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INNOVATION APPROACHES IN SEISMIC MICROZONATION TAILING DUMP DESIGNING

Рассматриваются современные подходы оценки влияния локальных условий на сейсмическую опасность территорий. На примере хвостохранилищ горно-обогатительных комбинатов показано, что привлечение цифровых моделей среды и расчетных методов является важным элементом при прогнозировании влияния строения грунтовой толщи, ее физических свойств и антропогенного рельефа на усиление сейсмических колебаний грунта.

Розглядаються сучасні підходи оцінки впливу локальних умов на сейсмічну небезпеку території. На прикладі хвостосховищ гірничо-збагачувальних комбінатів показано, що залучення цифрових моделей середи і розрахункових методів є важливим елементом при прогнозуванні впливу побудови грунтової товщі, її фізичних властивостей та антропогенного рельєфу на посилення сейсмічних коливань грунту.

Current approaches of assess the impact of local conditions on the seismic hazard areas are considered. On the example of ore-dressing and processing enterprises tailings is shown that engaging of digital environment models and calculation methods is an important element in predicting the effect of the structure of a ground layer, its physical properties and anthropogenic relief to seismic ground motion amplification.

Introduction. Mining and smelting complexes are the most important element in the economy of Ukraine. The ore-dressing generates huge quantity of gangues – tailings requiring storage. Tailing dumps of large ore-dressing and processing enterprises are especially important class structures, the destruction of which might have serious environmental and socio-economic consequences. One of the factors affecting safety of such enterprises functioning is strong seismic loads from earthquakes of tectonic and technologically-induced nature.

Tailing dumps are anthropogenic objects which fundamentally change engineering-geological environment and landscape areas. Anthropogenic changes in the geological environment associated with construction and operation of the tailing dumps significantly influence local seismicity changes.

Seismic microzonation of construction and operation tailing dumps sites is performed by quantitative assessment impact of local conditions onto the study of variations ground motion parameters from earthquake in seismic hazard zones. Firstly, influence of surface soils structure and properties composed anthropogenic low-velocity soils (tailings) and terrain features are investigated. Besides, variations of environment conditions associated with construction and operation of the tailing dumps should be taken into account in the future.

Purpose - approbation of modern approaches of assess the impact of local conditions on seismic effect amplification in ore-dressing and processing enterprises tailing dumps environment.

Methods. In the study of seismic microzonation of construction and operation of the tailing dumps sites the following questions are solved:

- the study of the structure and seismic properties of the surface soils;
- the construction of under analysis object seismological model;

- the estimation of structural features and seismic behavior of surface influence;
- the study of a medium geometry influence onto a seismic amplitude;
- the consideration of engineering-geological environment and landscape areas probable changes while building-up existing tailing dumps and further assessment of these changes influence on a seismic intensity increase.

The first two questions assume digital model creation of the main geological elements geometry of studied area and the study of the ground velocity-properties by field and borehole seismology methods.

Firstly, the information allows to estimate strengthening action of local conditions onto seismic loads. Similar surveys are based on average shear-wave velocity V_S^{30} in the upper 30 meters analysis [2]. Secondly, it is possible to create more complicated models to attract calculation methods to detail obtained amplification parameters.

The calculation methods application is necessary for consideration engineering-geological environment and landscape areas changes influencing seismic intensity increase. This fact is actual in construction and operation of the tailing dumps (the huge anthropogenic objects) later greatly influence onto changes of local seismological area descriptions. The first stage of computer simulation technique of transformation earthquake shaking process at the expense of structural features and seismic properties of ground surface is choice both medium model and input seismic load model (accelerograms for conversion). A number of assumptions simplifying both model and calculation taking into account the most important object parameters are used.

In this study calculations are made as follows:

1. One-dimensional horizontally layered soil deposits models are used for estimating the effect of low-velocity sedimentary rocks mass. This is acceptable in parallel layered sedimentary boundaries.

2. More complicated – two-dimensional models are used for evaluating the effect of anthropogenic topography which is determined by construction and operation of the tailing dumps.

The assessment of sedimentary rock impact onto seismic signal transformation is made by accelerogram recalculation from “firm rock” (basement) up to day surface. The calculations are made by computer program SHAKE [3]. The program computes the response in a horizontally layered soil rock system subjected to transient, vertical traveling shear waves. The method is based on Kanai's solution of the wave equation and the Fast Fourier Transform algorithm. While computing medium transfer function is defined when plane shear-wave falls off on horizontally layered soil deposits. The ground motion spectrum on the surface is calculated by multiplication seismic wave spectrum coming from “firm rock” onto corresponding transfer function.

