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Analytic Study on Diagrid Structure

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Abstract:- As you can see in growing population countries were demand of high rise building is drastically increasing, due to which different types of structural frame system have to look for economically, structural stability and aesthetically aspects. These different structural system such as conventional, braced tube, outrigger, diagrid are most commonly used for high rise buildings, among them Diagrid System are new trends for high rise buildings due to its Structural and aesthetical properties. Diagrid systems consists of diagonal columns instead of vertical columns (Vertical columns are deleted in this frame system). Diagrid systems are diagonally connected due to which there is reduction in lateral loads and some portion of gravity load also as compared to other structural system. Diagrid used in different angels depends upon the height of the structure which is useful in reducing the forces. In early days architectural view of the high rise buildings are very important, due to the different angels of diagrid with respect to height the combination gives better architectural view than the Conventional and braced system. At the start of the construction of high rise building only conventional frame system is used for construction later braced tube or braced frame system is adopted in which both vertical column as well as diagrid members are used for construction later and recently Diagrid frame system were highly used it is some were similar to braced tube system, only the vertical columns are deleted. So in this thesis I am studying why diagrid frame system are more adopted nowadays instead of other structural system such as Conventional frame and braced frame system. A rectangular plan of size 15 m × 18 m and 20 story consist of 3m floor to floor of RCC building is considered for analysis with same parameter and same loadings for all buildings. The software used for analysis and various data collections of all building for comparison is Staad Pro. IS 456:2000 are used for designing of all structural members and load combinations of seismic forces are considered as per IS 1893(Part 1): 2002. After analysis of all the buildings with same data the comparison is done by comparing the beam forces, column forces, lateral displacement, story drift, reinforcement in column, beam and footings etc. Most of the lateral load are resist by external diagonal columns at periphery of the building which gives less effect of lateral loading to the internal column. This causes reduction in the forces and reinforcement in diagrid building as compared to conventional & braced structure. As also there is less effect of lateral loading there is less displacement and story drift in diagrid building as compared to other buildings.

I. INTRODUCTION

In a construction of high rise buildings lots of frame system have been used such as shear wall, conventional frame, brace tube system, diagrid system. But most efficient and recently used system is diagrid. Diagrid consist of diagonals with grids it is framework of diagonally intersecting beams consist of Concrete, Steel or wooden. Diagrid consist of diagonal column instead of vertical column in the periphery of structure. All vertical columns are eliminated on the exterior portion of the structure. In recent days it is observed that diagrid frame system on the periphery of the high rise building is commonly used as compared to other frame buildings such as convention and braced tube system. As diagrid frame structure is more popular than other due to its structural performance and aesthetically shape for construction of high rise buildings. The diagrid frame structure resist more lateral loadings due to wind and earthquake (this are the main forces which acts as an important role in designing of high rise buildings) than any other frame structure. Diagid is similar to or you can say evolution of braced tube system. The only difference is that the vertical column in the exterior are eliminated in diagrid frame structure. The diagonal members act both inclined column as well as bracing elements due to which they form triangulated configuration. The shear forces and the bending moment developed due to which the vertical columns bends in most cases are resisted by axial action of these diagonal members. Due to lesser no's of obstruction at the exterior portion of the diagrid buildings gives better outer view and also the appearance of building from outside.

II. OBJECTIVES

The main objective of this thesis is to investigate why diagrid structural system is adopted more than the other structural system such as Conventional frame and Braced frame system for that I am analyzing the different structural system with same parameters under different seismic and dynamic loadings. The work is to be carried out by conducting-

(a) Study behavior of all buildings in various seismic zone such as III, IV, V.

(b) Comparative study on behavior of both buildings in various soil types.

(c) Comparative results of conventional, braced frame building and diagrid building.

(d) Study on behavior of all buildings with uniform and varying column sizes at different levels.

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III. SCOPE

The future demand in construction of high rise building is common so for the different structural system is experimented therefore adoption of Diagrid system is needful in terms of increasing the efficiency of work and also cost reduction. To meet these requirements, the structure should have adequate lateral strength & sufficient ductility. The unique compositional characteristic of the structure provides great structural efficiency for tall buildings. One can maximize the structural efficiency of the diagrid structure by optimizing its grid geometries. There are several factors that need to be considered in the design of the diagrid system such as the number of stories of the tall buildings, the optimum angle of the diagrid structures, the material and size used in constructing the diagrid, beam and column elements, the size of the columns and the method employed to join the diagrid members. Structural design of high rise building is governed by lateral loads due to wind or earthquake. Lateral load resistance of structure is provided by interior or exterior structural system. Generally shear wall core or braced frame and their combination with frames are the interior system, where lateral load is resisted by centrally located elements. Usually in conventional & braced frame, vertical columns are closely spaced while in diagrid structure consists of incline columns on the exterior surface of building. These inclined columns resist the lateral loads by axial action of the diagonal compared to bending of vertical columns in conventional & braced framed.

