14th International Research/Expert Conference
"Trends in the Development of Machinery and Associated Technology"
TMT 2010, Mediterranean Cruise, 11-18 September 2010

STATIC AND DYNAMIC DESIGN OF THE BEHAVIOR CONSTRUCTIVE PART OF THE ROTARY EXCAVATOR

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ABSTRACT

The static and dynamic calculations of the one part (pillar with lug) of the rotary excavator were done. All calculations were based on corresponding technical characteristics which were valid for the mentioned type of structure. The calculations were done by using the Finite Element Method and the programmed package KOMIPS Computer Modeling and Structural Calculations.
Key words: Finite element method, rotary excavator, pillar, lug, deformation.

1. INTRODUCTION

Rotary excavator revolving as a whole is quite complicated and thus requires genuine static and dynamic calculations. Static and dynamic analysis of the behavior of various constructions is usually performed using Finite Element Method (FEM). The calculations were done by using the Finite Element Method and the programmed package KOMIPS Computer Modeling and Structural Calculations [4].
The basic static equation in matrix form, for the global system of coordinates, can be represented in the form:

$$[K]\{8\} = \{N\}. \qquad ..(1)$$

Where:
[K] is the stiffness matrix;
{8} is deflection vector;
{N} is loading vector.
The basic dynamic equation damping oscillations is:

$$[M](t)\}+ [A\} (t)\} + [K] \{6(t)\} = \{N (t)\}. \qquad ..(2)$$

With the following notation:
[M]- Mass matrix;
[A]- Damping intensity factor;
(t)} (t)} {(t)} - Acceleration, speed and deflection changes in time;
{F (t)} - Dynamic loading compulsion vector; t - time.

2. THE ANALYSIS OF THE BEHAVIOR

The comparative stress is usually calculated using Hanky-Misses hypothesis for all nodal points and finite elements. The basic elements for the identification of the behavior of one construction are: disposition of the loading, distribution of the membrane and bending stresses, energy of deformation potential and kinetic [1, 2, 3]. Distribution of the loading lines through the (1) considered construction is defining the behavior of the construction. Loading lines are always extended over the cross sections with the aught resistance.

2.1. Membrane and bending stresses

Distribution of the membrane and bending stresses can be calculated in beam and plate finite elements. Relations between these two kinds of stresses in all parts of considered structure are indicated where the critical sections are located. A great deal of bending stress in some parts of the construction is showing that the construction has to be reconstructed.
If the influence of the bending stresses is small compared to the membrane stresses, the finite element model can be reduced on the simple one.

2.2. Normal stresses and the shearing stresses

The behavior of the considered construction can be analyses using distribution of the normal stresses and the shearing stresses, for the models consisted of beam and plate finite elements. The analysis is similar as one presented in previous section. Using calculated distribution critical places on the structure could be obtained of shearing stresses. Normal stresses and shearing stresses have independent calculation, because there is no connection between them in the elasticity matrix. The calculation of the normal stresses has better conversation.

2.3. Deformation energy

The equation of the balance of the potential energy and the energy of the external forces can be derived from the basic static equation (3) and can be represented in the following form:

$$\{\delta\}^T \cdot [K] \cdot \{\delta\} = \{\delta\}^T \{D\} \equiv E_d \,. \qquad ..(3)$$

The equality between the sum of the deformation energy of all finite elements and the power of the external forces is showing that the finite element model is correct with the aspect of the boundary conditions. Distribution of the energy of deformation across the groups of finite elements (parts of structure) is effective indicator for the validity of the structure. Energy method in analyzing is very effective method for the choice of the reconstruction of the considered structure, too.

2.4. Kinetic and potential energy on the main modes of oscillations

The equation of the balance of potential and kinetic energy has the usual form,

$$[\mu]^T \cdot [K] \cdot [\mu] = [\mu]^T \cdot [M] \cdot [\mu] \cdot \{\lambda\}. \qquad ..(4)$$

All presented distributions are giving us important information about the behavior of the considered structure and information about possible modification.

3. MODEL FOR CALCULATION

The virtual model for calculation using the Finite Element Method (FEM), it was founded on plate and beam elements, Figure 1.

