COPARATIVE STUDY OF DIAGRID SYSTEM, HEXAGRID SYSTEM AND SHEAR WALL SYSTEM IN TALL TUBE-TYPE BUILDING

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ABSTRACT

In this paper consistent floor plan of 36 m x 36 m located in seismic zone V for G+49 storey tall building is considered, and all physical members are planned as per IS 456:2000. Earthquake factors are measured from 1893-2002. Dead & live loads are mentioned as per Indian Standards. Here, analysis of diagrid and hexagrid system will be directed by using design software STAAD Pro. Twelve models are modelled in staad.pro collectively of corner shear wall, core shear wall, diagrid system and hexagrid system buildings with regard to variation in their combination of exterior structural system and internal structural system. Both dynamic (Response spectrum analysis) and static analysis of these models have been conceded out to regulate their performance. The model so prepared is been compared to the normal building parameters like Storey displacement, Storey drift, base Shear and bending moment to determine the efficient structure.

Keywords-- Shear wall, diagrid, hexagrid, tall tube building

1 INTRODUCTION

1.1 General

Emporis standards

- Buildings height between 35-100 meter is termed as multi-storey building.
- Buildings higher than 100m is termed as skyscraper building.
- Buildings 300m or higher is termed as super tall building.
- Buildings 600m or taller is termed as mega-tall building.

High rise buildings are more popular in these days due to following reasons

- scarcity of land
- increasing demand for business and residential
- economic growth
- technological advancement
- innovations in structural systems

- desire for aesthetics in urban settings
- cultural significance and prestige
- human aspiration to build higher
- to make denser city and
- to reduce the transmission losses of energy

1.2 Lateral Load Resisting System for Tall Buildings

1.2.1 Introduction

Taller buildings demanded by socio-economic trends, structural engineers were pressed to provide lateral load resisting systems that would cut off cost of structural and reinforcing steel for buildings of greater height to width aspect ratios and different vertical heights.

Structural Engineers may use concepts in order to control building response to lateral loading, which are as follows:-

1. By Increase stiffness of the system
2. By Increase building weight
3. By Increase density of the structure with fill-ins
4. By Use of efficient shapes
5. By Generate additional damping forces (tuned mass dampers)

1.2.2 Classification

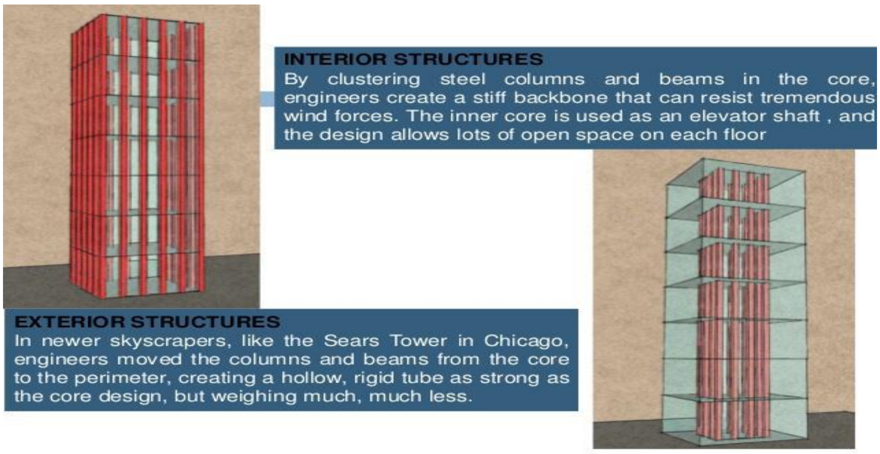
Lateral load resisting system is broadly classified as

