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MODIFICATION OF THE DYNAMICS CHARACTERISTICS USING A REANALYSIS PROCEDURES TECHNIQUE – NEW RESULTS

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ABSTRACT
The present paper deals with the problem of dynamic improving characteristics for a sub-structure (bucket wheel excavator) of a complex mining structure. The procedure used in this paper is concerned with the analysis of the distribution of potential and kinetic energy in every element of structure, which gives prediction for which elements need reanalysis. Reanalysis technique can be done for the structure using finite element methods. Therefore, some information like material, size, and boundary conditions should be prepared before FE model is constructed. Because the optimum structure design has high natural frequency, the main aim of dynamic modification is to increase natural frequencies and to increase the difference between them.
Key words: Structural dynamic modification, reanalysis, FEM, eigenvalues, design variables

1. OVERVIEW OF THE EXISTING TECHNOLOGIES FOR WATER DISINFECTIONS

Dynamic analysis is more complex than static analysis, and the design requirements must include dynamic properties such as vibration level, resonance range, response properties, eigenvalues, dynamic stability and modal forms. To avoid dynamic problems, some modification will be done for structure in process of reanalysis. Reanalysis is a technique through which the dynamic response of the structure is improved. Finite element method is a powerful method to perform these processes using simple procedures. Modelling of complex structures using finite elements method is a helpful approach in solving problems in short time with reliable results.
The procedure of reanalysis depends on the concept of energy distribution through the structure. Study of the energy distribution leads to finding out the right place, which will be conducted by some modifications to improve the eigenvalues of the structure. Therefore, determination of distribution of kinetic and potential energies on the elements of whole structure is the main step in the reanalysis procedure. Complex structures need several steps during the analysis to reach the most accurate results. Starting with initial rough analysis of a structure which is followed by the precise analysis based on the sensitivity of each element of the structure. The improvement of dynamic characteristics, during the reanalysis steps, can be achieved by making some adjustment to the structure such as

geometrical modifications, material properties and boundary conditions. The process of analysis is done using a computer program, based on the using of finite element methods and the implementation of structure energy distributions. The distributions of potential and kinetic energies of elements of the whole structure give a clear view to the problem, which help to make appropriate decision for structure modifications. The decision of the final modification can be made according to the structure dynamic behaviour during reanalysis steps and its obtained results. Several studies have been addressed to the subject of modal reanalysis and structure dynamic modifications [1-6]

2. THEORETICAL CONSIDERATION

For the system with no damping and no external force, the equation of motion in the matrix form is:

$$[M]\cdot\{\ddot{Q}(t)\}+[K]\cdot\{Q(t)\}=\{0\} \tag{1}$$

Then, the eigenvalues of the previous differential equation for r-th mode can be expressed as:

$$[K]\cdot\{Q_r\}-\lambda_r[M]\cdot\{Q_r\}=\{0\} \tag{2}$$

Where λ_r - is the r -th eigenvalue, and Q_r - is the r -th eigenvector for the structure.

Now, by multiplying the left side of equation (2) by transposed value of r-th eigenvector and divided by 2 one can get:

$$\frac{1}{2}\{Q_r\}^T[K]\{Q_r\}=\frac{1}{2}\lambda_i\{Q_r\}^T[M]\cdot\{Q_r\} \tag{3}$$

Equation (3) is the balance equation of potential and kinetic energy for a structure in main modes of oscillation. Furthermore, the potential energy of a structure on r-th main oscillation mode, having in mind the previous equation, can be rewritten as:

$$E_{p,r}=\frac{1}{2}\{Q_r\}^T[K]\{Q_r\}. \tag{4}$$

In the same way, the kinetic energy is:

$$E_{k,r}=\frac{1}{2}\lambda_r\{Q_r\}^T[M]\{Q_r\}, \tag{5}$$

For free vibration case the modified system can be describe by a modified equation (perturbation equation) as:

$$[K]'\{Q_r\}'=\lambda_i'[M]'\cdot\{Q_r\}' \tag{6}$$

After some manipulations and neglecting the higher order terms, the change of i-th eigenvalue under system modification can be expressed as:

$$\frac{\Delta\lambda_r}{\lambda_r'}=\frac{\frac{1}{2}\{Q_r\}'^T[\Delta K]\{Q_r\}'-\frac{1}{2}\lambda_r'\{Q_r\}'^T[\Delta M]\{Q_r\}'}{\frac{1}{2}\lambda_r'\{Q_r\}'^T[M]'\{Q_r\}'} \tag{7}$$

