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DINAMIC RESPONSE ANALYSIS OF CRUSHER FOUNDATION

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ABSTRACT
The objective of this paper is to perform analysis of two-dimensional crusher foundation model supported on a multi-layered soil, subjected to dynamic loading represented by frequency curve in terms of an amplitude as a function of frequency. A preliminary eigenvalue analysis is done to determine the eigen modes of the system and the resulting graphs are representing frequency response for accelerations and displacement for selected nodes of all characteristic parts of the structure. Practical calculations are shown that this method can accurately determine the maximum level of acceleration, which is input parameter to assessment comfort due to dynamic excitation of foundation, in addition to displacement. In this paper dynamic response analysis is carried out using program for nonlinear analysis with finite element method called DIANA.
Keywords: frequency response analysis, frequency curve, dynamic excitation of foundation, DIANA

1. INTRODUCTION
Determination of dynamic characteristics of the system starts with eigenvalue analysis. The simplest case with single degree of freedom was analysed. In eigenvalue analysis damping has no effect, and the external excitation is not taken into account. Neglecting the external load and damping matrix, the equation were obtained:

$$M\ddot{x}(t) + Kx(t) = 0 \quad \text{... (1)}$$

where M and K are mass and stiffness matrix, and $\ddot{x}(t), x(t)$ are acceleration and displacement at time t, so that the entire system could be replaced with the oscillatory system which consists of mass associated to the fixed point through a linear spring, thereby assuming that it is allowed to move only in one direction, the direction of the spring.

$$\left[[M]^{-1}[K] - \omega^2[I]\right]\{X\} = 0 \quad \text{... (2)}$$

Solving of the characteristic equation (2) eigen frequencies are evaluated, and finally, for each their eigen frequency, its eigen vector (mode shapes).

The basic steps that should be followed in the dynamic response analysis are:
1. Develop model from the geometry specifications
2. Use realistic material parameters
3. Simulate field conditions through appropriate boundary conditions
4. Assign proper loads
5. Set up analysis procedure

The methods of analysis that are available for solving the dynamic problem of structure in DIANA are:

- Free vibration analysis
- Response spectrum analysis
- Time history analysis
- Hybrid frequency time domain analysis

In this paper, frequency response analysis of a crusher foundation are performed.

2. EXAMPLE OF DYNAMIC ANALYSIS OF CRUSHER FOUNDATION

Two dimensional model for crusher foundation analysis is developed. Base of the foundation is measured 9x9m, height 1,5m and depth of 1,0m funding. Under the foundation three layers are extending. The first is 7m depth, makes of the heterogeneous composition of the bank material, the second layer is a white and gray-white limestone to a depth of -36 m and the third pyrite ore to a depth of -55m. These data are based on the analysis of geological and geomechanical core drilling. Model is subjected to a horizontal cyclic acceleration in X direction in all nodes on the top of foundation structure (Figure 1). Dynamic loading are represented by frequency curve in terms of an amplitude as a function of frequency. In this case, frequency curve is sinusoidal with frequency period of 0,46 and an amplitude of 0,02. The dynamic loading from industrial machinery derives principally from the inertia effects of moving parts. Every machine behaves differently and it is usually the responsibility of the manufacturer to calculate the forces that will be imposed on the supporting structure. The rotation speeds or frequencies at which machines operate are also important and should be specified.

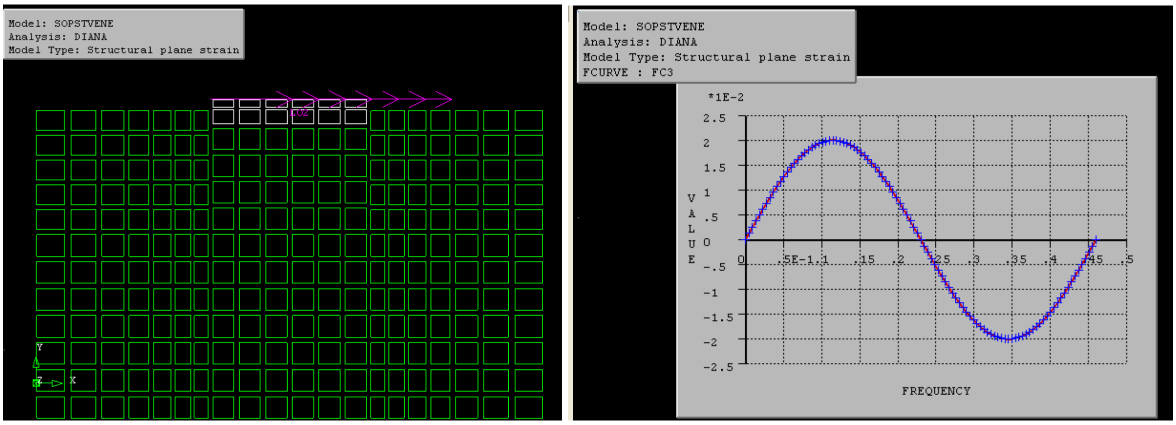

Figure 1. Dynamic loading of crusher foundation

The characteristics of the material and the characteristics of these three layers are analysed in particular for more realistic representation of the problem.