One-dimensional model geometrical parameters are set on the digital seismic model base of the object.

To obtain the better accuracy of calculated data the calculations are made with different frequency content of accelerograms.

The decision is based on inelastic and nonlinear behaviors of soils.

The use of horizontal-layered (one-dimensional) models makes it impossible to estimate influence of anthropogenic topography onto transformation of seismic transients.

To estimate the effect of anthropogenic topography onto seismic intensity increase Tesseral-2D software was used. Referred program lets make full-wave modeling in heterogeneous medium for the elastic wave equation [http://www.tesseral-geo.com].

Modeling possibility of factors depending on difficult surface conditions including severe topography is the most important characteristic of Tesseral-2D.

Results and conclusions. In this study it is demonstrated that it is possible to use the latter approach in the terms of construction and operation of the tailing dumps sites in Krivoy Rog (Ukraine). The latter having big amount of mining and smelting enterprises is one of the biggest iron ore mining areas in the world.

So, building-up existing and new tailing dumps construction is proved to be urgent and highly necessary in these terms.

Influence assessment of low-velocity anthropogenic soils onto ground motions amplification was considered with the one example of construction site. Influence of both existing anthropogenic mass and its change during building process has been studied.

Based on geological and topographic data a digital model of the main geological elements of the studied area has been built. Some elements of the model are presented on fig.1.

Velocity behavior of soil was estimate by refracted wave method results.

It was obtained dependence between shear-wave velocity V_S^{30} in the upper 30 meters and anthropogenic soils thickness. Based on the model of anthropogenic soils thickness were calculated V_S^{30} (Fig.2).

Using the approach of [1] the amplification factors of short- and mid-period ground motions F_a (T=0.1-0.5 s) and F_v (T=0.4-2.0 s) were calculated, respectively (Fig.3).

Amplification was estimated relatively to nature surface soils with Vs^{30}_{ref}=450 m/s. The results and forecast of medium changing influence during new tailing dump building was adjusted by calculation methods.

For the model of tailing dump (Fig.4) influence of anthropogenic soils thickness onto ground motions amplification of different frequency content by SHAKE program (Fig.5) was estimated. Results are close to assessments of V_S^{30} (Fig.3) however little bit higher. It is caused by resonance effects from bed top.

To evaluate the effect of anthropogenic topography propagation plane shear-wave modeling was made by Tesseral-2D in corresponding terms. Ricker impulse was taken as input. For the modeling wavelength was changed from 80 till 400 m because of potential earthquake shaking predominant periods and anthropogenic soils velocity characteristic. The ground motions amplification was calculated relatively to horizontal topography (Fig.7).

We see that resultant ground motions amplification might approach to 2 which is caused by anthropogenic low- velocity soils and anthropogenic topography. This fact is important for tailing dump design.