(A) Interior Structural Systems

(B) Exterior Structural System

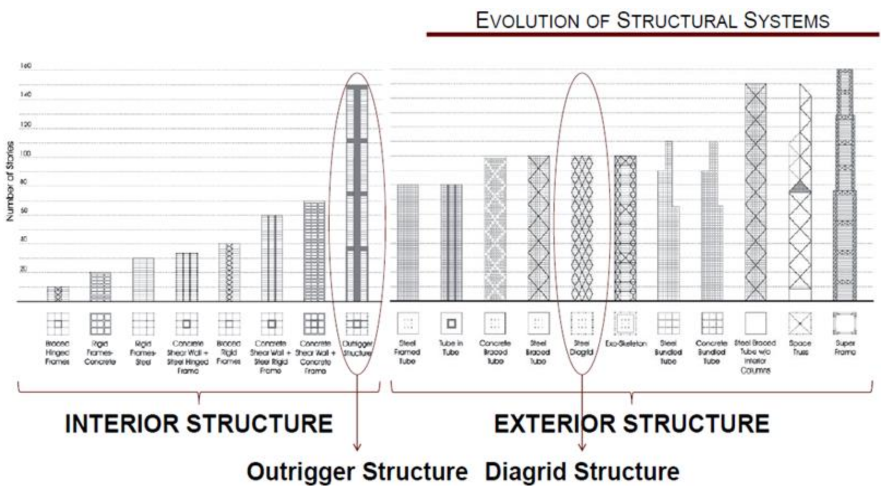
A system is classified as an interior structure in which the major part of the lateral load resisting system is detect in the interior of the building in the same way, if the vital part of the lateral load resisting system is detect at the building perimeter, a system is classified as an exterior structure. In interior structure, components of the lateral load resisting system are at the exterior face of the building perimeter. In exterior structure components of the lateral load resisting system is within the interior of the building to oppose gravitational load

Figure 1 Lateral load resisting systems



Source: from Wikipedia

Figure 2 Evolution of structure system

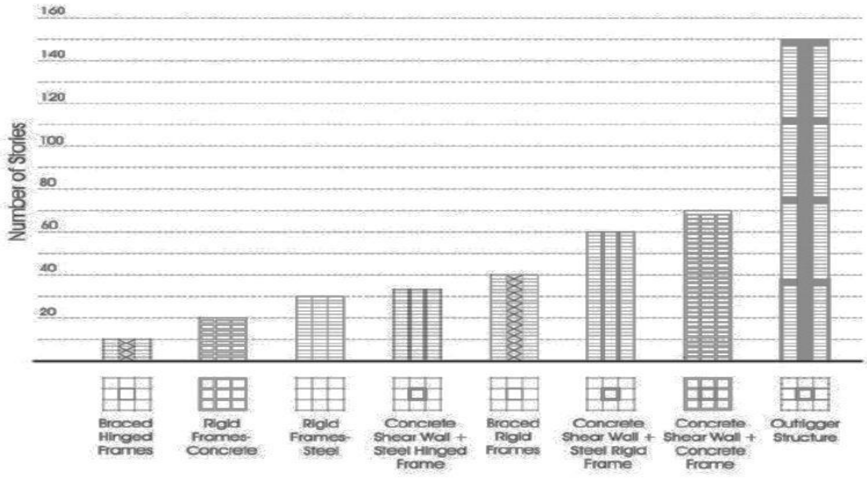


Source: From Wikipedia

1.2.3 Interior Structural System

The two basic types of lateral load-resisting systems are the moment-resisting frames and shear trusses/shear walls. These systems are commonly arranged as planar assemblies in two principal orthogonal directions and may be take on together as a combined system in which they interact. Another very important system in this category is the core supported outrigger structure, which is very extensively used for super tall buildings. The MRFs consists the horizontal and vertical members rigidly connected together in form of a grid. Moment-resisting frames can be located in or around the core, on the exterior, and the across the interior of the building with grid lines.

Figure 3 Interior structure systems

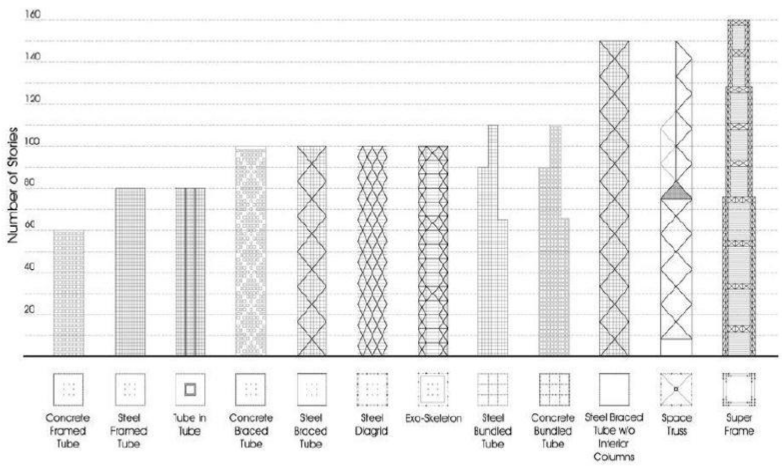


Source: from Wikipedia

1.2.4 Exterior Structure System

The tube structure is one of the most typical exterior structure, which can be defined as a three-dimensional structural system utilizes the perimeter of the entire building to resist lateral loads. The earlier application of the tubular notion is associated to Fazlur Khan, who came up with this concept in 1961, and the first known building was designed as a framed tube. By using this concept world's tallest buildings are the the 110-storey World Trade Centre Towers (destroyed in 2001 by a terrorist attack) in New York and 110-storey Sears Tower. Tubular forms have many types based on the structural efficiency that they can provide of several heights.

