Analysis of a High Rise Building Frame Determining Lateral Force Resistivity of Diagrid and Infill Frame

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Abstract-As most of the northern zone of India is situated in mountainous region, there is a lack of plain surface. (India is number two in population in the world therefore to settle this population there is a high demand of high rise structure). But in areas where lateral forces are very high therefore high rise structures are to be built resisting these lateral forces, the primary target of this study is to decide the effect of seismic forces on the high rise structures. Considering Steel diagrid or infill wall frame at the outer periphery of structure to resist lateral forces, considering seismic zone III with soft type soil conditions. Comparative study have been made on a unsymmetrical (Medical College plan) of G+12 floors considering seismic zone as per I.S. 1893 part 1 2002. For analyzing and modeling purpose STAAD.Pro programming is utilized and study is done on the premise of maximum storey displacement, axial forces, shear forces, maximum bending and displacement and most importantly cost analysis of both the structure as per S.O.R. 2017. In this study we adopt 13 loading combination in each case as per Indian Standards and dimensions of column (450 mm x450 mm), beam (400 mm x300 mm) and diagrid (ISMB 250) in all the cases.

Keywords: Diagrid, Structure analysis, Cost Estimation, Infill, Staad.pro.

I. INTRODUCTION

The word diagrid is a blending of the words diagonal and grid and refers to a structural system tat is single thickness in nature and grains its structural integrity through the use of triangulation. Diagrid systems can be planar, crystalline or take on multiple curvatures. Diagrid structures often use crystalline forms or curvature to increase their stiffness. This differentiates a diagrid from any of the three dimensional triangulated systems such as space frames, space trusses or geodesic structures, although it will be shown that some of the developments of diagrid structures have been derived from the details of these three dimensional systems. Whereas Masonry infill walls are widely used as partitions all over the world. Proofs are that uninterrupted infill masonry walls can reduce the vulnerability of the reinforced concrete structure. Frequently masonry walls are not considered in the design process because they are supposed to act as non-structural members or elements. Separately the infill walls are stiff and brittle but the frame is relatively flexible and ductile. The composite action of beam-column and infill walls provides additional strength and stiffness.

(a) diagrid

(b) Infill

Fig 1: Lateral Load Resisting Members

The present study attempts to estimate typical variations in magnification factor of a high rise building accounting for

the variability of lateral forces due to earthquake prone zone and modulus of elasticity of diagrid system frame comparing to Infill wall frame as both are lateral force resistive members. So that it can help designers facing trouble with heavy designs for a structure of High rise building, with the given material properties, geometry and loadings in particular.

II. LITERATURE REVIEW

Ravi K Revankar et.al. (2014) analyzed a G+10storey structure which consist of diagrid members, the geometry of structure consider in his study was 27 X 27 m in lateral dimensions and 48 m in height consist of 12 storey considering 4m each storey height. Modelled and analysed the structure using analysis tool SAP2000, considering dead, live and seismic loads as per Indian Standards and conducted non linear analysis (pushover analysis), designed the structure as per specifications, and concluded that structure with diagrid are more stable and resistable during collapse and found more durable to counteract forces in terms of displacement.

Kiran Kamath et. al. (2015) performed a comparative study on a circular plan with different angels of diagrid are considered as 64.00°, 72.00°, 76.30° and 90.00°. the geometry of circular plan is G+36 storey tall structure with 3.6 m each floor height and 36 m diameter of lateral dimensions are provided, considering wind load as per 875 part3 and seismic zone III as per 1893 part-1. Compared the structure in terms of base shear, top storey displacement, concluded that As the angle of diagrid increases, axial rigidity of the diagonal columns decreases, time period is minimum for 72o whereas top storey displacement is minimum for angle of 64.0°.

Moon et al., (2007) studied the behaviour of diagrid structure square in plan. Size of the plan is 36m x 36m. Braced core is also provided. Shear lag effect is compared between diagrid and tubular structure. They concluded that for a diagrid structure square in plan, the optimal angle lies between 65° to 75°. They also suggested member sizing methodology for preliminary design of diagrid structure so that structural and architectural decisions can be made at an early stage.

HarshitaTripathiet. al. (2016) Deteremined the effect of dynamic analysis on tall structures of different storey G+24, G+36 and G+ 48, with same dimesions in length and width directions as 36 m x 36 m. and work is done on csiEtab, an analyzing and designing tool with considering lateral forces both seismic as per 1893 part-1 and wind forces as per 875 part-3 and conluded that storey displacement and storey drift values are within the permissible limit and stiffness to the diagrid structural system which reflects the less top storey displacement.

III. METHODOLOGY

Steps to be follow are as follows:

- Modelling in staad of building geometry and properties.
- Assigning of seismic load and soil condition as per 1893-part-I.
- Analysing of building frame to counteract errors and warnings.
- Comparing results in terms of forces and cost and plotting graphs using M.S. Excel.
- Concluding results of study to determine variations in both the cases.

