COMPARATIVE ANALYSIS OF DIFFERENT LATERAL LOAD RESISTING SYSTEM IN FLAT SLAB MULTISTOREY BUILDING

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Abstract - *In this study we consider different lateral load resisting system i.e., Outrigger braced system, diagrid system and shear wall system. The outrigger bracing system provides the solution to control excessive drift and displacement in high rise buildings. It consists of the outrigger bracings or the outrigger trusses which connects the central core of the building with the peripheral columns and the peripheral columns relate to one another through the belt trusses. In this study, the conventional structural model having the central core of reinforced concrete and the models with outrigger at top, top and 0.75H, top and 0.5H and top where H is the total height of the building are modeled for the 20 storey building heights. The main objective of the study is to determine the optimum location of the outrigger system. And find out the best and economical lateral load resisting system. The results obtained from different analyses suggests that the optimum location of the outrigger bracing system for high rise building is at the top and mid height of the building for which the top displacement and drift is minimum. The outrigger structures are stiffer than the conventional, diagrid and shear wall structures system. The top and 0.5H model of outriggers showed the maximum decrease in storey displacement, base shear and minimum stresses on slabs.*

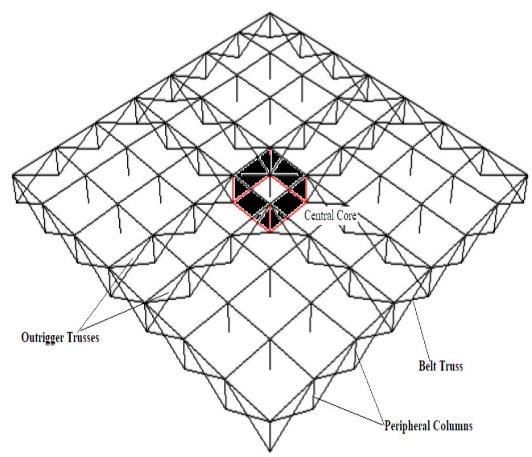
***Key Words*:** Outrigger braced system, Diagrid Structure, Response Spectrum Method, Storey Shear, Node Displacement. Stresses in Slab and beam.

1.INTRODUCTION

The demand for the high-rise buildings has been increased rapidly in the recent times owing to the rise in population and decrease in the available land. The advancements in the engineering techniques and technological advancements have made it possible to develop super high-rise structures with perfection and safety. There is a trend of constructing tall and more slender structures owning to the aesthetic demands and more essentially because of the small land area available due to the raise in land prices and rapid urbanization. The tall buildings are more subjected to the lateral loads due to wind and seismic forces and hence must be designed accordingly to resist any lateral loadings. In the design of high-rise buildings, the requirements of strength and stiffness must be adequately met and the lateral displacements and drift arising due to the seismic and wind loads must be properly controlled to avoid the structural as well as nonstructural damages. For this purpose, various types of the structural systems emerged over the ages which are briefly described.

1.1 Introduction of Outrigger System

It has been found through various research that the shear wall when used alone provides resistance effectively only upto a certain height and beyond that it becomes uneconomical when compared with the benefit it provides. Thus, there is necessity of some other more efficient structural system offering more stiffness and strength to the high-rise structures against wind and seismic loadings and considering the economy criteria. The outrigger bracing system provides more stiffness to tall buildings against the lateral displacement and drifts without paying any extra cost on the steel and proves to be very economical solution for the drift control.



1.2 Diagrid Structural System

Diagrid buildings are rising as structurally economical furthermore as architecturally important assemblies for tall buildings. Recently the diagrid structural system has been wide used for tall buildings due to the structural efficiency and aesthetic potential provided by the distinctive geometric configuration of the system. Generally, for tall building diagrid structure steel is employed. In present work, concrete diagrid structure with vertical geometric irregularity is analyzed and compared with a conventional concrete building. The diagrid structural system may be outlined as a diagonal member shaped as a framework created by the intersection of various materials like metals, concrete or wood beams that are used in the construction of buildings and roofs. Diagrid structures of the steel members are efficient in providing a solution both in term of strength and stiffness. But these days a widespread application of diagrid is employed within the giant span and high-rise buildings. Diagrid structure consists of inclined columns on the exterior surface of the building, Due to inclined columns, lateral loads are resisted by axial action of the diagonal compared to bending of vertical columns in framed tube structure. Diagrid structures typically, do not need core because of lateral shear may be carried by the diagonals on the outer boundary of a building.