Figure-4 Exterior structure systems

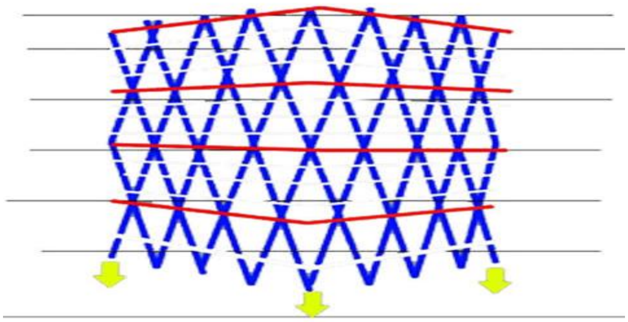


Source: from Wikipedia

1.2.5 Diagrid Structure

Diagrid is a form of space truss. It contains of perimeter grid made up of a chain of triangulated truss system. Diagrid is placid by crisscrossing the diagonal and horizontal members. Diagrid has good look and it is recognizable from far. For less obstruction to the elevation it is necessary to the diagrid system is lessen the number of vertical column as well as horizontal column and rises the diagonal members on the aspect of the buildings. Perimeter "diagrid" system reduce the 20 percent of the structural steel weight related to other structure.

Figure 5 Diagrid system

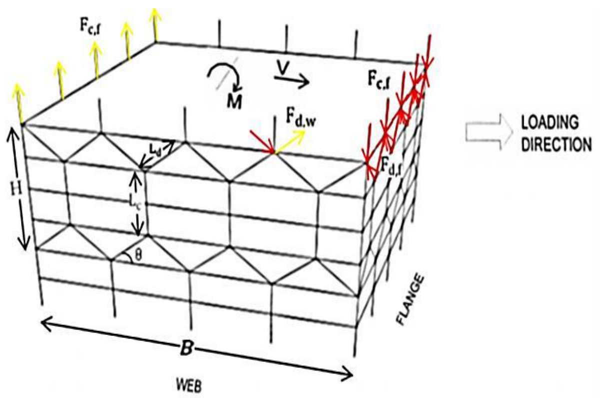


Source: from Wikipedia

1.2.6 Hexagrid Structure

In hexagrid structural system, all the vertical columns are reserved. Hexagrid structural system is mostly of two type vertical hexageid system and horizontal hexagrid system. It will be designed of Hexagon which is a group of hex-angulated truss system. Hexagrid is accumulated by crisscrossing the diagonal and horizontal members.

Figure 6 Hexagrid Structural system



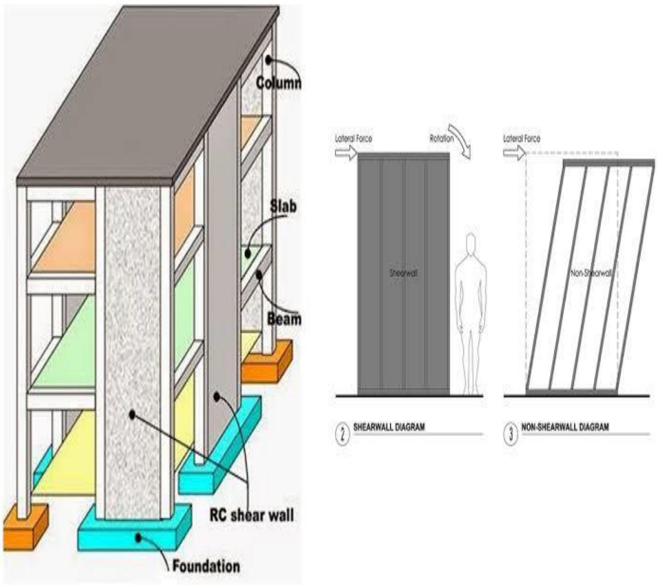
Source: from Wikipedia

1.2.7 Shear Wall Structural System

Shear wall is a structural member which is used against lateral forces i.e. parallel to the plane of the wall. By the Cantilever Action Shear wall resists the loads where the bending deformation is more.