Layer depth				
		0-7	*7-36*	*36-55*
		Bank material	*Limestone*	*Pyrite ore*
Elastic modulus (N/m²)	*E*	*8.66x10⁶*	*8.10x10⁶*	*8.49x10⁶*
Poisson's ratio	*ν*	*0.34*	*0.30*	*0.34*
Density (kg/m³)	*ρ*	*2681*	*2706*	*3180*
Cohesion (N/m²)	*c*	*7.36x10⁶*	*11.81x10⁶*	*16.90x10⁶*
Friction angle (°)	*φ*	*46*	*36*	*40*

Table 1. Values of material parameters

2.1 Eigen value analysis:

Eigenvalue analysis of the model is performed for better understanding of mode shapes and eigen frequency. This eigenmode are displayed as the deformed shape of the model in red (Figure 2). The result monitor shows the mode number and the frequency display the deformed shapes of all required eigenmodes that were determined (first ten eigenmodes are calculated but only four are presented in Figure 2).

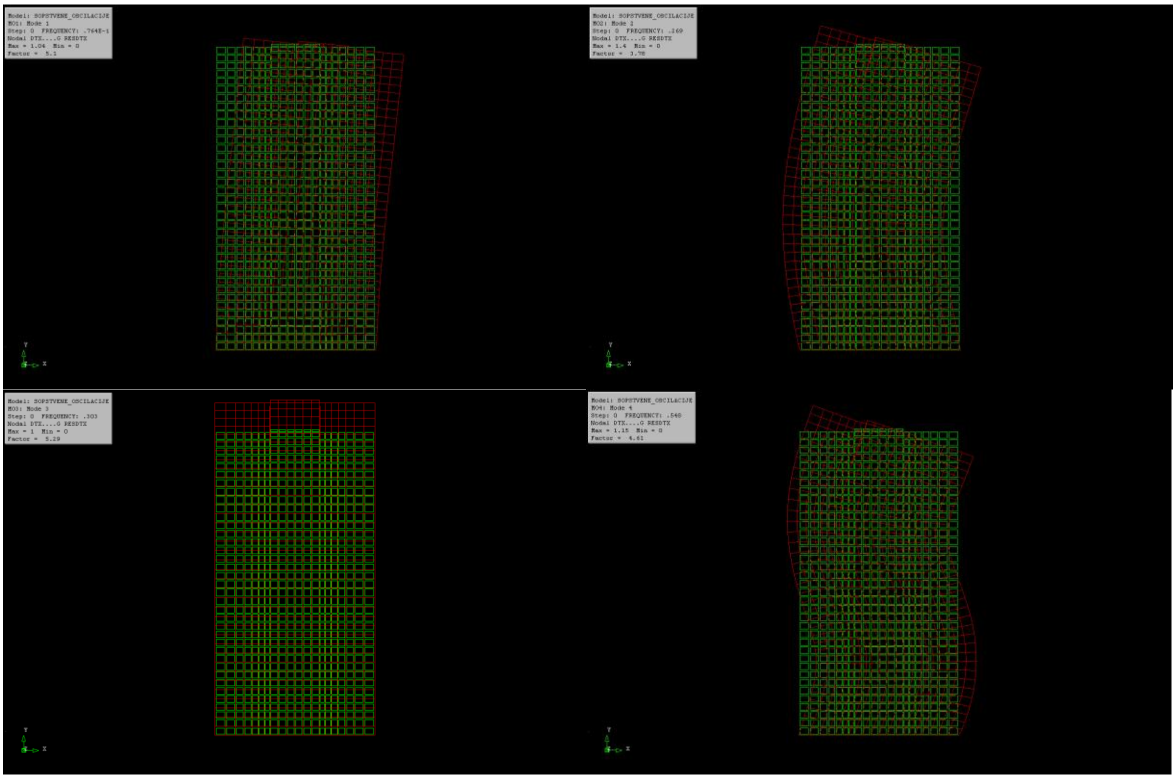

Figure 2. 1st and 2nd mode shapes for crusher on rigid foundation

2.2 Frequency response analysis:

Results of modal frequency analysis are presented as displacement and acceleration in the frequency domain. In comparison with direct analysis, lack of the modal analysis is requiring for preliminary calculation of eigen frequencies. Analysis was performed by the following main steps:

1. The dominant tones of the oscillation are used, which causes the greatest deformation of the foundation layer and under it: 1, 2, 4, 5, 8, 9,
2. If any of the excitation frequency is equal to the eigenfrequency, damping ratio is required. The actual damping ratio is often unknown. It is common to choose value for critical damping ratio between 0 and 10%. The damping ratio wouldn't be overestimated if critical value of 1% is selected. It is otherwise referred to as hysteretic damping and representing form of damping that is independent of frequency and it is proportional to displacement. This type of damping is purely used to analyze the dynamic response of structural elements of the model.