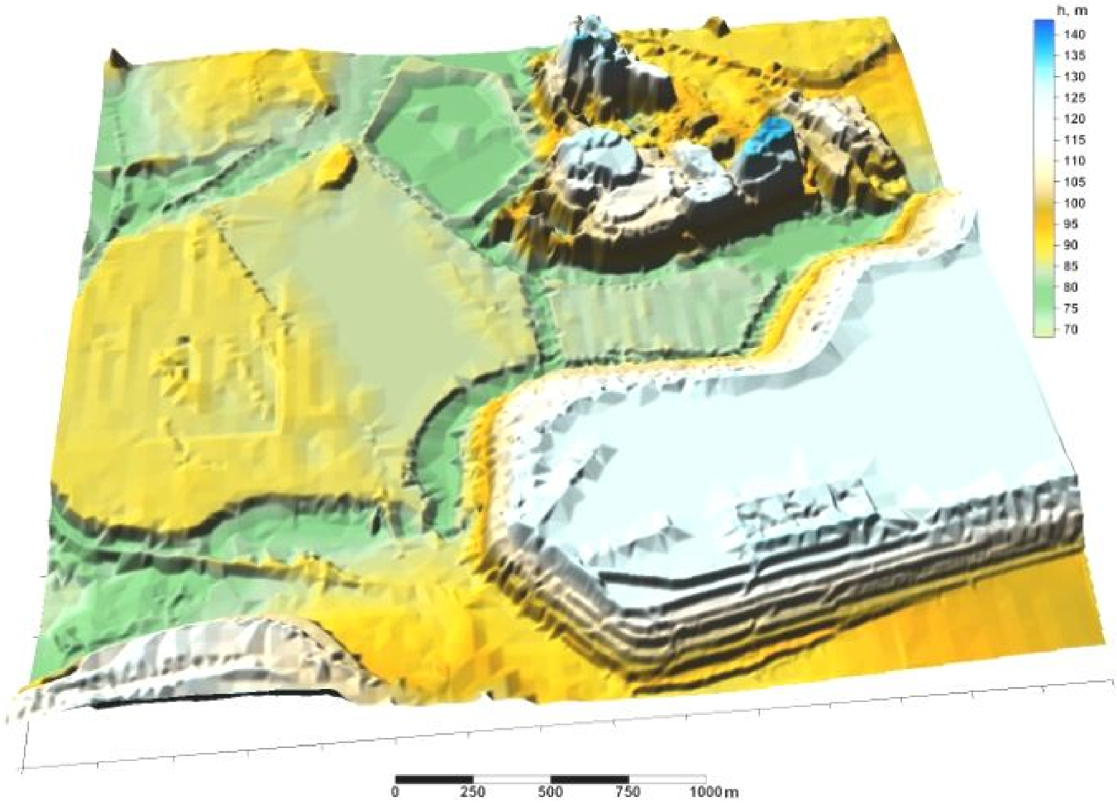

Fig. 1. The component of digital model of the main geological elements of the studied area (anthropogenic topography)