IV. METHODOLOGY

In this thesis comparison of diagrid, conventional & braced building with uniform and varying column sizes under seismic and wind forces is done. Here G+20, story buildings is taken and same static and dynamic load is applied for its behavior and comparison.

The high rise buildings of different frame structure are subjected to different vibrational forces due to earthquake and wind therefore seismic analysis and wind analysis is essential for these building frames. The fixed base system is analyzed by employing in building frames in different seismic zones in various soil types by means of Staad.Pro software. The response of the building frames is studied for useful interpretation of results

Structural models

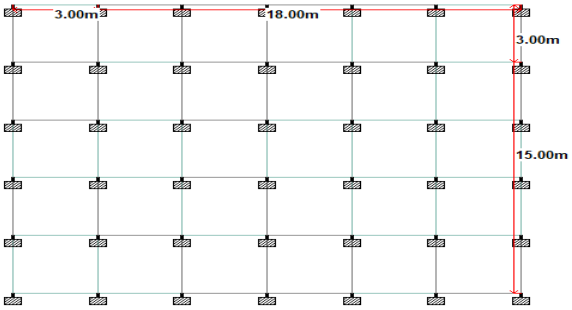

Fig. 1. Plan of conventional & braced & diagrid building

Table. 1- Properties of Different Materials involve in the study.

Properties of Materials	Values
Density of RCC	25 Kn/ m3
Density of Brick Masonry	20 Kn/m3
Young's modulus , EC	27386 N/mm2
Poisson ratio, μ	0.17
Compressive strength, of conc Fck	30 N/mm2
Grade of Steel	Fe 500

Loading conditions

Following loading are considered for analysis -

(a) Dead Loads:

Self-wt of slab considering 150mm depth of slab = 3.75 kN/m2

Floor Finishing load = 0.75 kN/m2

Masonry Wall Load for inner wall = 9 kN/m

Masonry Wall Load for parapet wall = 3 kN/m

(b) Live Loads:

Live Load on typical floors = 3 kN/m2

Live Load on roof = 2 kN/m2

(c) Earth Quake Loads:

All the building frames are analyzed for various seismic zone and different soil type

The earth quake loads are derived as per IS: 1893(2002)

Table. 2- Seismic parameter

Seismic parameters	Data/ Value	Data/ Value	Data/ Value
Earth Quake Zone	III	IV	V
Response Reduction Factor	5	5	5
Importance Factor	1	1	1
Damping	5%	5%	5%
Soil Type	Hard Soil	Medium Soil	Soft Soil

V. RESULTS

Interior column analysis

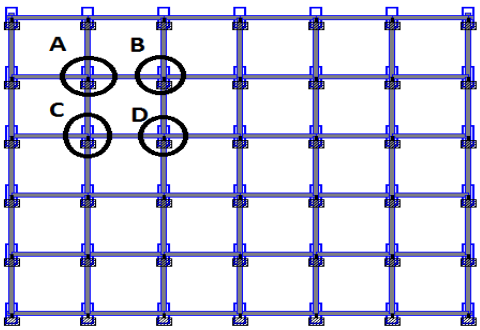

Fig. 2. Interior column

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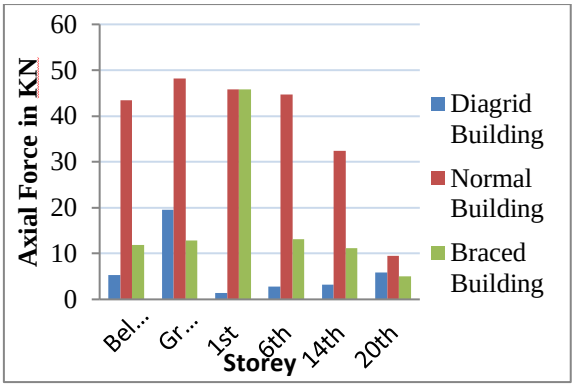

Fig. 3.Comparison of Shear Force

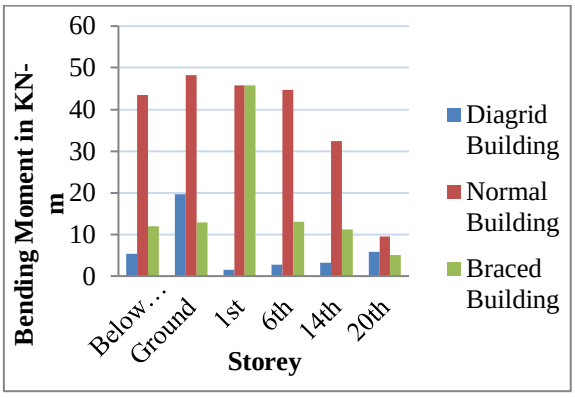

Fig. 4.Comparison of Bending Moment.

