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Seismic Analysis of Modified Industrial Structure using Bracings and Dampers

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ABSTRACT

Resistance of structures against earthquake plays an extensive role in construction industry. A structure should consist of strength, stability and ductility to accommodate both horizontal and vertical loadings. Horizontal loading leads to the production of sway and further results in vibration and storey drift. Strength and stiffness are two major keys for any structure to resist gravity and lateral loads. Provision of bracings or dampers to any structure contributes to lateral stability. After assigning dampers or bracings, the general system changes to lateral load resisting system (LLRS). The present work involves in proposing the suitability of type of damper or bracing for controlling the seismic activity on industrial structures in respective seismic zones II of India. Industrial structures also associate high dead load as it provides residence to heavy sized members. Therefore, this is necessary to investigate seismic response of buildings with various bracings and dampers to control vibration, lateral displacement and storey drift. Natural time period, frequency, roof displacements are the major parameters considered for observing response of structures. Response spectrum analysis of 3D industrial structure with distinct concentric bracings and dampers using SAP 2000 will be carrying in this research under respective base shear.

Keywords : Steel Structure, Analysis, Industrial Frame, Drift, Seismic Zone

I. INTRODUCTION

Earthquakes are perhaps the most unpredictable and devastating of all natural disasters. They not only cause great destruction in terms of human casualties, but also have a tremendous economic impact on the affected area. An earthquake may be defined as a wave like motion generated by forces in constant turmoil under the surface layer of the earth (lithosphere), travelling through the earth's crust. It may also be defined as the vibration, sometimes violent, of the earth's surface as a result of a release of energy in the earth's crust. This release of energy can cause by sudden dislocations of segments of the crust, volcanic eruption, or even explosion created by humans. Dislocations of crust segments, however, lead to the most destructive quakes. In the process of dislocation, vibrations called seismic waves are generated. These waves travel outward from the source of the earthquake at varying speed, causing the earth to quiver or ring like a bell or tuning fork. The concern about seismic hazards has led to an increasing awareness and demand for structures designed to withstand seismic forces. In such a scenario, the onus of making the building and structure safe in earthquake-prone areas lies on the designers, architects, and engineers who conceptualize these structures. Codes and recommendations, postulated by the relevant authorities, study of the behavior of structures in past earthquakes and understanding the physics of earthquake are some of the factors that helps in the designing of an earthquake resistant structure.

II. Objectives of the Study

The main objectives of this study are as follows:

1. To determine the stability of the structure with bracing system in Industrial Frame.
2. To determine the bracing type which is enhancing steel structure life economically.
3. To justify the utilization of analysis tool in steel sections analysis.
4. To design the industrial structure considering Gantry Crane load.

III. Literature Review

Ramamurthy and Nagababu (2019)[12] The research paper presented a three dimensional geometry of the workstation gantry crane using catia. Then analysis of section beam, the part which is used to carry the loads in gantry crane, is carried out by using finite element method in ansys software for different loads apply on I-section, clamp, hook and at different positions. Using materials in this project structural steel, 34crmo4 chrome steel, carbon steel 1020, aisi 4130. The load bearing capacity of i-section beam was estimated by placing the loads at different positions i.e. (from left end of isection as 1300mm, 4300mm and 5300mm) and by observing von-missies stresses, shear stress, and deflections generated from static analysis in ansys 14.5. The results stated that the von-missies stresses, vonmisses, shear stress and deflections in static analysis using ansys 14.5. For the load of 15000n load considering the i-section beam maximum values at three positions. By placing different materials (carbon steel 1020, chrome steel, structural steel, aisi 4130) at different positions. Conclusion stated that chrome steel is the best material because of less von-misses stress, shear stress, and total deformation also it is observed that chrome steel is the suitable for gantry crane .with respect to both static and modal analysis.

Ravali and Poluraju (2019)[4] Proposing the suitability of type of damper or bracing for controlling the seismic activity on industrial structures in respective seismic zones III and V of India. Industrial structures also associate high dead load as it provides residence to heavy sized members. Therefore, this is necessary to investigate seismic response of buildings with various bracings and dampers to control vibration, lateral displacement and storey drift. The conclusion stated that As stiffness of structure increases, time period decreases. While comparing bracing and damper, bracing reduces the time period. Acceleration is inversely proportional to time period and as time period decreases, acceleration of structure increases. Similar to acceleration, frequency also inversely proportional to time period. X- Bracing system greatly influences the base shear of structure and reduces it. Using of X-bracing greatly reduces the lateral displacement of the structure when compared to other bracings and dampers. Also, dampers require regular maintenance for their effective behaviour.