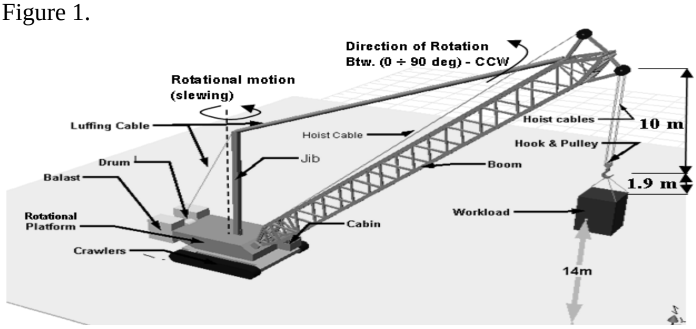

Figure 1. Virtual model of the rotary excavator

3.1. Static analysis of the behavior of the pillar with lug

Using static finite element analysis was consisted of *1640* nodal points, 1730 plate elements and 131 beam elements.

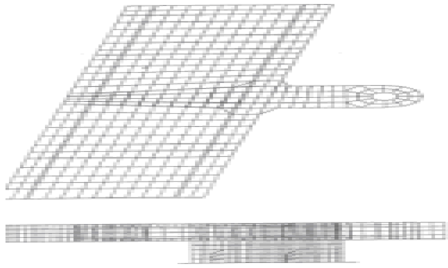

Figure 2. Model for calculation

In Figure 2 is shown the model of the pillar in two projections and econometrically. The loading of model consists of two vertical forces which intensity where 450 kN and 210 kN and it are represented in Figure 3 together with the accepted boundary conditions. The deformed configuration of the considered structure of the excavator is shown in Figure 4.

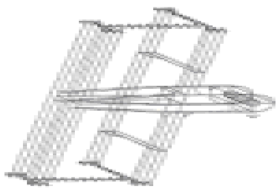

Figure 3. Loading and boundary conditions

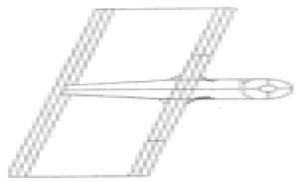

Figure 4. The deformed structure

Maximal value of displacements is 0.450 cm. Calculated stress distribution is shown in Figure 5. Maximal stress intensity was obtained on the places shown in Figure 6.

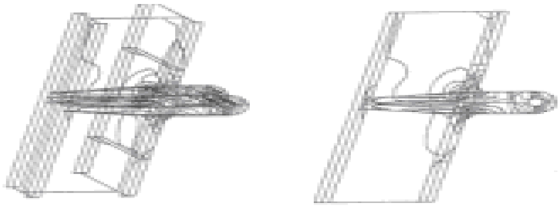

Figure 5. Stress distribution, 0-8.4 step 0.8 kN/cm^2

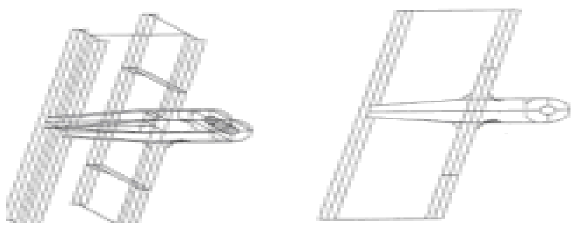

Figure 6. Maximal stress intensity, 7-9.4 kN/cm^2

Static analysis of the behavior of the pillar with lug can be analyzed using distribution of the membrane and bending stresses and the distribution of the normal stresses.

3.2. Dynamic analysis of the behavior of the pillar with lug

Distribution of the potential and kinetic energy for 2 main modes of oscillations in the pillar, lug and webs is presented in Table 1. On the all frequencies, the greatest part of the energy is accumulated in the plate elements of the pillar. Kinetic energy in the elements of the lug is greater then potential energy. Using dynamic finite element analysis, two main modes of oscillation were obtained. Calculated frequencies are f_1=43.6 Hz and f_2=52.8 Hz.

Table 1. Potential and kinetic energy

E_p/E_k [%]	f_1	f_2
Pillar	98/86	79/73
Lug	1/12	14/24
Webs	2/2	1/1

The corresponding deformations of the model for two oscillation modes can easily be seen in the Figure 7.

f_1=43.6 Hz *f_2=52.8 Hz.*

Figure 7. Deformations two oscillation modes

4. CONCLUSION

Static analysis it is possible to conclude that there is a good relation between membrane and bending stresses in all parts of structure. The highest values of the deformation energy are obtained in the plate elements of the lug. Dynamic analysis is showing that on the all frequencies, the greatest part of the energy is accumulated in the pillar and that the energy distribution in the elements of the lug is adverse. So, it is possible that the structure has to be reconstructed. Kinetic energy in the elements of the lug is greater then potential energy.

5. REFERENCES

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