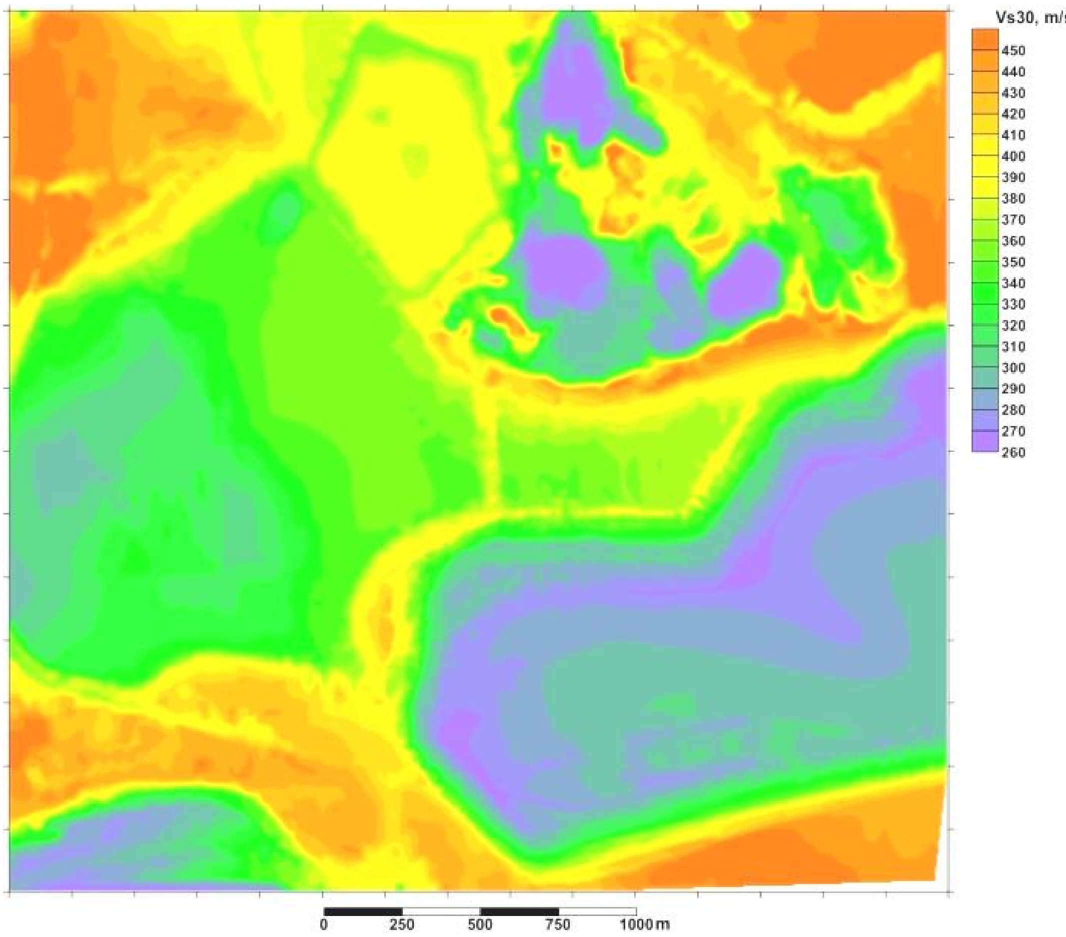

Fig. 2. The model of shear-wave velocity V_S^{30}

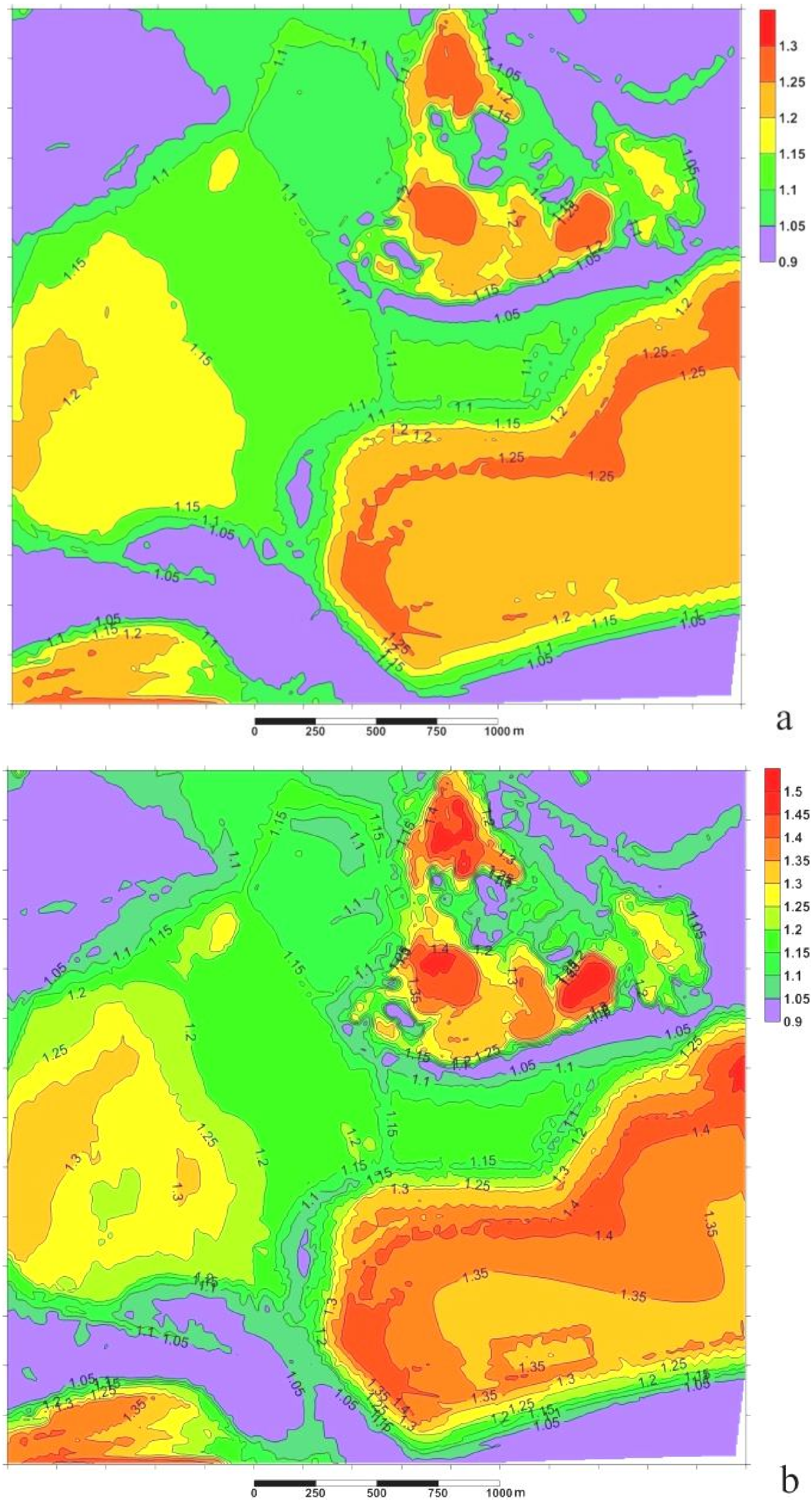

Fig. 3. The model of amplification factors:
a – short- period (T=0.1-0.5 s) ground motion; b – mid-period (T=0.4-2.0 s) ground motion

