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DYNAMICAL ANALYSIS OF LIFTING PLATFORM

DYNAMICKÁ ANALÝZA ZVEDACÍ PLOŠINY

Abstract

The presented paper deals with the dynamic properties analysis of the steel structure. The construction consists of the stationary and movable parts, the significant dynamic loading caused by the change of motion state during run up and run down is expected. The three ways of the dynamic analysis realizations – by finite element method for two types of 3-D finite elements and by experimental verification of modal properties using experimental modal analysis are presented.

Abstrakt

Předložená práce se zabývá analýzou dynamických vlastností konstrukce, která sestává ze stacionární a pohyblivé části a u níž je v provozu očekáván významný podíl dynamického zatěžování vyvolaného změnou pohybového stavu při rozjezdu a zastavování. Je prezentováno trojí provedení analýzy dynamických vlastností, která byla řešena jednak metodou konečných prvků pro dva typy 3D modelů, a to pro nosníkovo-skořepinový a pro objemový model, a jednak experimentálním ověřením modálních vlastností vybrané skupiny vlastních tvarů.

1 INTRODUCTION

Numerous engineering projects are inseparably linked with a design and analysis of steel structures properties despite of a construction itself represents an insignificant part of a particular project. It is essential to verify its dynamic behavior and possibly carry out necessary adjustments especially, when the construction is kept in motion or submitted to different loading ranges.

The assignment described below is analysis of construction dynamic properties. The device consists of a stationary and movable components. It is expected a significant portion of dynamic loading caused by motion state during run up and run down. The analysed construction serves as a stand for testing, a development and drive control adjustment of movable platforms. The testing stand itself, the moving platforms in particular, is nearly identical with real operating devices. On that account, realized testing simulations is an accurate "mirror" of the complete system operating in real conditions in-service.

The aim of implemented analyses is to identify dynamic properties of the movable components, that is finding out the eigenfrequencies of the platforms bedded in the stationary part. The dynamic properties analysis has been made numerically with use of two models. Identified results verification has been achieved experimentally by EMA method (experimental modal analysis).

This article presents a reached agreement of numerical simulation results with experimentally obtained results. Further, it demonstrates positive and negative features of particular solution meth-

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ods. The aim is to verify the construction dynamic properties regarding to the expected significant operational dynamic loading.

The construction consists of two movable platforms, two guiding pillars, base frame and driving unit. General data:

- overall dimensions: 6,5x3,7x3,0 m (w . d . h)
- movable platforms – weight: approx. 750 kg + considered load of 1000 kg
- construction – total weight: approx. 6 200 kg

Fully equipped construction 3D drawing is depicted in Fig. 1.