Figure 3 shows graphs for selected, characteristic nodes response in horizontal displacement u_X and horizontal acceleration $\ddot{u}_X$, in the soil about 3,5m beneath the foundation structure.

3. RESULTS AND CONCLUSION

The objective of this paper is to present the most important part of frequency response analysis of a crusher foundation resting on a soil. A preliminary eigenvalue analysis is done to determine the eigen modes of the system and subsequently, modal frequency response analysis is performed. Results are

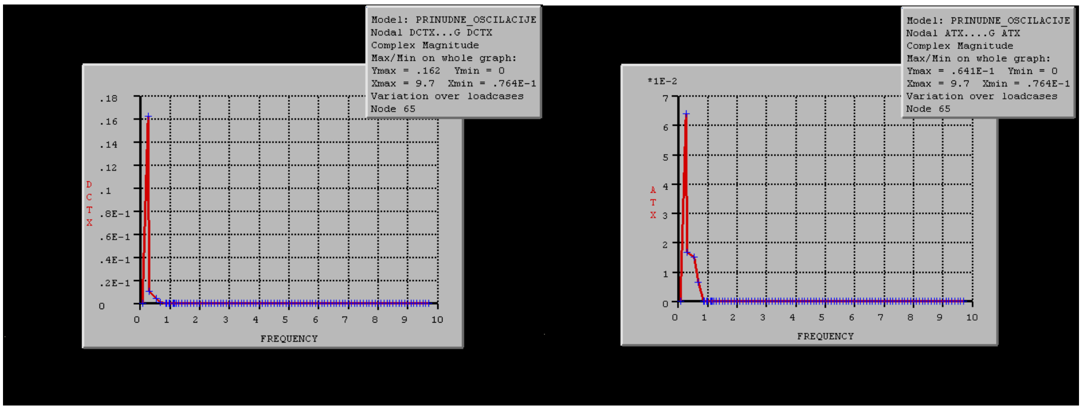

Figure 3. Accelerations and displacements at depth -3,5m

shown as displacement and acceleration due to dynamic excitation system, represented by the frequency curve, which are input parameter to assessment comfort due to dynamic excitation of foundation. If any of the excitation frequency is equal to the eigenfrequency, some measures must be taken for the normal operation of construction. Calculation of crusher foundation must include the determination of the static pressure at the surface, as well as resistance control of certain elements. Figure 4 shows the stress and dilatation response of the foundation and soil in direction of excitation due to dynamic loads. From this results can be concluded that the actual stresses in the soil is less than the allowable stress obtained by testing the soil.

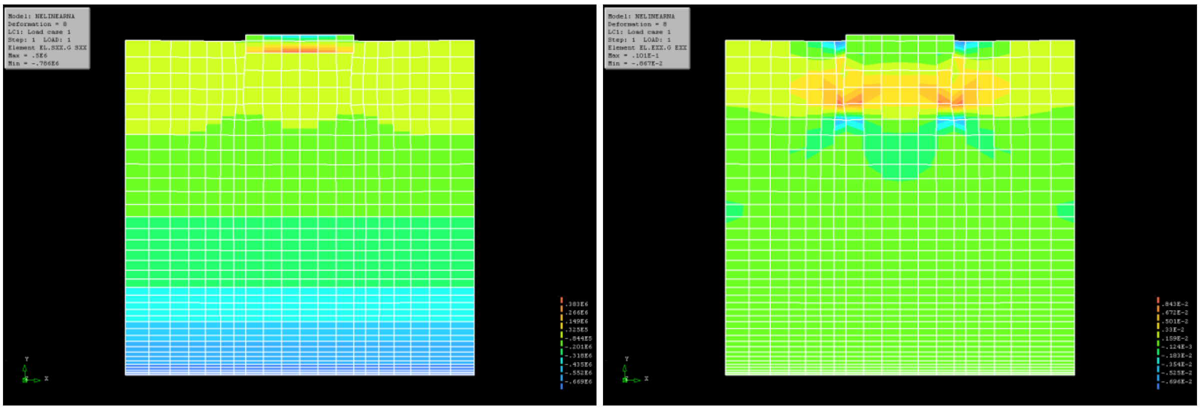

Figure 4. Stress and dilatation response of the foundation and soil after dynamic loading

4. ACKNOWLEDGEMENTS

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