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Comparative Analysis between Diagrid and Normal Frame Structure with Contrasting Parameters.

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ABSTRACT:-
The diagrid system nowadays widely used for high rise buildings due to its structural efficiency. In present research work, steel diagrid structure at an outer portion of the building at 60 degrees having an inner core of R.C.C columns with R.C.C beam and the slab is analyzed and compared with a conventional concrete building. The diagonal member of diagrid structure transferred the lateral loads by axial action compared to bending of vertical columns in the conventional building system. A regular eleven storey RCC building with plan size 16 m × 16 m located in seismic zone V & III is considered for analysis. STAAD.Pro software is used for modeling and analysis of structural. Seismic zone is considered as per IS 1893(Part 1): 2002. The Comparison between the diagrid and conventional building analysis results presented in terms of a node to node displacement, bending moment,story drift, shear forces, an area of reinforcement, and additionally the economical aspect.

Key words: soft story analysis, etabs, stadd.pro, SAP2000, time history analysis, response spectrum analysis, pushover analysis.

I. INTRODUCTION:-

Tall buildings emerged in the late nineteenth century in the U.S.A. They constituted a so- called "American Building Type," meaning that most important tall buildings were built in the U.S.A. Today, they are a worldwide architectural phenomenon. Many tall buildings are built worldwide, especially in Asian countries, such as China, Korea, Japan, and Malaysia. Based on data available and published in the 1980s, about 49% of the world's tall buildings were located in North America. The distribution of tall buildings has changed radically with Asia now having the largest share with 32%, and North America's having 24%. This data demonstrates the rapid growth of tall building construction in Asian countries during this period while North American construction has slowed. In fact, eight of the top ten tall buildings are now in Asia and only two of them namely- the Sears Tower and the Empire State Building, are in North America. Generally, the function of tall buildings has been as commercial office buildings. Other usages, such as residential, mixed- use, and hotel tower developments have since rapidly increased. Tall building development involves various complex factors such as economics, aesthetics look, technology, municipal regulations, and politics. Among these, economics has been the primary governing factor. For a very tall building, its structural design is generally governed by its lateral stiffness. Comparing with conventional orthogonal structures for tall buildings such as framed tubes, diagrid structures carry lateral wind loads much more efficiently by their diagonal member's axial action. Today's architects have been losing interest in aesthetic expressions provided by conventional braced tubes composed of orthogonal members and large diagonal members because they always seek something new and different. A Diagrid structure provides great structural efficiency without vertical columns have also opened new aesthetic potential for tall building architecture. Diagrid has a good appearance and it is easily recognized. The configuration and efficiency of a diagrid system reduces the number of structural element required on the façade of the buildings, therefore less obstruction to the outside view. The structural efficiency of diagrid system also helps in avoiding interior and corner columns, and therefore allowing significant flexibility with the floor plan. "Diagrid" system around perimeter saves approximately 20 percent of the structural

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steel weight when compared to a conventional moment- frame structure. The diagonal members in diagrid structural systems carry gravity loads as well as lateral forces due to their triangulated configuration. Diagrid can save upto 20% to 30% the amount of structural steel in a high- rise-building.

Study Objective:-

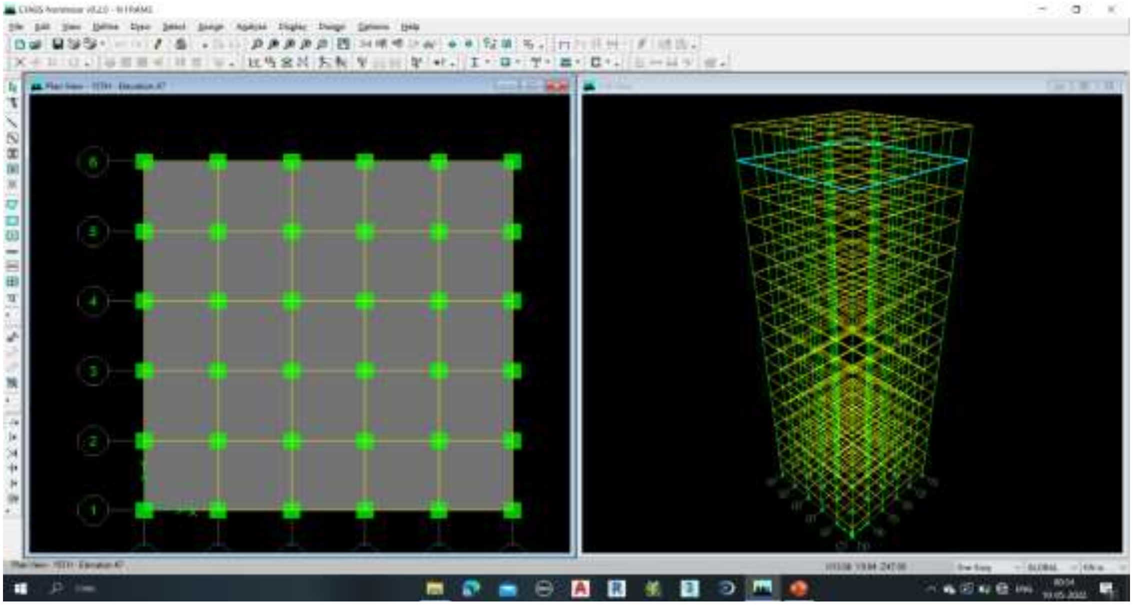
- To determine the optimum section required for stability of buildings.
- To determine the behavior of composite diagrid structural system in a seismic condition.
- To determine the variation in forces due to diagrid structure under seismic forces.
- Comparison of results in terms of Max story drift, max story displacement, base shear in different load & seismic case, time period
- Comparison of cost between the bare frame and composite diagrid frame.