Beam Analysis

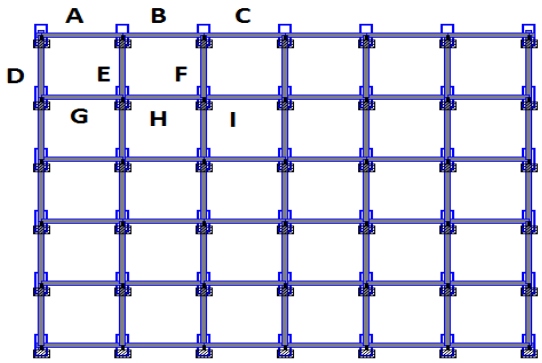

Fig. 5. Beam location

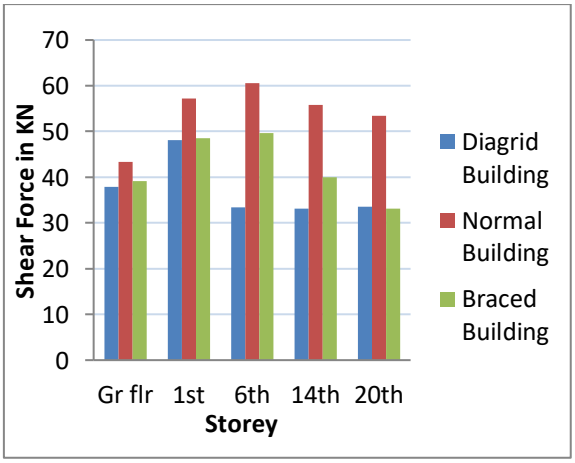

Fig. 6.Comparison of Shear Force.

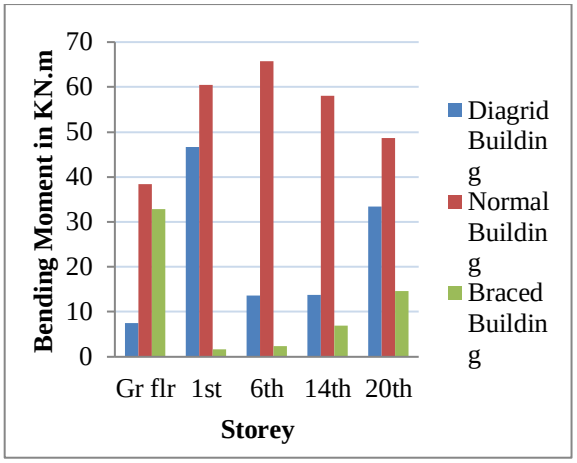

Fig. 7.Comparison of Shear Force.

Footing Column Analysis

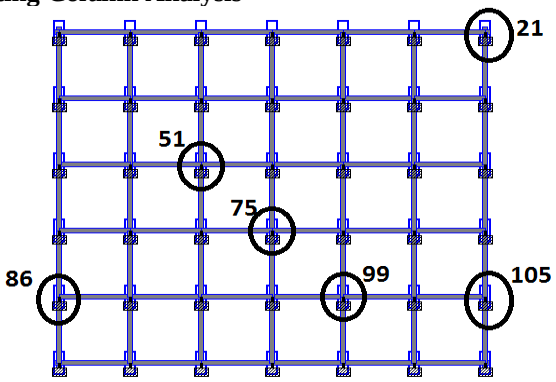

Fig. 8. Column footing location

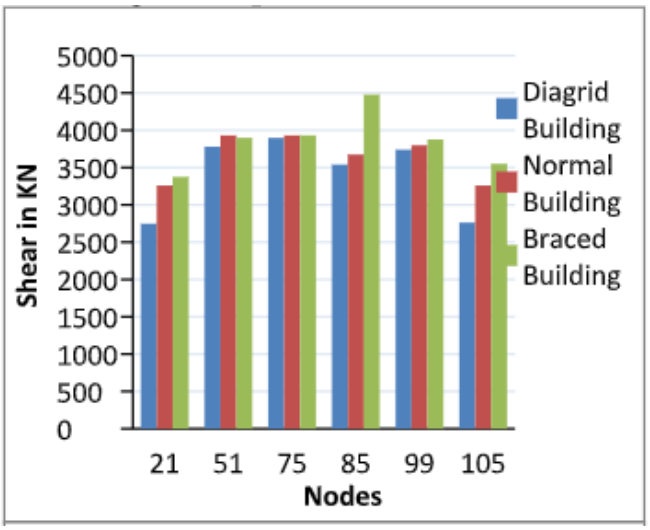

Fig. 9. Comparisons of Shear force.

