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Cost Analysis of a Composite Diagrid Structure Frame with Bare Frame under Dynamic Loading

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ABSTRACT

As now days a huge requirement of tall structure is needed due to increasing population in India, As India is a developing country which has moderate economy therefore cost of project plays a vital role in acceptance of technology and its application. In this paper, the author has compared the cost of construction of a high-rise building with and without diagrids.
Authors have analyses a G+11 storey building in different seismic zones with different types of soil using software Staad.pro V8i. Total eight cases were modelled and designed for comparison. At the end concluded that introduction of Steel diagrid members decreases the cost of same building. It was found that diagrid structure is also capable of reducing the effect of dynamic loading on building.

Keywords : G+11 storey, Staad.pro V8i, Steel diagrid

I. INTRODUCTION

The structural component of a project is probably the most straight forward element to estimate. It is usually the most advanced during the design stages which paints the estimators a good 'picture' of the structural design even at the early stages. The main structural members that are defined early and are easily quantified but, more often, the structural connections are developed at later stages so estimators tend to assume the cost for the connections as percentage of the total concrete weight of the project cost. This approach is widely accepted when estimating new-build structures, since the structural connection costs are only a fraction of the overall cost and can easily be covered as an allowance, based on the estimator's judgment.

The main intention of this technical paper is to provide the reader a general understanding of cost analysis of a high-rise building using diagrids to enhance its lateral stability but also to check its cost of construction and understanding the potential impacts to a structural estimate. This will help an estimator weigh the cost impact of the structural connections so the allowances applied are rather more 'educated' than just a guess.

Kyoung (2011) studied the behaviour of diagrid structure with floor twisting at different rates. He found that twisted tower perform better than straight

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tower under across wind loading. Optimal angle of twist is though not established.

Montuori et al., (2014) varied the diagrid density and angle of diagonal columns along the height for square plan. The models are compared in terms of structural weight and performances. The efficiency potentials of different models are discussed.

Giulia Milana et. al. (2015) analyzed a G+40 tall structure with Different diagrid structures were considered, namely, three geometric configurations with inclination of diagonal members of 42°, 60°and 75°, and geometry considered is 36 x 36 m in lateral dimensions, and 160 m tall structure with circular shape. In this work the consider seismic Zone IV and did pushover analysis and concluded that providing diagrid is not only making economical building but also much stable in terms of safety.

Harshita Tripathi et. 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 csi Etab, 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.

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 72° whereas top storey displacement is minimum for angle of 64.0°.

OBJECTIVES:

1. To study the concept of diagrid structural system on a high rise structure.
2. To determine the optimum configuration for buildings using STAAD.pro software.
3. To determine the variation in forces due to diagrid structure under seismic forces.
4. Comparison of results in terms of Max story drift, max story displacement, base shear in seismic case, time period.

Table 1. Geometry & load consideration

Type of structure	**Residential building (G+11)**
Plan dimension	20 m X 20 m
Total height of building	33 m
Hight of each storey	3.0 m
Diagrid section	Steel section
Seismic zone	III & V
Dead load	875-part-1
Live load	875-part-2

II. METHODOLOGY

STEP-1: FIRST STRUCTURE IS MODELLED WITH AND WITHOUT DIAGRID ELEMENT IN STAAD WITH SAME PLAN AREA.

STEP-2: IN STEP 2 APPLICATION OF SEISMIC FORCES AS PER INDIAN STANDARD 1893-PART-1 IS APPLIED ON THE STRUCTURES.

STEP-3: IN THIS STEP BOTH THE STRUCTURES COPMPARED TO DETERMINE THE USE OF IMPLEMENTATION OF DIAGRID.

STEP-4: BY THE USE MS EXCEL WE PLOTTED THE RESULT IN THE FORM OF GRAPH.