Utility of building	DIAGRID STRUCT	NORMAL FRAME STRUCT
No. of stories	12	12
Grade of concrete	M25	M25
Grade of reinforcing steel	HYSD Fe 500	HYSD Fe 500
Type of construction	RCC Framed structure	RCC Framed structure
Dimension of beam	-	-
Dimension of column	-	-
Thickness of slab	175mm	175mm
Thickness of wall (masonry)	230 mm	230 mm
Height of bottom story	3.0m	3.0m
Height of remaining story	3.0m	3.0m
Total building height	39m	39m
Live load	5 KN/m^2	5 KN/m^2
Dead load	2 KN/m^2	2 KN/m^2
Load of Masonry Wall	9 KN/m^2	9 KN/m^2
Load considered in building	Dead load, live Load, Wind load, Earthquake load	Dead load, live Load, Wind load, Earthquake load
Method of analysis	Seismic Analysis, Response spectrum method, time history analysis	Seismic Analysis, Response spectrum method, time history analysis

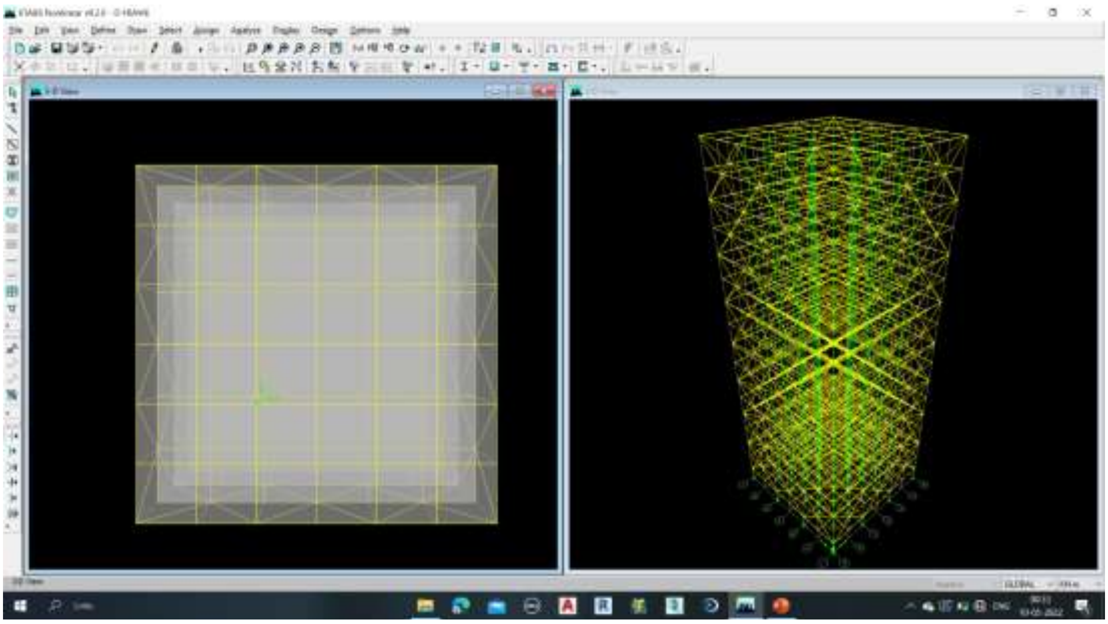
RCC design code	IS 456:2000	IS 456:2000
Steel design code	IS 800:2000	IS 800:2000
Earthquake design code	IS 1893:2016 (PART 1)	IS 1893:2016 (PART 1)
Wind Design Code	IS 875 (Part 3) - 1987	IS 875 (Part 3) - 1987
Software used	Etabs v.9.2	Etabs v.9.2

MODEL USED

1) NORMAL FRAME STRUCTURE



2) DIAGRID STRUCTURE



II. METHODOLOGY:-

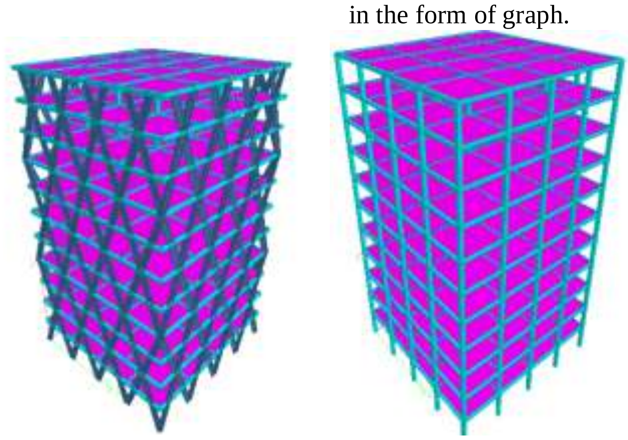
In this study comparison of diagrid and conventional building under various forces is done. Here same live load is applied in both the buildings for its behaviour and comparison. The framed buildings are subjected to vibrations because of earthquake and therefore seismic analysis is essential for these building frames. The fixed base system is analyzed by employing in both building frames in same seismic zone by means of Staad.Pro software. The response of both the building frames is studied for useful interpretation of results.

STEP-1: First structure is modelled with and without diagrid element in STAAD.PRO 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 compared to determine the use of implementation of diagrid.

STEP-4: By the use MS excel we plotted the result in the form of graph.



III. RESULTS & ANALYSIS:

STOREY DISPLACEMENT:-

Analyses of the frames are done having consideration of different zones (III & V) and keeping the soil conditions hard and soft. The sections are provided in frames are the minimum requirement of the frames to maintain the stability of the structures. From the analyses, it is evident that the bare frame having huge storey displacement. To maintain the displacement in permissible limit have to provide column and beam of heavy sizes. In the bare frame, the heaviest columns are provided in zone v with soft soil condition. While exterior columns of the bare frame are replaced by the steel diagrid, it is seen that the storey displacements are reduced tremendously even the provided sections of interior column and beams are of much smaller size than compared with the bare frame. It is also found that by providing the heavy size of interior column and beams in our composite diagrid frame the displacement is reduced to a much higher extent. By the use of smaller interior columns and beam the diagrid frame become more economical than the bare frame and by the use of steel sections it is required less handling of material and during execution, much less formwork is required which includes another factor to make the frame economical. The analysis also shows that the value of axial force, shear force, and bending moments are also. The different displacement results are shown in below figures.

