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APPROACH FOR DYNAMIC PROPERTIES ADJUSTMENT OF STEEL STRUCTURE FEM MODELS

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Abstract: *The presented paper deals with an analysis of steel structure dynamic properties. The construction, which consists of stationary and movable parts, is expected to be under a significant dynamic loading caused by a change of motion state during run up and run down. The following three ways of the analysis are presented – the finite element method for two types of 3-D models, both the beam-shell and the volume model, and an experimental verification of modal properties relating to a selected type of eigenshapes.*

Keywords: ***Lifting platform, simplification, eigenshape, eigenfrequency, FEM.***

1. Introduction

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

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

The aim of the implemented analyses is to identify the dynamic properties of the movable components, i.e. to determine the eigenfrequencies of the platforms bedded in the stationary part. Taking into consideration the reliability of the results, the dynamic properties analysis is made numerically with an application of the two models. Additionally, the verification of the identified results is achieved experimentally by EMA (experimental modal analysis) method.

This article presents the reached agreement of the numerical simulation results with experimentally obtained outcomes. Furthermore, it demonstrates positive and negative features of the particular solution methods. The purpose of the task is to verify the construction dynamic properties in regard to the expected significant operational dynamic loading.

The construction consists of two movable platforms, two guide pillars, base frame and driving unit. General data: overall dimensions: 6.5 × 3.7 × 3.0 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 represents Fig. 1.

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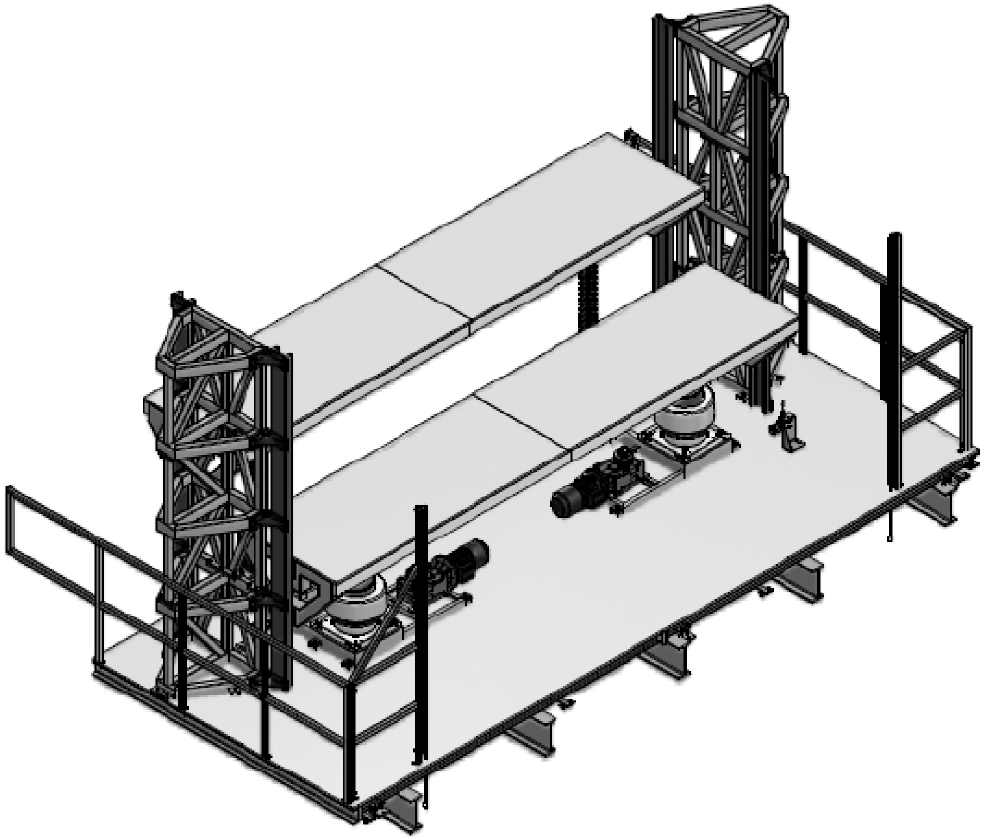

Fig. 1: 3D Model of Lifting Platform.

