RESEARCH ON THE STRENGTH OF THE OVERHEAD TROLLEY WITH A LOAD OF 1000 KG

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ABSTRACT: The paper includes a study on the static analysis of the loads of a trolley of a bridge equipped with an electric hoist for lifting and transporting loads, static study of the loads with the load at the middle of the crossbar but also with the load at a certain distance. The loads were then calculated using the SolidWorks software program, the analysis domain was discretized, with the input quantities, design calculations were performed, simulations were performed to determine the Von Mises stresses but also the visualization of the displacements with the load established at the design.

KEY WORDS: overhead crane trolley, tasks, loads, displacements, optimization.

1. INTRODUCTION

Modern cranes must have very high technical and economic properties parameters. They must be designed to withstand frequent changes in working modes, like any other machines that produce dynamic motion [1]. During dynamic working modes, significant dynamic effects occur.

The working times of some cranes consist of stationary and non-stationary periods of movement. Non-stationary movement mode causes the appearance of variable loads on the mechanisms and supporting structure of the crane. [2]

Dynamic analysis must be performed during the crane design process in order to analyze the stress and deformation conditions of the elements of the crane mechanism and supporting structures [3].

Numerous theoretical and experimental research of the dynamic behavior of the bridge crane have shown that critical dynamic states occur during lifting or lowering of the load [6]. Dynamic behavior of large machines is the focus of research in the last decade [4, 5]. Extensive research is being conducted to develop strategies for vibration damping [7]. The influence of the type of restraints and the change in the position of the loading force on the Huber-Misses stress generated in the crane girder was estimated in [8].

In [9] and [10], the deflection values occurring in the main girder of a gantry crane under various loads were investigated theoretically, numerically and experimentally. The object of study in the paper [11] was the angle of deviation of the crane from the perpendicular to the rails in a horizontal plane. The purpose of the paper was to develop a mathematical model of the crane beam misalignment. The model was created in MATLAB Simulink. Based on the resulting model, a control system was implemented that compensates for the misalignment that occurs when the crane drives accelerate or decelerate. The modeling procedure for a flexible jib crane driven by hydraulic cylinders and modeled as a planar multibody system is presented in the paper [12].

The paper [13] deals with the analysis of the load motion, considering wind pressure and the deformation of the cable system.

From the above-mentioned papers this area of research is in the focus of interest of researchers today. Modeling the interconnections of crane elements in a dynamic calculation is very complex and often not necessary, since not all factors have the same influence on the dynamic loads. Therefore, during mathematical modeling, all factors that are not essential for calculations can be ignored [14]. The most important parameters are the number of concentrated masses, their arrangement on the supporting structural elements, the rigidity of the supporting elements and structures and the possibility of their change, the dependence of the driving and braking force of the drive mechanisms on time, the speeds and frequencies of engine revolutions, the attenuation of oscillations in the crane structure and its elements, etc. In each case, some of the above-mentioned parameters will have a major impact, and some of them can be ignored. Bridge cranes are characterized by a special arrangement of assemblies (characterized by their respective mass, stiffness and damping).

From the point of view of dynamic analysis, it can be stated that a crane has an unlimited number of degrees of freedom. The crane mechanisms, as well as the elastic supporting construction, form a complex oscillatory system subject to oscillatory motion in a vertical plane. Any change in the system parameters directly affects the dynamic behavior of the system. Most research in recent years has focused on [15]. Static loading on a bridge refers to all forces applied to the structure in a state of rest (without dynamic effects, braking, acceleration), [16, 17,18].

Types of reactions in a bridge:

Vertical reactions (support forces):

Longitudinal horizontal forces: transverse horizontal forces, overturning moments. I

The importance of reactions in design gives specialists information regarding the dimensioning of structural elements, ensuring stability, or preventing excessive vibrations, etc.

The suspended crane moves on a suspended road placed on its own pillars that support the roof and walls of the hall in which it is installed.

2. PROCESS FLOW DIAGRAM

In figure 1 is the model of the overhead crane, where the following have been noted:

l_1= gauge length
V_1, V_2 = end supports
m= overhead crane trolley table
h = beam height
v(x,t)= trolley travel speed
M = load

The static load on a bridge refers to all forces applied to the structure at rest (without dynamic effects, braking, acceleration).

The main components of the static load are (Figure 2.1.):

Payload (Q) – the actual weight of the object lifted by the winch, the weight of the winch (G_t) – the weight of the lifting equipment itself moving on the beam, the weight of the bridge (G_p) – the weight of the metal structure of the bridge, including the running ends, the reactions in the supports (R_1, R_2) – the vertical forces transmitted by the wheels to the running tracks and further to the resistance structure of the hall.

These loads are used to calculate the dimensioning of the beam, running track, columns and foundations.

