MODEL FOR DETERMINING THE STATIC LOAD ON MOVABLE SPATIAL CONSOLE LATTICE GIRDER BOUNDED WITH CLAMPS

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Abstract: *This paper presents a model for determining the static load on movable spatial console lattice girder and the clamps which bounded the same one. The paper presents guidelines for theoretical determination of the static load using an appropriate software package and conducted modeling for this purpose. Also, the paper displays the methodology for experimental determining the static load by setting a model for the experimental measurement on the specific measuring points of the clams and the characteristic positions of the carrying console. The research is carried out on a concrete real object and the results are shown numerically and graphically, which enables carrying out an analysis of the load and deducing concreting conclusions about the research object.*

Keywords: CARRYING CONSOLE, CLAMPS, STATIC LOAD, THEORETICAL DETERMINATION, EXPERIMENTAL MEASUREMENT

1. Introduction

The carrying construction of the working wheel on a rotating excavator is a spatial steel console bounded with clamps, which can be moved in a horizontal and vertical plane. In the horizontal plane, moving this console is enabled by turning the lower construction of the excavator. In the vertical plane, the moving is from nethermost position where digging is below the ground level to the uppermost position at the maximum digging height above the ground level.

The spatial carrying console is with a lattice design, which at its first end is jointly connected, and at the free end carries the working (rotating) wheel of the excavator. The console is bounded with two clamps, usually with a rectangular cross-section, which with the opposite ends are carried on to the upper construction of the counterweight of the excavator (ballast construction).

The static load of the clamps of this spatial console lattice girder is by its own weight from the construction that they hold, and theoretically these are the load sizes for the standby condition of the excavator. In particular, the static loads of the clamps are tensile forces as a reaction from the weights of the elements on the working wheel and its carrying construction.

The static load of the clamps can be determined by theoretical and experimental way. The theoretical determination is based on a static calculation of the forces in the clamps using the static balance conditions for the three characteristic positions of the carrying console - uppermost, horizontal and nethermost position. The experimental determination is based on an experimental measurement of the forces in the clamps, at measuring spots (points) in the most loaded cross-section of the clamps, for the characteristic positions of the carrying console.

2. Theoretical determination of the static load

For theoretical determination of the static loads onto the clamps, it is necessary to set up the model of the carrying console and its clamps. The mathematical (numerical) model needs to implement a computer static calculation, and the same one should be close to the real model.

For a concrete rotating excavator, the excavator SRs-630/I product of the German company TAKRAF, which works in the coalmine "Suvodol" Bitola, sets the real and mathematical model of the carrying console and its clamps (Figure 1 and Figure 2).

Knowing the technical characteristics of the construction and application of a matrix analysis of the construction with a software package for this purpose, the static loads for the characteristic positions of the load carrying construction are determined, or loads on the excavator's standby without taking into account the working conditions.

The theoretical (analytical) determination of the static loads on the clamps of the rotating excavators finds justification in the development phase of the excavators (even when there is no real object) because it is a faster and cheaper way but with less accuracy than the experimental determination.

Calculated sizes of forces in the clamps which come from static load, using the SAP 2000 software package, are listed in Table 1.

