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Experimental Stress Analysis

ANALYSIS OF THE MEASURED FORCE VALUES IN THE GRAB DREDGER CABLES

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Abstract: A dredger analysis is presented in this paper. A strain-gauge device for measuring of dynamic forces in cables was designed. Measurements of typical operational work cycles during sand extraction from the bottom of water streams were done. Course of loading was elaborated into a form of two-parametric and one-parametric loading spectra of grab dredger loading.
An influence of operational parameters (as extraction conditions and dredged material types) on loading was examined. Experimental measurements during operation provided basic data for an assessment of design loading spectra for dredging crane calculations according to CSN and EN standards. By means of FEM static and dynamic models, forces and local ranges of stress for fatigue damage accumulation were stipulated, especially in the welded part of dredger structure.

1. Introduction

This study relates to the article "Forces measurement in extraction digger ropes" introduced at the EAN 2006 conference. A strain-gauge device for measuring of dynamic forces in cables was designed and manufactured, Fig. 1. Purpose of the realised measurements, was to acquire basic data for the fatigue life prediction of the dredger welded

Figure 1: Force scanning in the lifting and closing cables

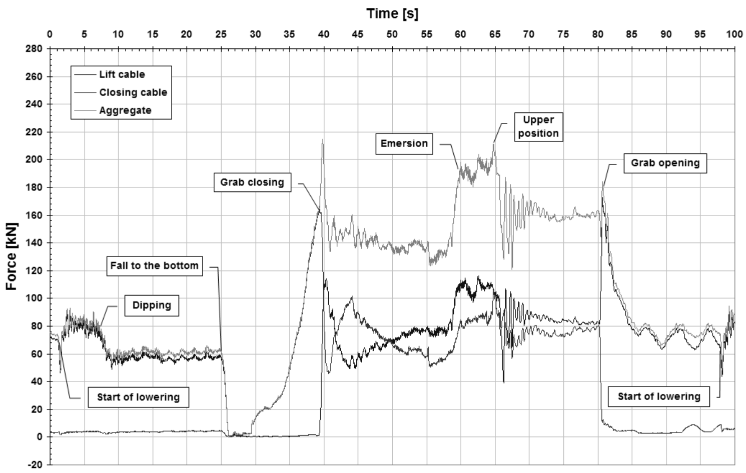

Figure 2: Dredger working cycles (forces in individual cables and their summation)

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steel structure. Measurements of typical working cycles during sand extraction from the bottom of stream were made in various modes of real operation, Fig. 2. The course of typical loading was elaborated into a form of two-parametric and one-parametric loading spectra (histograms) of the grab dredger.

2. Data Processing

As you can see on the Fig. 2, the measured force-time curves are non-stationary. Step changes of the force mean value will have a considerable influence on the lifetime of structure. Measured forces histories can be thus distributed into typical operation sections completed by cycles of mean value changes, or considered as a part of a "pseudorandom loading file". After an analysis, the measured data were processed by a "Rain-flow Method" as a whole using the computer program PragTic (project of the Faculty of Mechanical Engineering, CTU in Prague - www.pragtic.com). By means of this method, the data were decomposed into complete cycles and half-cycles with calculated range and mean values of force cycles.
On the basis of maximum values of the both parameters, partial intervals were formed, where the mean and ranges of forces were sorted. Depending on both parameters, there was stipulated a count frequency of occurrence in stated intervals.
A graphic representation of the composed two-parametric matrix is presented in Fig. 3.