With the dimensions established by the design calculation, the reactions from the supports and the maximum moment were calculated: Beam length L=10m, distributed load q=2.4kN (weight of the bridge), concentrated load P=20.00KN (winch+1000kg payload) applied at a=4m from the left end.

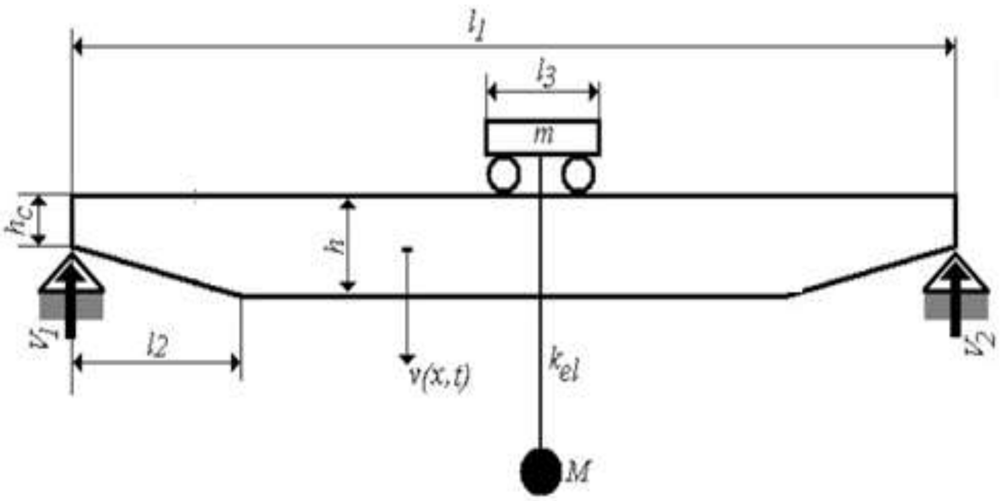

Figure 2.1. Process flow diagram

3. DESIGN AND SIMULATION OF OVERHEAD TROLLEY LOADS

Through finite element analysis, the behavior of the cart under different loading conditions with different loads can be visualized through simulation, which provides us with information about the weak points of the structure and how to proceed to optimize the process.

From a safety point of view, each overhead crane must have a clearly marked maximum load, manipulators must respect these limits in order not to overload the cart.

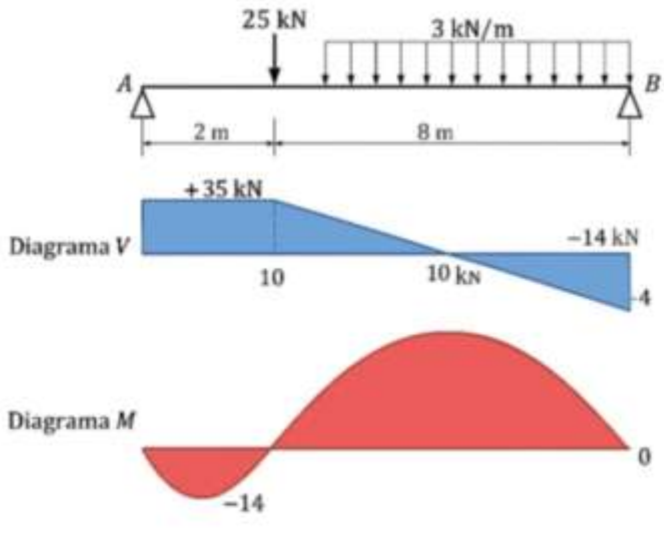

Figure 3.1. Shear force and bending moment diagrams eccentric load

The load calculations for P=25kN, the eccentrically distributed load, were calculated and sketched in figure 3.1.

The geometric modeling of the overhead crane trolley subassemblies and the discretization of the static analysis domain can be seen in figure 3.2.

Figure 3.2. Combining constructive elements and discretizing the analysis domain

In fig. 3.3. the Von Mises stresses can be visualized, and in figure 3.4. the stress areas with considerable loads can be observed. In figure 3.5, the obtained values of the deformations in the overhead crane trolley are shown through a colored map, and in order to visualize the displacements, the figure was enlarged 1000 times.