Rahaman et. al. (2018)[6] The research paper focused on the main modelling aspects and results from analysis of seismic performance upon integration with site-specific hazard, the structural risk assessment, that is, a probability of failures. These buildings require large and clear areas unobstructed by the columns. The large floor area provides sufficient flexibility and facility for later change in the production layout without major building alterations. The industrial buildings are constructed with adequate headroom for the use of an overhead traveling crane. There are various international codes available for the design of steel structures.The results stated that point of confinement state strategy is more solid and efficient than the working pressure technique for planning structure. The consequences of the point of confinement state strategy for twisting minute and load conveying limit is higher than working pressure technique. The consumption of steel is less in LSM with respect to WSM. For same working forces, WSM will require higher steel section than LSM. Working stress method is simple to use but does not give consistent values of a factor of safety. That is the reason Limit states methods were developed. The limit states provide a checklist of the basic structural requirements for which design calculations may be required. Limit states design, by providing consistent safety and serviceability, ensures an economical use of materials and a wide range of applications.

IV. Methodology

Step-1 Literature survey related to industrial steel structures.

The past research papers were examined for basic investigation. Progressively modern examination techniques keep on improving the exactness with which the conduct of structures can be anticipated.

Step-2 Second step is to model structures using analysis tool SAP2000

Case I: 15 x 15 m

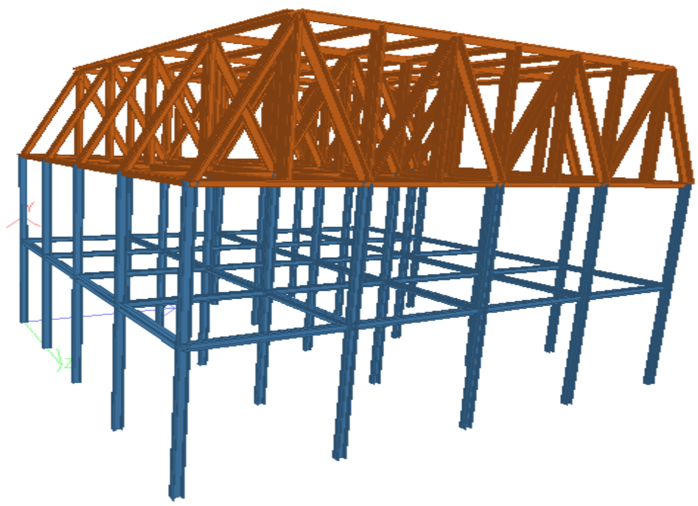

Fig a) General Structure

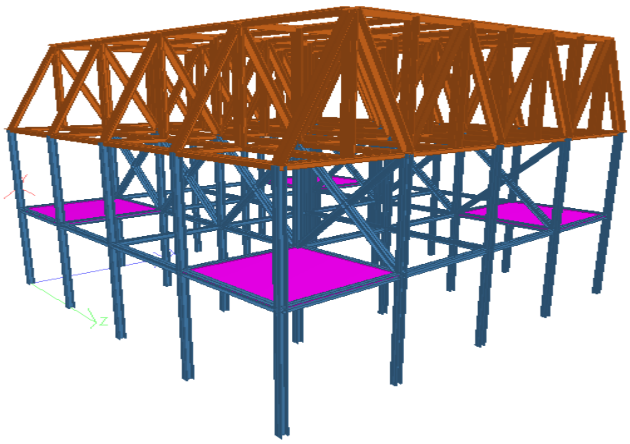

Fig b) Structure with Dampers and Bracings

Figure 1 Modelling of Industrial structure 15 x 15 m using SAP2000

Case II: 20 x 20 m structure

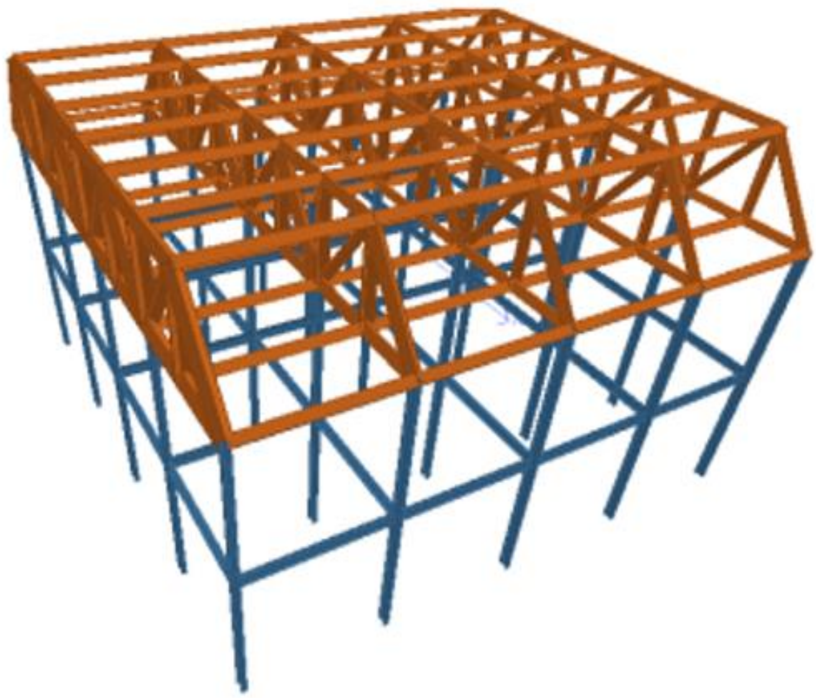

Figure a) General Structure

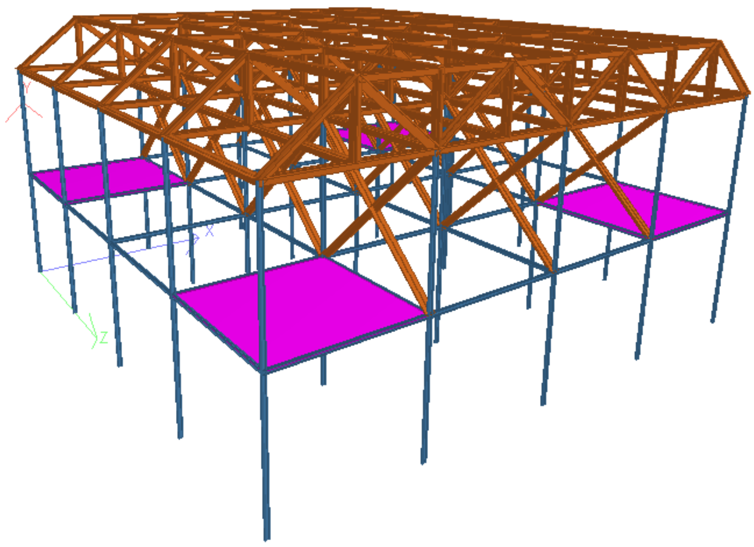

Figure b) Structure with Dampers and Bracings

Figure 2. Modelling of Industrial structure 20 x 20 m using SAP2000

Case III: 25 x 25 m

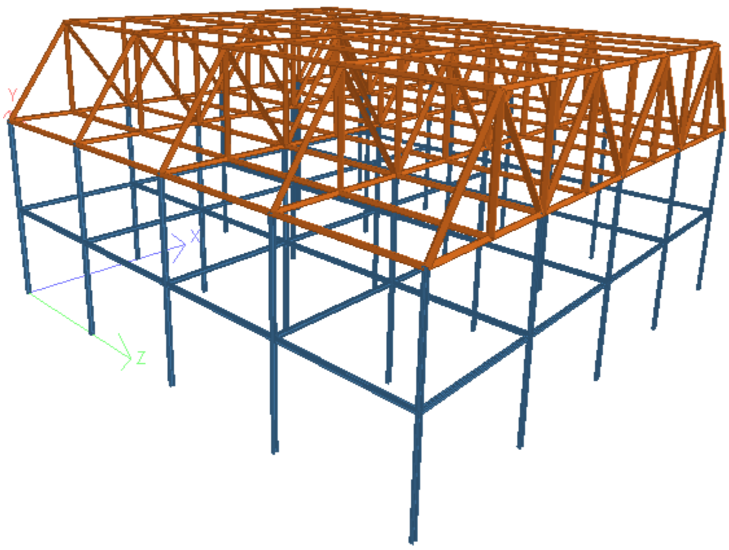

Figure a) General Structure

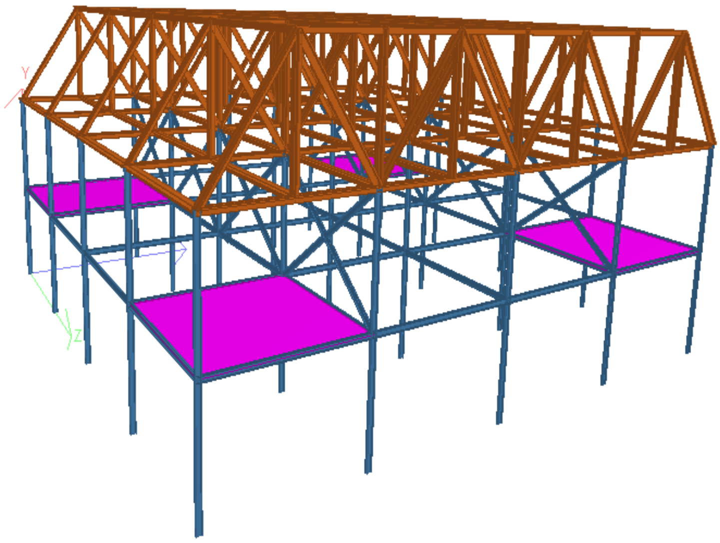

Figure b) Structure with Dampers and Bracings

Figure 3. Modelling of Industrial structure 25 x 25 m using SAP2000

Step-3 To assign section data as per Steel Table and material properties.