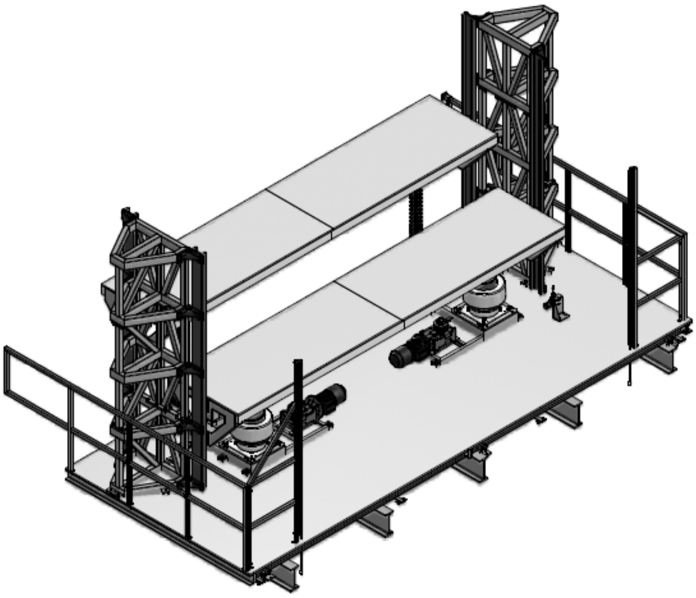

Fig. 1 3-D view of analyzed steel structure

2 DETERMINATION AND VERIFICATION OF THE DYNAMIC PROPERTIES

The computational modeling method and simulation of the dynamic properties of the steel structure by finite element method (FEM) was used for the solution of given problem. The finite element software ANSYS Workbench 11 and 12 was used for the realization of the task. The experimental measurement of the eigenfrequencies and eigenshapes by the experimental modal analysis method realized by measuring system PULSE by Bruel&Kjear was performed for the adjustment and verification of the mathematical model [2]. The veracity and reliability of the dynamic analyses results is strongly depending of the discretization quality, i.e. type and size of finite elements and the rate of geometry simplification regarding to the real system, which is usually necessary [3]. Since both performed analyses – modal and analysis of the platform fetch-up response are highly time-demanding the aim was to create possibly simple numerical model to shorten the solution time without loosing the accuracy of the results [1],[4].

Within the solution the two computational models were created:

- Model A – after the adjustment, this model will be used for further realization of the numerical simulations of the system behavior. The model is consists of the beam and shell elements. Those elements are from the system requirements point of view less demanding than solid elements which are used in Model B. On the other hand, to describe the reality correctly, the mentioned model is more settings-sensitive due to the higher amount of simplifications. This model was created on the base of obtained technical drawings.

- Model B – the described model was created on the base of volume CAD model of the lifting platform. Even in this model, certain simplifications in the form of removed screws, nuts or washers were carried out. The rest of the geometry was preserved. The details of this model are depicted in the Fig. 2. The modal analysis for three different platform positions was performed for this model. On the base of calculated results the Model A was adjusted so that the eigenfrequencies and eigenshapes reach the values of eigenfrequencies and eigenshapes obtained from Model B which describes the reality more authentically.

The next source for possibly best adjustment of the Model A was the measurement performed by the method of experimental modal analysis. The eigenfrequencies and eigenshapes were measured on both platforms (not at the pillars) for the vibration in vertical direction. Thus, the eigenfrequencies and eigenshapes describing the vibration in other directions will not be captured by this measurement. Since this is only the support tool for the adjustment of mathematical model, this simplification is acceptable. From the mentioned facts follows that the properties of adjusted mathematical model (Model A) are the intersection of the results obtained from computational modal analysis of the Model B and the values obtained in the experimental way. The reached agreement is presented in Tab. 1. It can be stated that by successive adjustments of the Model A the good agreement between results from Model B and experimental modal analysis was reached. Thus, Model A can be considered as nominal and can be used e.g. for the numerical simulations of the dynamic phenomena of steel structures.

Tab. 1 Eigenfrequencies and eigenshapes during the numerical model adjustment

Eigenshape	Model A $[Hz]$	Model B $[Hz]$	Experiment $[Hz]$
Platform bending (motion against each other)	20,035	20,5	N/A
Bending with wave	24,14	22,6	28,5
Platform bending (motion in phase)	25,65	21	28,8