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CHART 1:- ZONE III STOREY DISPLACEMENT IN SOFT SOIL

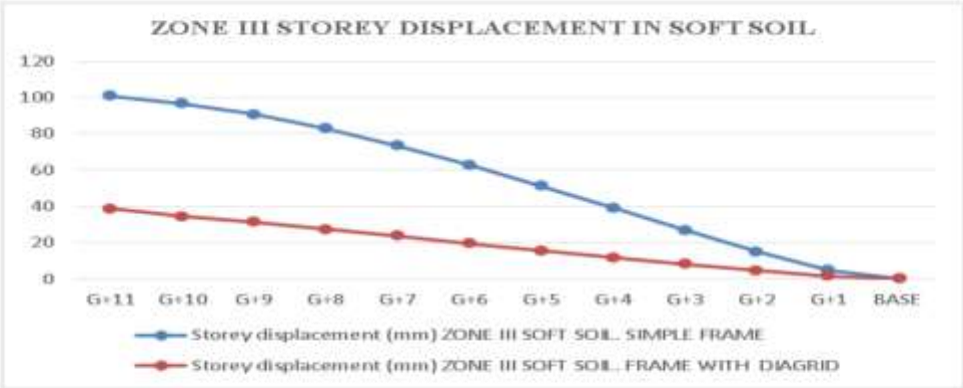
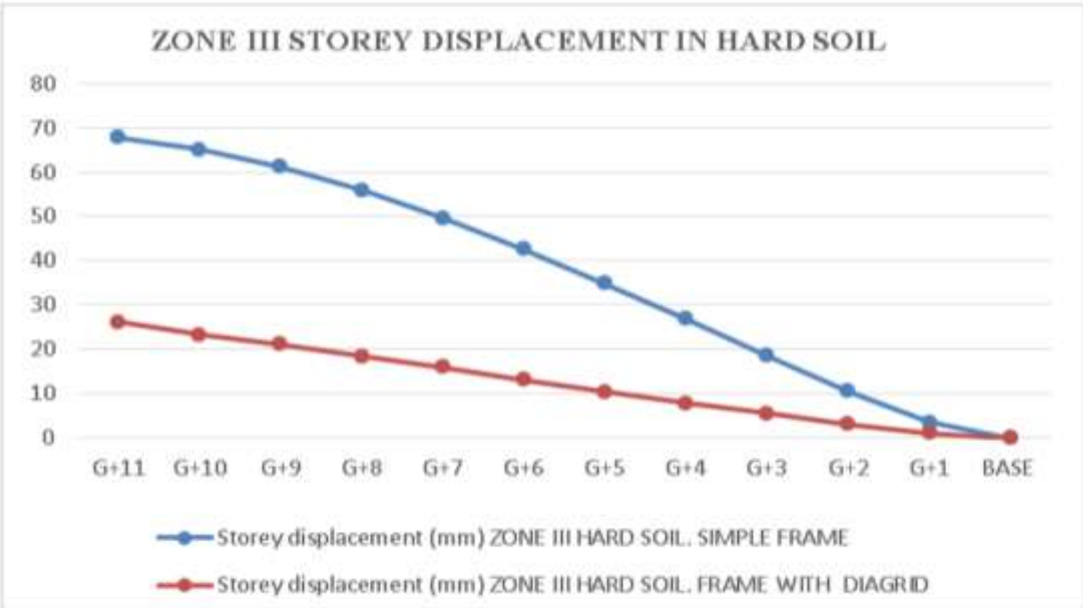
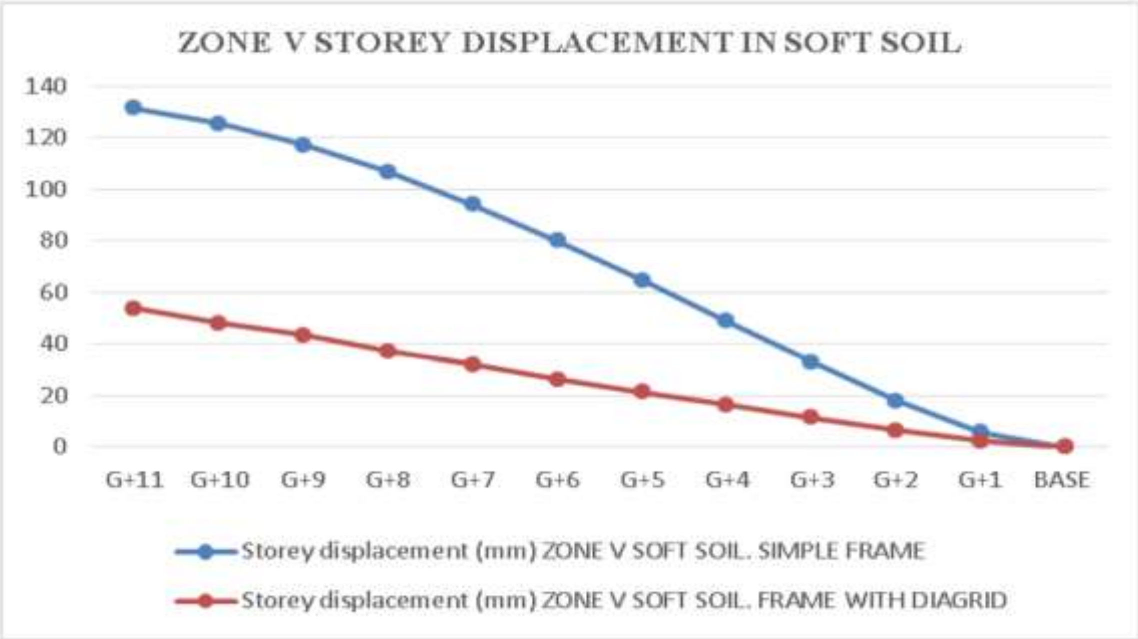


CHART 2 :- ZONE III STORY DISPLACEMENT IN HARD SOIL



ZONE V STOREY DISPLACEMENT IN SOFT SOIL



ZONE V STOREY DISPLACEMENT IN HARD SOIL

The above graph shows the comparative storey displacement in between bare frame and composite diagrid frame and it is evident from the graph that the story drift reduces in diagrid frame which means the diagrid frames are more stable with the bare frame for same environmental conditions.