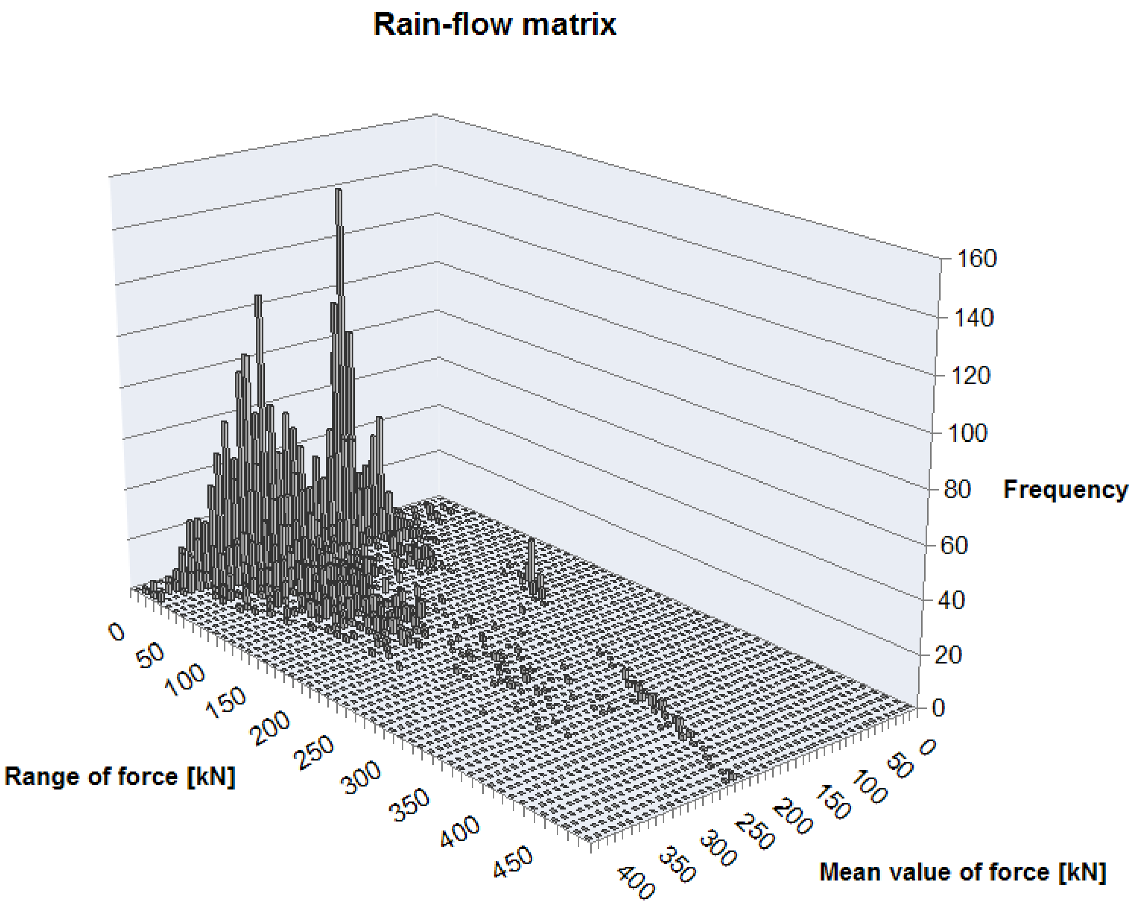

Figure 3: *Rain-flow matrix – bar chart*

Further, a relative range values were determined, which was stated by a relation of the actual range to the calculated maximal theoretical force in the cable, according to the Czech standard CSN 27 0103. Thus, one-parametric spectra were generated, which are more appropriate for a relative comparing or standardization. Furthermore, the count frequency was modified to a cumulative frequency and plotted in the chart, depending on the force range, Fig.4, and on the quantile of the Gaussian probability curve, Fig.5. It is evident from this chart that such plotted experimental points can be approximated with a sufficient exactness by a linear dependence. The construction is thus actuated dynamically by loading, the amplitudes of which can be approximated by a normal (Gaussian) statistical frequency distribution.

