Varying Angle Diagrid Structural System

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Abstract— Diagrids have emerged as an architectural choice in the creation of tall buildings. Diagrids have widely used in tall structural system because of their structural efficiency. Uniform angle diagrid structures such as Hearst towers, New York and angle variation along height diagrid employed by lotte super tower project in Seoul. This paper presents another way of varying angle for diagrid, along the width and combination of along height and along width angle variation, which has not been employed for any tall building in world. A regular floor plan of 40 m x 40 m is considered for 80 storey diagrid structure. ETABS software is used for modelling and analysis of structural members. Comparison in terms of displacement, storey drift is presented.

Key words: Tall building, Diagrid Structural system, Varying Angle, Lateral load resistance system

I. INTRODUCTION

Innovative structural systems for the next generation of sustainable ultra-high tall buildings and megastructures is essential. A major challenge for multi-use tall structures is to make them adaptive to possible changes in occupancy at different floor levels responding to the demands pf the prevailing real estate market. [1]. The term "diagrid" is a blending of the words "diagonal" and "grid" and refers to a structural system that is single-thickness in nature and grains its structural integrity through the use of triangulation [2]. The difference between conventional exterior-braced frame structures and current diagrid structures is that, for diagrid structures, almost all the conventional; vertical columns are eliminated. This is possible because the diagonal; members in diagrid structural system can carry gravity loads as well lateral forces owing to their triangulated configuration, whereas the diagonals in conventional braced frame structures carry only lateral loads. Compared with conventional framed tubular structures without diagonals, diagrid structures are much more effective in minimizing shear deformation because they carry shear by axial action of the diagonal members, while conventional framed tubular structures carry shear by the bending of the vertical columns.

II. STIFFNESS-BASED DESIGN OF DIAGRID STRUCTURES

A diagrid structure is considered as vertical cantilever and subdivided into modules based on repetitive diagonal pattern. Depending upon the direction of loading the face may act as either web or flange elements. The diagonal members are considered as truss element, So they carry shear and moment through axial action. In diagrid structures, it is possible to assume that the diagrids members carry the lateral load primarily by their axial actions due to the catechistic of their triangular configuration. The diagonal members on the web planes (i.e. planes parallel to wind) carry shear forces and those on the web planes (i.e., planes perpendicular to wind) as well as on the web planes, except those around the neutral axis, carry the moments through their axial actions as shown in fig.1

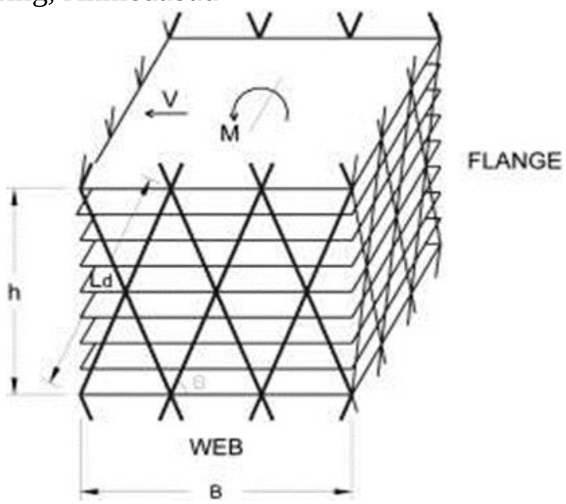

Fig. 1: A Typical 8-storey module

III. BUILDING CONFIGURATION

A regular floor plan of 40 m x 40 m is considered for 80 storey steel building. The typical storey height is 4.0 m. The typical plan of building is shown in figure 2. The dead load and live load on floor slab are 3.75 kN/m2 and 2.5 kN/m2 . Dynamic end loading is computed based on wind speed 39 m/sec for Ahmedabad city and terrain category III as per IS 875-part III (Gust factor method) [4]. Earthquake load is computed for zone-III and medium soil with importance factor and response reduction factor 5 for 2% damping as per IS 1893[5]. Fy 415 grade steel for structural members and M30 grade concrete for slab is used .ETABS software is used for modelling and analysis. Design of members is done as per IS:800-2007[6].