STRUCTURAL PLAN :- In fig no. 1 there is structural plan view of all the models having plan of 20m x 20m. In this plan R1 notation is for column and R2 notation is for beam. The structure is considered as a residential building so live load on the building is 2 KN/m^2. A member load of 11 KN/m is considered on all the beams for the wall load considering the wall to be made of light weight bricks. The end condition for diagrid is assumed as fixed. The support conditions are assumed as fixed. The design of member is carried out on the basis of IS-456-2000. The design earthquake load is computed based on the bases of IS 1893-2002 having zone factor 0.16, 0.35 soil type hard and soft, importance factor 1, Response Reduction 5

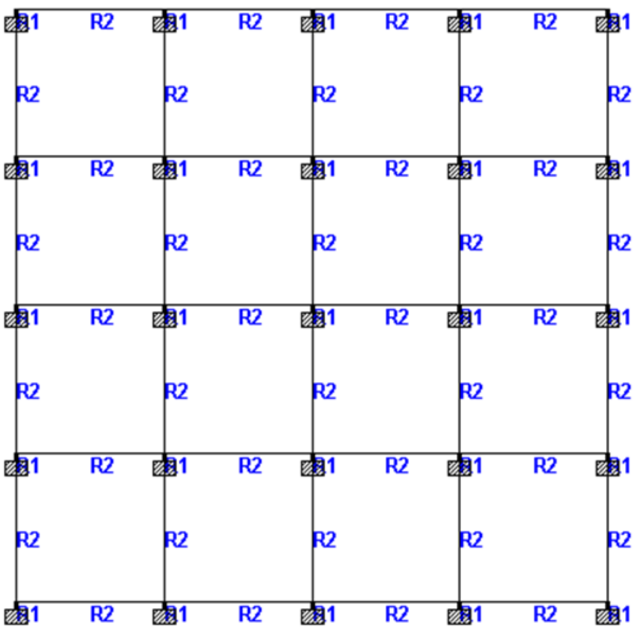


Fig 1. Structural Plan

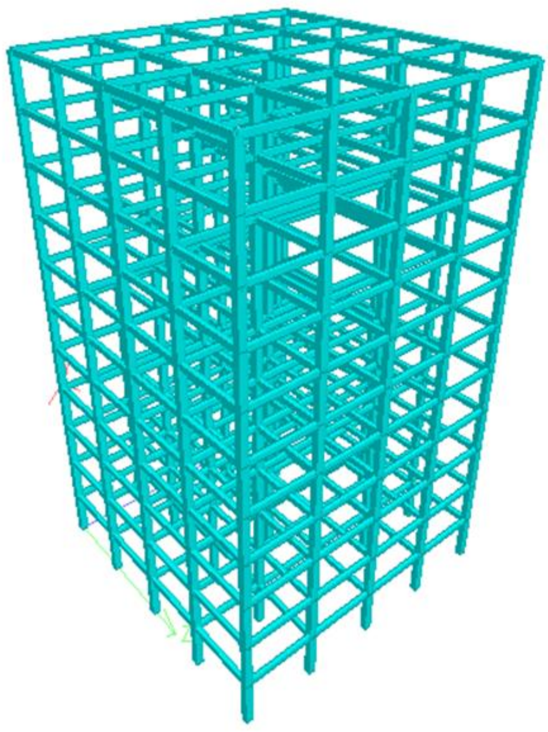


Fig 2. Bare Frame

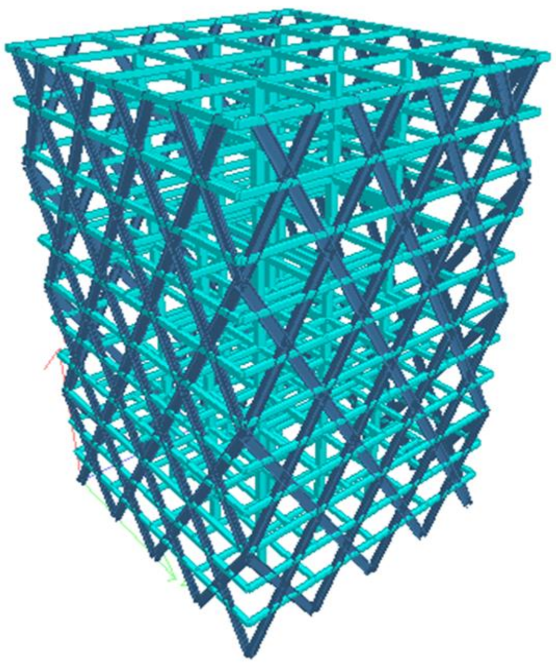
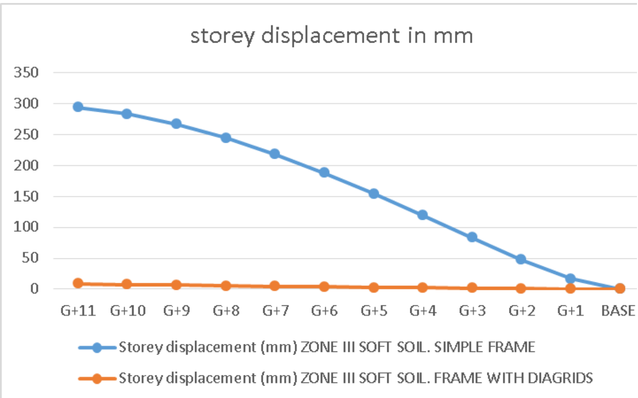
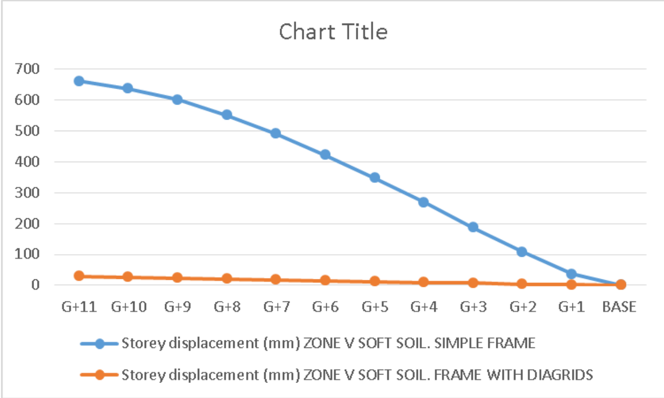


Fig 2. Diagrid Frame

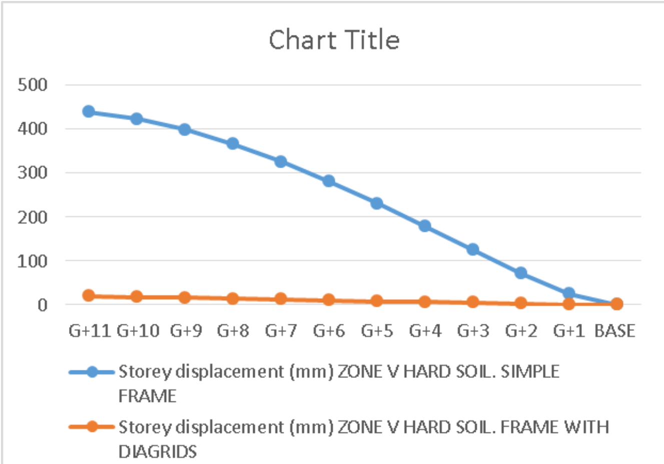
III. RESULTS & ANALYSIS

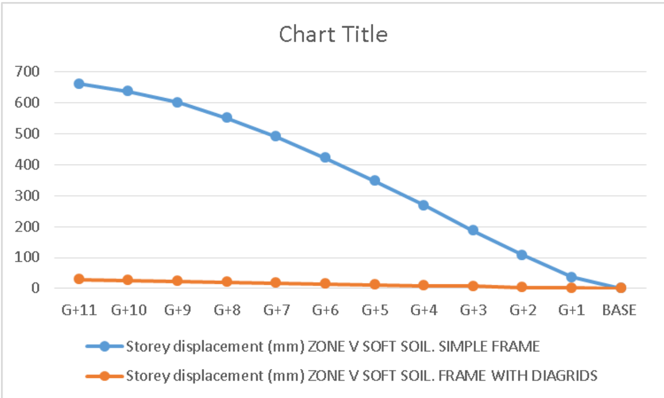
Storey displacement in seismic zone III & V with soft soil:-





