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COMPARISON BETWEEN CONVENTIONAL AND DIAGRID STRUCTURES BY PUSHOVER ANALYSIS

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ABSTRACT

The tremendous increase in the cost of land, need for protection and preservation of agricultural land had led engineers and architects design the cities more in vertical direction than on horizontal land. When the height of the buildings starts increasing the lateral load resisting system (includes seismic loads and wind loads) becomes more important than the structural system that resists gravitational load. Recent developed trends shows the use of Diagrid-diagonal grid-structural system is widely used for tall steel buildings due to its structural efficiency and aesthetic potential provided by the unique geometric configuration of the system. For the present study ETABS software is used for modeling and analysis of diagrid structural system and conventional structural system for 10 storey building is considered. A floor plan of 9*9m is considered for both the structures. Pushover analysis will be conducted to find out the performance point that is Immediate Occupancy, Life Safety, and Collapse prevention of Diagrid elements and for the conventional buildings as well. At the same time Base shear and Displacement are studied and is compared to know the adequacy of structure.
Keywords— ETABS, Diagrid,Performance Point ,Immediate Occupancy, Life Safety, Collapse Prevention

I. INTRODUCTION

The emersion of the tall buildings arises to cover up the increasing cost of the land and to avoid the continuous urban sprawl. The new structural buildings have to be such that it should be 'lighter' and 'stiffer' and should possess high strength and durability. The increasing height of the buildings experiences more lateral loads and the structure will start to buckle due to more wind load and seismic loads. This buckling can be avoided by the use of diagrid structures (steel structure) as it is susceptible to withstand more lateral loads than conventional buildings.

Diagrid is a combination of the words "diagonal" and "grid" and refers to a structural system that is single-thickness in nature and gains its structural integrity through the use of triangulation. The major advantage of diagrid being used is it avoids the use of vertical column and uses braces instead which can take more lateral loads (seismic load and wind loads) as well as gravity loads than it is taken by the conventional buildings whereas the diagonal in conventional buildings can take lateral loads only. Diagrid structures are much more effective in minimizing shear resistance because they carry shear by axial action of the diagonal members, while conventional structures carry shear by the bending of the vertical column.

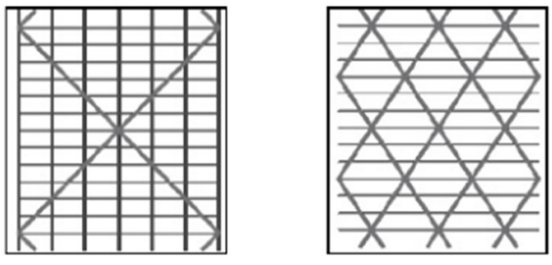

Fig 1: (i) Conventional building; (ii) Diagrid structure

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II. NON LINEAR STATIC ANALYSIS OR PUSHOVER ANALYSIS

In the curve which shows the relationship between stress and strain, there are generally two regions namely: Elastic and Plastic region. Elastic region(portion AB) is the linear part of the graph. The analysis for the same is called as linear analysis. After the yield point the non-linear plastic region(from point D to F) starts. This is however called as non-linear portion and analysis done for the steel after the yield point is called as non-linear analysis as shown in fig 2.

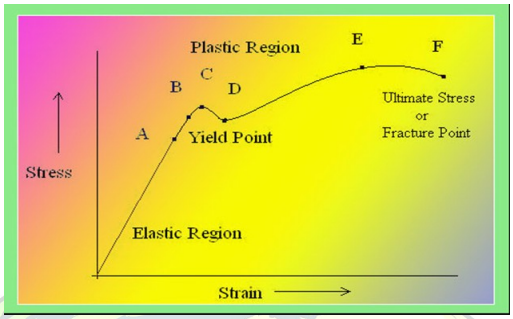

Fig 2: Relationship between stress and strain for steel

Pushover analysis is the non-linear analysis, is a technique in which computer model of a structure is subjected to a predominant lateral load pattern. The loading pattern includes pushing of a building thereby increasing lateral loads and the sequence of development of the cracks, yielding, plastic hinge formations, and the load at which the structure attains collapse is recorded as function of increasing lateral load until the structure attains collapse. Pushover analysis will be conducted to find out the performance point that is Immediate Occupancy, Life Safety, and Collapse prevention.

