MODELING AND STATIC MODAL ANALYSIS OF GANTRY CRANE USING VARIOUS MATERIALS

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ABSTRACT

A crane is lifting machinery, discontinuous movement aimed at raising and distributing loads in space, suspended from a hook. Cranes available in the market are grinder travelling crane, overhead travelling crane, jib cranes, wire rope hoist, and gantry cranes. The Gantry cranes are one of the most important mechanical components in the heavy weight lifting and loading in to cargos, into trains, in to heavy truck vehicles, etc. Different types of gantry cranes available in the industries are container cranes, workstation gantry cranes (or) light weight mobile gantry cranes and semi gantry cranes. These vase verity of gantry cranes are differed based on the tonnages and area to be covered for lifting and moving the weights.

The workstation gantry crane is the most economical solution in all those places where it is desired or civil works or expensive fixed mount metal structures, and where necessary make loading (or) unloading on a regular basis and at points different.

In our project, first, three dimensional geometry of the workstation gantry crane is built in, SOLIDWORKS. Then analysis of I-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. We estimate the load bearing capacity of I-section beam by placing the loads at different positions i.e. (from left end of I-section, 1st position is 1300mm, 2nd position is 4300mm and 3rd position is 5300mm) and by observing von-missies stresses, Shear stress, and deflections generated from static analysis in ANSYS 14.5. finally concluded the suitable material on these 4 materials and which position and find out the deformations in different frequencies by using modal analysis

I. DEFINITION OF CRANE:

Lifting device, used to elevate or lower loads vertically and to move them horizontally while they are hanged It will be presented all types of cranes with their mainly characteristics. The classification will be done as follows

- According to design.
- According to movement possibilities.
- According to the device control.
- According to orientation possibilities.

Figure 1 bridge crane

Gantry cranes, bridge cranes, and overhead cranes, are all types of cranes which lift objects by a hoist which is fitted in as hoist trolley and can move horizontally on a r rail or pair of rails fitted under a beam. An overhead travelling crane, also known as an overhead crane or as a suspended crane has the ends of the supporting beam resting on wheels

running on rails at high level, usually on the parallel side walls of a factory or similar large industrial building, so that the whole crane can move the length of the building, while the hoist can be moved to and from across the width of the building. A gantry crane or portal crane has a similar mechanism supported by uprights, usually with wheels at the foot of the uprights allowing the whole crane to traverse. Some portal cranes may have only a fixed gantry, particularly when they are lifting loads such as rag always cargoes that are already easily moved beneath them.

COMPONENTS OF BRIDGE CRANE TYPE

- **The Bridge:** It travels along the working area (building, harbor, construction site…)
- **The trolley:** It moves over the bridge and along the width of the working area.
- **The hoist:** Mounted in the trolley and performs the lifting and lowering action via a hook or lifting attachment.

GANTRY CRANE

Crane whose carrier elements are supported on a raceway through support legs the difference with the overhead crane ibis that the rails are in a horizontal plane much lower than tithe trolley off the crane.

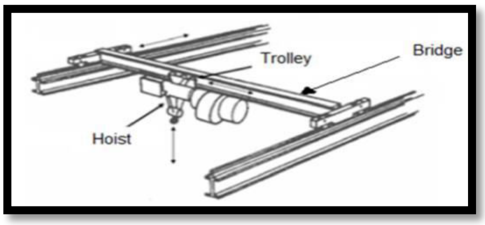


Figure 2 translation of the bridge

WORKSTATION GANTRY CRANES

Workstation gantry crane s are used to lift and transport smaller items around a working area in a factory or machine shop Some workstation gantry cranes are equipped with an enclosed track, while others use an I-beam, or other extruded shapes, for the running surface. Most workstation gantry cranes are intended to be stationary when loaded, and mobile when unloaded. Workstation Gantry Cranes can be outfitted with either a Wire Rope hoist as shown in the above hoist (device) picture or a lower capacity Chain Hoist.