Lateral forces from exterior walls, floors, and roofs to the foundation in a direction parallel to their planes is transfer by rigid vertical diaphragm. I.e. RC wall. Shear walls are plane or flanged in section and core walls are of channel sections. To resist lateral displacements, they also provide enough strength and stiffness.

Figure 7 Shear wall



Source: from Wikipedia

2 OBJECTIVE OF STUDY

- The main objective of this study is to understand the analysis and design methodology of new concept diagrid structural system and hexagrid structural system. .
- Analysis of building frames considering seismic analysis.
- To carry out assessment on a tall tube type structure models with Shear wall, diagrid and hexagrid system for well presentation.
- The performance of the structure is considered based on the storey displacement, storey drift, base shear and bending moment.

3 LITERATURE REVIEW

Lots of research work is carried out in diagrid structure. Some important works are mentioned here such as 1) Introductory design of tall building structures with an exterior structure system, 2) A Study on the Seismic Presentation of exterior structure system Hexagrid System with Diverse Patterns, 3) Relative Study of two exterior structure system Pentagrid and Hexagrid System for Tall Building, 4) Relative Study of Diagrid Constructions over Braced tube Structures. In this above researches comparison of building data of diagrid, hexagrid / pentagrid etc. structural system with different shear wall location are not studied so I do this study. The brief description of these works are described below.

Farhan Danish obtainable Initial design of tall building structures with a hexagrid system by stiffness method. Study and design of 60 storey building has been modelled in MIDAS a commercial finite element software. Hexagrid system is designed for varying size and type. Based on the above design studies, it is suggested that to use a vertical hexagrid system structure for the reason is a vertical hexagrid system was stiffer than a horizontal hexagrid system and hexagrid structural system is more reasonable and provide conflict to lateral forces.

Mobi RIA Mathew presented) A Study on the Seismic Presentation of exterior structure system Hexagrid System with Diverse Patterns. They concluded at the end for 36-storey hexagrid structures, which briefly described below. In this study the building of 1296 sq. m. with storey height 3.6 m. is modelled In ETAB. In hexagrid structural system the angle is 1200. Comparing the performance of hexagrid structural system with different patterns. From calculation results, it is indicated that Storey drift for all structure models are in the permissible limits and decreased hexagrid density increases the storey drift and storey displacement.

Relative Study of two exterior structure system Pentagrid and Hexagrid System for Tall Building: This paper focus on the comparison of pentagrid and hexagrid systems behaviour in tall diagrid Building. Taranath S. D considered for the analysis tall buildings of 40, 50 and 60 floors. From calculation results, it is indicated that Pentagrid system is more efficient than Hexagrid system.

Comparative Study of Diagrid Structures over Braced tube Structures: Arpitha L M presented a paper on the models of diagrid system and braced tube systems ware compared for result like the maximum storey displacement, store drift, base shear, and time period. Analysis result shows that the model braced structures is stiffer than the diagram structures since the columns are provided in periphery. The hexagonal plan structure is stiffer and due to square plan displacement is higher and displacement due to hexagonal plan is less and due to square plan base shear is higher

4 METHODOLOGY OF WORK

4.1 Static Analysis

1. Equivalent static load method

Static analysis is an engineering branch which studies the stress in materials and structures subjected to static or dynamic forces or loads. The objective of the analysis is generally to determine whether the collection of elements, usually referred to as a structure or component, can safely withstand the specified forces and loads.

This is possible when the defined stress from the applied force is less than the yield strength and the material is to be able to withstand. This relationship referred as factor of safety (FOS) and is used as an indicator of success or failure of the analysis.

4.2 Dynamic Analysis

1. Response spectrum method

"Response spectrum is defined as the study of the maximum response of single degree of freedom that have a certain period and damping during seismic ground motion". Response Spectrum analysis should be done to attain the design seismic force. It is required to have a time history record to perform the seismic analysis and design of a structure built at a particular location. Further, as the response of the structure depends on the frequency content of the ground motion and its dynamic properties, the seismic analysis of structures cannot be carried out that depends on the ground acceleration's peak value. To overcome these difficulties, the most popular method is response spectrum in the seismic analysis of structures. In the prediction of displacements and member forces in structural systems, this method has computational advantages in using the response spectrum method for seismic analysis.