1.3 advantages of Steel outrigger braced system

I. The outrigger systems may be constructed in any combination of steel, concrete, or composite construction.

II. Core overturning moments and their associated induced deformation can be reduced through the reverse moment applied to the core at each outrigger intersection.

III. Significant reduction and possibly the complete elimination of uplift and net tension forces throughout the column and the foundation systems.

IV. The exterior column spacing is not driven by structural considerations and can easily match with aesthetic and functional considerations.

V. Exterior framing can consist of "simple" beam and column framing without the need for rigid-frame-type connections, resulting in economies.

1.4 Flat Slab

Residential housing demand grew exponentially. The multi-story house should be affordable and, from an engineering point of view, should have less design elements. Flat slab construction would be preferred for that. The Flat Slab is a slab that does not have a beam portion and passes its load by vertical columns directly to the surface. There are commonly two types of slabs, the R.C.C slab and the Flat slab. If the slab beam is there, it is called the R.C.C slab, and if the beam is not there, it is called the flat slab. In a multi-story structure, flat slab is used to lower the total construction costs to require more headroom. Even, as opposed to R.C.C slab, the building process of flat slab is almost unsophisticated.

2. OBJECTIVE OF STUDY

- To comparative study the concept of outrigger structural system with other lateral load resisting system like Diagrid system and Shear wall system and examine the response of the same using the dynamic analysis.
- To vary the location of outrigger bracings with belt trusses along the height of structure and find out the best location of outrigger system in terms of performance, least lateral displacement, and economic consideration.
- To compare the results in terms of storey drift, storey shear, top storey displacement of outrigger system with the conventional framed structural system, Diagrid structural system & Shear wall system.
- To compare the moment in the peripheral columns of the outrigger system models with that of the conventional models, Diagrid Model & shear wall model.

3 METHODOLOGIES

In this study comparison of outrigger system with conventional structure, diagrid system and shear wall lateral load resisting system under seismic as well as gravity loading is worked out, and concept of outrigger structural system is studied. To achieve the objective of this study the methodology used is as follows:

- Review the existing literature and various standards on outrigger structural system, diagrid system and shear wall system.
- Selection of the building's geometry and Seismic zone.
- Calculation of loads on building using Indian Standard Codes.
- Formation of load combination as per IS: 1893 (Part I): 2016
- Preliminary member sections are assumed and modeling of conventional frame with central core and conventional frame with central core and outrigger system and diagrid and shear wall is done by using Staad pro software.
- The models are of 20 storey heights. In seismic zone IV.
- The position of one outrigger is kept fixed at top and other one is varied along the height as 0.5H and 0.75H where "H" is height of structural model.
- The linear dynamic analysis is done to find out parameters like displacement, inter storey drift, moment, base shear, time period and axial force in the peripheral column.
- The results are compared with linear dynamic analysis i.e. Response Spectrum Analysis.
- The efficiency of outrigger system, diagrid & Shear wall system is found out based on above parameters and the optimum location of outrigger for which displacement and drift is least found.
- In the end, the number of outriggers bracing systems is also increased one by one and a comparative study of the subsequent reduction in lateral displacement is done.

The data used in this study is summarized below:

Types of model Conventional Building Conventional building with outriggers.

Location of outriggers One fixed at the top and location of second one is varied at 0.5H and 0.75H

Number of storey	20 storey
Plan area	20 m x 30m
Storey height	3 m
Spacing of columns	5 m
Grade of concrete	M25
Grade of steel	Fe415
Size of columns	500 mm x 500 mm
Size of Cantilever beams	2000 mm x 500 mm
Slab thickness	200 mm

- Shear Wall Thickness 150 mm
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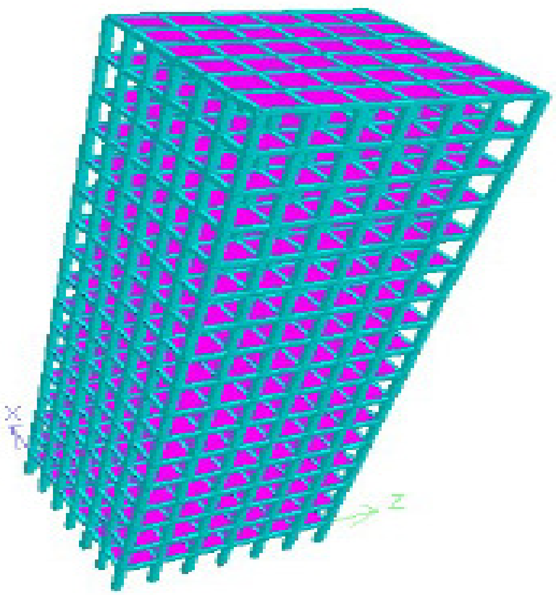