Figure 3 workstation gantry cranes

II. LITERATURE REVIEW

[1] JAVIER IZURRIAGALERGA: Cranes are industrial machines that are mainly used for materials movements in construction sites, production halls, assembly lines, storage areas, power stations and similar places. Their design features vary widely according to their major operational specifications such as: type of motion of the crane structure, weight and type of the load, location of the crane, geometric features, operating regimes and environmental conditions

[2] TREVOR NEVILLE HAAS: After an extensive literature search, no peer reviewed journal publications were found relating to crane end buffer (end stop) impact forces. Other sources of information which exist are; experimental investigations, the crane manufacturer's guidelines for the selection of crane buffers, the various codes of practice for structural design and the guidelines presented by various professional associations. A limited number of journal publications exist on the estimation of forces imposed by the crane on the crane supporting structure, other than the crane end buffer impact forces.

[3] MD AZRIQIZWAN BIN MD YUSOP: Precise position control and rapid rest-to-rest motion is the desired objective in a variety of applications. The requirement of precise position control implies that the residual vibration of the structure should be zero or near zero. Literature review is done in this chapter to make a review of the several techniques of input shaping that will reduce the vibration and part of it is discussed below.

[4] APEKSHA.K.PATEL: Main Component of Overhead Crane is Girder Beam which transfers load to structural member. In Present Practice, industries overdesign girder beam which turns costly solution. So, our aim is to reduce weight of girder which has direct effect on cost of girder and also performance Optimization is done for fatigue (life) point of view.In this paper FE analysis of girder beam is carried out for the specific load condition i.e. turning operation. Here, we done a mathematical design calculation crane component, and thrust forces are used in FE analysis..

[5] SERGIO ARMAN MORALES: The main aim of the project is: for given loads, analyse and design (analytically and with SOLIDWORKS software) different beams for an overhead crane. For this purpose, it will be study the theory of cranes and structures calculation and from this theory I will design an algorithm that allows finding the necessary beam from de European standard metallic beam list. After obtaining the analytical and the software (SOLIDWORKS) results for each beam, it will be compare the results between them and presented the conclusions. On the other hand it will be done as well, an overview of all types of cranes that exist in the industry and their applications and features. Also it will be presented widely the bridge crane type, as it is the target of the project.

[6] ILKEROZKAN: Riveted steel connections were used throughout most of the United States for many years (Roeder et all. 1996). Connections between metal parts are required in most applications, and are a critical part of every design. The joining of parts by cylindrical fasteners passing through holes has a long history. More recently, fusion welding has provided another very flexible means of connection. For the connection of relatively thin members in steel construction, rivets were traditionally used. These are cylinders of mild steel with forged heads, one formed in the factory and one formed in the field on the hot rivet. Such connections proved very reliable, giving excellent service.

[7] Gantry is particularly suited to lifting very heavy objects. Huge gantry has been use for steep building, where the object like ship engine to lifted and moves over the ship. The first over gantry built in 1969 are Samson and Golith in Belfast, Northern Ireland. This gantry having span 140meter and can lift load up to 840 tones. The same type of gantry is use in ware houses to loading and unloading of material.

[8] Gantry crane are basically made up of aluminum and mild steel structure. But small size of Bag Palletizer Gantry is made up of aluminum profile .The main disadvantage of aluminum bag palletizer gantry is their high cost. Because, extruded aluminum profile is expensive in manufacturing and machining also. Bernarda and Ferreira introduce a method to evaluate and develop new gantry concept. The evaluation is done with the help of House of quality method. Which is best concept design method in early industrial development with the help of this method Bag Palletizer Gantry concept design time and all design aspect? Every possibility of product development is provided with House of quality study. In 1979 Toyota motors reduce 20% of starting cost and in 1984 it turns to 61% using House of quality study. This method for gantry design and development gives an engineering focus toward concept design. Cold Rolled C-section of mild steel member in gantry design is considered because of Gabor and Jakobs research work. An experimental program on compression member made up of mild steel cold rolled section. Various C-section analyses which were not studied previously. Mild steel section is capable various load condition and structural strength capacity is analyze in this research work. Gantry structure analyze by Finite element analysis and changing various material property to improve solidity of member. An numerical and analytical results varies proportionally while changing steel property in main longitudinal girder part in gantry model.