Where $[\Delta K]$ and $[\Delta M]$ are the corresponding changes in stiffness and mass matrices respectively, and $\Delta\lambda$ and $\{\Delta Q_r\}$ are changes of eigenvalues and eigenvectors, respectively. The previous equation has an important definition to understand the procedures of reanalysis and to define the position of elements that require modifications to improve the dynamic behavior of the structure. Because the denominator has the same value, the numerator is the main interest of analysis. Consequently, the modification (increase/decrease structure rigidity or mass) which will be done for the structure depends on the sign value of numerator in equation (7). The main point of improving dynamic behavior of the structure is increasing its natural frequencies and maximizing the interval between adjacent natural frequencies. Hence, study of energy distribution will be done for each element in the structure to determine places of modification. The main point of improving dynamic behavior of a structure is increasing its natural frequencies and maximizing the interval between adjacent natural frequencies. This request, as previously mentioned, can be achieved by changing the design parameters of the structure. The procedure used in this paper is developed in PHD thesis [8] and concerned with distribution of potential and kinetic energy in all elements of structure. Calculations of main modes of oscillation were performed using KOMIPS software [7]. Structure has a good dynamic behavior when its first eigenvalue is high and the interval between adjacent eigenvalues is large.

2. DEMONSTRATION EXAMPLE

Crane bucket wheel excavator is a truss structure associated with one hand stationary hinge connection on the other lamella, which can be characterized as a elastic support. The dynamic behavior of the said excavator boom is interesting, because the natural frequencies and low stick close together and close to the frequency of coercive force digging. The figures 1 and 3 show the first and third main form of oscillation excavators and distribution of energy of the excavator boom, and on the basis of changes in the energy interval can be located segments for the modification of arrows. In this case it is technically feasible stiffening structure by adding new elements to the energy difference between the highest places.

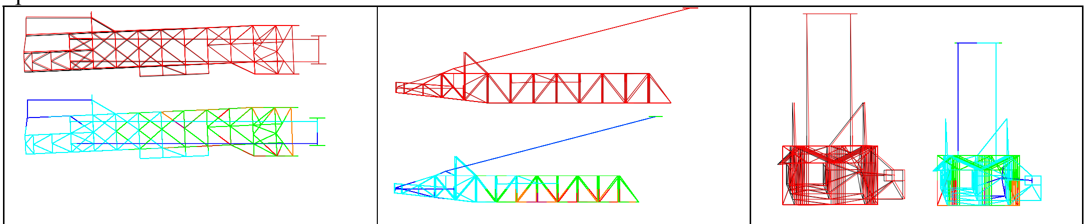

Figure 1. The first major form of oscillating boom bucket wheel excavator in the first frequency, f_{01} = 1.6 Hz. Diagram of distribution differences of potential and kinetic energy ($E_p - E_k$) [kNcm].

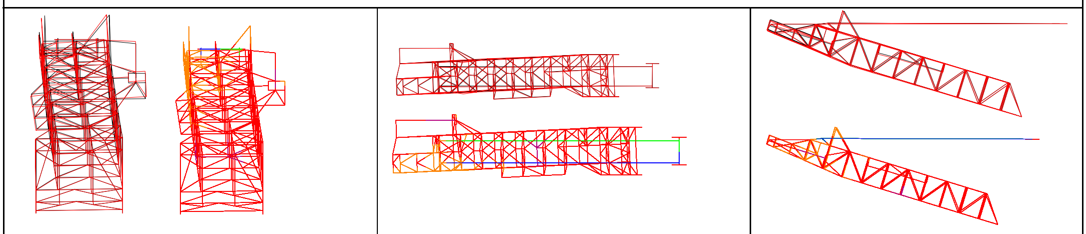

Figure 2. The third major form of oscillating boom bucket wheel excavator in the second position. The third frequency isf_{03} =1.6 Hz. Diagram of distribution differences of potential and kinetic energy (Ep-Ek), boom bucket wheel excavators for the second position observed, III form of oscillation [kNcm].

Two kinds of the models are used in analysis. First one is initial, unmodified model and second one is arbitrary, uniformly modified model. It is important to note that changes must be small. Distributions of the increment difference of potential and kinetic energy evaluated for the arbitrary, uniformly modified structure and unmodified.

3. CONCLUSIONS

Studying the dynamic behavior of structures can be predicted responses due to changes in its shape, size or design elements change materials. The main goal of dynamic optimization is to increase natural frequencies and to increase the difference between them. Especially, the lowest frequencies are the most interesting and those whose values are close to frequency excitation force in the system.

Consequently these are further characteristic areas:

- I The elements with kinetics and potential energy, which values are negligible comparing to other elements.
- II Elements with the kinetics energy greater than the potential energy.
- III Elements with the potential energy greater than kinetics.
- IV Elements with kinetics and potential energy, which values are not negligible comparing to other elements.

By observing diagrams of the distribution difference of the increment potential and kinetic energy on the modes shape of interest, modification can be suggested. The application of mentioned procedure of real structures shows its practical side.

4. ACKNOWLEDGMENT

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