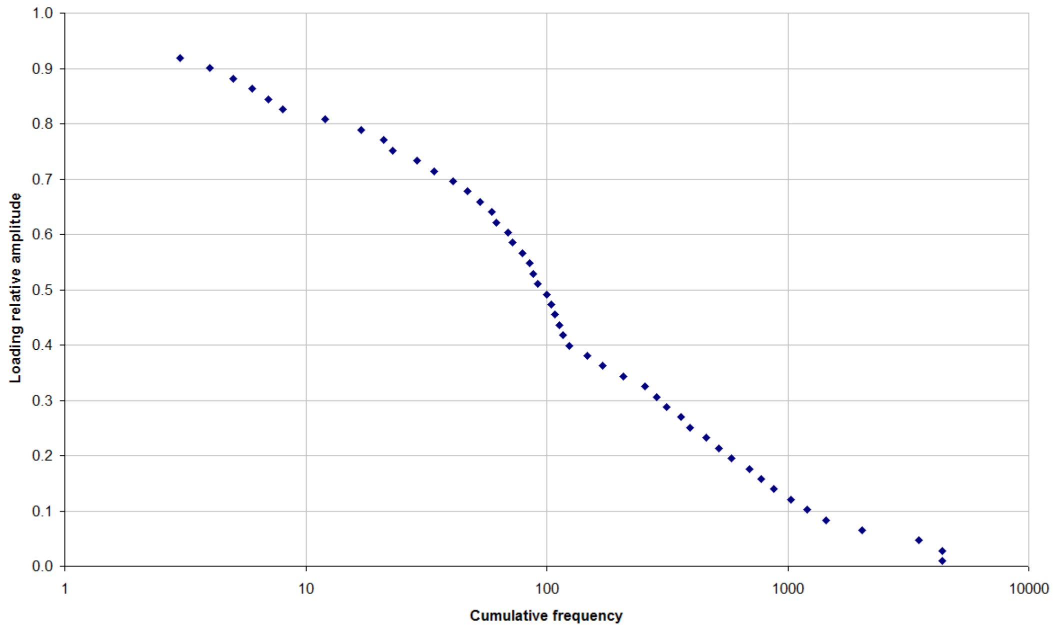

Figure 4: *Dependence of loading relative amplitude on cumulative frequency*

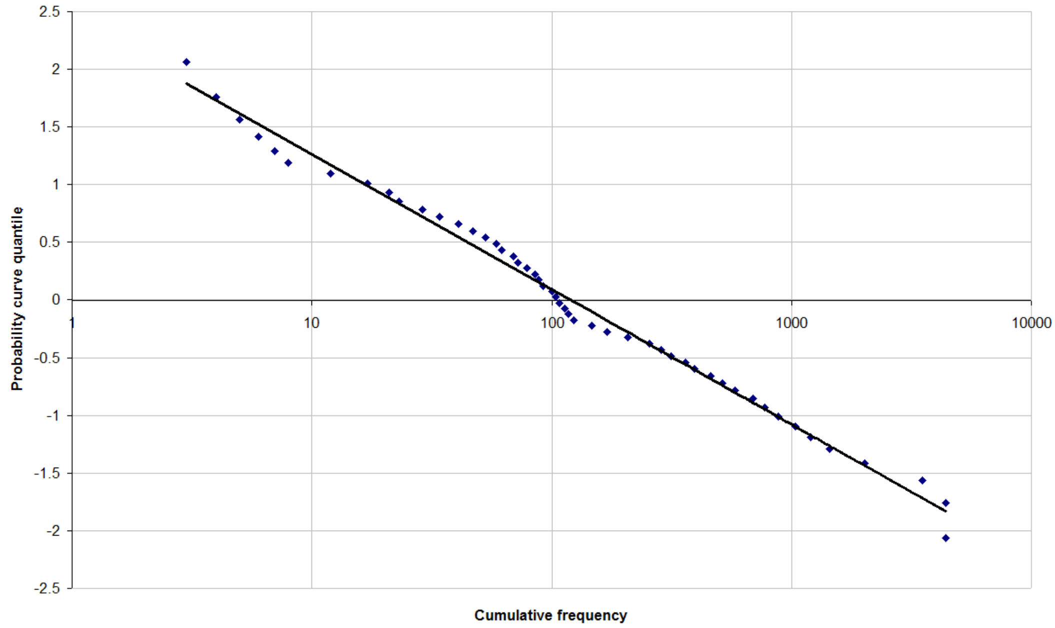

Figure 5: *Dependence of probability curve quantile on cumulative frequency.*

3. Assessment of the Crane Structure

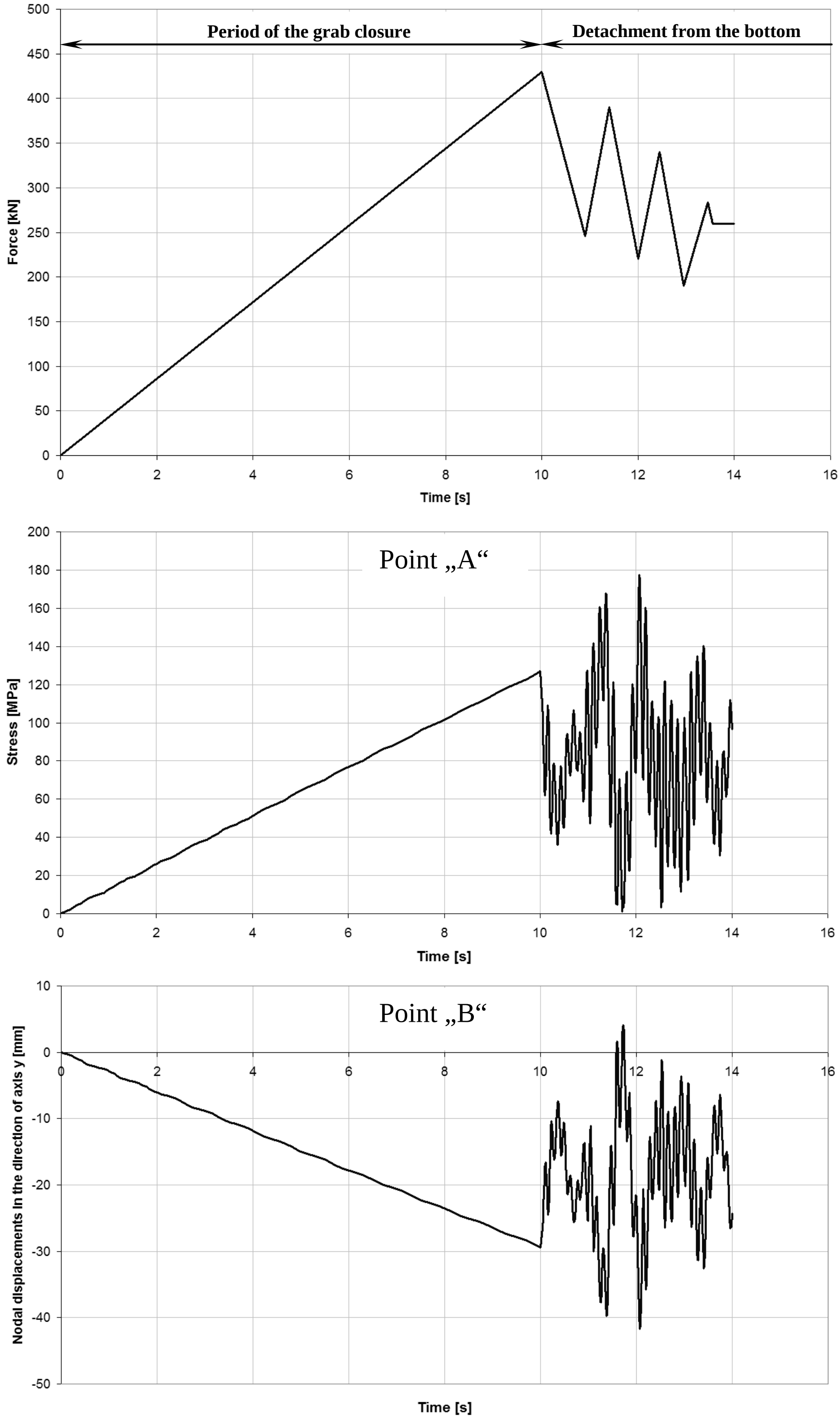

Figure 6: *Dynamic calculation – loading force, stress and nodal displacements in selected points of the structure*

Due to the time insufficiency and operational reasons it was not possible to measure off, by means of strain-gauges, a transfer of dynamic forces from cables to the crane structure. Therefore the finite-element model of a crane was created for a numerical computation of stress dynamic response. The aim of the FE model was to describe the state of stress in the crane structure caused by the load of closing and lifting cables. Measured operational forces in cables were applied in FE model as time dependent loads and dynamic response of structure was calculated. Structural model of the crane including pulleys on cables and cables enabled to simulate it's loading by means of measured cable loads and evaluate complete stress distribution in the structure and local stress ranges in welded joints.