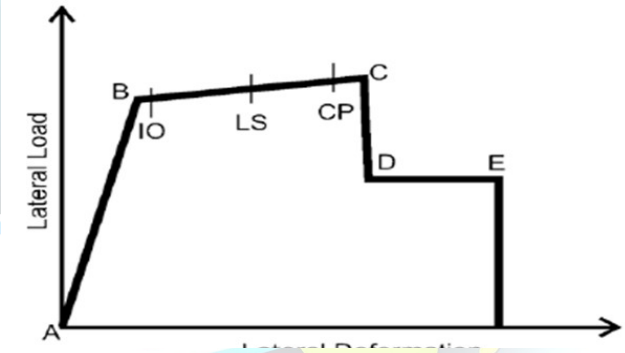

Fig 3: Static Pushover Curve

III. OBJECTIVES

For any design engineer or architect the prime consideration for the basis of any structural design are safety of the structure and serviceability. To satisfy these criteria the building should possess sufficient strength to overcome load due to seismic waves, vertical load due to wind and horizontal gravity loads. For the present study, two buildings each of 10 storey and each storey height of 3m has been chosen. One of which is conventional building and the other is diagrid structures.
The work to be accomplished for the study as listed below.

- Modeling of both the structures.
- To perform pushover analysis for both the buildings using ETABS.
- To compare the analysis values of base shear and displacement for the structures.
- To find out the performance point that is Immediate Occupancy, Life Safety, and Collapse prevention of Diagrid elements and for the conventional buildings as well..
- To find seismic capacity and demand of both the structures.

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IV. METHODOLOGY

In this thesis ETABS software is used for modeling and analysis of the conventional buildings and diagrid structures. All the structural elements in the study are designed as per IS 800:2007 considering all load combinations. Seismic load as per IS 1893-2002 along with the self-weight of the structure are considered for analysis of the structure. Pushover load cases are defined using seismic load case as load pattern. Auto hinges are assigned to every steel unit for pushover analysis. The structure is then analyzed for the defined load cases and the state of load cases are obtained using deformed shapes of the individual load case. Then the spectral shear, displacement and drift for the structures are found out from the values of the analysis.

Table 1: Buildings Details

Area of a plan	9m x 9m
No of Stories	10 No's
Height of the building	30m
Storey height	3m
Slab thickness	150mm
Type of the structures	Diagrid structure(with 62.93 angle)
	Conventional building
Type of analysis	Non-linear Analysis

Table 2: Data for Analysis

Density of reinforced concrete	25KN/m^2
Density of steel	76.9729KN/m^2
Intensity of live load	5KN/m^2
Importance Factor(I)	1.5
Response Reduction Factor(R)	5.0
Poisson's Ratio of Concrete	0.2
Poisson's Ratio of Steel	0.3
Seismic Zone	V
Seismic Zone Factor	0.36
Soil Type	TYPE III

V. RESULTS AND DISCUSSIONS

The modeled building is analyzed using pushover analysis. This chapter presents pushover results and discussions. Pushover analysis was performed first in a load controlled manner to apply all gravity loads on to the structure .Then a lateral pushover analysis in the transverse direction was performed in a displacement control manner starting at the end of gravity push. The results obtained from this analysis are checked by comparing spectral displacement demand and spectral displacement capacity from the pushover curve.

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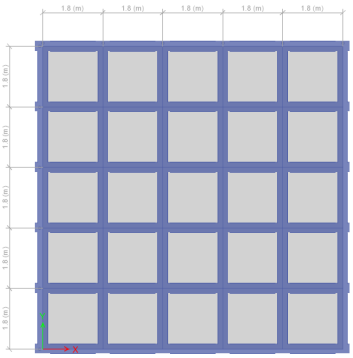