Storey displacement in seismic zone III & V with hard soil :-

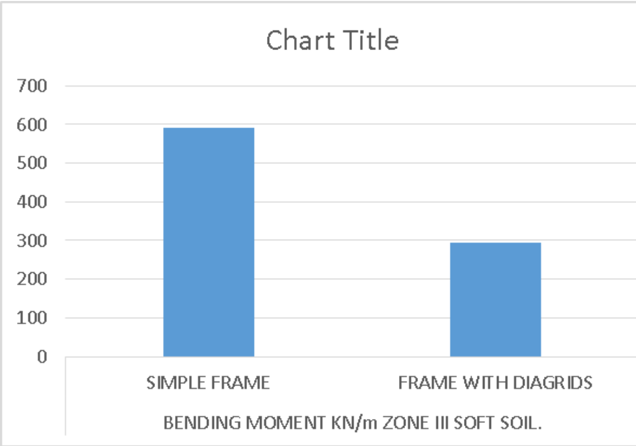


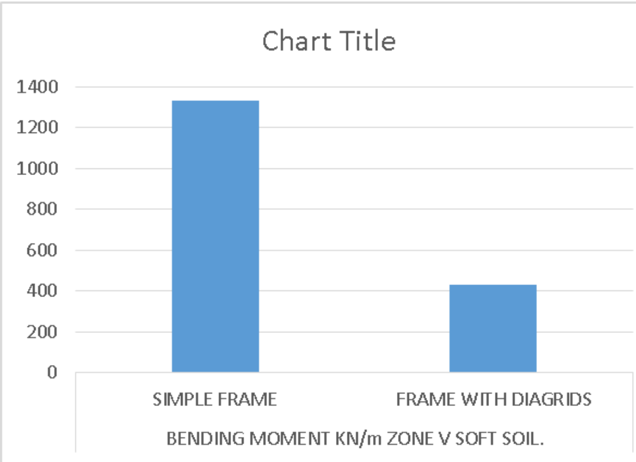


Here results shows that displacement is gradually decreases with the use of diagrid.

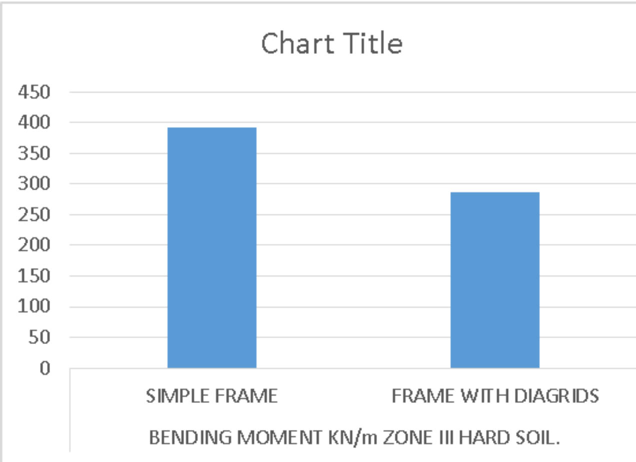
BENDING MOMENT:

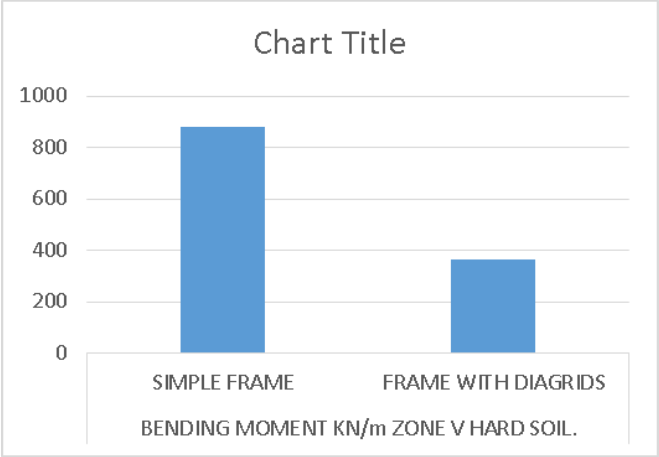
Max B.M. In Zone III & V with soft soil :-





