

Seismic Data Analysis in Odyssey Software

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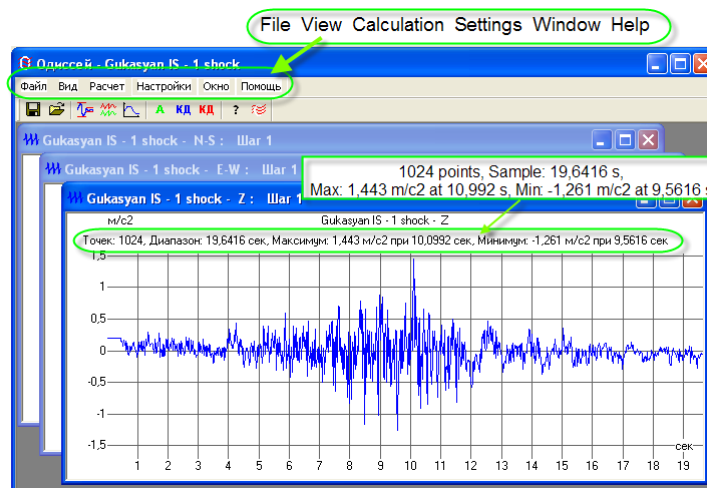
Abstract: This article describes tools of Odyssey software (Eurosoft Co., Russia), that help engineers to create more accurate and reliable integrated seismic action model and make seismic data analysis. The main instruments are based on vector, correlation and spectral analysis of the seismic data. For time-domain analysis initial accelerograms are scaled, changed the range and filtered. Filtering based on Fourier transform with removing shortest waves that are safe for the construction. It is possible to create a generalized seismic wave model to compute rotations of a building. For frequency-domain analysis by modal response spectral method the amplification factors, response spectrums and theirs envelopes are calculated for a translational and, if it is necessary, rotational motion.

Keywords: seismic analysis; seismic rotations; seismic stability; response spectral method; seismic action; accelerograms

I. Introduction

The Odyssey software is developed by Eurosoft Co. (Moscow, Russia). This is a handy tool to calculate initial data for integrated model of seismic action. Theoretical fundamentals and algorithms are described in [1-3] and based on multi-year experience in the field of seismic stability analysis in Central Research Institute of Building Constructions named after V.A. Kucherenko, Moscow, Russia. The main features of software are describes in this paper (hereinafter options of the menu item *Calculation* (Fig.1) are italic).

Figure 1. Odyssey software. Accelerograms of natural earthquake intended for seismic analysis.



II. Calculations

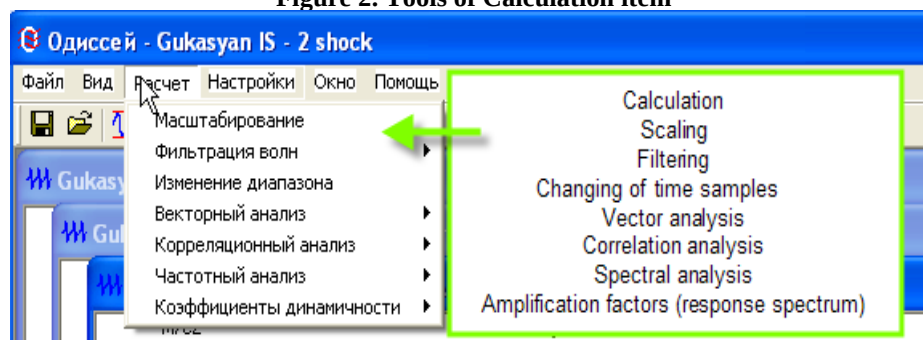
Accelerograms for seismic analysis is shown in Figure 1. The menu *Calculation* is shown in Figure 2. Menu *Calculation* includes *scaling*, *filtering* waves in frequency and wavelength, *changing of time samples*, *vector*, *correlation*, *spectral analysis* and calculating of *amplification factors*.

Scaling of accelerograms is used when it's necessary to switch to other dimensions of physical quantities, or if there is a scaling coefficient device during measurements. The *filtering* allows excluding high frequency components or wavelengths, which are much smaller than structure's dimensions in the plan, from the spectrum of the seismic action. These components are not dangerous for buildings.