BENDING MOMENT:-

CHART 1 :- MAX. BENDING MOMENT IN ZONE III SOFT SOIL

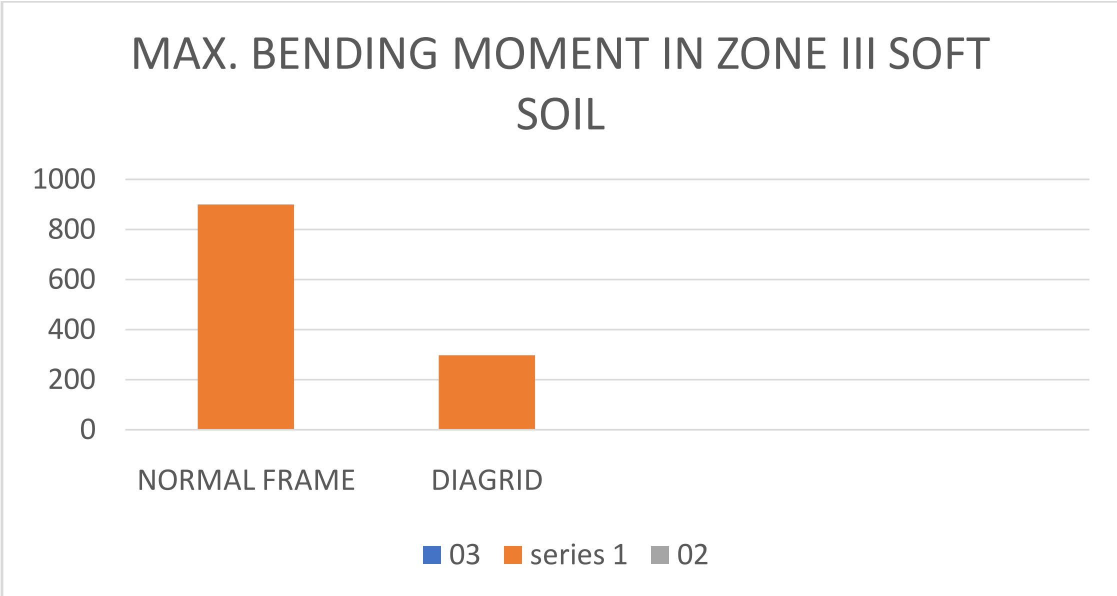


CHART 2:- MAX. BENDING MOMENT IN ZONE III HARD SOIL

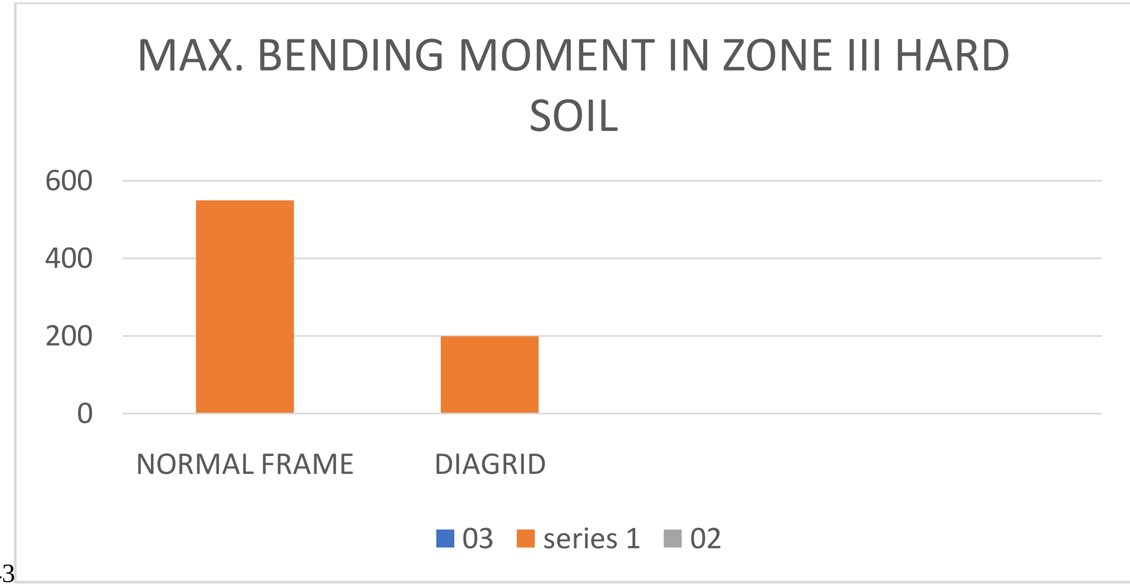


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CHART 3:- MAX BENDING MOMENT IN ZONE V SOFT SOIL

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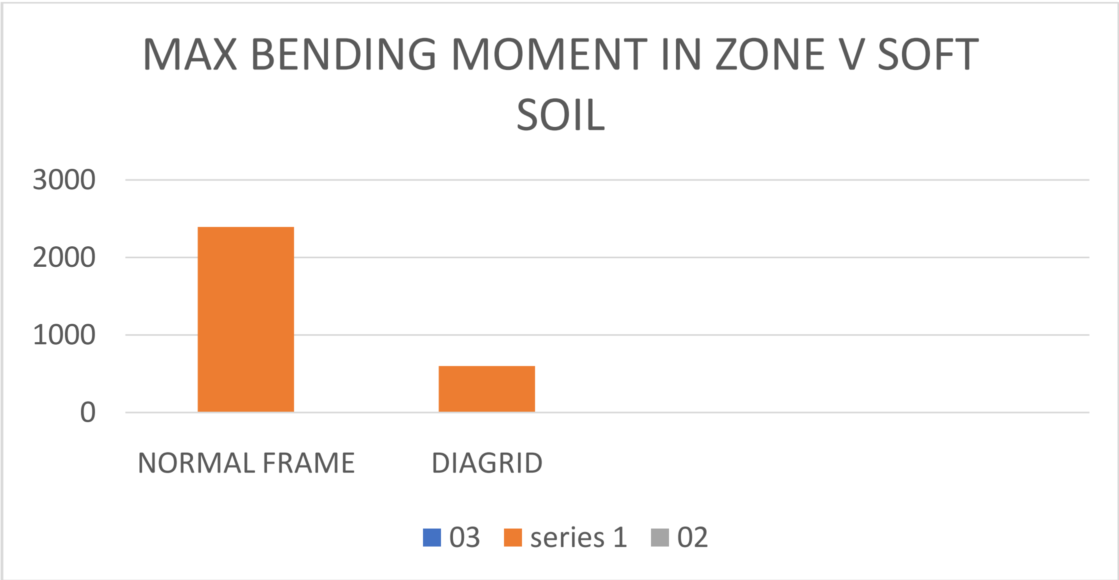
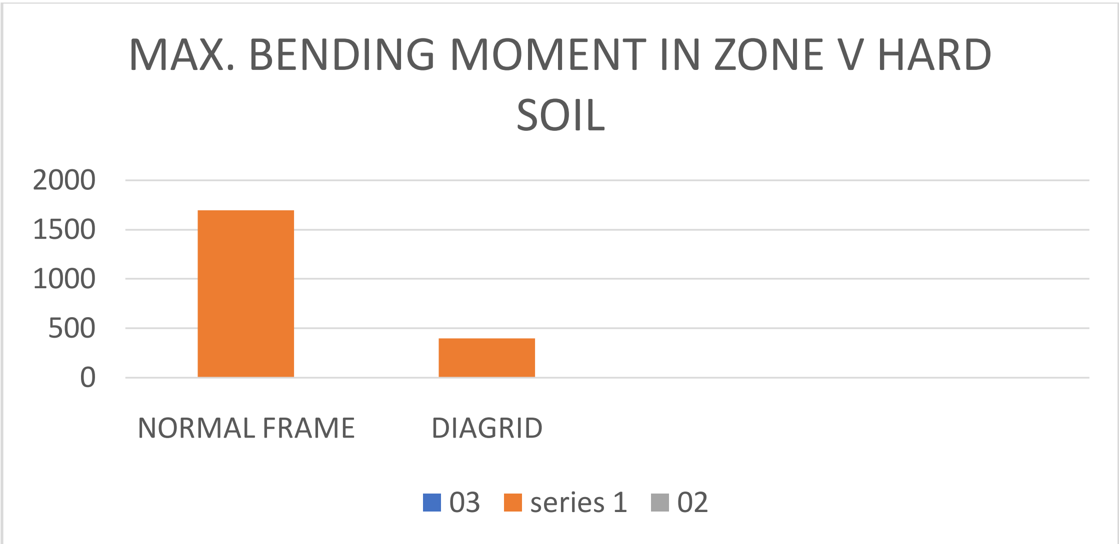