[9] Distortional buckling of C section is tested by ***CHENG YU AND BEN SCHAFER*** in The American iron and steel institute, the experimental validation of wide verity of mild steel C-section. This study indicates that distortion buckling is most likely failure mode. This study contain test setup for C-section and various C-member are tested for buckling and all those condition are verified with finite element analysis with same lode and constrain use in test setup. The result of the study shows reasonable and conservative prediction for both local and distortional buckling strength of beam .Which is use for member selection for gantry design for particular load condition.

[10] C.ALKIN, C.E.IMRAK, H.KOCABS work on solid modeling and finite element analysis of gantry crane. While analysis material property of mild steel is used and evaluate stress and deflection. The analysis study concludes that four node quadratic shell element is gives accurate result than four node tetrahedral element use in mashing model in FEM software. This study helps while calculating concept model with its applied load and boundary condition

[11] J.I.LERGE studied in modeling and simulation research on metal structure on bridge crane. The main objective of this study is to reduce structural weight of girder of gantry crane. For these purpose several model of girder structure have been designed. The new lighter model is design is analyzed with load condition. The structural material used in this model is economical too. This designed model has been losing its weight by holes in structure. That can reduce structural weight without affecting structural strength of gantry structure.

PROJECT OVER VIEW

- Have sufficient mechanical strength and stiffness.
- Can effectively Load bearing capacity on GRANTY crane I section, clamp, hook
- Select less corrosion resistance material.
- Design process using SOLIDWORKS software and analysis process using ANSYS software
- Finally find out the stresses, deformation, shear stress in static analysis and find out frequencies in deformations (modal analysis) on GRANTY crane I-section clamp and hook, finally concluded the suitable material on these materials carbon steel1020, chrome steel, structural steel, AISI 4130 steel

III. METHODOLOGY

1) In our project, first, 3D geometry of the workstation gantry crane is built with a CAD program or SOLIDWORKS.

2) Then analysis of I-section beam is carried out by using finite element method in ANSYS software for different positions (1300, 4300, and 5300) and different materials.

3) The main criteria for the analysis of I section, clamp, hook is obtained stress, total deformation, shear stress and modal analysis.

4) Finally concluded the suitable material on these carbon steel1020, chrome steel, structural steel, AISI 4130 steel materials

SPECIFICATION OF THE PROBLEM

- The objective of the present work is to design and analyze the chassis of the Granty crane with the material it is manufactured and also for the other metal alloys viz., grey cast iron, AISI 4130 alloy steel and ASTM A710 STEEL GRADE A (CLASS III). The solid model of the granty was created in SOLIDWORKS. Model was imported in ANSYS 14.5 for analysis by applying the normal load conditions on I-section, clamp, hookin different positions. The model was tested for stress and deformation as the design constraints. After analysis a comparison is made between existing structural steel, chrome steel, carbon steel, and AISI 4130 viz., in terms of deflections and stresses, Shear stresses, strains to choose the best one.

- Gantry crane is used to transfer the loads from one place to another place. The major part of gantry crane is I-section beam, which is fixed at two ends of the gantry crane stand bars. It is used for carrying the loads. In I-section beam failure may occur due to carrying heavy load .Even Impact (or) sudden loads also effects the load bearing capacity of I-section beam.

- In our project, first, three dimensional geometry of the workstation gantry crane is built with a CAD program, SOLIDWORKS. Then analysis of I-section beam is carried out by using finite element method in ANSYS software for different loads and at different positions on the I-section beam. The main criteria for the analysis is, obtained stress values should not exceed the safety stress of the material used. Now we can observe how the I-section beam will behave when loads are applied at different positions.

MATERIAL PROPERTIES:

MATERIAL PROPERTIES				
	STRUCTURAL STEEL	CARBON STEEL 1020	34CrMo4	AISI4130
Density (Kg/mm³)	7.85	7.75	7.83	7.798
Modulus of elasticity (MPa)	200	195	205	203
Poisson's ratio	0.3	0.28	0.29	0.3
yield strength(MPa)	250	490	1100	910
Tensile strength(MPa)	460	635	1066	1030

Table: 1material properties

MODELLING OFGANTRY CRANE IN SOLIDWORKS

Workstation gantry crane s are used to lift and transport smaller items around a working area in a factory or machine shop .Some workstation gantry cranes are equipped with an enclosed track, while others use an I-beam, or other extruded shapes, for the running surface. Most workstation gantry cranes are intended to be stationary when loaded, and mobile when unloaded. Workstation Gantry Cranes can be outfitted with either a Wire Rope hoist as shown in the above hoist (device) picture or a lower capacity Chain Hoist.