Fig 4: Plan of Conventional Structure

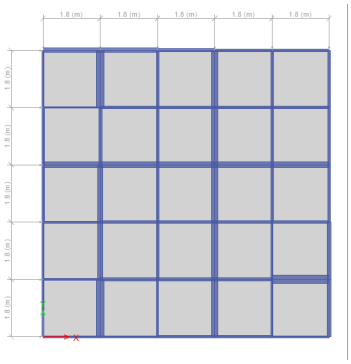

Fig 5: Plan Of Diagrid Structure

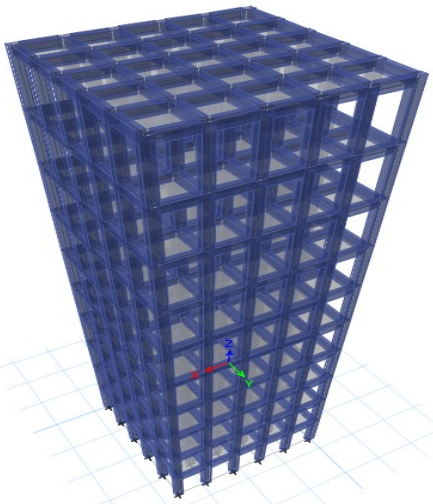

Fig 6: 3D View of Conventional Structure

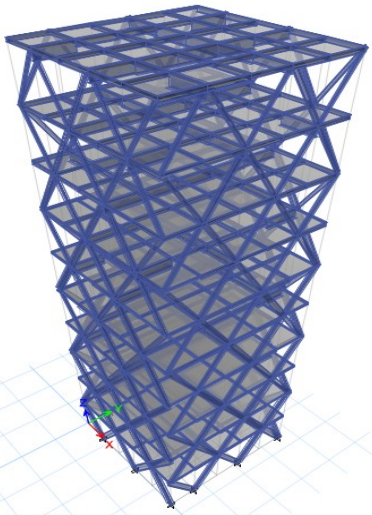

Fig 7: 3D View of Diagrid Structure

- **Pushover analysis results:**

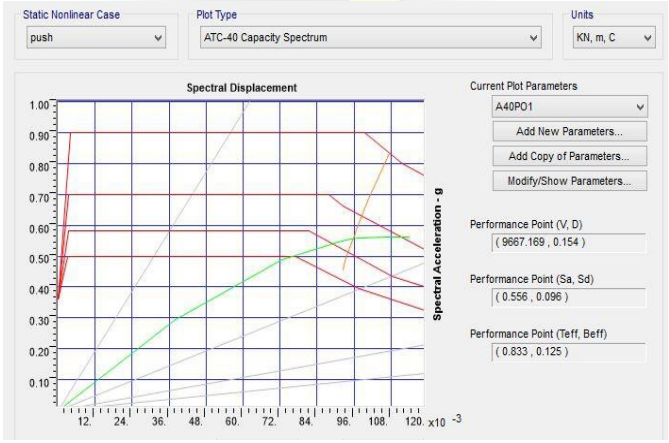

Fig 8 : Spectral Displacement curve of conventional structure

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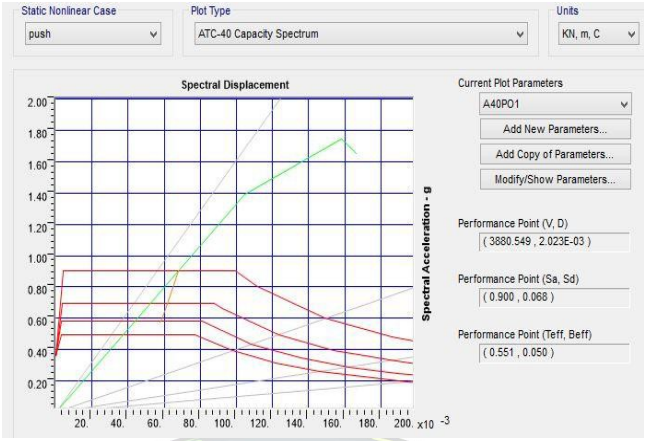

