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MAIN GIRDER BEAM DESIGN AND FINITE ELEMENT ANALYSIS OF 2X160 TON GANTRY CRANE

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ABSTRACT
Today in the world, Turkey has a great role in ship building industry. Shipyards work continuously and build a ship in almost every three months. In order to achieve this, a lot of cranes in different tonages are needed to lift and move the ship parts. Crane Projects are designed in need of the shipyards. While designing the crane geometry, hoisting load, the lifting height and the situation of the area where the crane will work should be considered. First of all, the main characteristics as the height of the crane, the distance between the rails, the lifting height, speed of the crane and speed of the trolley are determined. After that, the geometry of all parts, and the features of the power and transmission components are specified. The construction geometry is analyzed by Abaqus Software program. First, three dimensional geometry of the crane is built with a CAD program, then this geometry is modelled by using finite elment method. The crane is tested under the effects of its self weight, the weight of the load, the hook and the trolley, and also the wind load and the dynamic loads occuring with the movement of the crane. The obtained stress values should not exceed the safety stress of the material used. If any component has an unpermitable stress value, the thickness of the sheets should be increased or suitable supports should be added.
Keywords: Gantry Crane, Strength Equations, Stress Analysis

1. INTRODUCTION

A gantry crane is a type of crane with a hoist in a trolley which runs horizontally along gantry rails, usually fitted underneath a beam spanning between uprights which have wheels so that the whole crane can move at right angles to the direction of the gantry rails. These cranes come in all sizes, and some can carry and move very heavy loads, particularly the extremely large examples are used in shipyards or industrial installations.

In this study, a gantry crane with a hoisting capacity of 2x160 ton is modelled in 3D using Solidworks computer software. Then, the cross section of gantry crane parts are checked by accomplishing the strength equations due to FEM, DIN norms.

Considerable research studies have been carried out about structural and equivalent stresses in order to provide safety under static loading and dynamic behavior of cranes. Finite element analysis is a powerful technique originally developed for numerical solution of complex problems in structural mechanics, and it remains as a method of choice for complex systems.[1] The basic principal of this numerical method is dividing all the large structure into small elements having simple shapes. The unknown variables of an element are the displacement values for each nodal point.

2. MAIN BODY

The specifications of gantry crane are the max. height of hoist as 45.000 mm and the hoisting capacity is as 2x160.000daN. The carriage walk span is 36 m and the walk span is 360 m. The loads are considered due to FEM norms. The coefficents given in these norms are multiplied with the load values. The inertia forces which are formed due to the movement of the trolley and crane are considered in the dynamic analysis.

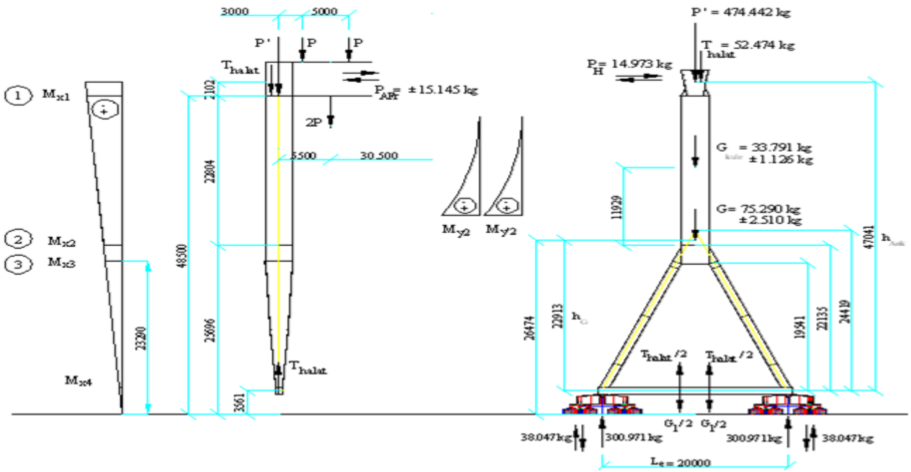

Figure 1. The free body diagram of the gantry crane

For the finite element analysis, the element type used in the model is four node quadratic shell element (S4R). The total node number used is 392745 and the element number is 398602 for the gantry crane. All of the parts are meshed separately and then, they are combined to each other with node to node connection. The gantry crane parts are composed of St42 material and the material properties of St42 are described in Table 1.