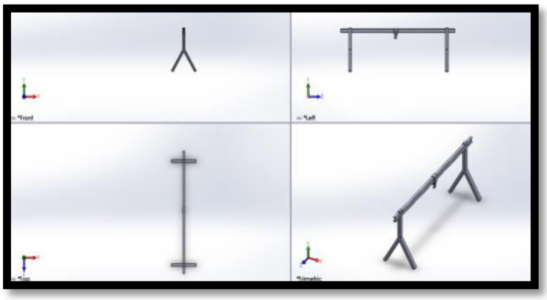


Figure 4 Modeling of Gantry crane in solid works

CALCULATIONS FOR TAKING LOADS ON I-SECTION BEAM:

- 1 Newton = 9.81
- 1 kg=1000
- Where load is considered by taking 15000N. So the final load considered on I-section beam
- 1000kg =1 ton
- 15 ton=1500kg
- 15000N =1.5 Ton
- **Consider load is 15000N**

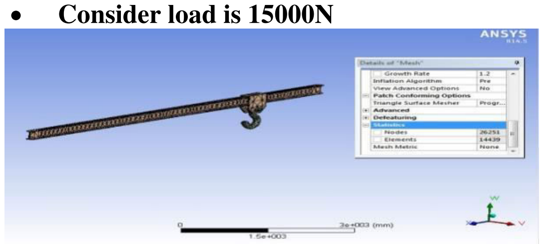


Figure 5 Mesh at 5300 position

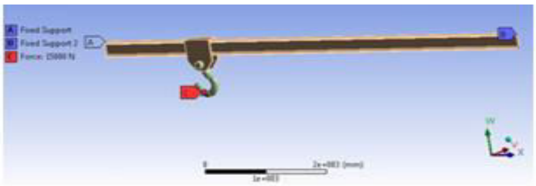


Figure 6 Boundary condition at 1300 position

Figure 7 Boundary conditions at 4300 position

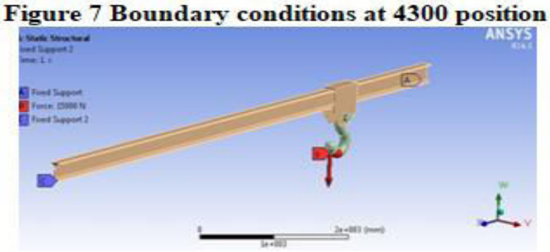


Figure 8 Boundary conditions at 5300 position

IV. RESULTS AND DISCUSSIONS

Gantry crane is used to transfer the loads from one place to another place in vertical direction. The major part of gantry crane is I-section beam, which is fixed at two ends of the gantry crane stand bars. It is used for carrying the loads. In I-section beam failure may occur due to carrying heavy load .Even Impact (or) sudden loads also effects the load bearing capacity of I-section beam. These analysis have been carried out on the I-section beam for a material carbon steel 1020,chrome steel, structural Steel, AISI 4130 at three different positions for 1300,4300,5300 load consider 2000N.