CHART 4:- MAX. BENDING MOMENT IN ZONE V HARD SOIL



The result shows that bending moment is decreasing in composite diagrid structure which means less reinforcement is required.

AXIAL FORCE:-

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CHART 1 :- AXILAL FORCE IN ZONE III SOFT SOIL

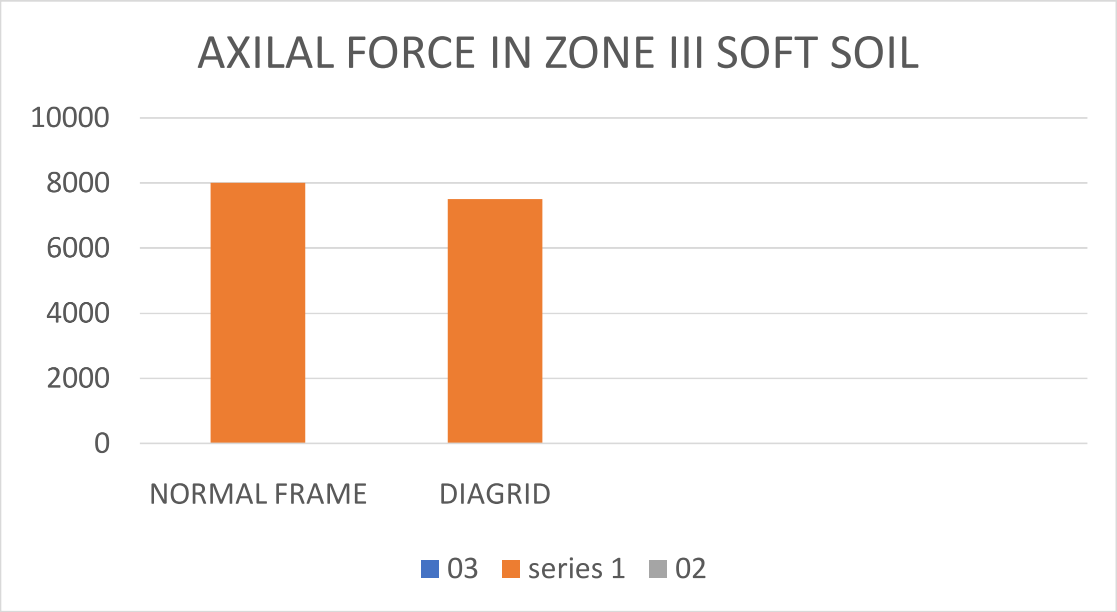

CHART 2 :-AXIAL FORCE IN ZONE III HARD SOIL

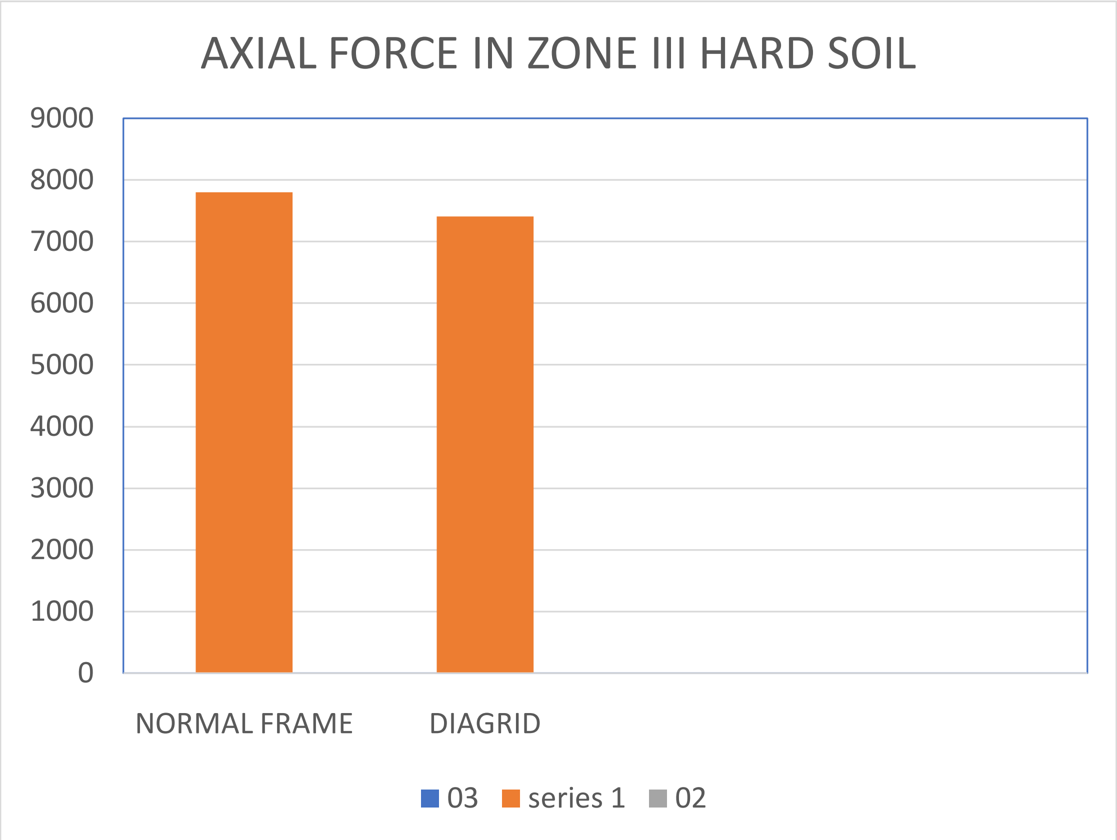

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CHART 3 :-AXIAL FORCE IN ZONE V SOFT SOIL