Materials make up the essential components, which all assembling procedures need to work with. Assembling top-notch items easily require itemized information on complex collaborations among an enormous number of variables including item plan necessities, materials and their properties and assembling forms that convert these materials into required structures. Today there is a wide scope of materials and procedures accessible and the assignment of choosing the most ideal material while limiting the expenses of assembling is a significant test. Meeting such a test requires an intensive comprehension of the attributes of materials and forms and the related assembling innovation.

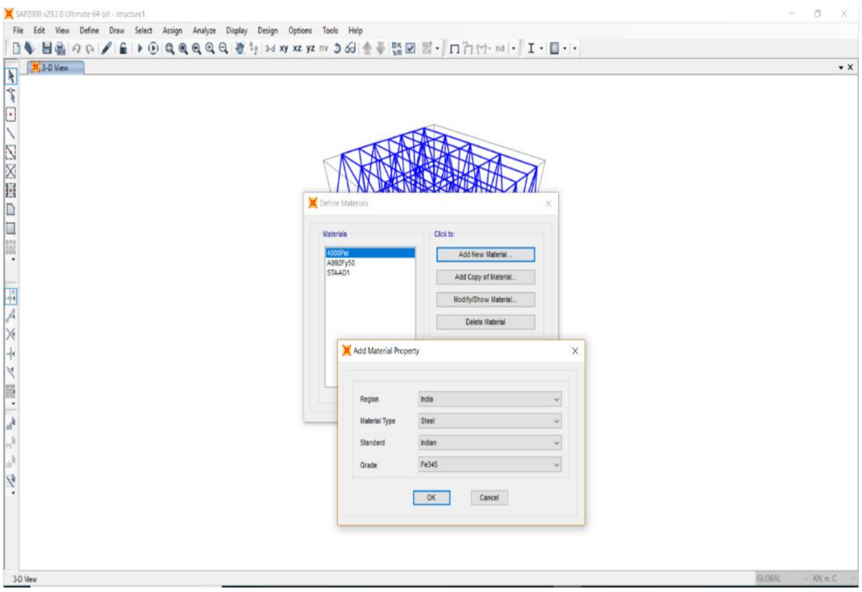

Figure 4. Assigning Material properties

Step-4 **To Assign support conditions.**

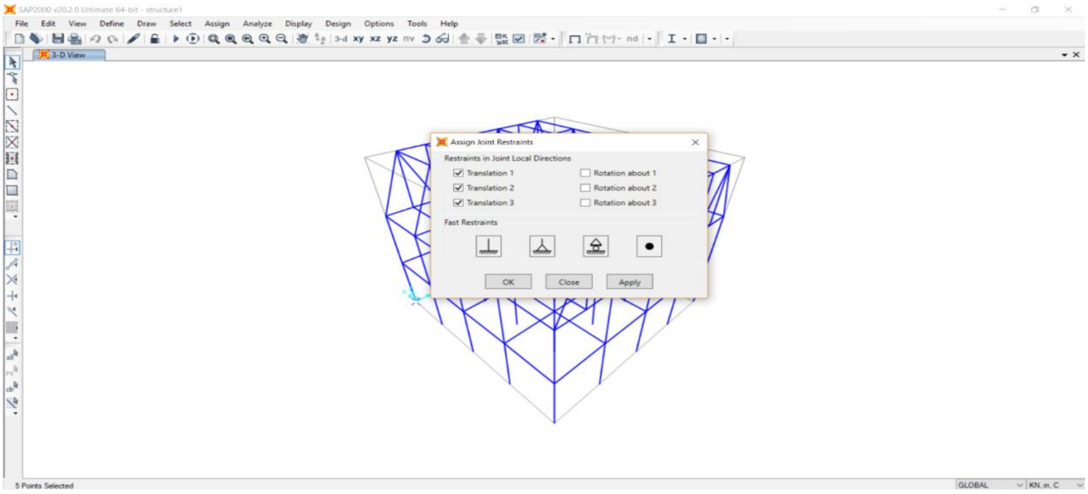

Figure 5 Assigning support conditions

Step-5 To assign Seismic Forces as per selected zone and soil type.

A Load combination results when more than one Loading condition follows up on the structure. Development guidelines usually decide a combination of weight mixes with trouble factors (weightings) for each load type to ensure the security of the structure under different most extraordinary foreseen stacking circumstances.