STATIC ANALYSIS

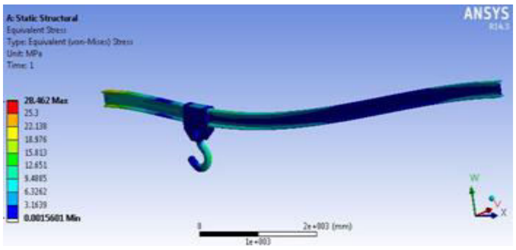


Figure 9 Von-misses stress at 1300 position 34CrMo4 steel material

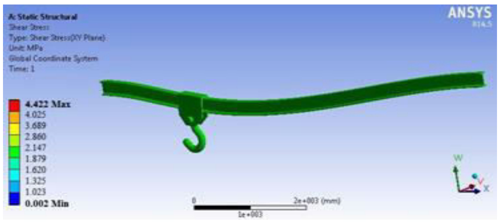


Figure 10 Shear stress at 1300 position 34CrMo4 steel material

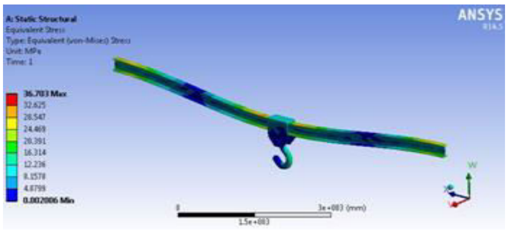


Figure 11 Von-misses stress at 4300 position 34CrMo4 steel material

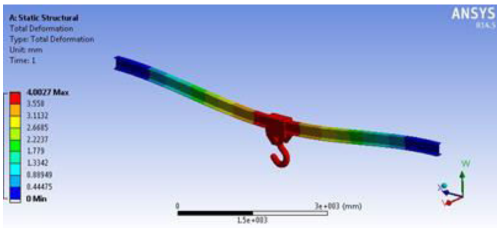


Figure 12 Total deformations at 4300 position 34CrMo4 steel material

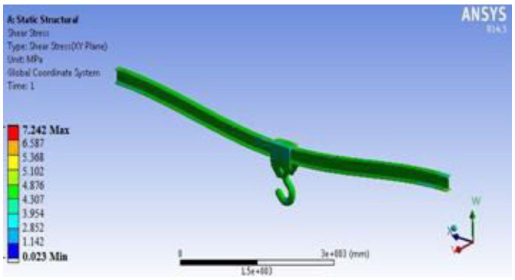


Figure 13 Shear stress at 4300 position 34CrMo4 steel material

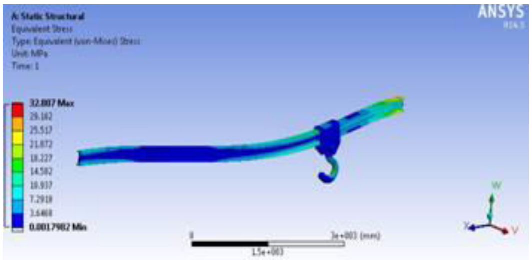


Figure 14 Von-misses stress at 4300 position 34CrMo4 steel material

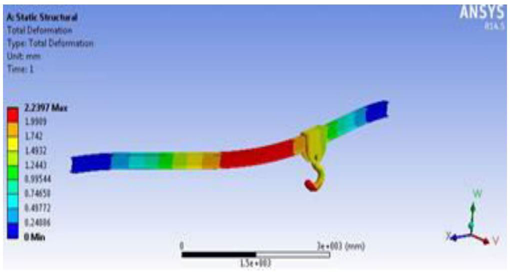


Figure 15 Total deformation at 4300 position 34CrMo4 steel material

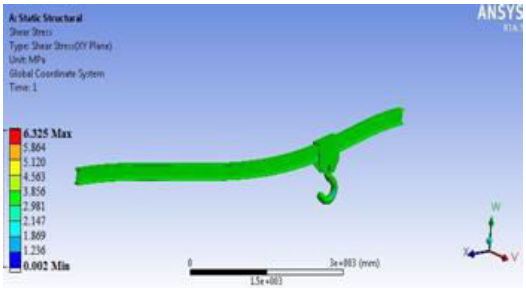


Figure 16 Shear Stress at 4300 position 34CrMo4 steel material

Modal analysis is the study of the dynamic properties of structures under vibration excitation. Modal analysis, or the mode-superposition method, is a linear dynamic-response procedure which evaluates and superimposes free-vibration mode shapes to characterize displacement patterns.