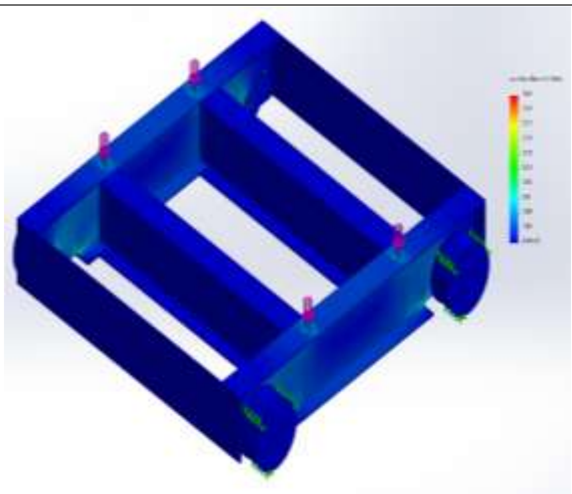

Figure 3.3. Viewing von Mises stresses from the overhead bridge trolley

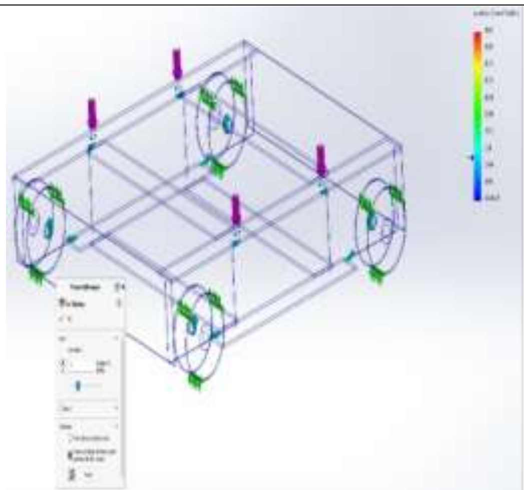

Figure 3.4. Visualization of the voltage area with more important values

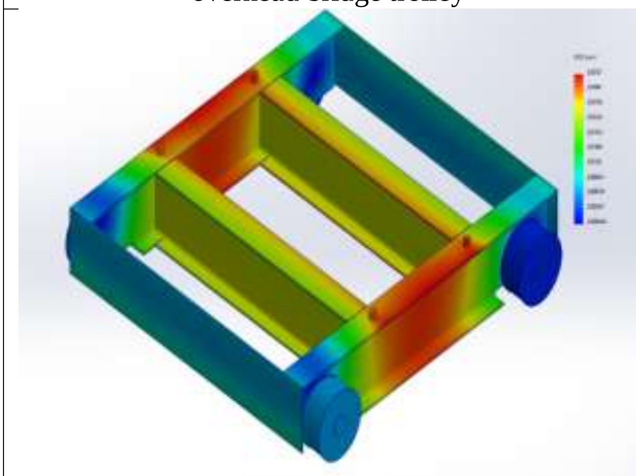

Figure 3.5. The obtained values of the deformations in the overhead crane trolley

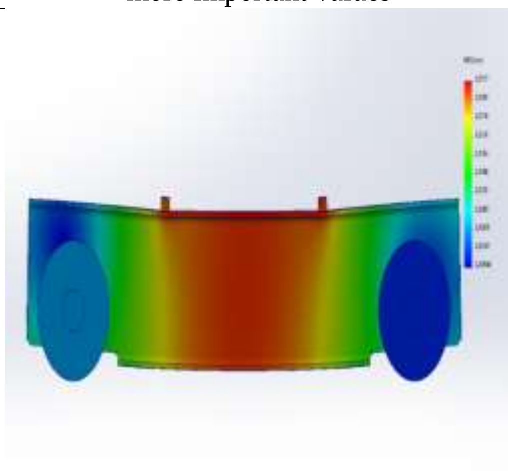

Figure 3.6. Viewing the movements of the overhead crane trolley (movement multiplied by 1000 times)

1. CONCLUSIONS

The work includes stages of design and calculation of the reactions from the supports of an overhead crane equipped with a trolley and an electric chain hoist.

The geometric model created has passed to the discretization phase, dividing the study domain into several finite elements where the loads take place for the visualization of the results.

The type of analysis was static, according to the composite stresses of the overhead crane, highlighting the stresses and deformations that occur.

The simulation, as the last stage of modeling, highlighted the Von Mises stresses, the maximum moments in the metallic structure, and because of the study, no dangers resulted in the metallic structure, as long as the load does not have values above those allowed by the construction standards.

The material of the structure was chosen to be the S 235 construction steel, with homogeneous material properties, isotropic and respecting the elastic characteristics of the material.

The results obtained from the simulation can constitute starting data for a dynamic analysis of the loads that exist in the structure due to vibrations or the action of factors such as wind, rain or quantitatively significant snow.

REFERENCES

[1] Q. Yang, X. Li, H. Cai, Y-M. Hsu, J. Lee, C. Hung Yang, Z. Li Li și M. Yi Li. Energy consumption modeling of industrial robot of based on simulated power data and parameter identification, Advanced in Mechanical Engineering, 173:108545, 2021,

[2] S. Wang, Z.Ren, G.Jin, and H Chen. Modeling and analysis of offshore crane retroffited with cable-driven inverted tetrahedron mechanism. IEEE Acces, 2021

[3] Q. Jiao, B.Li, Y. Qin, F.Wang, J.Gu,J. Wang, and C. Mi, Research on dynamic characteristics of lifting rope-breaking for the nuclear power crane. Journal of Failure Analysis and Prevention.