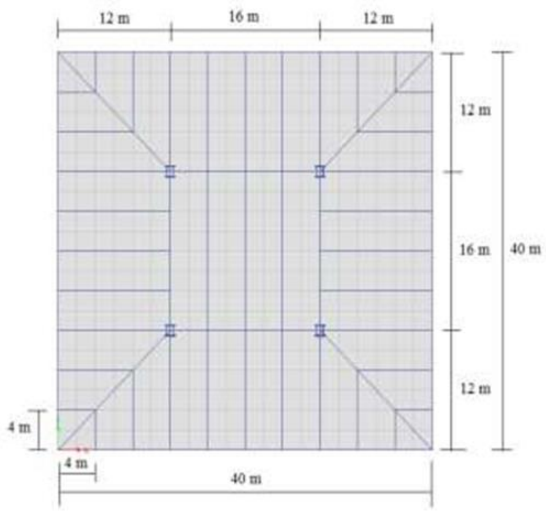

Fig. 2: Typical Plan

IV. OPTIMAL ANGLE

To find optimal angle for uniform angle for 80 storey diagrid structures by stiffness based design methodology is used. To find optimal angle 50.18° , 67.37°, 74.47°, and 80.53° with

2,4,6,8 and 10 storey module respectively for each diagrid building as shown in figure3.

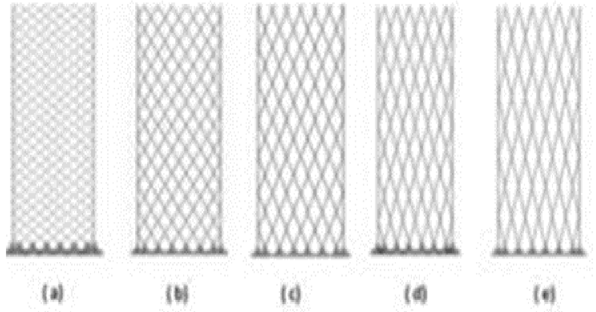

Fig. 3: Elevation of 80 storey model with (a)50.18°(b)67.37°(c)74.47°(d)78.23(e)80.53°

Structural steel usage for diagonal diagrid is shown in fig.4

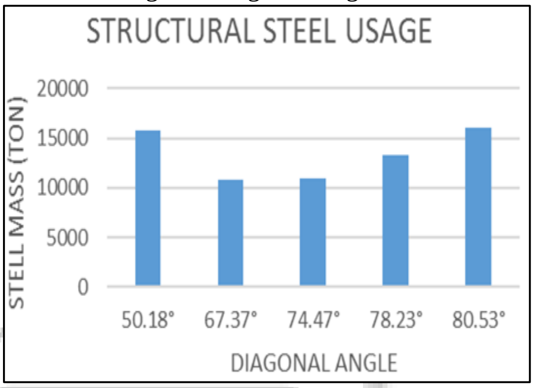

Fig. 4: Structural steel usage or diagonal diagrid

V. VARYING ANGLE

Three models Case I, Case II and Case III as shown in figure is considered for 80 storey diagrid structures. Case I is a uniform angle case, Case II is a angle variation along the width and last Case III is a combination of along height and along width angle variation diagrid structures.