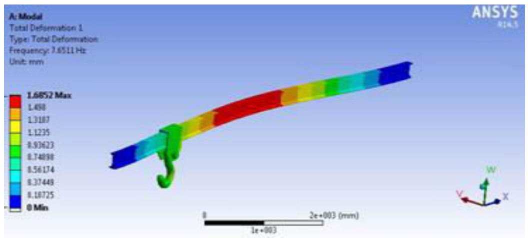


Figure 17 1st position mode 1

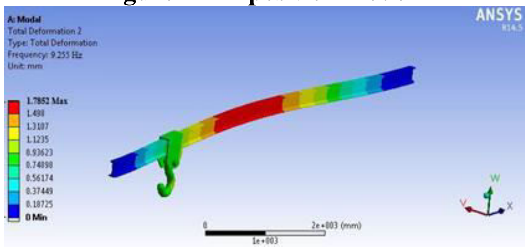


Figure 18 1st position mode 2

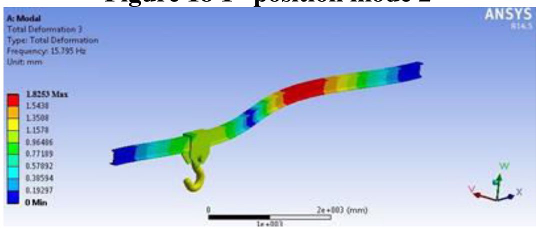


Figure 19 1st position mode 3

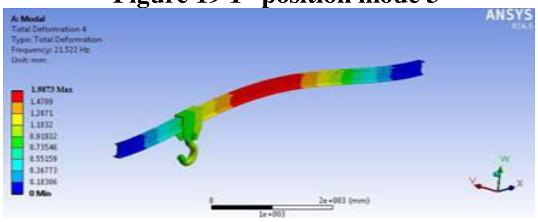


Figure 20 1st position mode 4

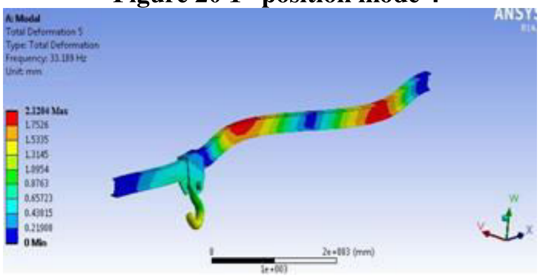


Figure 21 1st position mode 5

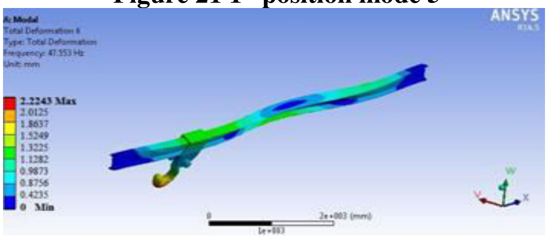


Figure 22 1st position mode 6

MODAL ANALYSIS OF CHROME STEEL (2^{ND} POSITION):