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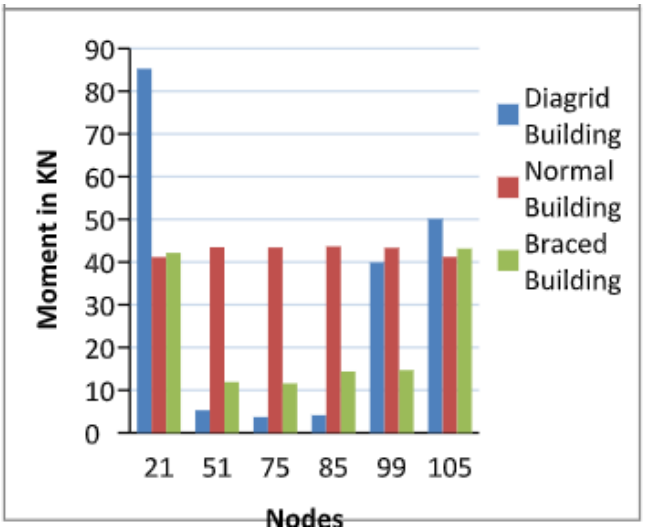

Fig. 10. Comparisons of Bending Moment.

Time period comparisons

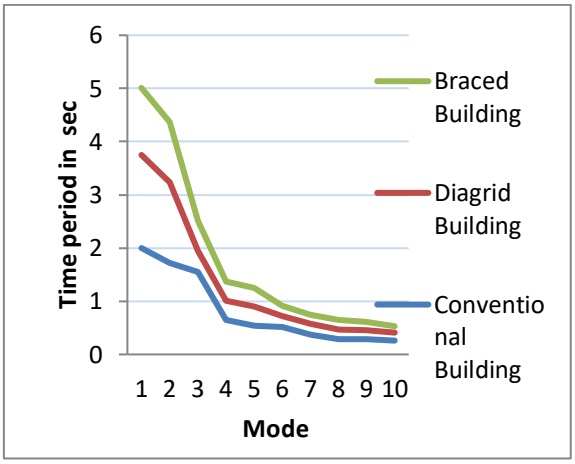

Fig. 11. Time period comparisons.

Lateral displacement

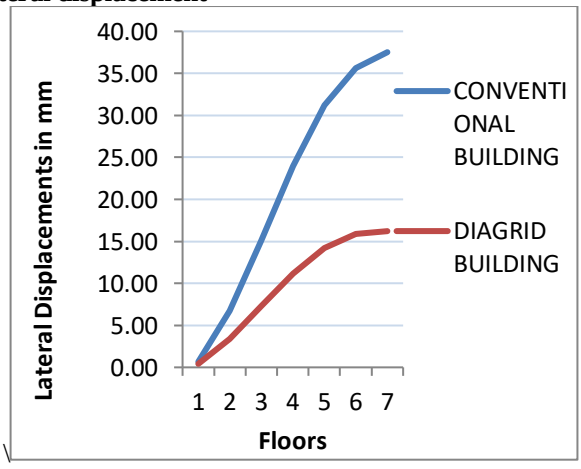

Fig. 12. Lateral displacement.

Material Comparison

Quantity of Material	Conventional Building	Diagrid Building	Braced Building
Volume of Concrete in Cu.m	1660	1115	1860
Weight of Steel in kN	1329	958	1358

VI. CONCLUSION

1. There is a reduction in various lateral and gravity loads parameters as compare to other frame structure which is useful in high rise building where lateral loads govern the design.
2. As diagrid frame structures does not have corner columns as compared to other structural frame system (Conventional and Braced Frame System) due to which there is a reduction in displacement of top storey and also column less corners gives better view and aesthetically appearance.
3. Diagrid helps in sustainable development as amount of construction material required is less and energy is saved due to less obstruction to incoming light at the periphery of building.
4. Material saving property: Although quantity of concrete used in building's is approx. Same, but diagrid shows more economical in terms of steel used. Diagrid building saves about 28 to 30% steel without affecting the structural efficiency.

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