4.3 Methodology adopted in Present work

In this present comparative study, the analysis of following structures is been carried out:

1. Normal building.
2. Only core shear wall building.
3. Only corner shear wall building.
4. With core shear wall and with corner shear wall building.
5. Only diagrid system building.
6. With core-with corner shear wall diagrid system building.
7. With core-without corner shear wall diagrid system building.
8. With corner-without core shear wall diagrid system building.
9. Only hexagrid building.
10. With core-with corner shear wall hexagrid system building.
11. With core-without corner shear wall hexagrid system building.
12. With corner-without core shear wall hexagrid system building.

The plan areas of all structures are same through the analysis, also the beam and column dimensions are kept constant.

The value such as beam column size, hexagrid-diagrid size, Density of rcc, Density of masonry, Young's modulus, compressive strength of steel and concrete etc. are kept constant in all buildings.

For same structure data and earthquake data 12 models are analysis by static and dynamic analysis.

The results parameters include the maximum displacement, maximum drift, and maximum storey shear.etc. Which are to be compared.

4.4 Modelling

The research work consists of hypothetical models of tall tube structures. The work consists of 12 models and which includes normal building, diagrid system, hexagrid system, core shear wall and corner shear wall structure.

4.5 Modelling Data

The following data is taken for the research work:

- Number of stories: 50 storey
- Plan: 36m x36m
- Seismic zone: V
- Floor height: 3 m
- Grade of concrete: 30 Mpa
- Grade of steel: Fe 415
- Size of columns: 900 mm x 900 mm
- Size of beams: 450 mm x 800 mm
- Wall thickness:230 mm
- Response reduction factor: 5
- Type of soil: Medium soi
- Depth of slab: 150 mm
- Diagrid:650 mm x 650 mm
- Hexagrid:300 mm x 300 mm
- Dead load: 17.25 KN/m²
- Live load: 3.75 KN/m
- Floor finish: 1 KN/m²
- Angel of diagrid / hexagrid:65
- Zone factor: 0.36
- Importance factor: 1
- Damping ratio: 0.05

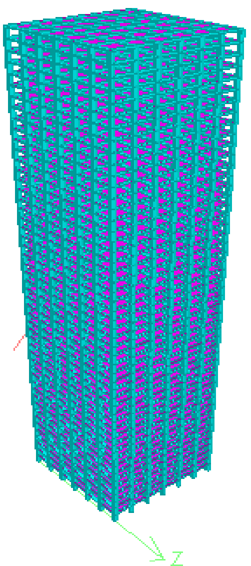
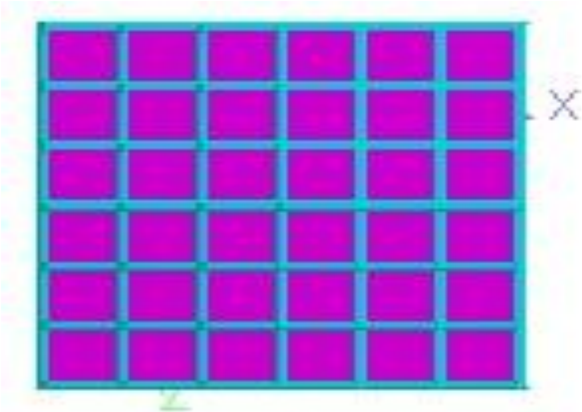