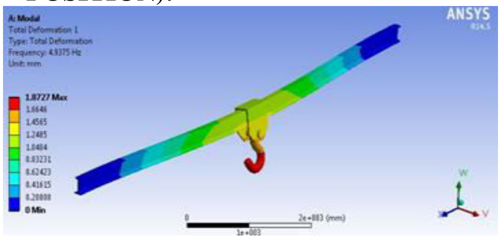


Figure 23 2^{nd} position mode 1

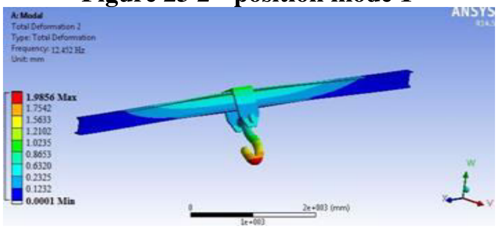


Figure 24 2^{nd} position mode 2

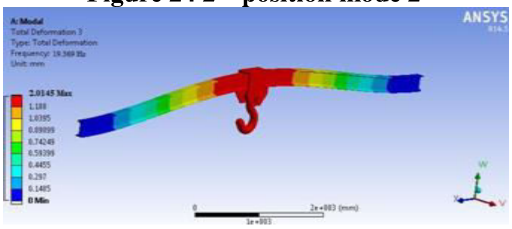


Figure 25 2^{nd} position mode 3

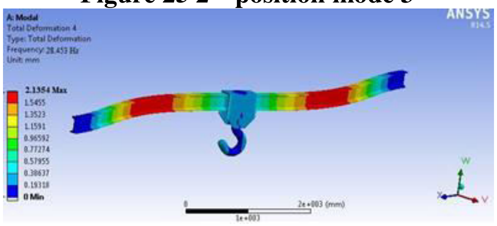


Figure 26 2^{nd} position mode 4

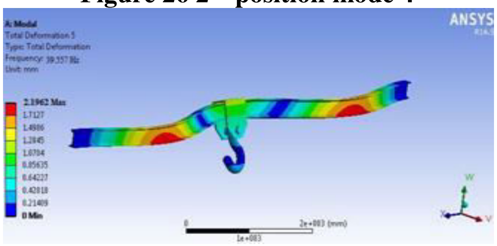


Figure 27 2^{nd} position mode 5

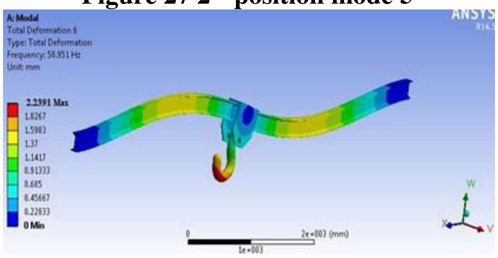


Figure 28 2^{nd} position mode 6

MODAL ANALYSIS OF CHROME STEEL (3^{RD} POSITION):

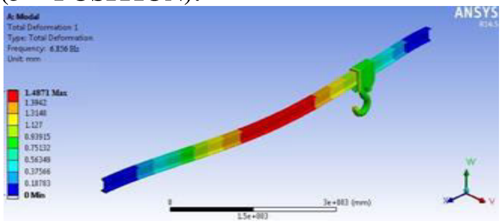


Figure 29 3^{rd} position mode 1

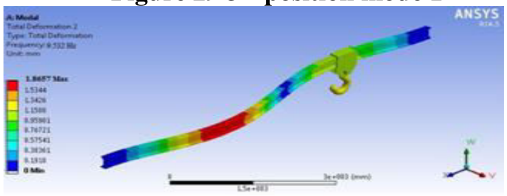


Figure 30 3^{rd} position mode 2

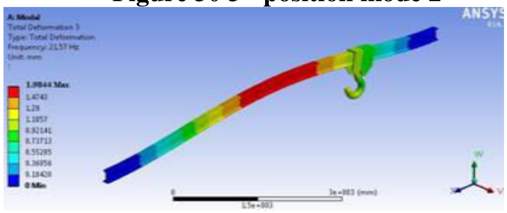


Figure 31 3^{rd} position mode 3

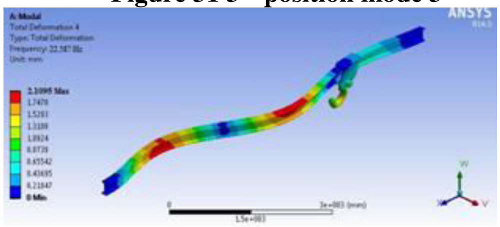


Figure 32 3^{rd} position mode 4

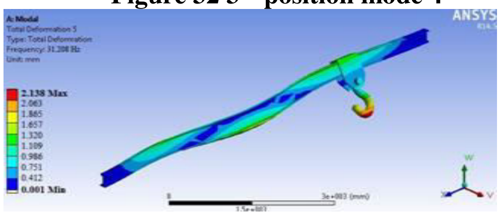


Figure 33 3^{rd} position mode 5

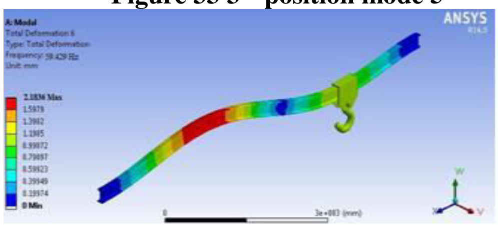


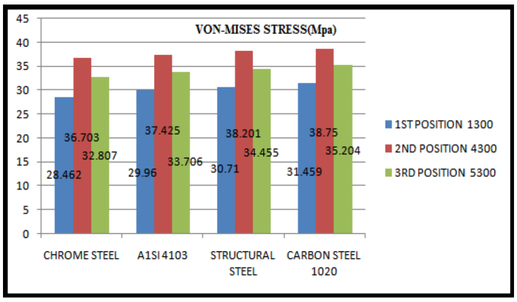
Figure 34 3^{rd} position mode 6

GRAPHS OF STATIC ANALYSIS:

The static structural analysis of Al I-section beam for a material carbon steel 1020,chrome steel, structural Steel, AISI 4130 at three different positions for 1300,4300,5300 load consider 15000N applied results are obtained for Equivalent (Von-Misses) stress, , total deformation, shear stress, These results are plotted graphically and a comparison is made between these results.