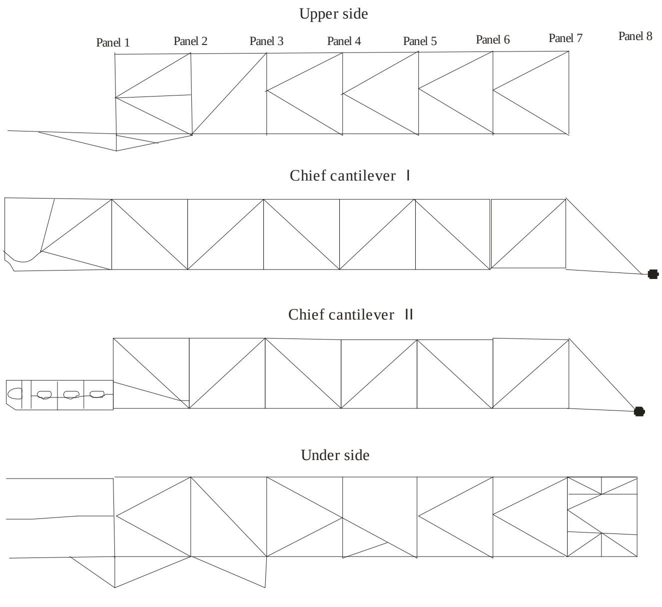

Fig. 1 *Real model of the carrying console*

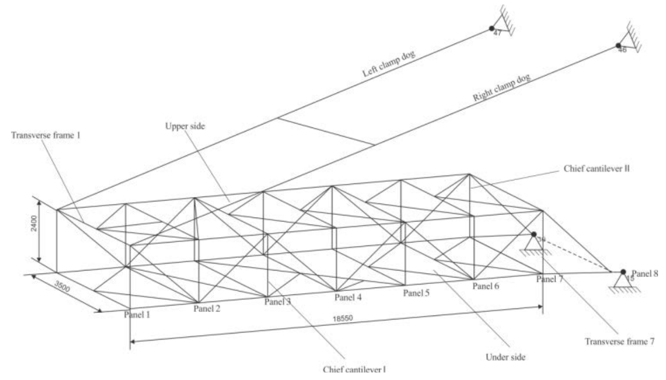

Fig. 2 *Mathematical model of the carrying console and its clamps*

Table 1. *Theoretical sizes of forces from static load*

Position of carrying structure	Tension force in [kN]	
	Right clamp	Left clamp
Uppermost	773.13	748.01
Horizontal	850.32	823.39
Nethermost	819.47	792.92

3. Experimental determination of the static load

The experimental determination of the static loads on the clamps of the carrying consoles could be done by measuring the strains to which they are exposed when the excavator is on standby, for characteristic positions of the console. The strains in excavator standby position are reaction to the own weight of the structural elements.

Stresses measurement of clamps is carried out in an indirect way, or by measuring the dilatations at certain measuring spots of the clamps with the most used method for this purpose - the tensiometric method. The dilatations of the measuring points are measured with the set measuring strain gages, and the connection of the dilatations with stresses and stresses with loads should be established using certain settings of the materials strength.

The measurement of the static loads of the two clamps on the carrying console of the rotating excavator working wheel requires a longer and more difficult preparation, given the working conditions of the excavator which is carried out according to a conceptual methodology for this purpose.

For the measurements of the excavator SRs-630 onto the both clamps there are placed five measuring gages for measuring axial stresses, with different layout on each clamp. The measuring gages on the two clamps are placed in the intersection, which according to the estimation is considered to be the most overloaded, and is located at the transition from the constant cross-section of the clamps toward the tilt, where the clamps with the little axles are joined to the carrying console of the excavator's wheel. The arrangement of the measuring gages for the right clamp is shown in Figure 3, and for the left clamp in Figure 4.

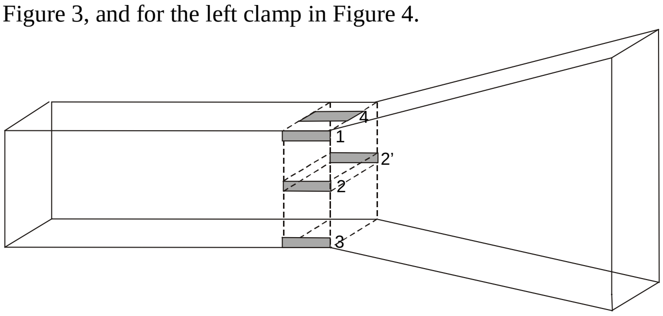

Fig. 3 *Measuring gages on the right clamp, with an inside view*

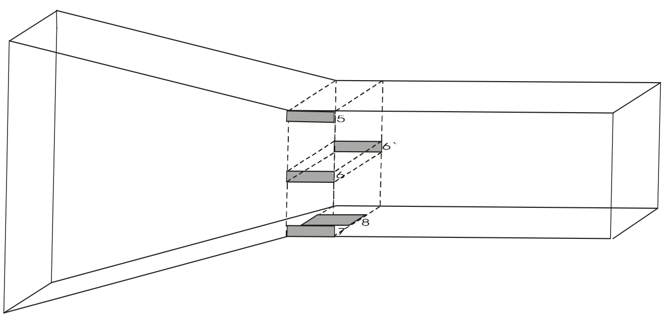

Fig. 4 *Measuring gages on the left clamp, with an inside view*

The measured sizes of loads from the static load, at each of the measuring points (spots) of the both clamps are shown in Table 2 for the three characteristic positions of the carrying console on the excavator's working wheel.