Table 1: Geometric Property

Type of structure	Girls hostel (G+4)
Plan dimensions	54.13 m × 43.72 m
Total height of building	38.5 m
Height of each storey	3.0m
Depth of foundation	2.5m
Bay width in longitudinal direction	54.13 m
Bay width in transverse direction	43.72 m
Size of beams	230 mm X 400 mm
Size of columns	450 mm X 450 mm
Thickness of slab	125 mm
Thickness of walls	115 mm
Seismic zone	III
Soil condition	Soft (type III)
Response reduction factor	5
Importance factor	1.5
Floor finishes	1 kN/m^2
Live load at roof level	1.5 kN/m^2
Live load at all floors	3 kN/m^2
Grade of Concrete	M25
Grade of Steel	Fe 415
Density of Concrete	25 kN/m^3
Density of brick masonry	20 kN/m^3
Design philosophy	Limit state method conforming to IS 456-2000

IV. RESULTS & ANALYSIS

Axial Force kN:

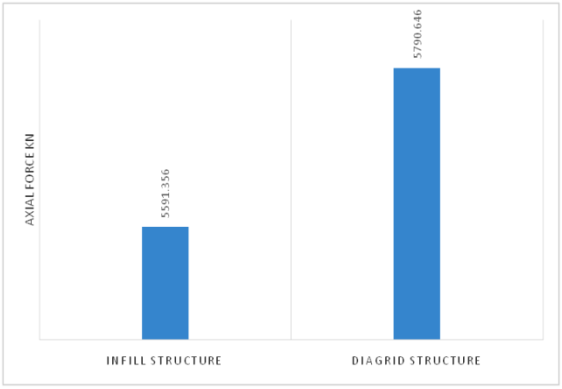

Fig 2: Axial Force

Shear Force kN:

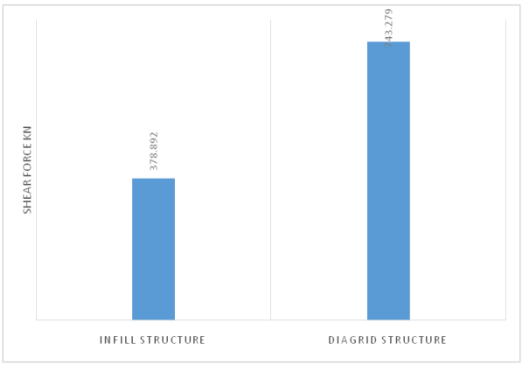

Fig 3: Axial force

Bending Moment KN-m:

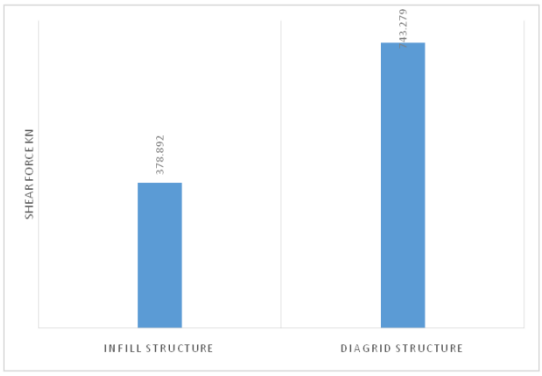

Fig 4: Bending Moment

Cost Estimation:

Table 2: Concrete estimation

Quantity of Concrete in cum.	
INFILL FRAME	FRAME WITH DIAGRIDS
301.7	271.8

As shown in Table above amount of concrete in Infill frame is comparatively higher than Diagrid frame as outer R.C.C. columns are removed in diagrid frame. This results in reduction of cost of construction

Table 3: Reinforcement estimation

Quantity of Concrete in cum.	
INFILL FRAME	FRAME WITH DIAGRIDS
301.7	271.8

As shown in Table above it is clearly determined that as outer column are removed by diagrid system as well as increase in stability of the structure it manages bending moment properly thus reinforcement requirement including steel for diagrid is comparatively less than Infill frame.

V. CONCLUSION

From the present study it is observed that In Comparison of Diagrid and Infill wall case lateral load resistive members structure is Diagrid one as well in reducing moment, storey displacement, stiffnnes& drift also ecocnomical in designing.

In terms of Axial force, Shear force & Bending moment:

Due to Absence of outer column in diagrid case there is an increamentin Axialnad shear force whereas due to proper load distribution bending moment is less In diagrid case.

In terms of Concrete:

As bending moment is comparatively less in diagrid structure thus Concrete requirement is low.

In terms of Reinforcement:

As per the Ast requirement is less in diagrid this can be stated as a economical section.

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