Considering the time demanding computation, the dynamic calculation was quantified only for the simplified history, where highest load amplitude, i.e. for the period of the grab closure and detachment from the bottom, Fig. 6.

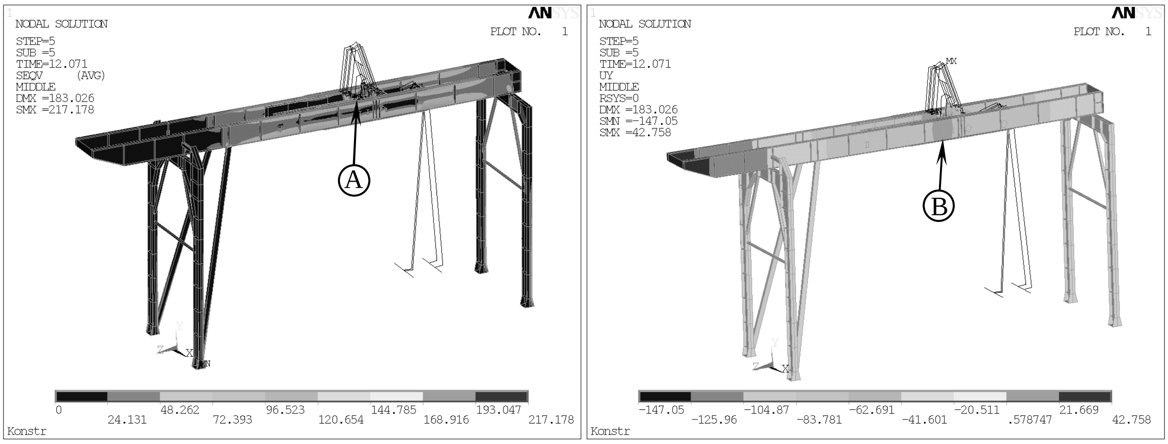

Figure 7: *Dynamic calculation of the crane structure and points of the stress values pick-up (on the left) and nodal displacements in the direction of axis y (on the right).*

4. Conclusion

On the basis of the experimental analysis, design loading spectra of equipment were created by excavating cranes calculations according to standards CSN and EN. It enables a more realistic and reliable dimensioning of excavating crane structures.
High stress range is evident in the dynamic calculation, which has an influence on the life expectancy of the structure. This analysis will be done in the future work.

References

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