VON-MISES STRESS (MPA):

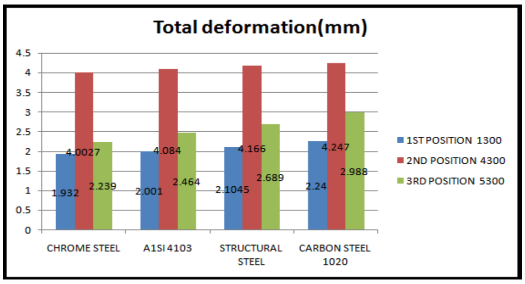
We can observe that in cases of equivalent (von-misses) stress, I section beam granty crane made up of carbon steel 1020,chrome steel, structural Steel, AISI 4130 these materials chrome steel is found to have least stress in all cases in comparison with remaining materials including the present material structural steel.



Graph 1 Von-misses stress graph

TOTAL DEFORMATION (mm)

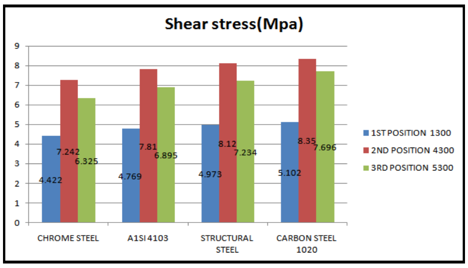
We can observe that in cases of Total deformation granty crane I section beam made up of carbon steel 1020,chrome steel, structural Steel, AISI 4130 these materials chrome steel is found to have least deformation in all cases in comparison with remaining materials including the present material structural steel.



Graph 2 Total deformation graph

SHEAR STRESS (MPa):

We can observe that in cases of shear stress granty crane I section beam made up of carbon steel 1020,chrome steel, structural Steel, AISI 4130 these materials chrome steel is found to have least shear stress in all cases in comparison with remaining materials including the present material structural steel.



Graph 3 Shear stress graph

MODAL ANALYSIS TABLES:

TABLE:21st Position (1300) chrome steel(34CrMo4)		
MODE	FREQUENCY	TOTAL DEFORMATION(mm)
1	7.6511	1.6852
2	9.255	1.7852
3	15.795	1.8253
4	21.522	1.9873
5	33.189	2.1204
6	47.553	2.2243

TABLE :32nd Position (4300) chrome steel(34CrMo4)		
MODE	FREQUENCY	TOTAL DEFORMATION(mm)
1	4.937	1.8727
2	12.452	1.9856
3	19.369	2.0145
4	28.453	2.1354
5	39.557	2.1962
6	58.951	2.2391

TABLE:43rd Position (4300) chrome steel(34CrMo4)		
MODE	FREQUENCY	TOTAL DEFORMATION(mm)
1	6.856	1.487
2	9.532	1.865
3	21.57	1.9844
4	22.587	2.1095
5	31.208	2.1378
6	59.429	2.1836

V. CONCLUSION

In our project, first, three dimensional geometry of the workstation gantry crane is modeled with a SOLIDWORKS. Then analysis of I-section beam, the part which is used to carry the load in Gantry crane hook 15000N, is carried out by using finite element method in ANSYS software and at different positions on the I-section beam

As a design and analysis of I-section beam of Gantry crane is carried out by placing the loads at different positions i.e. (from left end of I-section, 1st position is 1300mm 2nd position is 4300mm 3rd position is 5300mm) and by observing **von-missies stresses, von-misses, shear stress and deflections** for static analysis in ANSYS 14.515000N 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 we observed

We conclude that I-section beam, clamp, hook, chrome steel is the better because of less von-misses stress, shear stress, Total deformation finally in static and modal analysis both chrome steel is the suitable for granty crane .

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