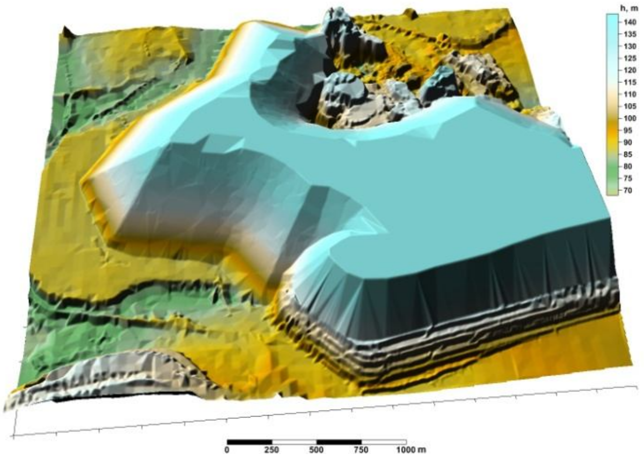

Fig. 4. The digital model of designed anthropogenic topography in the future

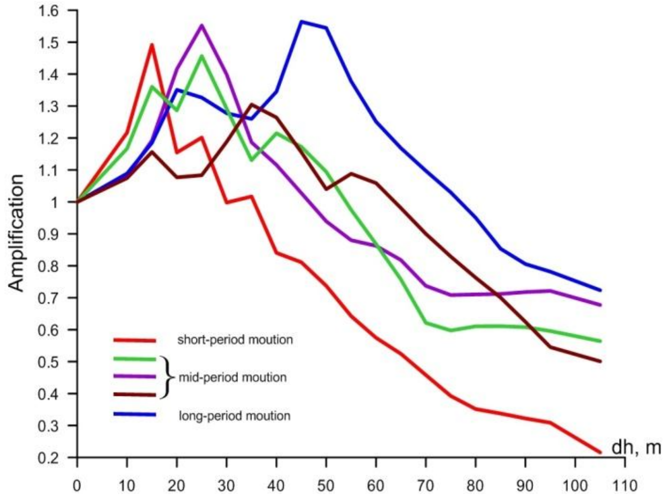

Fig. 5. The dependence between anthropogenic soils thickness and ground motions amplification

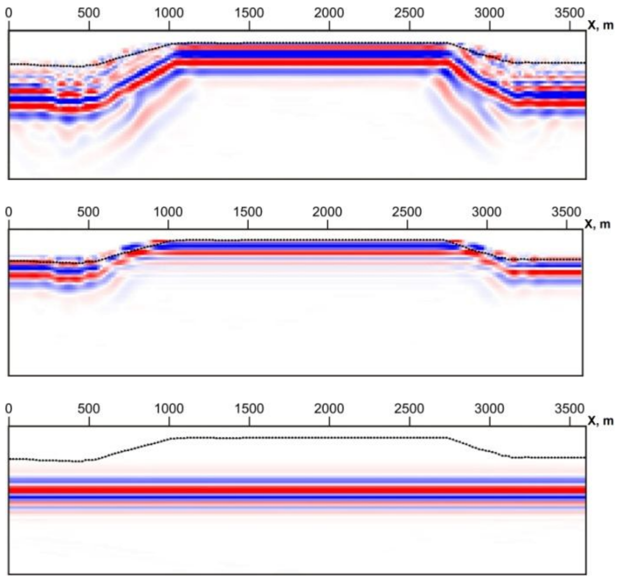

Fig. 6. The process of plane shear-wave propagation in anthropogenic topography

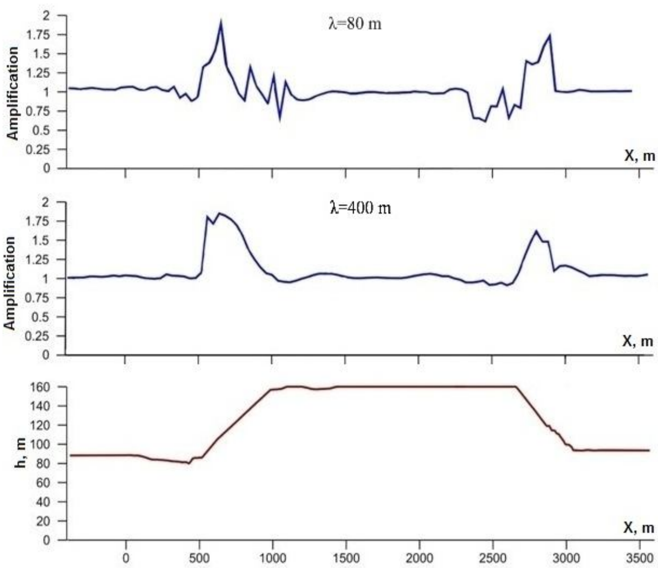

Fig. 7. The ground motions amplification in anthropogenic topography terms

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