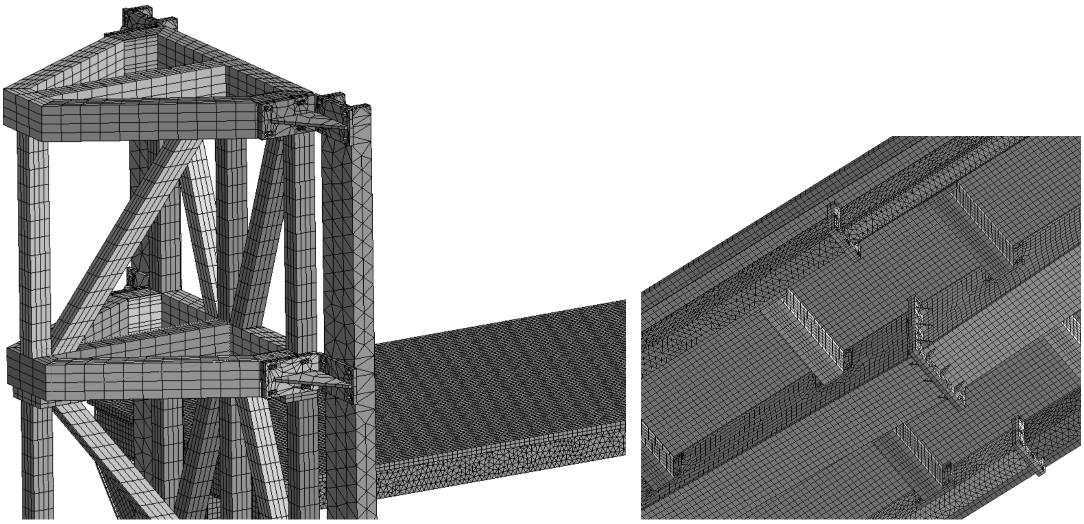

Fig. 2 Finite element mesh of the Model B

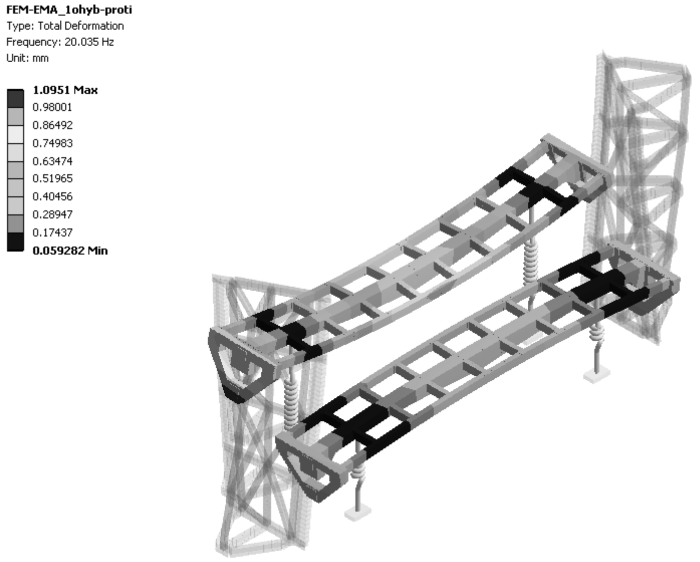

Fig. 3 First bending eigenshape 20.4 Hz - motion of the platforms against each other

3 CONCLUSIONS

The accomplished computer simulations and analyses in the conjunction with the experimental measurements allow to claim that the computational model created on the base of the adjustment and the experiment is able correctly describe the dynamic properties of steel structure and the consumed time for numerical modal analysis as well for eventual following transient analysis is acceptable.

The error of the eigenfrequencies in comparison of computational model A and the experiment are less than 4 Hz, the measured first and second eigenfrequencies were approximately 28 Hz and 30 Hz.

The determination of eigenfrequencies and eigenshapes was accomplished using the adjusted model in the range of <0, 40> Hz for various load of lifting platform (unloaded, uniform load, asymetric load).

The eigenshapes with dominant vertical component of the vibration were identified in the experimental way within the models adjustment. The analysis of the eigenfrequencies and eigenshapes has showed that the vertical platform arrangement does not play significant role in the values of eigenfrequencies and eigenshapes whereas the first eigenfrequency of the first bending eigenshape takes approx. 10 Hz.

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REFERENCES

[1] PORUBA, Zdenek; SZWEDA, Jan. Simulation and Optimization of the Electromotor Cooling. *METALURGIJA*. 2010, 49, 2, s. 474-478. ISSN 0543-5846.

[2] FERFECKI, Petr; ONDROUCH, Jan; SIKORA, Roman. Porovnání numericky vypočítané a experimentálně změřené odezvy na buzení odstředivou silou u rotorové soustavy Rotor KIT 4 s hřídelem zeslabeným trh vrubem. In Sborník konference Dynamics of Machines 2007. Praha : Institute of Thermomechanics AS CR, 2007. s. 63-70.

[3] SZWEDA, Jan, PORUBA, Zdeněk. Shape Optimization - Influence of Applied Model Symmetry. TRANSACTIONS of the VŠB - Technical University of Ostrava, Mechanical Series. 2009, vol. 55, no. 1, s. 239-244, ISSN 1210-0471.

[4] SZWEDA, Jan, PORUBA, Zdeněk. Thermal properties improving of the electromotor frame. In *Asian Pacific Conference for Materials and Mechanics 2009 : APCMM2009*. Yokohama : Japan Society of Mechanical Engineers, 2009. s. 228. No.09-202