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Load Functions on the Cantilever Beam Carrying Structure and its Clamps

Prof. Dr. Sc. Elizabeta Hristovska, Prof. Dr. Sc. Stojance Nusev, Assis. Prof. Dr. Sc. Ivo Kuzmanov,
Assis. Prof. Dr. Sc. Sevde Stavreva, Assoc. Prof. Dr. Sc. Zlatko Sovreski

Abstract—This paper via diagrams shows the load functions on both clamps of the working wheel's carrying structure in a rotating excavator working under concrete working conditions, and the load functions on the most loaded truss joint of this carrying structure. The load functions apply during the total exploitation lifetime of the excavator. As for the clamps, they are indicative of the change in the axial force of tension depending on the time, whereas for the most loaded truss joint they are indicative of the change in the forces at the constituent trusses of the joint, which forces may be tension forces or pressure forces depending on the external load of the truss.

Index Terms— carrying structure, clamps, load functions, rotating excavator.

1 Introduction

The knowledge of the load functions as to a respective machine element or to a particular machine as a whole is of great importance because it defines the load regime over the total exploitation lifetime.

In order to obtain the load function as for an element (part) of the metal structure in an excavator, it is necessary to carry out experimental research of deformation and stress shape of the element under all characteristic working regimes, most often by conducting experimental measurements of the working loads under those working regimes. However, the load function is also obtainable by conducting theoretical research of the load regime of the part during the lifetime of the excavator.

The theoretical researches are laborious and complex yet yielding unreliable results, while the experimental researches allow more accurate data making allowances for the higher cost of the latter however not always justifiable.

Besides the economic aspect of the experimental research of the working loads on parts of an excavator, it is worthwhile to note that this is not a simple matter and not enforced via simple procedure given the complexity of the excavator's structure and specificity of exploitation conditions.

Exploitation conditions have crucial impact on the durability of the certain parts of the excavator, and hence the excavator as a whole. Owing to this fact, the determination of the working loads closely relates to the definition of the working conditions according to their type and size before beginning to measure them. To this purpose, designing appropriate measurement, procedure and program of measurement is necessary, i.e. establishing an appropriate methodology for measuring.

- *Full Prof. Dr. Sc. Elizabeta Hristovska, Faculty of Technical Sciences, University "St. Clement of Ohrid"-Bitola, Macedonia, E-mail: elizabeta.hristovska@uklo.edu.mk*
- *All others co-authors are from the same institution E-mail: stojance.nusev@uklo.edu.mk ivo.kuzmanov@uklo.edu.mk sevde.stavreva@uklo.edu.mk zlatko.sovreski@uklo.edu.mk*

2 Basic Remarks for the Load Functions

The load functions of the clamps and the carrying structure of the working wheel determined in this paper, relate to the rotating excavator SRs-630 (shown on Figure 1) used in the coalmine "Suvodol"-Bitola in Macedonia.

Fig. 1. View of the rotating excavator SRs-630, the working wheel's carrying structure being marked with red pointer

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The load functions of the clamps (shown on Figure 2) obtained by processing records from experimental measurements of the loads' magnitudes in the clamps under different working regimes, cover all probable loads over the total lifetime of the excavator digging in aforementioned coalmine. This procedure takes into account the percentage share of each separate regime during the total lifetime of the excavator, estimated considering the experience from working this mining machine.

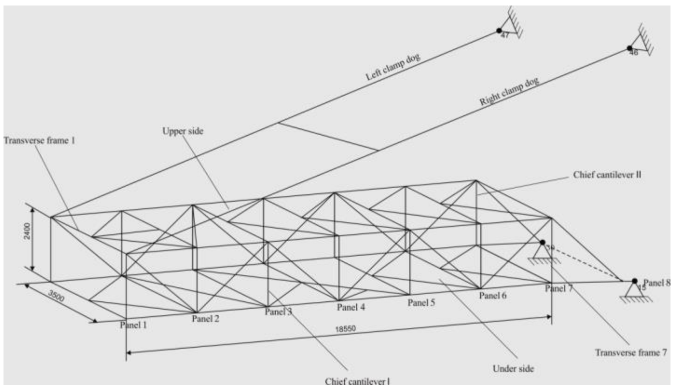

Fig. 2. Geometric model of the working wheel's carrying structure with its clamps

The load functions of the carrying structure (Figure 3) refer to its most loaded truss joint (marked by 24 on Figure 3), given the fact that the shortest lifetime is expected to occur exactly at that specific joint of the structure. Because the constituent elements of the joint during operation of the excavator receive various forces in magnitude and sense, the load functions for each of them are different. The loads functions for all constituent elements (trusses) of the joint are obtained from the theoretical research of the loads' magnitudes, which take into account different exploitation conditions of the excavator and all possible impacts on the carrying structure. To enable secure and reliable analysis it is necessary to establish a correlation between the loads of the clamps and the loads of the carrying structure.