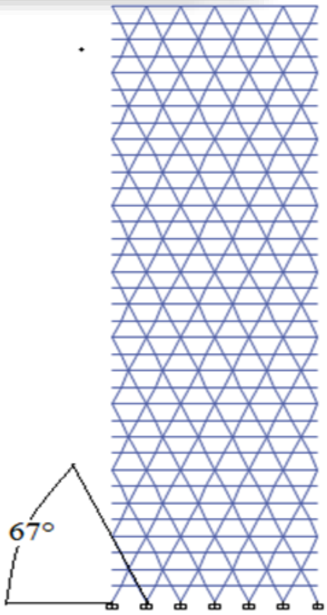

Fig. 5(a): Case I

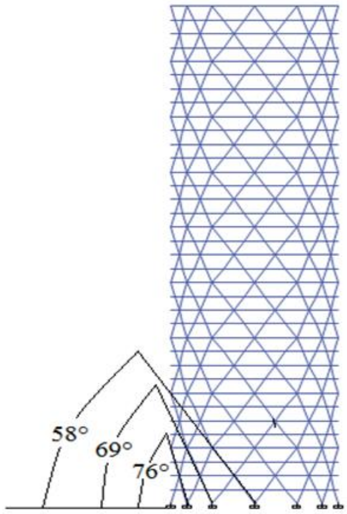

Fig. (b): Case II

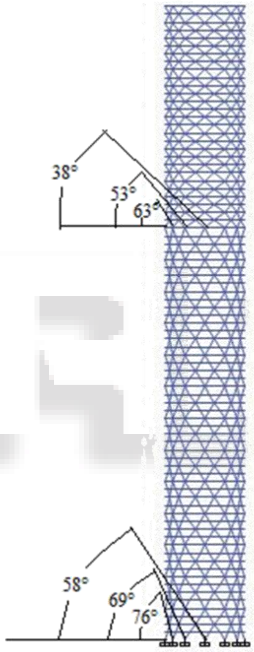

Fig. 6:

VI. RESULT

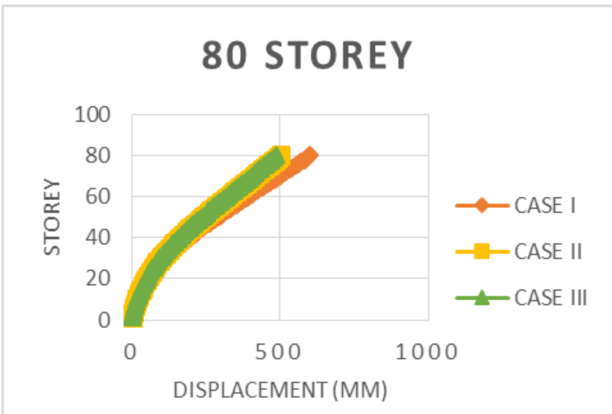

Fig. 7: Displacement comparison

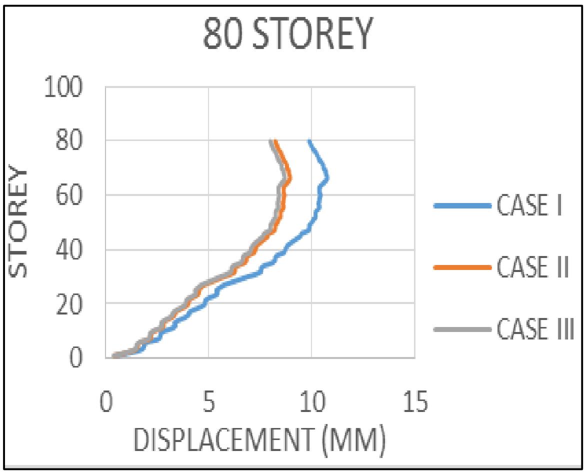

Fig. 8: Inter-storey drift comparison

STOREY	DIAGRID STOREY	SECTION SIZES
80	1-16	650 mm pipe section with 50 mm tk
	17-28	550 mm pipe section with 50 mm tk
	29-44	550 mm pipe section with 25 mm tk
	45-64	450 mm pipe section with 25 mm tk
	65-80	275 mm pipe section with 25 mm tk

Table 1: Diagonal Section Sizes

BEAMS	SECTION SIZES
PERIPHERIAL	ISMB 550
OTHER	ISWB 600 WITH 25 MM COVER PLATE ON TOP AND BOTTOM

Table 2: Beam Section

VII. CONCLUSION

As the diagrid angle become steeper towards the corner, it's lateral stiffness increases and corresponding lateral displacement decreases. As the angle become steeper towards corner the web diagonal also take part in resisting bending with flange diagonal. Diagrid structures with combination of horizontal angle and vertical angle variation shows lesser displacement compare to other cases.

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