Figure 8 Hypothetical model



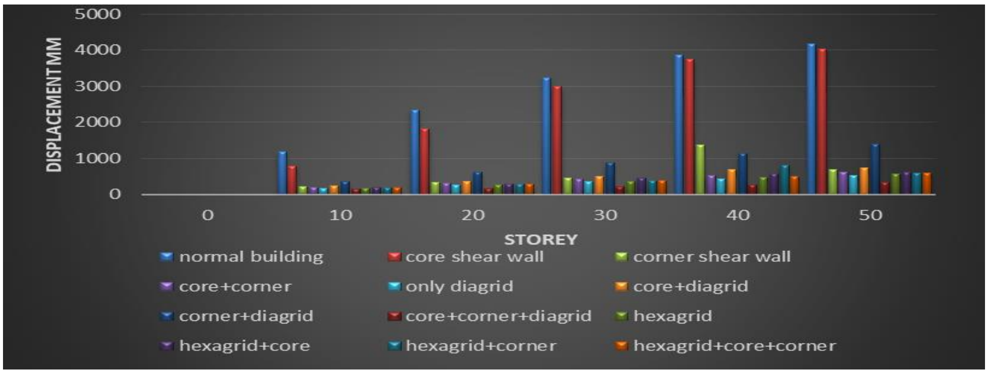
5 ANALYSIS AND RESULTS

Table: 1 Comparison of Displacement Results

Displacement (mm)	**Storey**	0	10	20	30	40	50
	Normal building	0	1182	2340	3240	3858	4178
	Core shear wall	0	790	1830	2990	3750	4041
	Corner shear wall	0	219	337	456	1363	682
	Core +Corner	0	200	308	417	526	624
	Only diagrid	0	166	257	347	437	528
	Core+ Diagrid	0	239	369	499	693	746
	Corner+ Diagrid	0	356	616	876	1136	1396
	Core+ Corner+ Diagrid	0	157	161	218	275	332
	Hexagrid	0	176	272	368	464	560
	Hexagrid+ Core	0	196	289	456	569	607
	Hexagrid+ Corner	0	186	287	388	815	590
	Hexagrid+ Core+ Corner	0	185	286	387	488	589

Source: from the analysis

Graph: 1 Comparison of Displacement



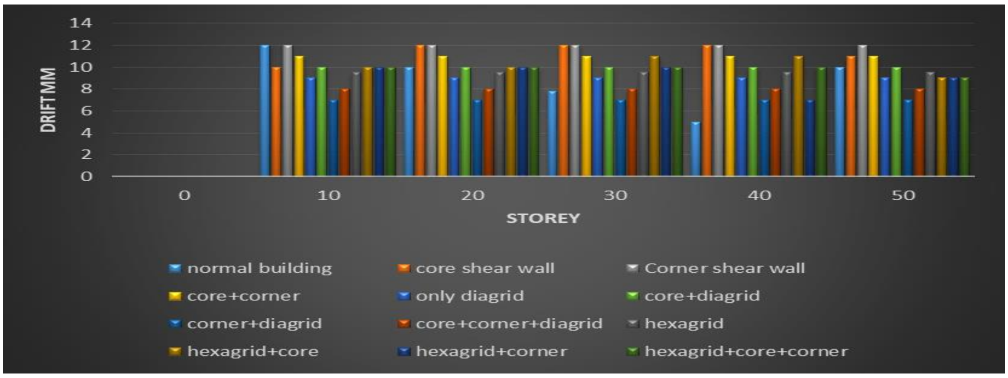
Source: from the analysis

Table: 2 Comparison of Drift Results

Drift (mm)	**Storey**	0	10	20	30	40	50
	Normal building	0	12	10	7.8	5	10
	Core shear wall	0	10	12	12	12	11
	Corner shear wall	0	12	12	12	12	12
	Core +Corner	0	11	11	11	11	11
	Only diagrid	0	9	9	9	9	9
	Core+ Diagrid	0	10	10	10	10	10
	Corner+ Diagrid	0	7	7	7	7	7
	Core+Corner+ Diagrid	0	8	8	8	8	8
	Hexagrid	0	9.5	9.5	9.5	9.5	9.5
	Hexagrid+ Core	0	10	10	11	11	9
	Hexagrid+ Corner	0	10	10	10	7	9
	Hexagrid+Core+Cornr	0	10	10	10	10	9