Table 2. *Experimental sizes of forces from static load*

Position of carrying structure	Magnitude of force from static load in [kN]							
	Right clamp				Left clamp			
	Measuring point				Measuring point			
	1	2	3	4	5	6	7	8
Uppermost	1270.08	812.45	555.31	1248.91	1141.9	788.26	604.65	782.01
Horizontal	826.56	853.07	1031.28	770.16	904.93	822.53	940.56	955.79
Nethermost	685.44	832.76	1150.28	666.09	1292.76	856.80	537.47	695.12

In order to obtain a clearer picture of the measurement magnitudes obtained by the experimental measurement, all the final results of the performed measurements are processed and systematized and the diagrammatic shown in Figure 5.

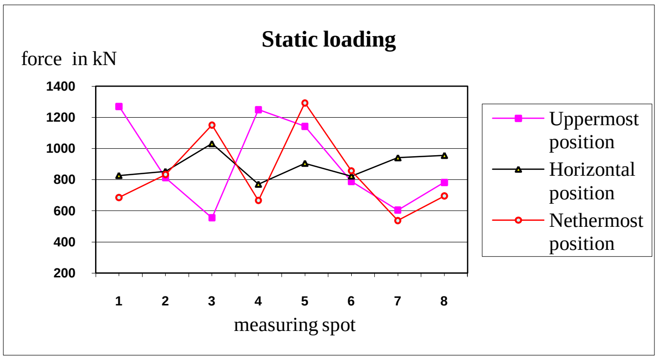

Fig. 5 *Static load on the clamps for the characteristic positions of the carrying console*

4. Measurement characteristics

The static load of the clamps was measured by the following way: the carrying structure of the working wheel was leaning in a lower position at rest, on supports with hydraulic pumps, in which position the clamps were loosened, or unloaded. This condition is the conditional zero of the load on the clamps. The carrying console is raised by about 2 m and the static load on both clamps is measured for a horizontal position. The carrying console was then lifted up to its uppermost position, for which position the static load of the clamps was measured. The static load on the clamps was also measured for the nethermost position of the carrying console on the working wheel.

During the measurement, the static load change in the clamps was followed from the influence of:
- removal of the hydraulic support of the carrying console;
- turning the console left and right ;
- turning the working wheel without load;
- the work of the conveyor tape on the carrying console without load;
- the transport of the excavator.

From all previously mentioned the following conclusion is ascertained:

The extraction of hydraulic supports does not cause a change in the static load on the right clamp, while in the left this change is small by increasing on the measuring spot 6 and decreasing on the measuring spot 7.

When turning the carrying console to the right, change in the load on the right and left clamp is recorded. On the right clamps - the measuring spot 1 and 4 have a lower force, which is 62% and 59% respectively of the load size in this position of the console before the turning starts; at the measuring spot 3, an increase of 69% of the load before turning; no change in load was recorded at measuring spot 2. On the left clamp - at the measuring spot 5 there is a 38% reduction in the load; on measuring spots 7 and 8 there is an increase of 100%; while no change has been recorded at measuring spot 6.

When turning the carrying construction to the left it is recorded for the two clamps the same load change at measuring spots as when turning to the right, but with some smaller forces.

The rotating of the working wheel without load does not cause a change in the load condition of the clamps.

The work of the conveyor tape without load does not cause a change in the load on the clamps.

The transport of the excavator also does not cause a significant change in the load. Negligible oscillatory load changes are recorded at measuring spot 3 on the right clamp and measuring spot 6 on the left clamp.

5. Conclusion

The theoretical determination results of the static loads on the clamps of carrying console should be treated as orientation values because they do not take into account the specific working environment impacts and the actual technical condition of the excavator, as well as the change in the size of the forces at different positions at the cross-section of the clamps.

The experimental determination results of the static loads on the clamps of carrying consoles are relevant for further analysis. The analysis of the results of the experimental measurement showed that the relevant sizes for the loads of the clamps are the measured forces at the neutral axis of the cross-section of the clamp (measuring spot 2 at the right and the measuring spot 6 on the left clamp).

The static loads of the clamps are the largest for the horizontal position of the carrying console, with the note that the load on the right clamp is greater.

The display on the same diagram of the measured forces for the two clamps per measuring spots and positions of the carrying console allows us to perceive the difference in the load sizes of the two clamps for the same position of the carrying console, for all measuring spots, as well as the difference in the load per measuring spots for the characteristic positions of the console.

6. References

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