Fig -1: Conventional Building

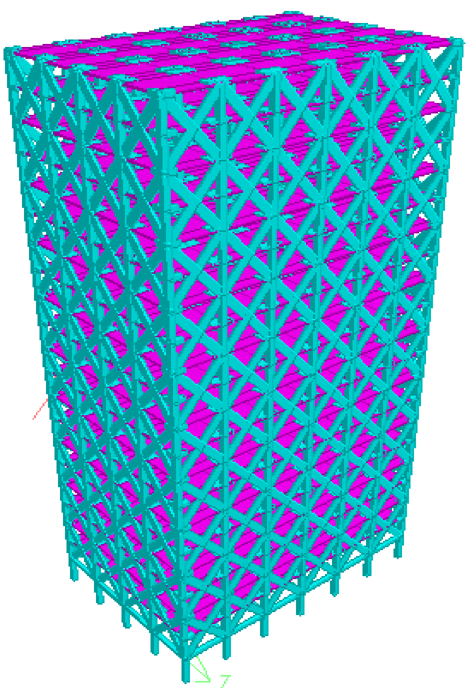


Fig -2: diagrid Building

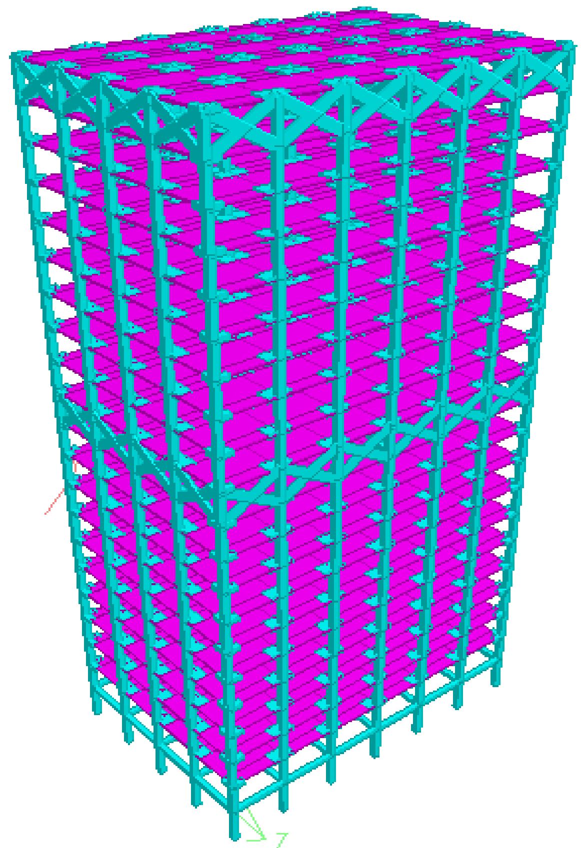


Fig -3: steel outrigger system Building