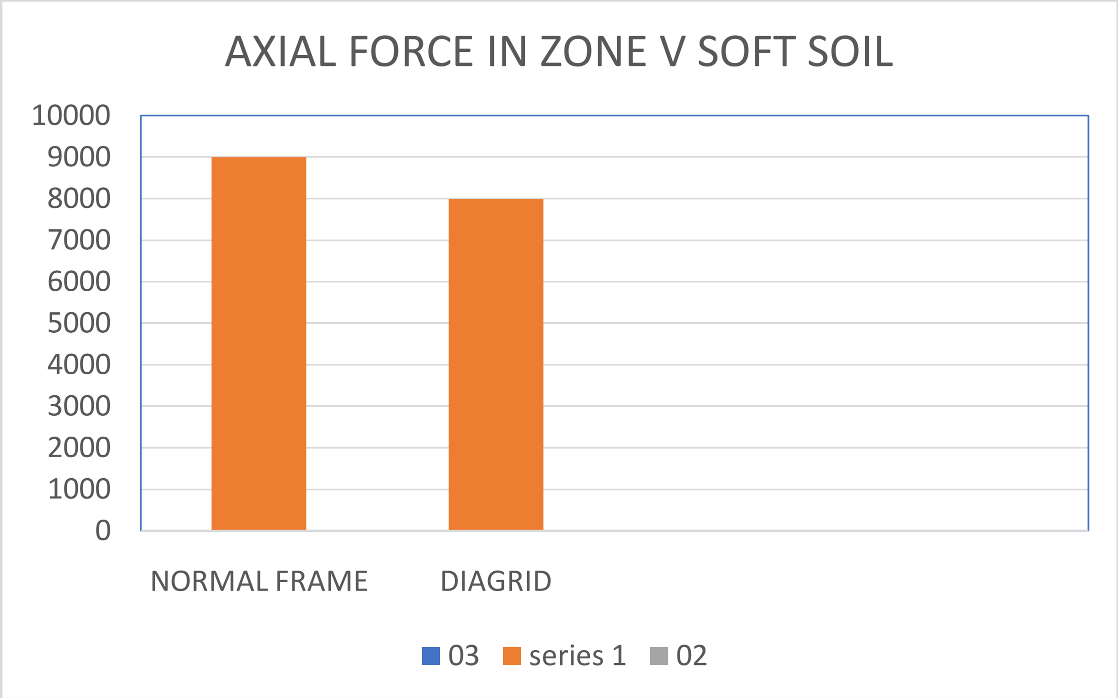
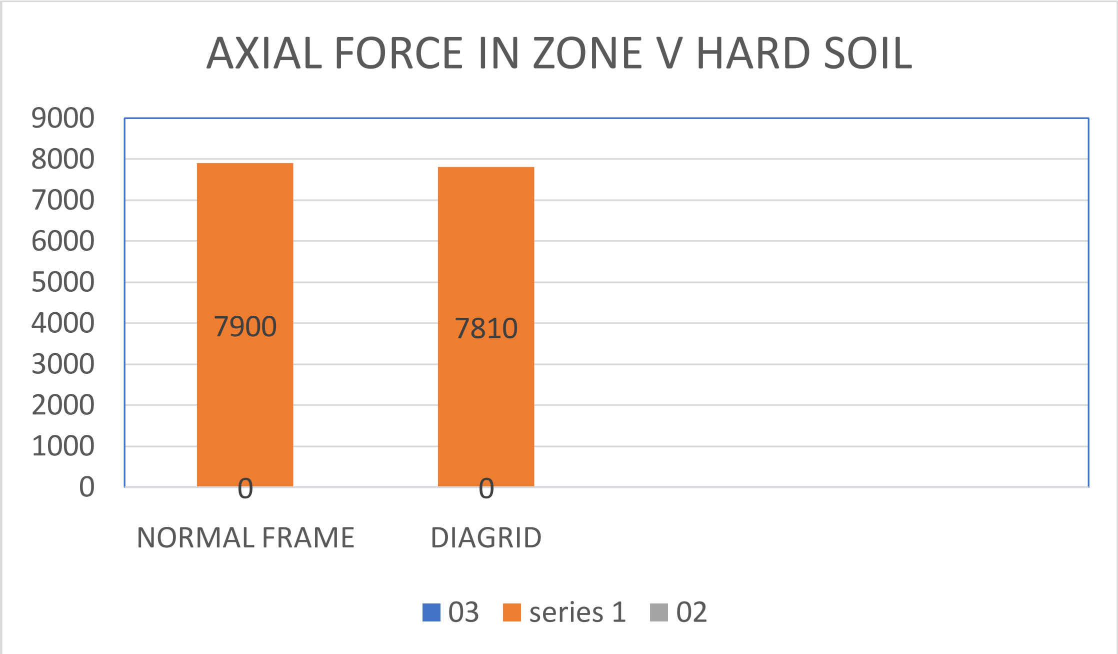


CHART 4 :- AXIAL FORCE IN ZONE V HARD SOIL



From the above four chart, it is evident that the axial force different in each case and it is less in zone V for composite diagrid frame as compared to the bare frame while in zone III axial force is more in composite diagrid frame as compared to the bare frame. The axial force increases by 6.30% in zone III with soft soil and increases with 5.30% in zone III hard soil.