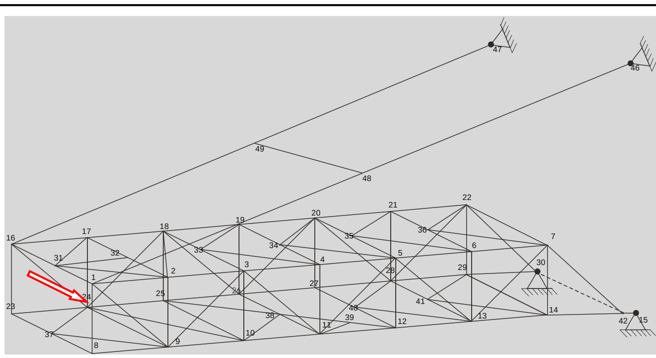

Fig. 3. Geometric model of the working wheel's carrying structure displaying the layout of all the truss joints and the most loaded truss joint marked by red pointer

3 Load Functions of the Clamps

The load functions for the both clamps of the working wheel's carrying structure in the rotating excavator SRS-630 (shown on Figure 2) obtained with the data from performed experimental measurements of working loads, take into account all the suggestions listed in the previous section of the paper. The working loads measured in all characteristic working regimes of the excavator make allowances for the normal and specific exploitation conditions. It takes into account the percentage share of each of these regimes over the total exploitation lifetime of the excavator.

Employing a selective approach to measuring of the loads simplified the measurement, whereas the length of the record of the working load and its iteration, the issue was closely related to the duration and cost of measuring of working loads, as well as to the reliability level of the obtained statistical indicators of the load's stochastic variables.

The load functions for the both clamps derived by processing of records from the conducted experimental measurement of the deformations respectively the loads on several measuring points on the clamps are indicative for ten characteristic working regimes of the excavator in mine "Suvodol"-Bitola, in winter and summer operating conditions.

The load functions of the both clamps shown on two separate diagrams, whereas each diagram represents the load function of the clamp via curve line giving the interdependence of the change in the axial force Fz (tension force) and the number of changes in the load over the total lifetime of the excavator.

Given the estimated lifetime of clamps with $N=10^7$ changes of the load, the function of interval load for the right clamp is shown on Figure 4, and for left clamp on Figure 5.

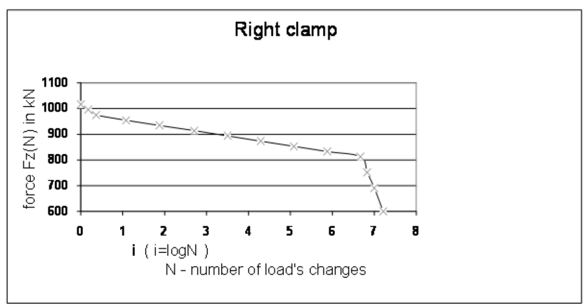

Fig. 4. Load function of the right clamp

4 Load Functions of the Carrying Structure

The total lifetime of the carrying structure of the working wheel in rotating excavator SRs-630 is conditional on the lifetime of its individual constituent components. The expectation that the shortest lifetime is to happen at the most loaded construction elements - the trusses of most loaded joint, is well justified. Therefore, an authoritative load function for carrying structure would be the load function at its most loaded truss joint, respectively the load functions of

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its component trusses.

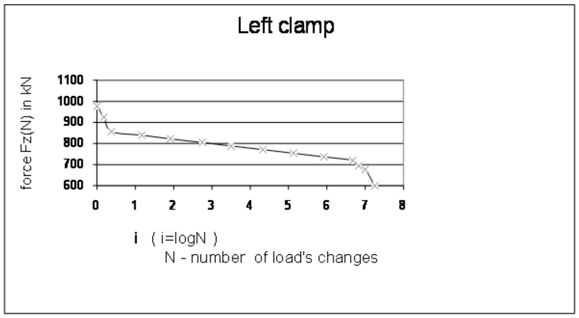

Fig. 5. Load function of the left clamp

A theoretical analysis of the loads of carrying structure under defined characteristic working regimes of the excavator, determines the most loaded joint, as already mentioned, designated by 24 on Figure 3.

The constructive design of this truss joint is very complex for several reasons: the constructive design of the joint being a three-dimensional one, the truss joint connecting eight trusses, each of the trusses having a complex transversal section, being worked out by connecting profiled carriers, and the mounting of the eight trusses onto the joint steel plate done by rivets.

The geometric model of this joint shown on Figure 6, displays the constituent trusses of the joint with their disposition and numbering. Since each of these trusses, numbered with 35, 36, 37, 48, 49, 82, 83 and 96, receives various forces in size and sense (tension or pressure) over the lifetime of the carrying structure, accordingly the load functions for each one of them are different.