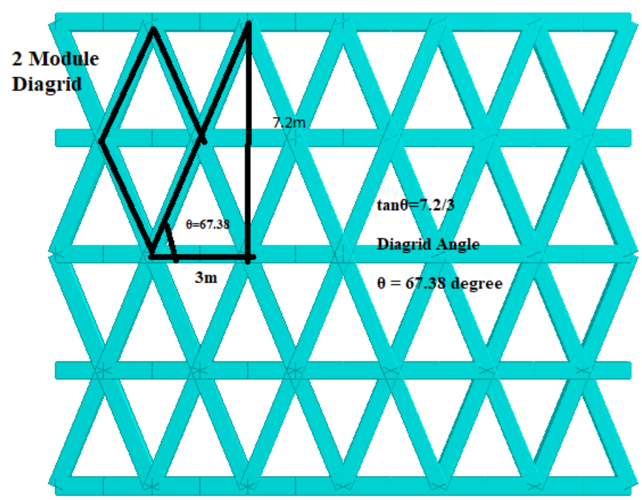


Fig -5: Square diagrid Module

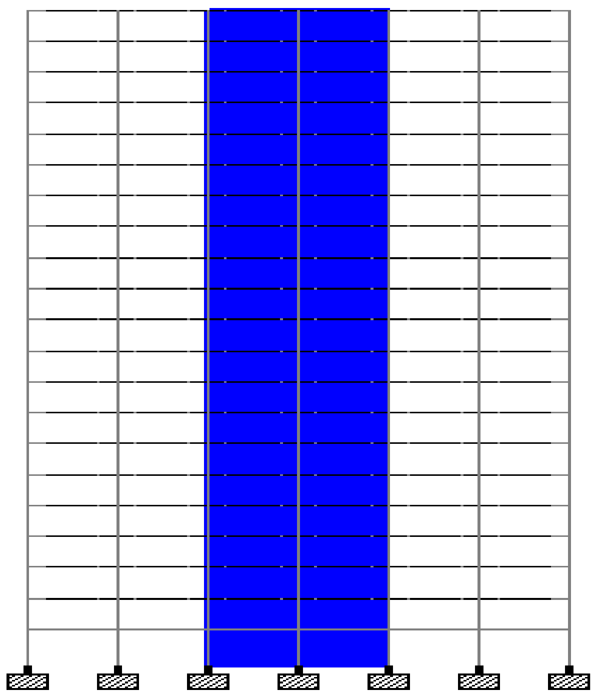
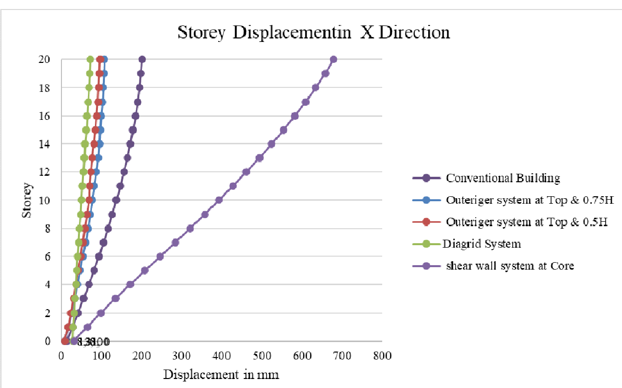
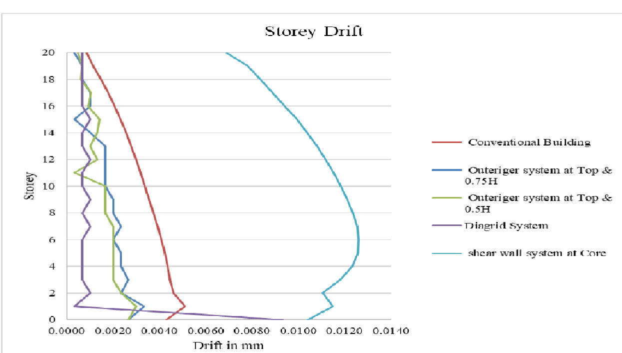