[4] D. Cekus, P. Kwiatoń, and T. Geisler. The dynamic analysis of load motion during the interaction of wind pressure. Meccanica, 2021.

[5] J. Yuan, C. Schwingshackl, C. Wong, and L. Salles. On an improved adaptive reduced-order model for the computation of steady-state vibrations in large-scale non-conservative systems with friction joints, Nonlinear Dynamics, 2021.

[6] H. Zhu, J. Li, W. Tian, S. Weng, Y. Peng,Z.Zhang, and Z.Chen. An enhanced substructure based response sensitivity method for finite element model updating of large-scale structures. Mechanical Systems and Signal Processing, 2021.

[7] I. Golvin and S. Palis. Robust control for active damping of elastic gantry crane vibrations. Mechanical Systems and Signal Processing, 2019.

[8] L. Sowa, W. Piekarska, T. Skrzypczak, and P. Kwiatoń. The effect of restraints type on the generated stresses in gantry crane beam. MATEC Web Conferences, 2018.

[9] Y.A. Onur and H. Gelen. Design and deflection evaluation of a portal crane subjected to traction load. Materials Testing, 2020.

[10] Y.A. Onur and H. Gelen. Investigation on endurance evaluation of a portal crane: experimental, theoretical and finite element analysis. Materials Testing, 2020.

[11] A. Komarov, A. Grachev, A. Gabriel, and N. Mokhova. Simulation of the misalignment process of an overhead crane in Matlab/Simulink. E3S Web Conferences, 2021.

[12] A. Cibicik, E. Pedersen, and O. Egeland. Dynamics of luffing motion of a flexible knuckle boom crane actuated by hydraulic cylinders. Mechanism and Machine Theory, 2020.

[13] D. Cekus and P. Kwiatoń. Effect of the rope system deformation on the working cycle of the mobile crane during interaction of wind pressure. Mechanism and Machine Theory, 2020.

[14] T. Wang, N. Tan, X. Zhang, G. Li, S. Su, J. Zhou, J. Qiu, Z, Wu, Y. Zhai, and R. Donida Labati. A time-varying sliding mode control method for distributed mass double pendulum bridge crane with variable parameters. IEEE Access, 9:75981-75992, 2021.

[11] L Cîndea, CO Hamat, O Barbu, T Ene, C Rudolf, A study concerning the critical path method for optimizing the design and crafting of a welded structure, IOP Conference Series: Materials Science and Engineering, 2018, Vol.393, pp. 012-022.

[12] Cîndea L, Hațiegan C, Modelarea și simularea sistemelor mecanice, Editura Eurostampa Timișoara, 2021, ISBN 978-606-32-0970-3.

[13] Hațiegan C, Suciu L, Fizică tehnologică -Teorie şi aplicaţii, Editura „Eftimie Murgu" Reşiţa, 2010, ISBN: 978-973-1906-77-5, Editura Eurostampa Timișoara, 2021.

[14] Constantin Marta,Ioan Doroftei, Lenuta Suciu, Iancu Tatucu, Gheorghe Prisacaru and Codruta Hamat, Influence of thermal field in the GMAW process: modelling and comparison with experimental results, Annals of DAAAM & Proceedings, Publisher: DAAAM International Vienna, p.817, 2008.

[15] L Nedeloni, P Pedrali, L Cîndea, A P Petrica, I L Conciatu, A Băra, Dry sliding wear research on C45 carbon steel, 41Cr4 alloyed steel and X3CrNi13-4 martensitic stainless steel, IOP Conference Series: Materials Science and Engineering, Volume 477, International Conference on Applied Sciences 9–11 May 2018, Banja Luke, Bosnia and Herzegovina.

[16] Cornel Hațiegan, Lenuța Cîndea, Cristinel Popescu, Florin Grofu, Coupled analysis of characteristics of electromagnetic dc cranes for traction, Annals of the „Constantin Brancusi" University of Targu Jiu, Engineering Series , No. 4/2024, p.196-161.

[17] M. Delić, M. Čolić, E. Mešić, and N. Pervan. Analytical calculation and FEM analysis main girder double girder bridge crane. TEM Journal, 6(1):48-52, 2017. doi: 10.18421/TEM61-07.

[18] M. Delić, N. Pervan, M. Čolić, and E. Mešić. Theoretical and experimental analysis of the main girder double girder bridge cranes. International Journal of Advanced and Applied Sciences, 6(4):75-80, 2019. doi: 10.21833/ijaas.2019.04.009.