2. Determination and verification of the dynamic properties

The computational modelling method and simulation of the steel structure dynamic properties by the finite element method (FEM) is used for the solution of the given problem. The method is realized with the finite element software ANSYS Workbench 11 and 12. Consequently, the adjustment and verification of the mathematical model is performed; the respective experimental measurements of the eigenfrequencies and eigenshapes are carried out by the experimental modal analysis method realized by the measuring system PULSE by Bruel&Kjear according paper (Ferfecki et al., 2007). The veracity and reliability of the dynamic analyses results strongly depend on a discretization quality, i.e. on a type and size selection of finite elements and the rate of geometry simplification as compared with the real system; in most cases the simplification is necessary according paper (Saeed et al., 2009). Since the performed analyses, both the modal and the platform fetch-up response analysis, are highly time-consuming (Laxalde et al., 2010), the aim is to develop the possible simplest numerical model to reduce the computation time without loosing the accuracy of the results according paper (Poruba et al., 2010).

Within the solution the two computational models are applied:

Model A – after the adjustment, this model is used for the further numerical simulations of system behaviour. The model consists of the beam and shell elements, which are from the computing requirements point of view less demanding than the solid elements used in Model B. On the other hand, to describe the real properties correctly, the mentioned model is more settings-demanding due to a higher degree of simplification. This model is created on the basis of the received technical drawings.

Model B – the model is created on the basis of CAD volume model of the lifting platform. Even in this model, certain simplifications in the form of removed screws, nuts or washers are carried out. The rest of the geometry is kept identical. The details of the model are depicted in the Fig. 2. The modal analysis is applied to this model for three different platform positions. Model A is adjusted according to the calculated results, so that the eigenfrequencies and eigenshapes reach the values of the same ones obtained from the reality closer Model B.

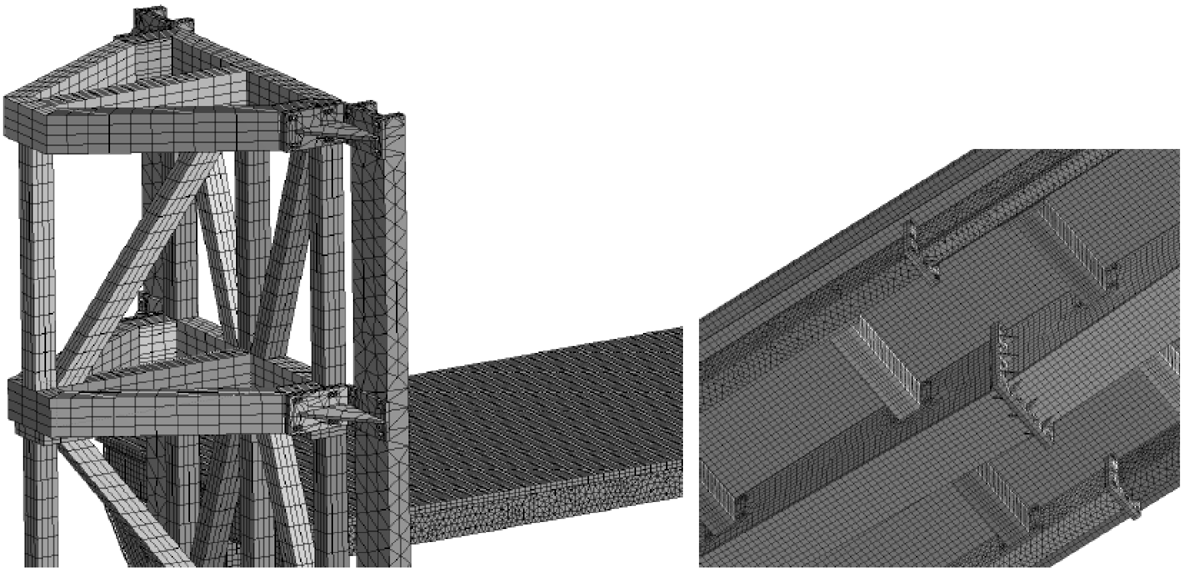

Fig. 2: Geometry and Mesh of Model B.

The next source of data for the best possible adjustment of Model A is the measurement performed by the experimental modal analysis method. The eigenfrequencies and eigenshapes are obtained from vibrations in the vertical direction on the both platforms (not the pillars). Thus, the eigenfrequencies and eigenshapes describing the vibration in other directions are not captured by this measurement. Since this is only the supporting tool for the adjustment of the mathematical model, this simplification is acceptable. The mentioned facts imply the properties of the adjusted mathematical model (Model A) are the intersection of the results obtained from the computational modal analysis of Model B and the experimentally detected values. The reached agreement is presented in Tab. 1. It can be stated the successive adjustment of Model A has reached the appropriate congruence level between results from Model B and the experimental modal analysis. Thus, Model A can be considered as the standard and be used e.g. for numerical simulations of the steel structure dynamic phenomena.