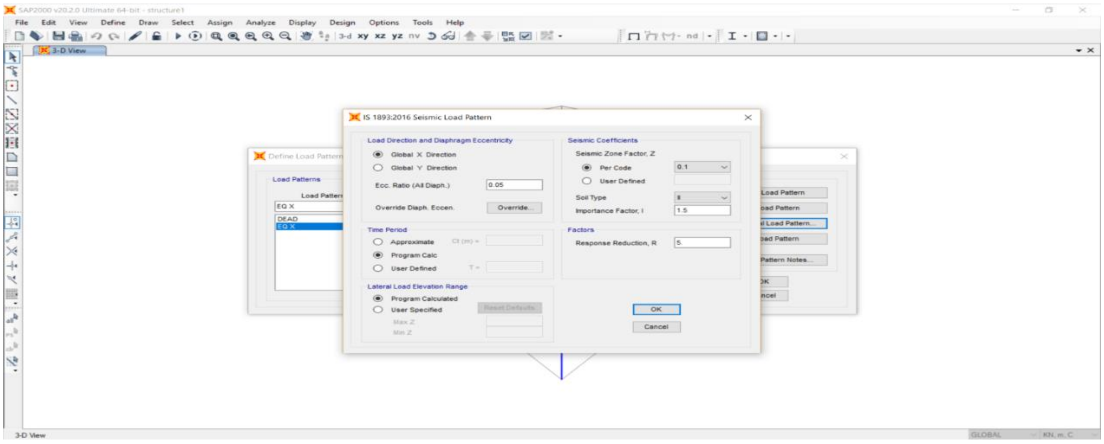

Figure 6: Seismic load

Step 6 To perform finite element analysis

The Finite Element Analysis (FEA) is the simulation of any given physical phenomenon using the numerical technique called Finite Element Method (FEM). Engineers use it to reduce the number of physical prototypes and experiments and optimize components in their design phase to develop better products, faster.

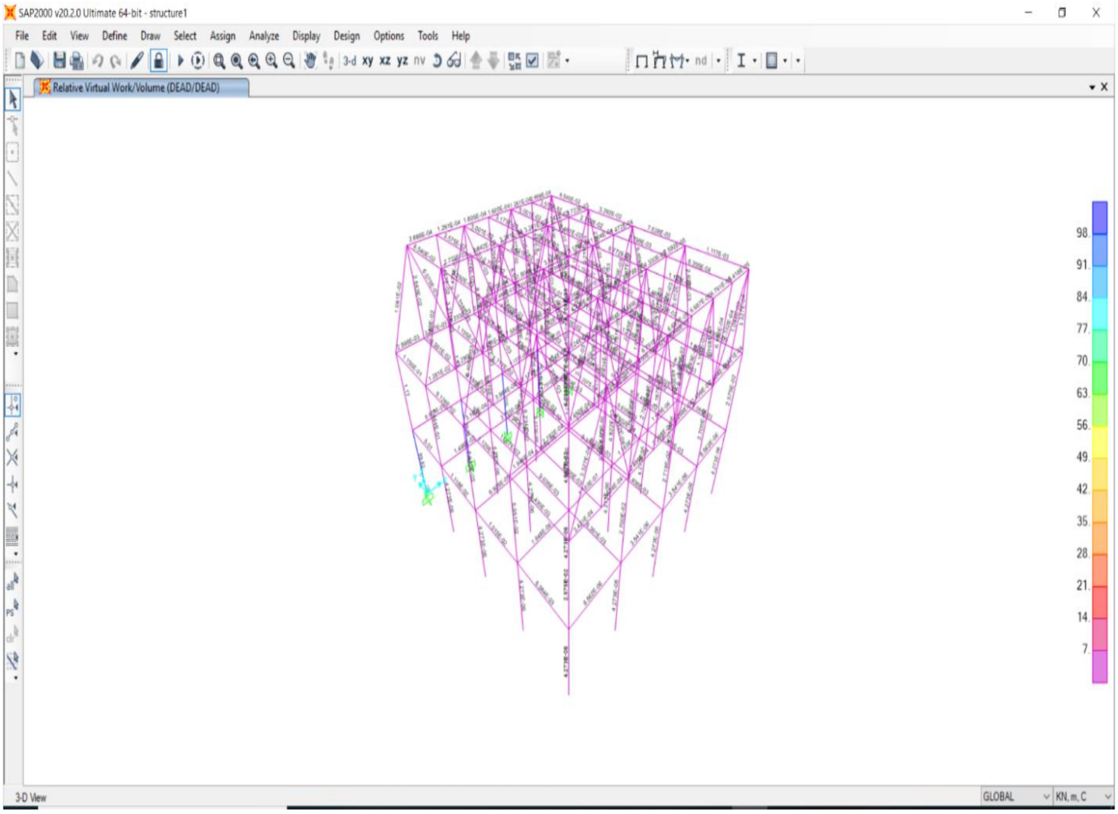

Figure 6 Analysis results

Step 7 To prepare comparative result in M.S. excel.

Step 8 To provide conclusion as per results

Table 1: Geometrical properties of the structure

1	**Number of Stories**	**Ground + 1**
2	Height of stilt floor	4.5 m.
3	Height of upper stories	4.5 m.
4	Depth of foundation	4.5 m
5	Grade of Steel	Fe 345
6	Steel Sections	Fe 345
7	Seismic Zone	II
8	Bracing	X
9	Sections Consider	Beam (ISMB 200) & Angle Section (150X150X10)
10	Width & Length	15 m x 15 m, 20 m x 20 m, 25 m x 25 m.