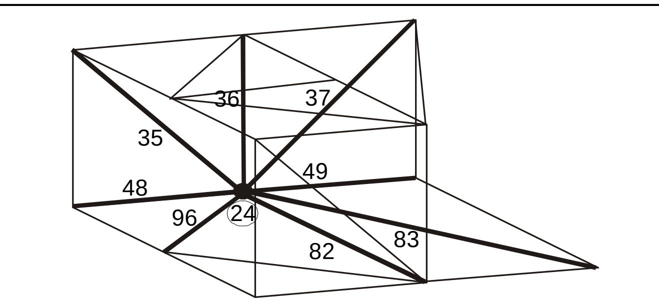

Fig. 6. Geometric model of the most loaded joint of the carrying structure with an outlay of the joining trusses

The load functions for the mentioned trusses of the joint are obtained by processing the results of theoretical analysis of the distribution of the external load upon the elements of this carrying structure, more precisely in the constituent elements of the joint 24, taking into account the loads stemming from the effects of wind.

The load functions of the constituent trusses of the joint 24 are shown on figures 7 to 14.

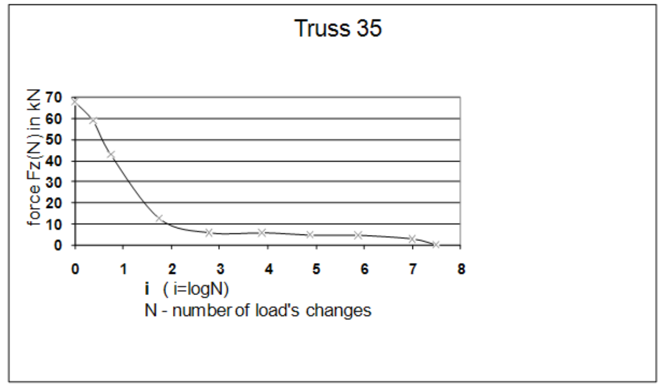

Fig. 7. Load function of the truss 35

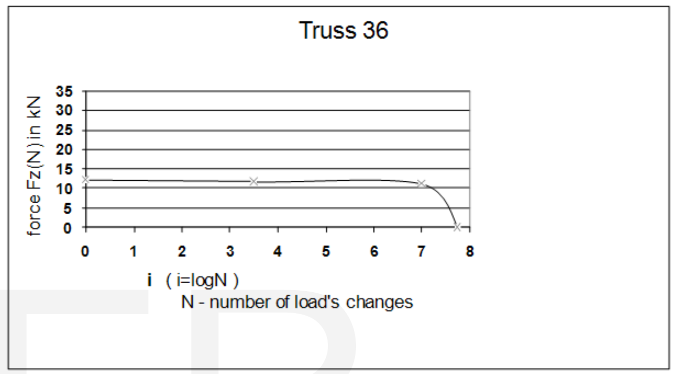

Fig. 8. Load function of the truss 36

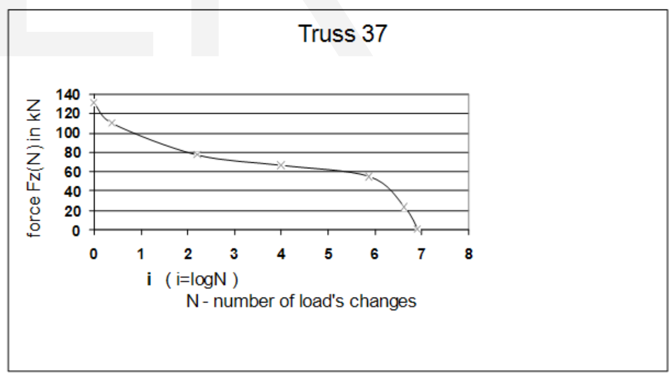

Fig. 9. Load function of the truss 37

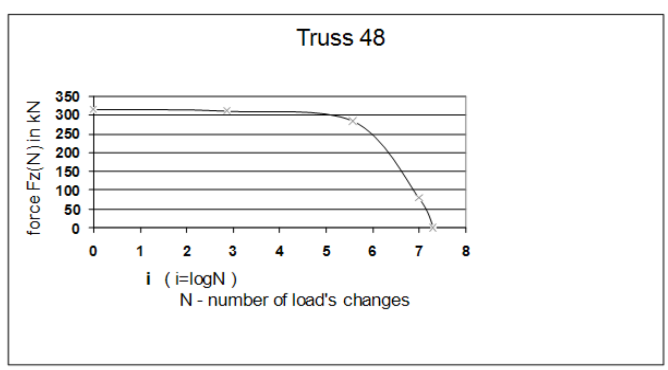

Fig. 10. Load function of the truss 48

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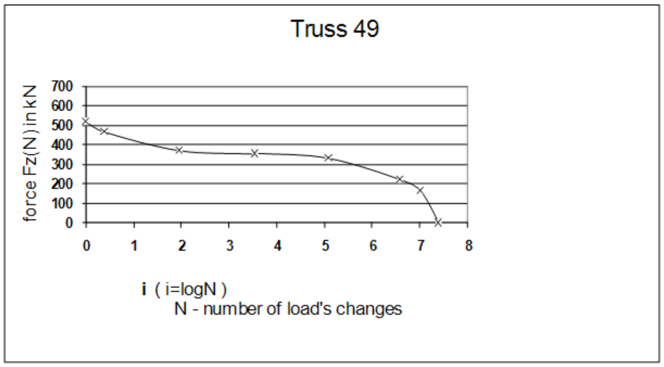

Fig. 11. Load function of the truss 49

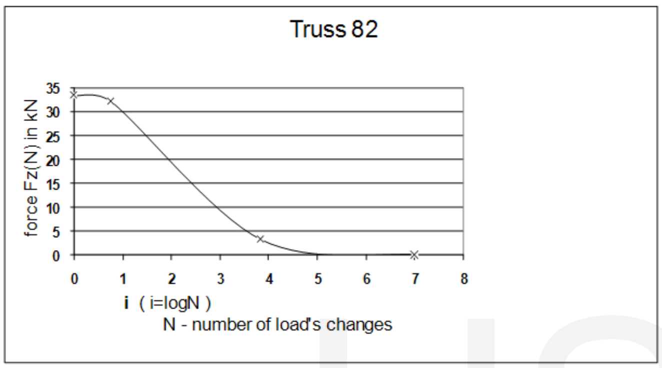

Fig. 12. Load function of the truss 82

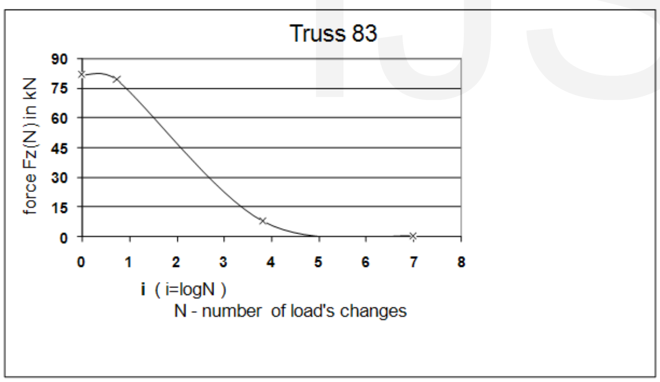

Fig. 13. Load function of the truss 83

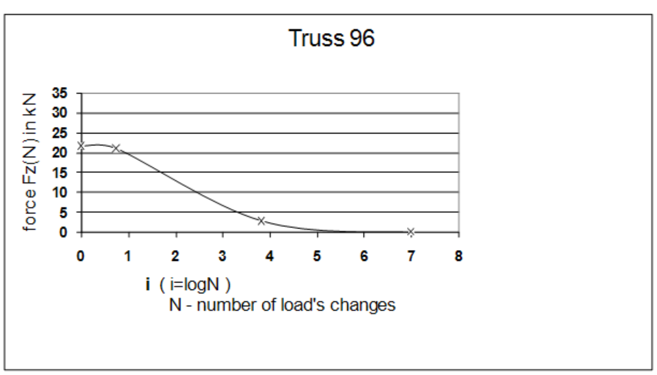

Fig. 14. Load function of the truss 96

5 Conclusion

Via the established methodology for this purpose, the load functions of the cantilever beam carrying structure of the working wheel and its clamps for a particular working machine and certain coalmine are obtained, more specifically for the excavator SRs-630 and exploitation conditions in the mine "Suvodol"-Bitola. These load functions provide objective parameters to evaluate the total exploitation lifetime of this carrying structure and its clamps, and thus the excavator as a whole, or provide data for allowed loads' magnitudes depending on their frequency of change and without any damage occurring them.

The terminate results of this established methodology are presented in this paper in the form of load functions previously shown in this paper. The methodology is designed for experimental and theoretical obtaining of load functions for carrying structure in an excavator and its clamps, which in this paper has been tested by its application to a specific excavator, and the results have been confirmed by analyzing the practical work of the excavator. This methodology can be applied to obtain the load functions on the other elements of the carrying structure of the excavator and other types of rotating excavators as well. To this purpose, it is necessary to have data on the size and change of the load in all working regimes of the excavator and the participation of individual regimes in its total lifetime. The methodology can be generalized to obtain the load functions of other structural elements in the dynamic conditions of work as well, with known external loads.

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