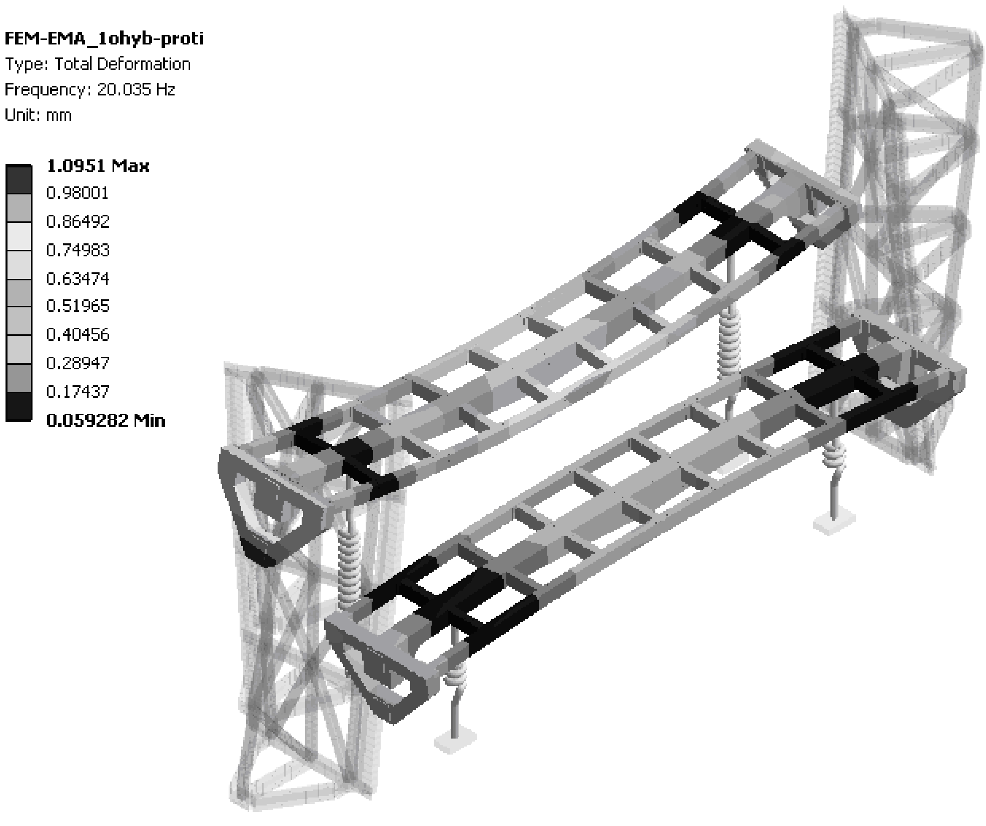

Fig. 3: First Bending Eigenshape – 20.4 Hz (platforms move against each other).

Tab. 1: Eigenfrequencies during the numerical model adjustment.

Eigenshape	***Model A [Hz]***	***Model B [Hz]***	***Measurement [Hz]***
Platform bending (motion against each other)	20.0	20.5	N/A
Bending with wave	24.1	22.6	28.5
Platform bending (motion in phase)	25.7	21.0	28.8

3. Conclusions

The accomplished computer simulations and analyses in the conjunction with the experimental measurements allow claiming that the computational model developed on the basis of the adjustment and the experiment is able to describe the dynamic behaviour of the steel structure accurately. Next, the consumed computational time of both the modal numerical analysis and possible following analyses of transition phenomena is acceptable.

Aberrations of the eigenfrequencies in comparison with the computational model A and the measurements are less than 4 Hz, the measured first and the second eigenfrequencies are approximately 28 Hz and 30 Hz. Thus adjusted model determines the eigenfrequencies and eigenshapes in the range of $\langle 0, 40 \rangle$ Hz for various load of the lifting platform (unloaded, symmetric load, asymmetric load).

The eigenshapes with the dominant vertical component of the vibration is experimentally identified within the models adjustment. The analysis of the eigenfrequencies and eigenshapes establishes that the vertical platforms arrangement does not have a significant influence on the values of the eigenfrequencies and eigenshapes whereas the first eigenfrequency of the first bending eigenshape takes approx. 10 Hz.

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