Fig Shear wall system

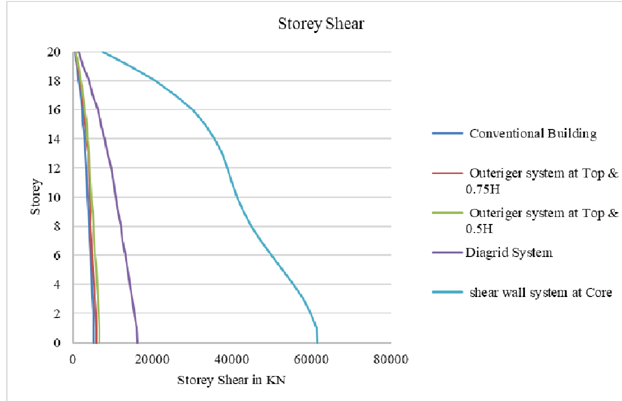
3. RESULTS



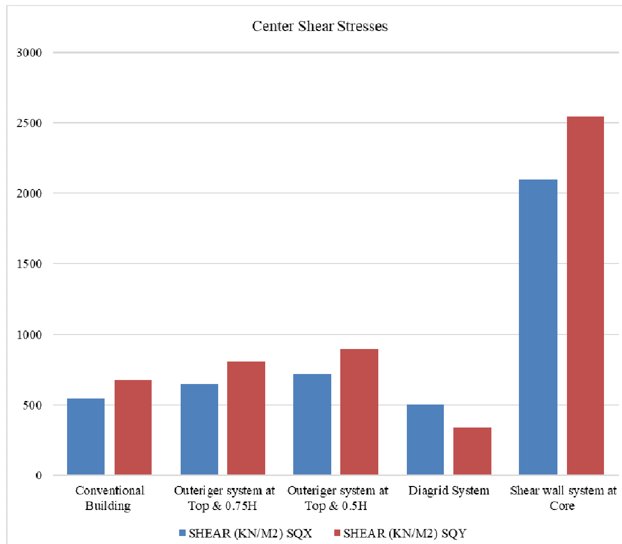
Graph 1 Storeys Vs Displacement



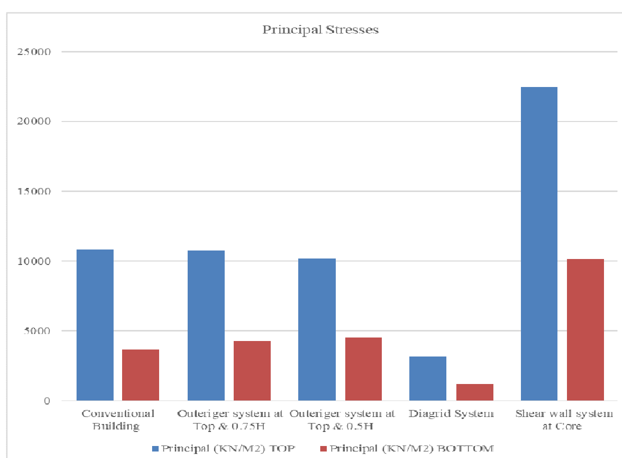
Graph 2 Storey Drift in different load resisting system



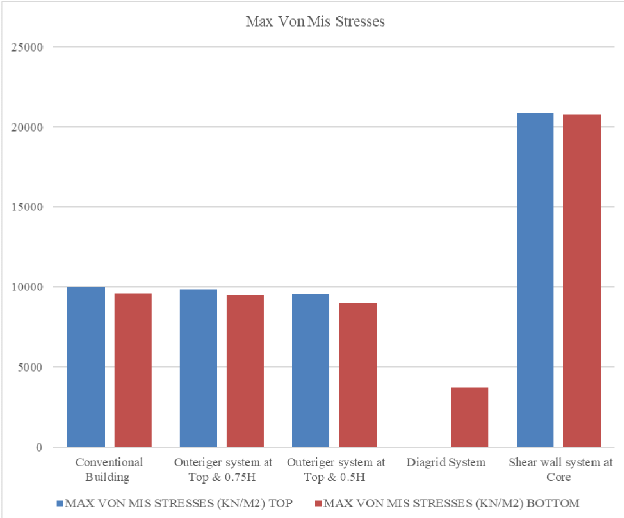
Graph 3 Storey Shear in different load resisting system



Graph 4 Center Shear Stresses Vs Different types of Building



Graph 5 principal stresses Vs Different types of building for Seismic Analysis



Graph 6 Max Von Mis stresses in Slab

4. CONCLUSION

The various conclusions drawn within the scope of present work are as follows:

1. The optimum location of outrigger system is found to be at top and 0.5 times the height of the structure. Significant reduction in lateral displacement and drift is seen in providing outriggers at this location.
2. The lateral displacement for 20 storey structural models with outrigger at top and 0.75H is reduced by 47%, & for 0.5H is reduced by 52% and for diagrid structure is reduced by 64% and for shear wall system is increased 238% respectively by Response Spectrum Method.

3.Structural models with outrigger at top and 0.5H & Diagrid Structural System show the best result in lateral displacement reduction

4.Similarly, the maximum storey drift for 20 storey structural models with outrigger at top and 0.5H & Diagrid system is reduced by 42% & 20% respectively when compared with it conventional model.

5.The base shear for the 20, 40 and 60 storey structural models with outrigger at top and 0.5H is increased by 35% when compared with conventional model.

6.The introduction of outrigger bracing system reduces the moment in the central core and a remarkable magnitude of moment is resisted by the peripheral columns. The peripheral columns form tension compression couple and helps in resisting the lateral loads more effectively.

7.After analysis is found that there no remarkable variation shown in slab stresses i.e center shear stresses, Principal Stresses and Max Von Mis Stresses when its compared conventional structural Model with different load resisting system.

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