Analysis Result:

Support Reaction:

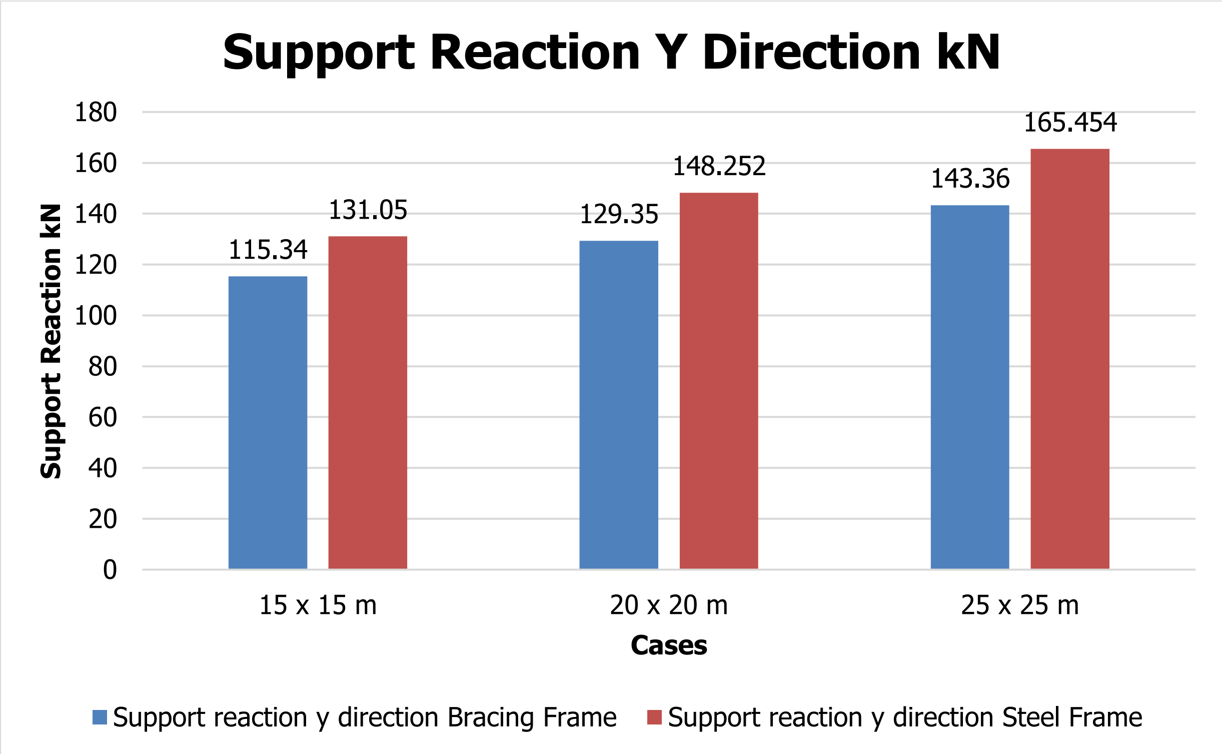

Fig 8: Support reaction

Max. Deflection

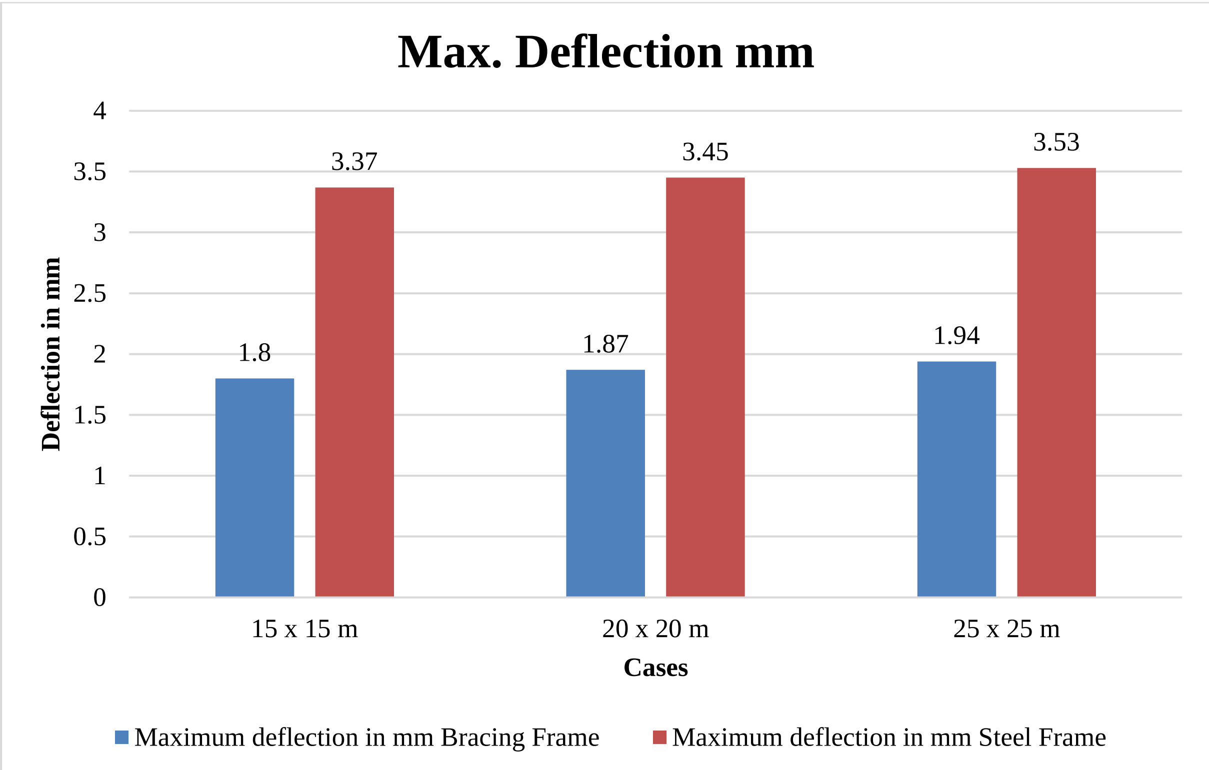

Fig 9: Deflection

Axial Force

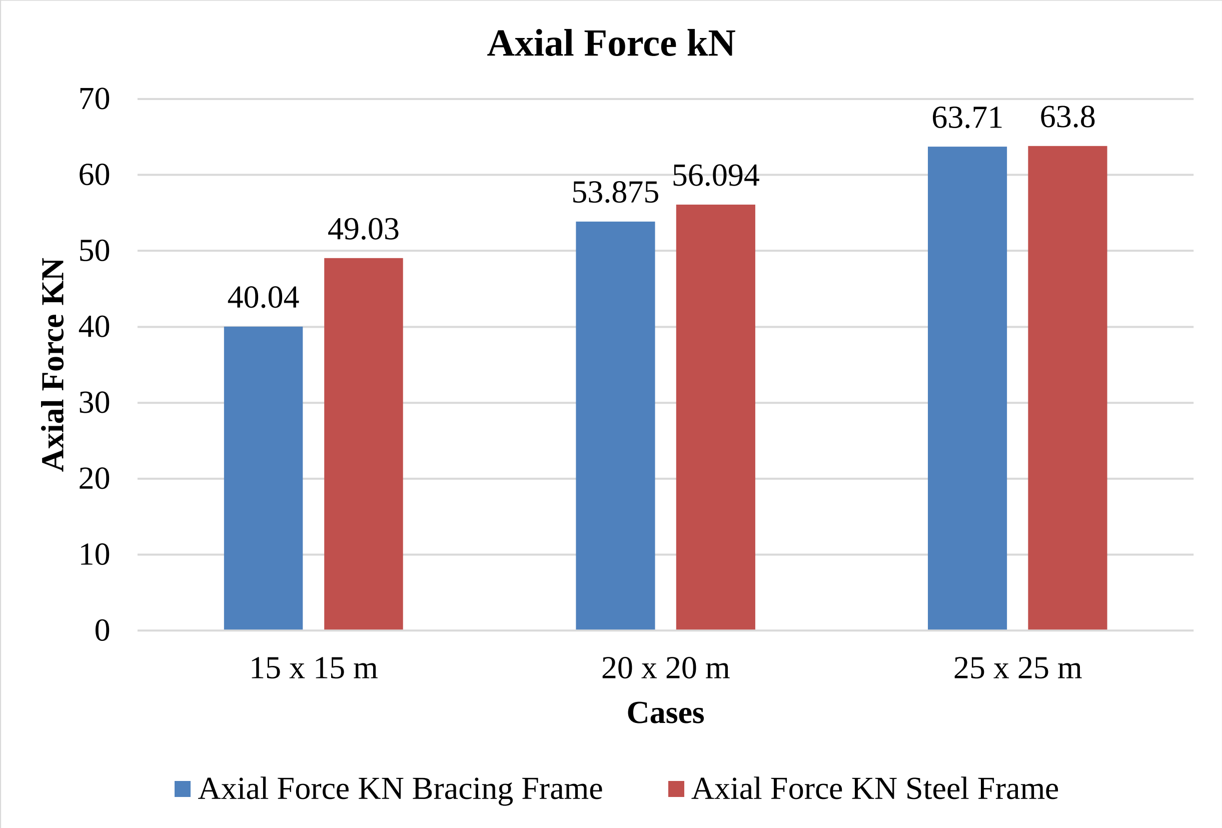

Fig 10: Axial Force

Shear Force

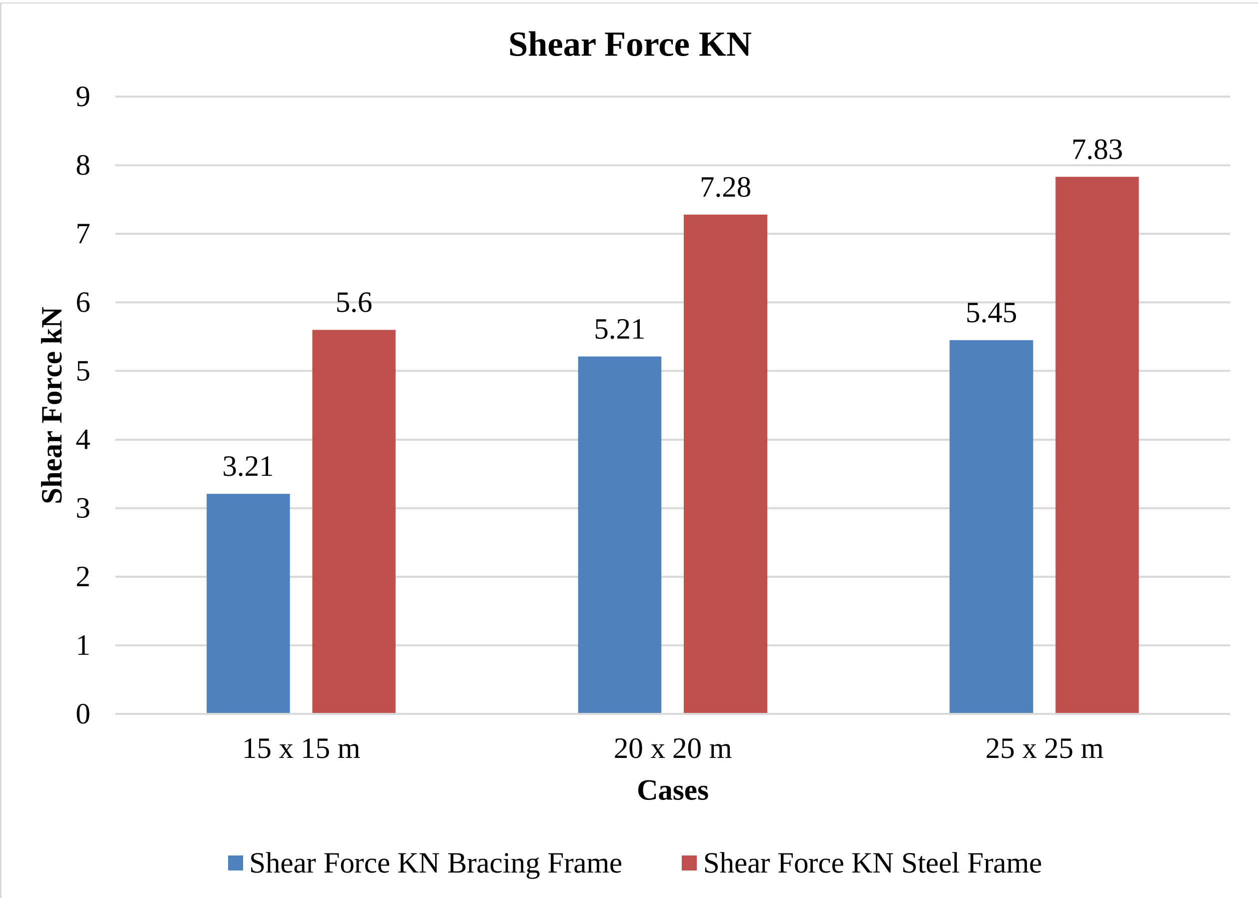

Fig 11: Shear Force

V. CONCLUSION

Following observations are in structure:

1. In structure we observed that support reaction value decreases by 11.8% which shows stability of the structure in distributing load to the soil.
2. Here it is observed that bracing and dampers resisting the deflection of the structure generating due to Gantry crane load by 46.6 % which is very important aspect for safety.
3. In terms of forces it is observed that unbalanced forces decreases from 5.6 KN to 3.21 KN which shows structure stability and stiffness.

VI. SUMMARY

In all the cases considered in this structure, it is observed that structure with bracings and dampers proved to be More stable and economical in all aspects. But out of all these cases 20 x 20 m span shows more stability and Stiffness as compared to other two cases.

VII. FUTURE SCOPE

1. In this structure we are considering seismic forces whereas in future one can select wind pressure.
2. In this study we are considering industrial frame whereas in future steel house can be consider.
3. In this study we are analyzing using SAP2000 whereas in future any other analysis tool can be use.

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