SHEAR FORCE:-

CHART 1 :- SHEAR FORCE IN ZONE III SOFT SOIL

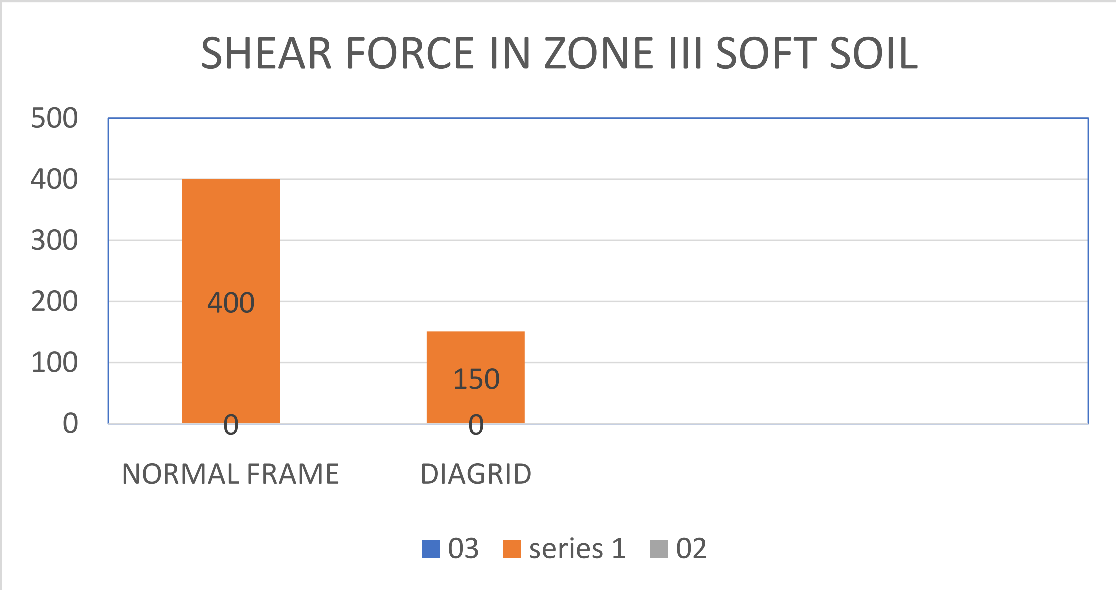


CHART 2:- SHEAR FORCE IN ZONE III HARD SOIL

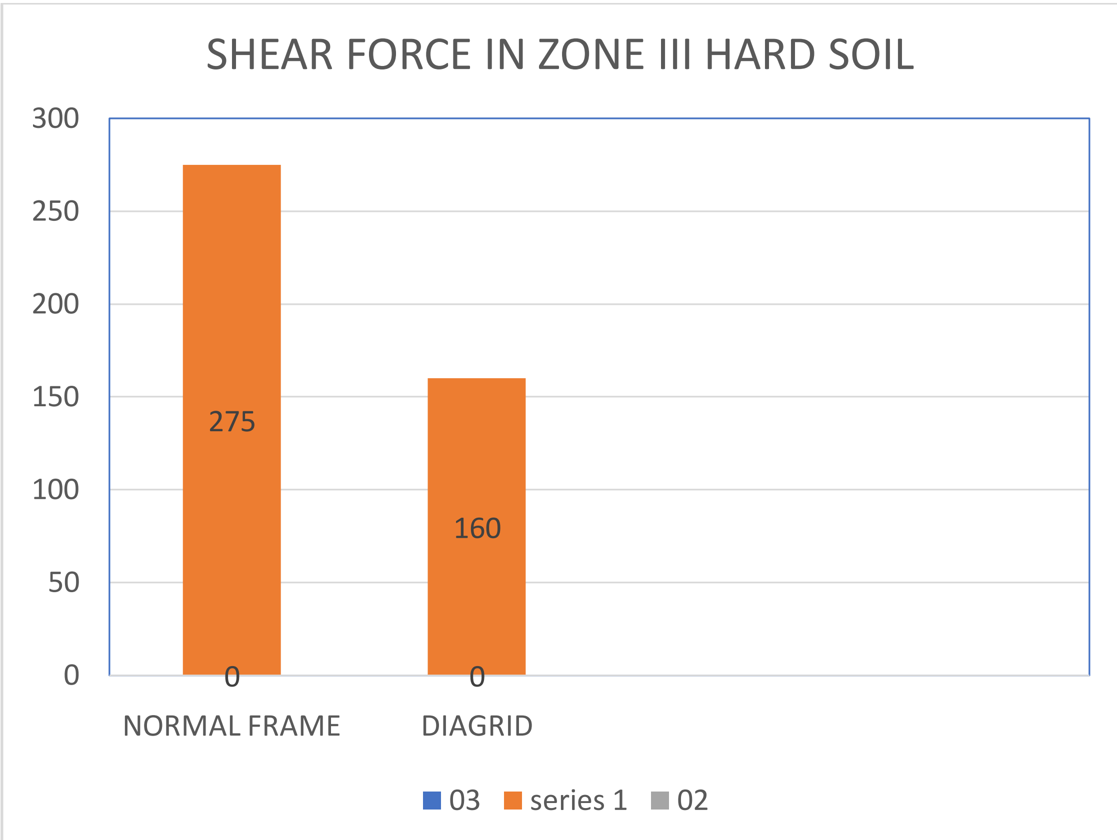


CHART 3:- SHEAR FORCE IN ZONE V SOFT SOIL

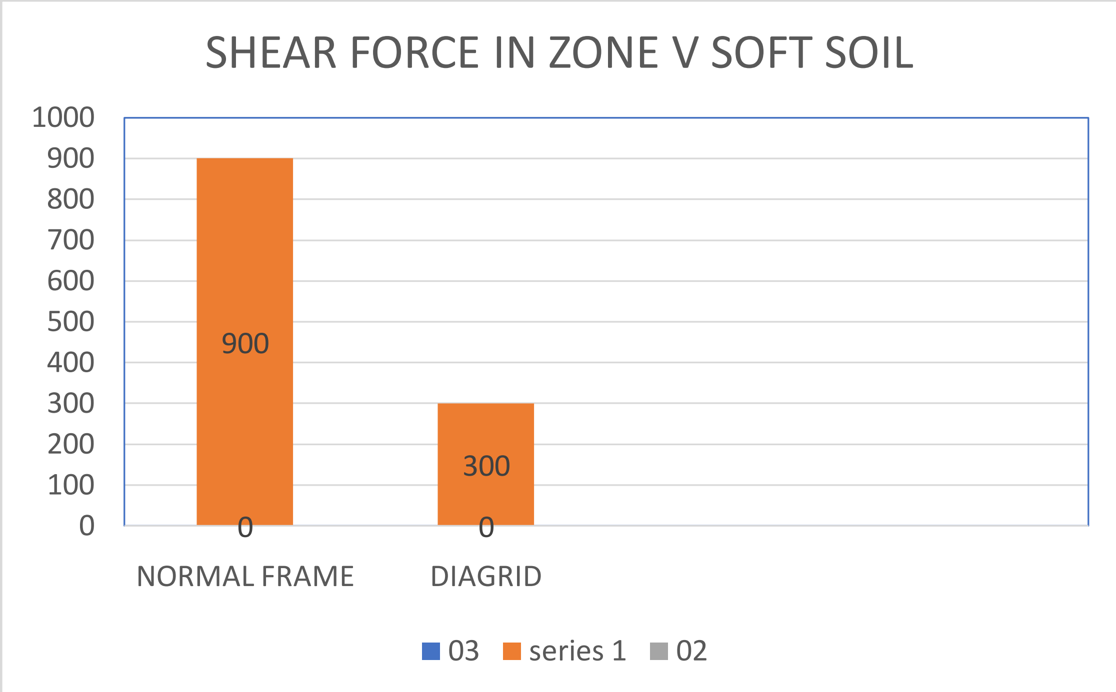
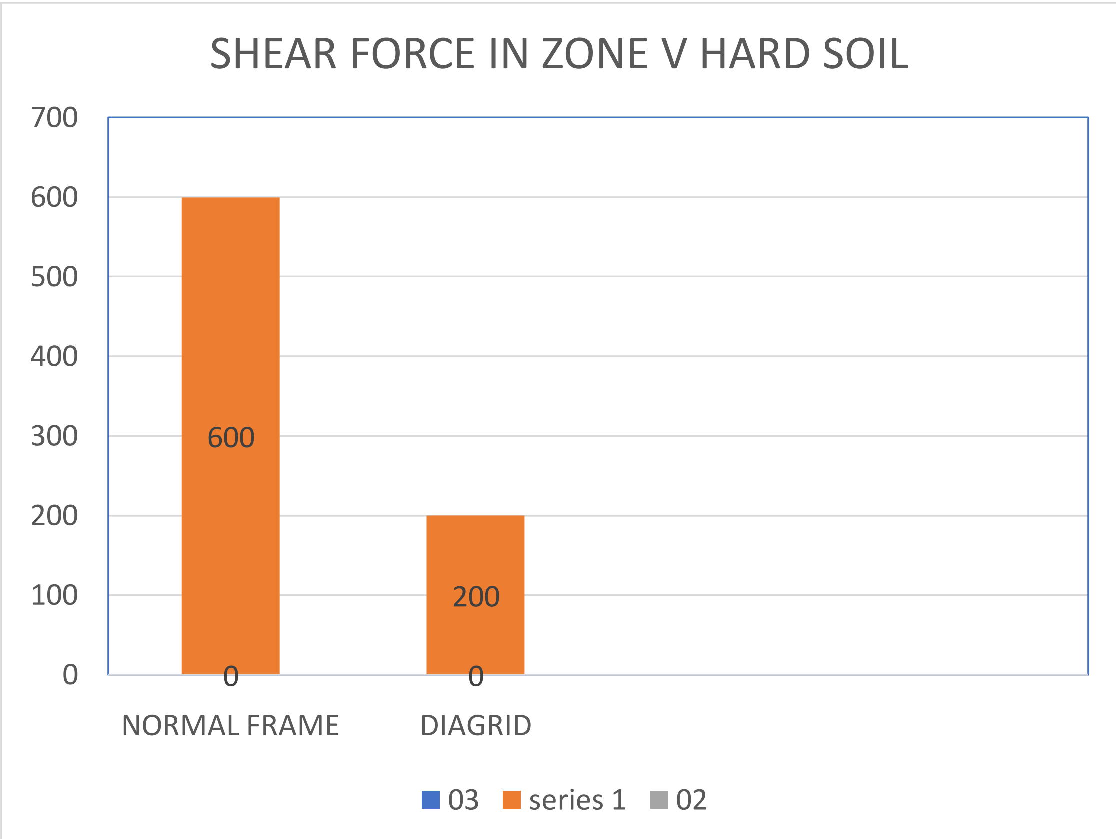


CHART 4 :- SHEAR FORCE IN ZONE V HARD SOIL



It is evident from the above four chart of shear force for different zones with different soil conditions is also decreases in composite diagrid frame in all cases in comparison with the bare frame.

IV. CONCLUSION:

it is perceived that due to diagonal columns at the outer periphery of the structures, the diagrid structure is more effectivelyresist the lateral load. Due to this property of diagrid structure, the interior column is used of smaller size for gravity load resistance and only small quantity of lateral load is considered for it. While in conventional frame building, both gravity and the lateral load is restricted by both exterior and interior columns. The following points are concluded from above study about diagrid structure .Study shows that diagrid structure decreases bending moment which in results decreases reinforcement requirement. • It shows that lateral displacement in tall structures can be minimized by using diagrids