Max B.M. In Zone III & V with hard soil

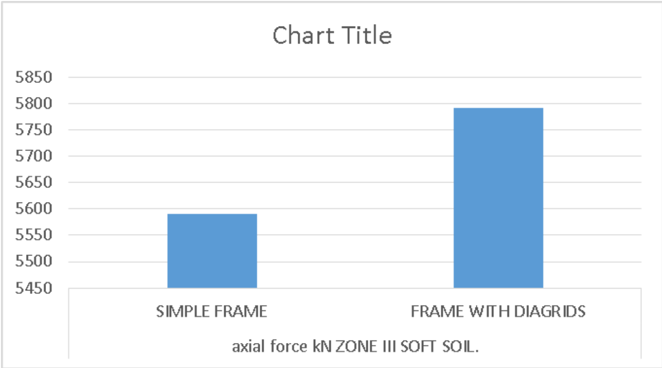


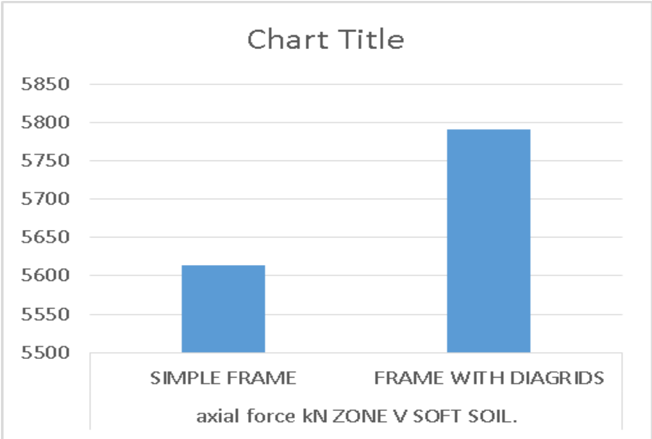


Here results shows that bending moment is decreasing in diagrid structure which means less reinforcement is required.

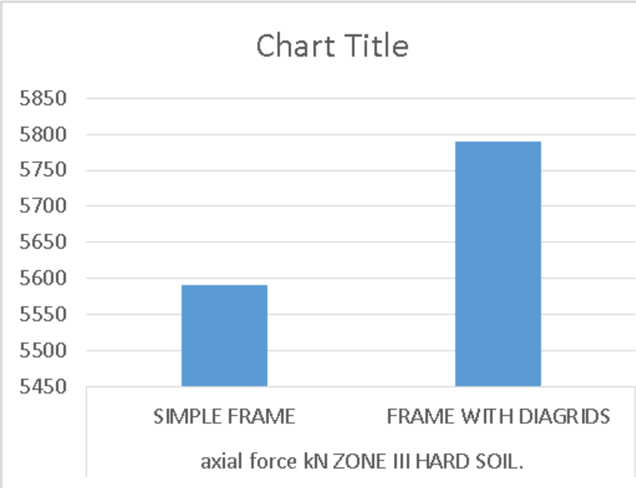
AXIAL FORCE:-

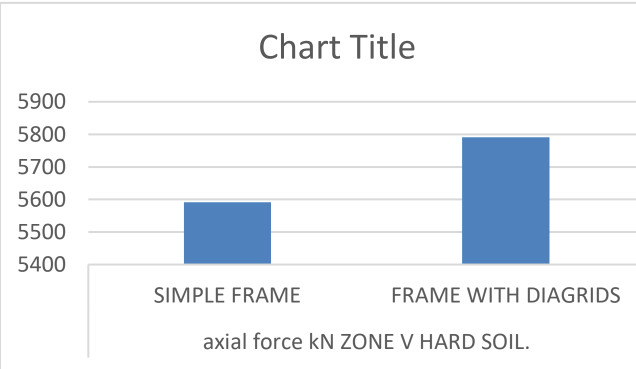
Axial force In Zone III & V with soft soil:-