Source: from the analysis

Graph: 2 Comparison of Storey Drift



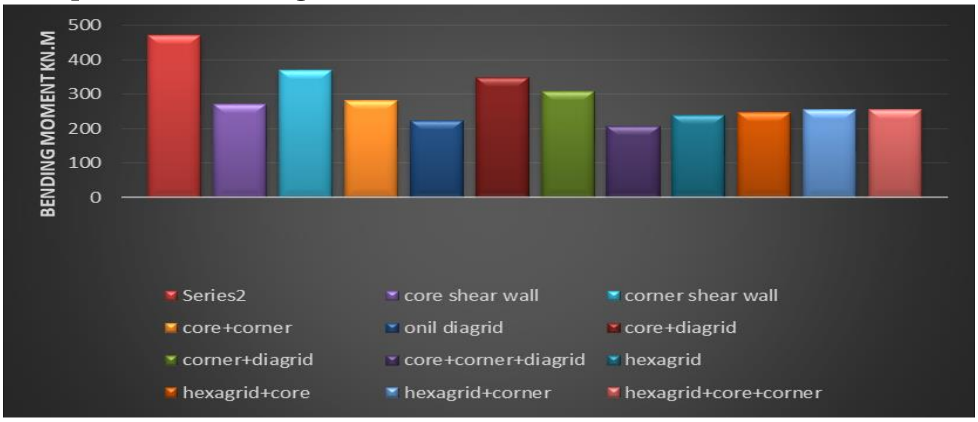
Source: from the analysis

Table: 3 Comparison of Bending Moment Results

Bending moment (KN. m)	
Direction	**X**
Normal building	471
Core shear wall	271
Corner shear wall	371
Core +Corner	281
Only diagrid	224
Core + Diagrid	349
Corner + Diagrid	310
Core+ Corner+ Diagrid	207
Hexagrid	240
Hexagrid+ Core	247
Hexagrid+ Corner	256
Hexagrid+ Core+ Corner	256

Source: from the analysis

Graph: 3 Comparison of Bending Moment



Source: from the analysis

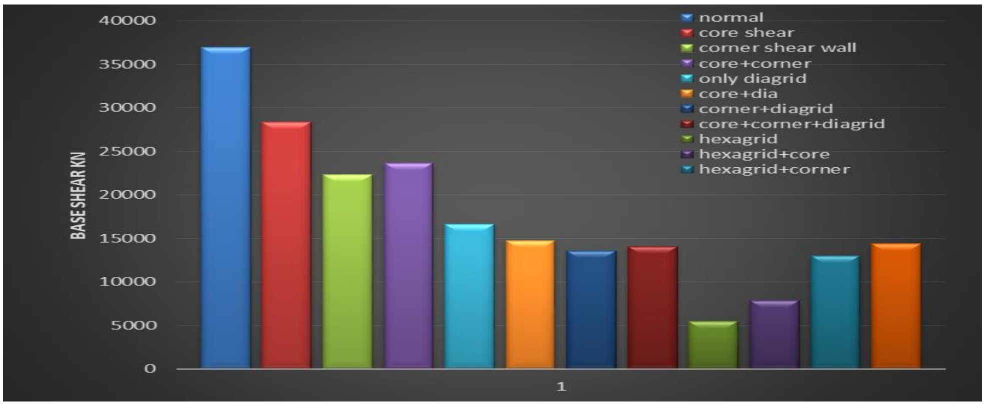
Table: 4 Comparison of Base Shear Results

Base shear (KN)	
Normal building	37000
Core shear wall	28405
Corner shear wall	22317
Core +Corner	23629
Only diagrid	16627

Core+ Diagrid	14783
Corner+ Diagrid	13588
Core+ Corner+ Diagrid	14096
Hexagrid	5498
Hexagrid+ Core	7871
Hexagrid+ Corner	13002
Hexagrid+ Core+ Corner	14448

Source: from the analysis

Graph: 4 Comparison of Base Shear



Source: from the analysis

6 CONCLUSIONS

1) Comparison of storey displacement:

The values from static and response spectrum method analysis displacement for normal building is 92 % more than the core + corner + diagrid model building. In Diagrid and hexagrid model's displacement is less as compare to normal building. So, diagrid and hexagrid system is good in storey displacement.

2) Comparison of storey drift:

The values of storey drift from the analysis in corner shear wall model is 41% more than the corner + diagrid model. Storey drift of Diagrid and hexagrid model is less than the normal building and shear wall buildings model. So, diagrid and hexagrid system is good in storey drift.

3) Comparison of bending moment:

In core + corner +diagrid building bending moment is less and high in normal building. Bending moment is 56 % more in normal building. So, diagrid and hexagrid system is good in bending moment.

4) Comparison of base shear:

Base shear in normal building is 79 % more than the hexagrid building model. Diagrid and hexagrid building model have less base shear so diagrid and hexagrid building modal is good in base shear. So, diagrid and hexagrid system is good in base shear.

- Comparison of diagrid-hexagrid building and normal building are shows that diagrid and hexagrid building has less displacement, less storey drift, less bending moment, and base shear in seismic analysis.
- Diagrid and hexagrid structure comparison to normal building provide more aesthetic look it becomes important for tall structure.
- So, from result comparison with normal building, one can adopt diagrid and hexagrid structure for better lateral and gravitational load resistance.
- So, from the results and conclusions final conclusion is diagrid system and hexagrid system is good for tall tube type RC building.

7 REFERENCES

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