The *changing of the time samples* is an important procedure to obtain data for further seismic computing. This procedure allows to remove insignificant *P*-waves (primary waves or compression wave) and consider only the intensive part of *S*-waves (secondary or shear). In addition, removing of the low intensity parts reduces the overall

nonlinearity of the seismic action. This instrument helps to select dangerous part of random process and, considering it as stationary, to perform a further correlation and spectral analysis more correctly. Input data for seismic analysis are natural or synthetic accelerograms of translational ground motion in three orthogonal directions. Such data allows representing the seismic action in the form of three-dimensional random vector with time-depending components.

Figure 2. Tools of Calculation item



There are operations for vector analysis: *coordinate system rotation*, calculation of the seismic vector *module* and *direction cosines*, calculation of *rotational components*. The *coordinate system rotation* is needed to direct the global axes of the structure with axes that specify seismic wave impact. The *module* of the seismic action is invariant parameter (independent of the chosen coordinate system), characterizes the vector magnitude of seismic acceleration. The *rotational components* of seismic ground motion are components of the angular accelerations vector relative to the corresponding axes. To compute rotations of a building we should determine a generalized seismic wave model [1-4]. Examples of accelerograms with corresponding rotations are shown on Figures 3-6.

Figure 3. Synthetic accelerogram (N-S direction)

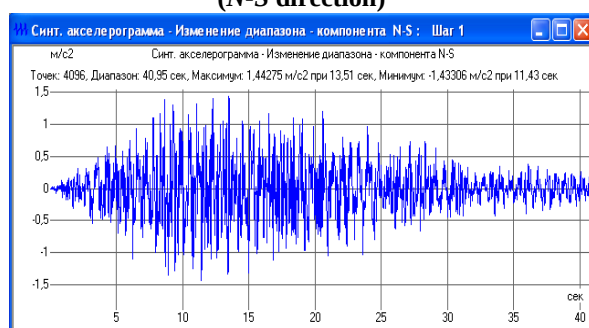


Figure 4. Natural accelerogram (N-S direction)

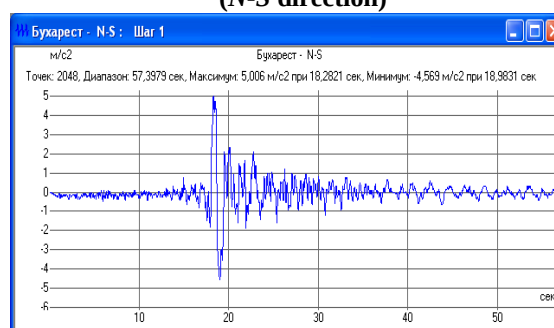


Figure 5. Rotation for synthetic accelerogram (about Z-direction)

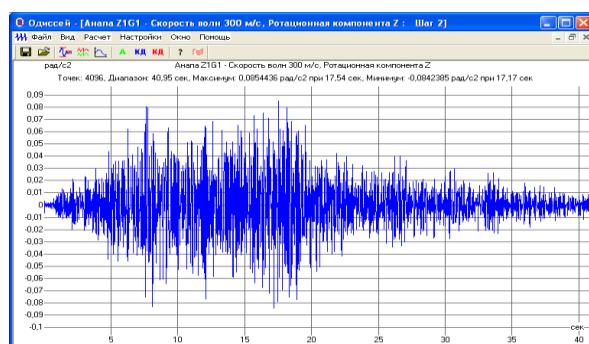
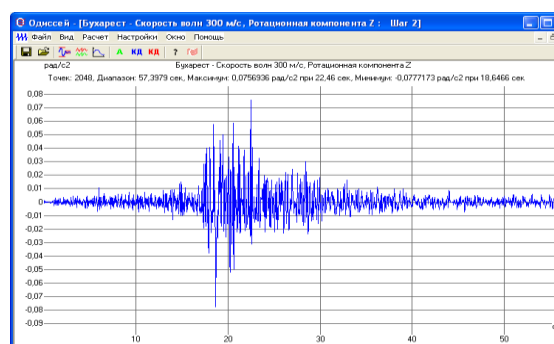


Figure 6. Rotation for natural accelerogram (about Z-direction)



The software has tools for *spectral* and *correlation analysis* to determine required statistical characteristics of random processes.