Axial force In Zone III & V with hard soil:-



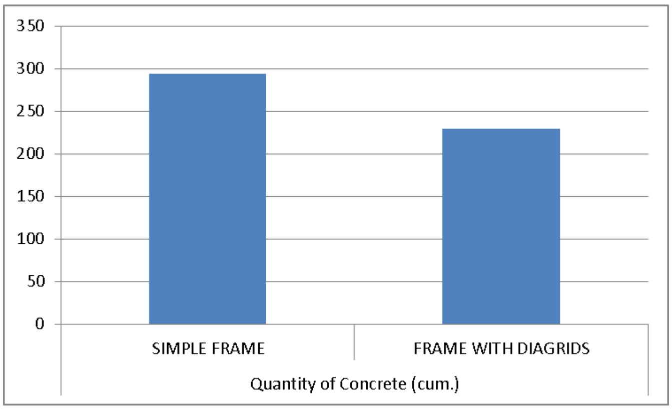


From the above four chart it is evident that the axial force is same in all the cases and it is increase with the same amount of 3.44% in the diagrid structure of all the cases in comparison with the bare frame which is in the permissible limit.

COST ANALYSIS:-

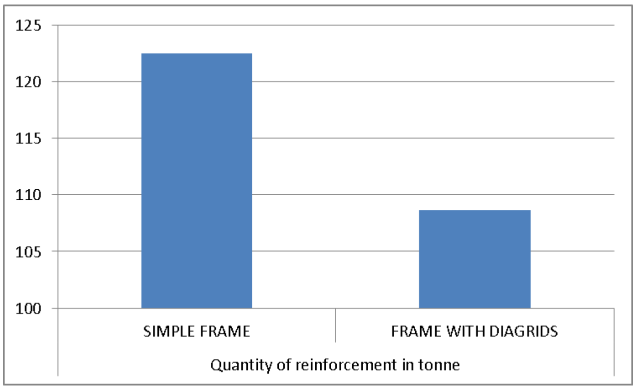
On the basis of above result and analysis calculate and compare the cost between the bare frame and the frame with diagrids and the results are shown in below charts.

Quantity of Concrete (cum.)	
SIMPLE FRAME	FRAME WITH DIAGRIDS
294.2	229.3



As shown in above chart amount of concrete in simple frame will be comparatively higher than diagrid frame as outer R.C.C. columns are removed in diagrid frame. There is a decreasing of 22.05 % of concrete in diagrid frames. This results in reduction of cost of construction.

Quantity of reinforcement in tonne	
SIMPLE FRAME	FRAME WITH DIAGRIDS
122.49	108.67



As shown in figure above it is clearly determined that as outer column are removed by diagrid system it manages bending moment properly that reinforcement requirement including steel for diagrid is comparatively less than bare frame. There is a reduction of reinforcement of 11.28% in diagrid frames.

IV. CONCLUSION

In this study, it is shown that by proving diagonal columns at the outer periphery of the structures, the diagrid structure is more effectively resist the lateral load in comparison with the bare frame structure.

By providing concept of diagonal column at the outer periphery of the structure the column at the interior part of the structure is used for resisting very small gravity load and a little amount of lateral load whereas in bare frame structure gravity load and lateral load are transferred by the both interior as well as exterior column.

Due to this phenomenon of providing column at outer periphery of the structure there is huge reduction of concrete and reinforcement in the diagrid structure which makes it more economical than the bare frame structure.

The different points concluded from the above study

- Due to reduction of bending moment in diagrid structure requirement of reinforcement is also reduced. The overall reduction of reinforcement is about 11.28%.
- By providing the steel diagonal member in place of concrete member at the outer periphery of the structure consumption of concrete is reduce tremendously. The overall reduction of concrete is about 22.05%.

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