Table1. Material properties of gantry crane parts [2]

MATERIAL PROPERTIES	
Young's modulus of elasticity	***2.1x10^5 N/mm^2***
Poisson's ratio	***0,3***
Density	***8 ton/m^3***

During the finite element analysis, some assumptions have been done. The nodes on the contact points of the boggie with the rail are constrained. 2 nodes are considered as restrained and 32 nodes are free. Each carriage has 8 boggies and load is applied to the nodes on the contact points of the boggie with the ground. The total load is divided equally on 16 boggie and the carriage is assumed as static. Considering these assumptions and the material properties in Table 1, each component of the gantry crane are meshed individually.

Hinged leg and rigid leg, equalizer beam which are the basic components of the gantry crane are illustrated as seen in Figure 2,3,4.

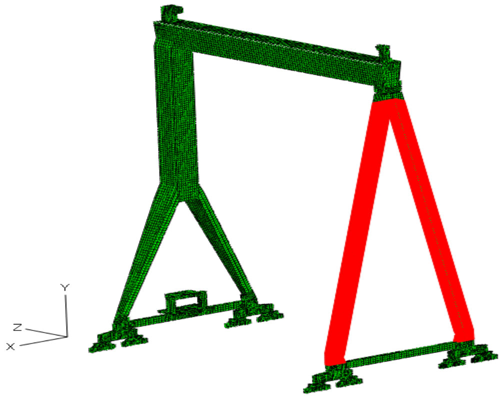

Figure 2. Meshed model of the hinged leg

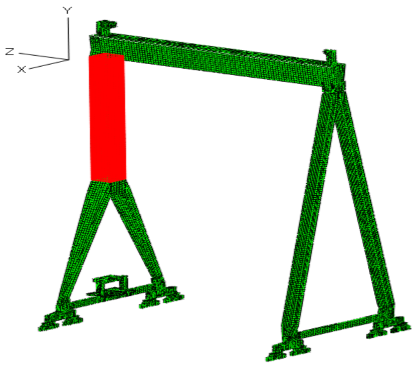

Figure 3. Meshed model of the rigid leg

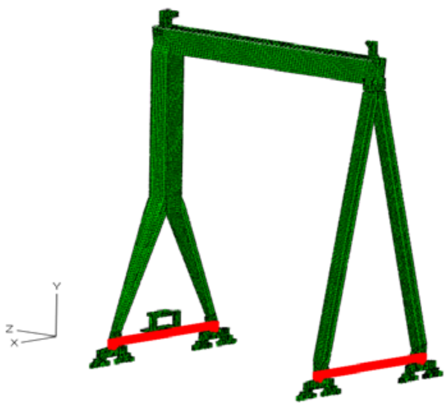

Figure 4. Meshed model of the equalizer beam

3. RESULTS

Static analysis is the most common analysis method which is used in engineering. As the loads are assumed to be applied instantly, the effects due to the time variation are neglected.

The comparison of the results which are achieved by finite element method and linear calculations are illustrated in table 2. The deviation between these two methods are not more than 20%. This deviation occurs because of the assumptions in analytical methods and the numerical approach used in finite element method. As the computed stress values are smaller than the allowable stress of the used material (180 MPa), it is observed that the gantry crane is safe according to DIN and FEM norms.

Table 2. Comparison between the analytical and FEM method results

Control Regions	**Analytical Cal. Compund Stress (N/mm^2)**	**FEM Analysis Compund Stress (N/mm^2)**
Main Girder Beam	168	163
Rigid Leg Tower	153	138
Rigid Leg Lower Side	157	141
Hinged Leg	170	135
B. Equalizer Beam	165	156
S. Equalizer Beam	147	127

4. CONCLUSION

In this study, the stress values on winkle supports which are employed for safety against wrinkle proves that they do not carry load and they do not provide strength for tension, compression and bending. Because of this, the strength of these parts can be decreased. For instance, the tower wrinkle supports, upper and middle sheet metal of the assembly box, middle sheet metal of the upper box of the leg, boggie upper sheet metal and upper sheet metal of bottom cross beam, the support sheet metals placed in the main beam are not under effect of high stress values. The sheet metal thickness of these parts mentioned can be decreased.

Considering the data obtained from the analyses, the material waste can be prevented in crane design. The construction is now more reliable, light and durable. This is crucially important in means of low cost production and low design duration.

5. REFERENCES

[1] David V. Hutton, *Fundamentals of Finite Element Analysis*, 1st Editon, McGraw-Hill Mechanical Engineering, 2004,

[2] http://www.e-pipe.co.kr/eng/DIN/17177.htm