The *correlation analysis* includes the calculation of the normalized autocorrelation and cross-correlation functions of random processes of translational or rotational motions relative to the given direction. *Expectation value*, *standard* and *correlation matrix* are determined for the following random processes: three components of the acceleration vector of translational motion, the module of this vector and three direction cosines. The obtained parameters of random processes are first and second order moments of seismic action. These data may be used to determine a building's response by using spectral representations method according to the stochastic formulation [5].

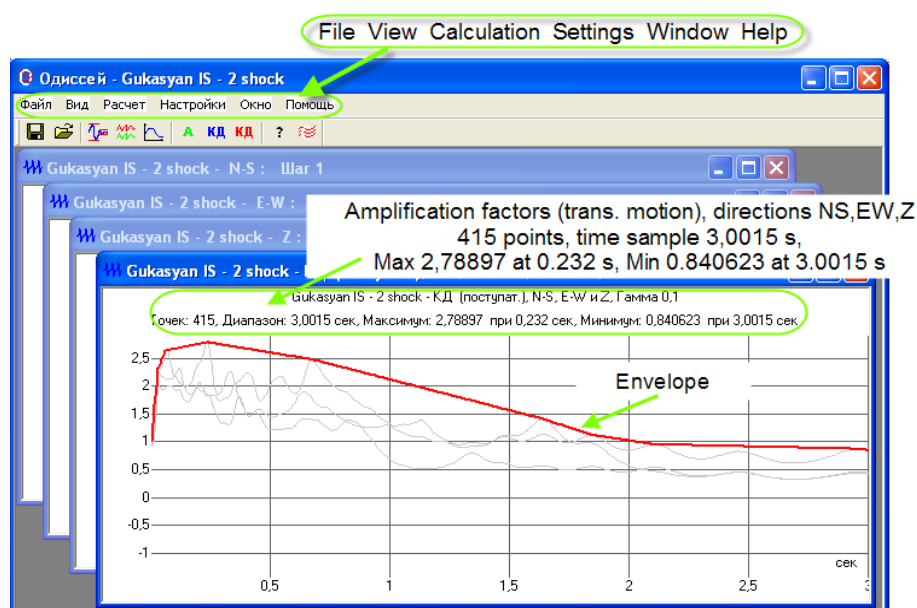
The spectral analysis of random processes includes direct and inverse *Fourier transforms* of seismic vector components (including rotational components), the *dependence of the standard of seismic action on frequency and spectral power density*.

There are six degrees of freedom of ground volume motion for integrated seismic model: first three are translational and the other ones are rotational. According to the conventional quasi-static deterministic approach [6, 7], the horizontal and vertical seismic loads are the product of translational acceleration on the appropriate nodal mass. Obtained products are multiplied by *amplification factors* to account the dynamic effects. If the seismic loads are random, the structural response is a random process too. Amplification factor is defined as the ratio of standard of generalized coordinate to the value of this coordinate in the case of static action. Odyssey software calculates the amplification factors for the translational motion in a given direction as a function of natural periods or frequencies. To obtain a response spectrum the amplification factor should multiply on the standard of corresponding accelerogram. Furthermore, there is the possibility to draw envelopes for amplification factors for each or all directions. The example of amplification factors and their envelope are shown in Figure 7.

In some cases [1-3, 5], there are additional loads from seismic rotations. Odyssey computes angular accelerations of the rotational movement (rotational components) as a function of time and amplification factors for them.

Thus, software provides data for integrated model of seismic actions. The amplification factors and their envelopes are data for quasi-static spectral analysis. The accelerations of translational and rotational motions are data for verification analysis in the time domain. All seismic data may be exported to different engineering software by using simple text format files and ready to use in FEM software STARK ES [8, 9].

Figure 7. Amplification factors and envelope for translational motion



III. References

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