Fig 9 : Spectral Displacement curve of Diagrid structure

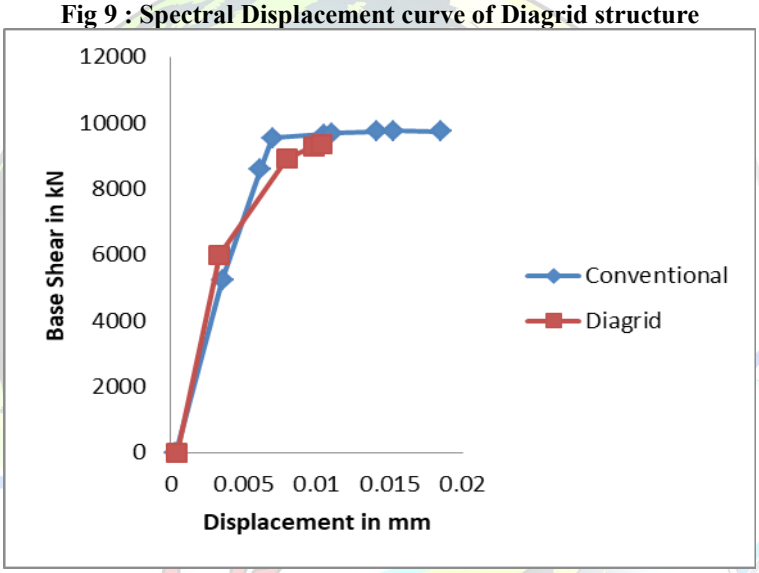

Chart 1: Comparison between Base shear and Displacement for both the models

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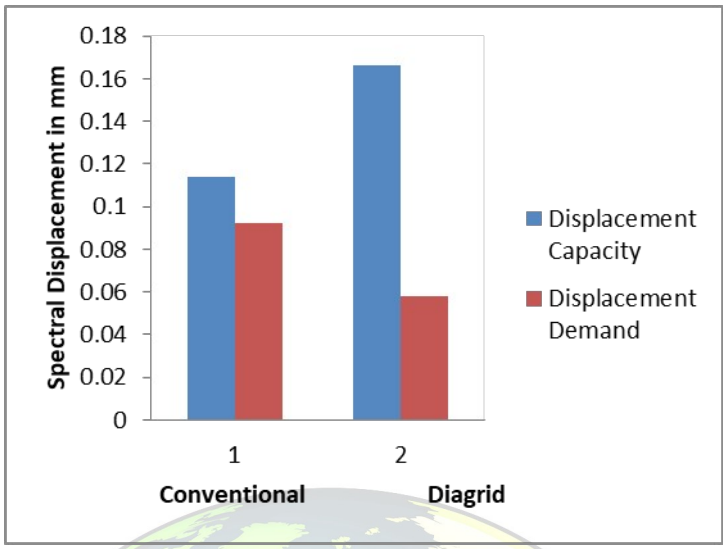

Chart 2 :Spectral displacement capacity and demand for both the models

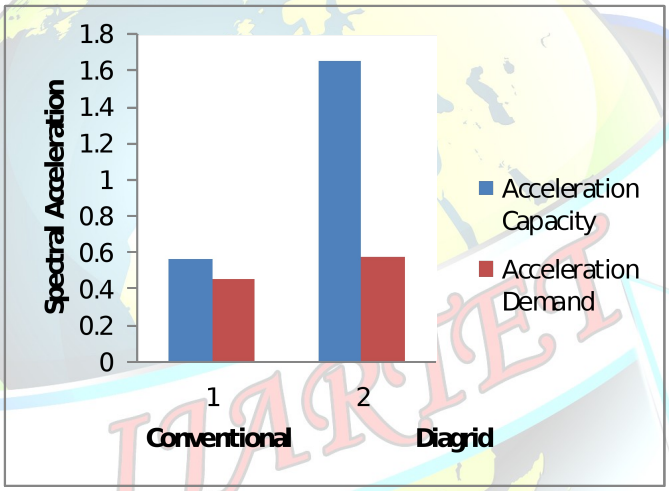

Chart 3 : Spectral acceleration capacity and demand for both the models

From chart 1 we can clearly observe that displacement and base shear of conventional structure is more than that of Diagrid structure. From chart 2 we can conclude that spectral displacement capacity is more for diagrid structures than conventional structures. Similarly From chart 3 we can conclude that spectral acceleration capacity is more for diagrid structures than conventional structures.

VI. CONCLUSION

Based on the nonlinear static analysis carried out on the 10 Storey conventional structure and diagrid steel structure following conclusions can be drawn:.

- Conventional buildings are found to have more displacement as compared to the diagrid structures.
- Seismic capacity of the Diagrid structure is more than conventional structure.
- Diagrid structure is more efficient than the conventional structure.
- Since the diagrid structure avoids the use of vertical column and uses diagonal grids as a column it resists more load. Here also it is found that diagrid resisted more lateral loads than the conventional which resisted gravity loads only.
- Diagrid structures saves the time of construction, economy as well as it gives aesthetic appearance for the building.

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