it is shown that by providing diagonal columns at the outer periphery of the structures, the composite diagrid structure is more effectively resist the lateral load in comparison with the bare frame structure. By providing the concept of a 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 both interior as well as exterior column. Due to this phenomenon of replacing vertical column at an outer periphery of the bare frame structure, there is a huge reduction of concrete in the diagrid structure while the steel may vary on bases of conditions but due to the reduction of concrete in huge percentage stills make the diagrid structure more economical than the bare frame structure. The different points concluded from the above study:-

- The composite diagrid frame providing in zone V with soft soil condition is 32.82% more economical than the bare frame structure as in this case both steel and concrete are reduced in composite diagrid frame as the provided adequate section for beam and column is much smaller.
- Due to the change of soil condition from soft soil to a hard soil in zone V the steel in composite diagrid frame slightly increases with 6.82% while on the same place the concrete is reduced with 63.13% so overall it makes the diagrid frame 22.06% more economical in this case.
- In zone III with soft soil condition the steel increases in composite diagrid frame with 17.45% while concrete reduces with 54.42% so this makes diagrid frame 11.58% more economical.
- In zone III with hard soil condition the steel increases in diagrid frame 32.41% while still the concrete is reduced by 57.35% in comparison with the bare frame which makes diagrid 3.02% more economical

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