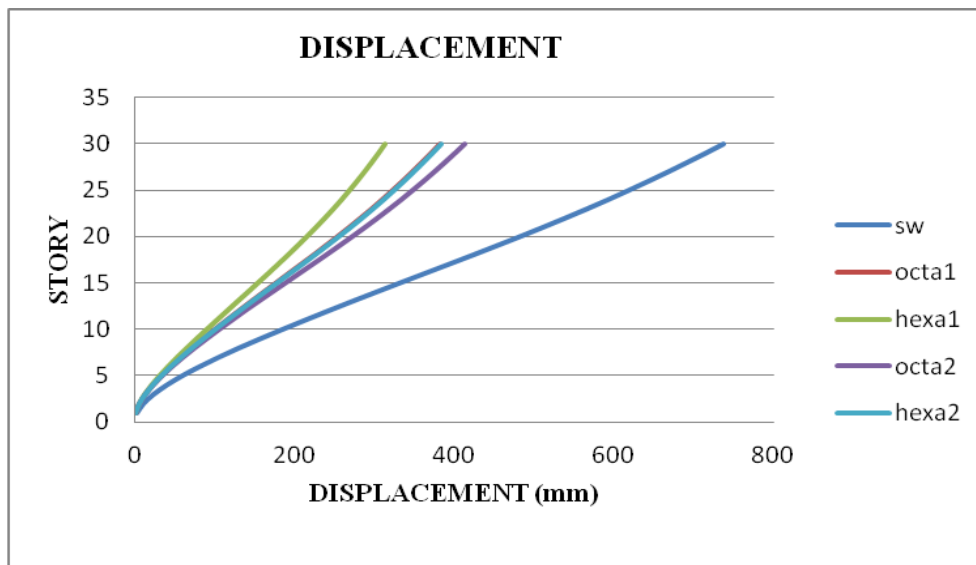

Fig.12 Story displacement for various grid systems for earthquake load (dynamic analysis)

Fig 10, 11, 12 show displacement profile over the height of the building. Obviously displacement increases with the height and is maximum at the top most story.In all the cases it was found that the frames with hexagrid system show the lowest displacement. Here octagrid 1 shows the lowest displacement. Difference of displacement between hexagrid and octagrid 1 is very small, ie 50 to 100 mm difference.

1.5.3 QUANTITY OF CONCRETE USED FOR THE STRUCTURE
Table 1: <u>For windload</u>

Types of structures	Quantity of concrete (kN)	Drift ratio	Displacement(mm)
Frame with shear wall	438530.467	0.000528	87.9
Octagrid 1	444245.392	0.000472	70.4
Hexagrid 1	451036.772	0.000372	54.9
Octagrid 2	438294.327	0.000631	74.6
Hexagrid 2	442046.178	0.000403	71.4

Table 1 Quantity of concrete required for the various types of frames with corresponding drift ratios and displacements.

Table 2: <u>For earthquake load</u>

Types of structures	Quantity of concrete (kN)	Drift ratio	Displacement(mm)
Frame with shear wall	438530.467	0.000589	75.3
Octagrid 1	444245.392	0.001171	146.4
Hexagrid 1	451036.772	0.000892	118.1
Octagrid 2	438294.327	0.001326	160.4
Hexagrid 2	442046.178	0.001089	155.5

Table 2 Quantity of concrete required for the various types of frames with corresponding drift ratios and displacements.

In all the cases it is observed that frames with octagrid 1 and hexagrid 1 consume very little amount of concrete followed by frame with ordinary shear wall. The drift ratio and displacements are lowest for frame with octagrid 1 system next to ordinary frame with shear wall.

VII.   CONCLUSIONS

In this work different types of framing systems are examined for lateral forces wind and earthquake. The types of frames analysed are the frames with octagrid 1, octagrid 2, hexagrid 1, hexagrid 2 and most common frame shear wall systems.Of all the above the frame with hexagrid and octagrid systems show very low top story drift and top story displacements. In tall buildings although the quantity of concrete consumed is slightly more the drift ratios are quite less for grid systems because the grids essentially are axial loaded systems.Further it needs to be seen how they behave during the inelastic behaviour of the frame during earthquake. It is not discussed in the present paper. It is being done on a future work.

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