УДК 624.39.329

N. S. Remez, doctor of technical sciences, Y. S. Yashchenko (NTUU «KPI»), S. A. Kraychuk (Rivne State Humanitarian University)

METHODSFOR DETERMINATION OF SEISMIC SAFE PARAMETERS OF THE EXPLOSION WORKS AND IT PROGRAMM REALEZATION

A package of applied programs was alaborated, which allows conducting the calculation of seismic stability of protected object for the specific conditions of the explosion with the possibility of rapid adjustment of blasting parameters was developed.

Keywords: *seismic safety, seismic blast waves, explosion, cylindrical charges, protected objects, amplitude-frequency spectrum, numerical simulation.*

Розроблено пакет прикладних програм, який дозволяє проводити розрахунки сейсмостійкості споруди, що охороняється, для конкретних умов проведення вибуху з можливістю оперативного корегування параметрів вибухових робіт для забезпечення сейсмобезпеки об'єкта.

Ключові слова: *сейсмостійкість, вибух, охороннів об'єкти, швидкість коливань, чисельне моделювання.*

Разработан пакет прикладных программ, позволяющий проводить расчеты сейсмостойкости охраняемого сооружения для конкретных условий проведения взрыва с возможностью оперативной корректировки параметров взрывных работ для обеспечения сейсмобезопасности объекта.

Ключевые слова: *сейсмостойкость, взрыв, охраняемые объекты, скорость колебаний, численное моделирование*.

Introdaction. With the increase of mining operations and the approaching of career fields to protected objects in practice the question of their seismic safety gets up sharply. This situation puts the researcher's simultaneously two priority tasks - providing quality crushing of rocks and seismic safety of buildings during the explosion works.

The theory of seismic stability of buildings is widely developed to estimate natural impact of earthquakes which explains the presence of a number of application programs, such as ABAQUS, STARK ES, MIDAS/CIVIL, StructureCAD (SCAD), Micro FE, ЛИРА, etc. Calculation of seismic loadings in these programs is implemented based on the finite element method and the spectral method of theory seismic stability theory. Because of the difference in frequency-temporal parameters of the waves from earthquakes and explosions this does not solve the question of the seismic safety of objects determining under explosive loads.

The purpose of work is development package of applied programs for the operational calculation of seismic safety parameters of explosion works.

Exposition of basic material. On the basis of algorithms it was developed an application program package in the programming language Delphi. The algorithms are based on mathematical modeling regularities of seismic explosive waves

ropagation in the ground massif and their interaction with the buildings [1 - 4]. Application program package is composed of three programs for solving consistently associated with each other tasks: 1) the calculation of the parameters of seismic explosive waves under the explosion of cylindrical charge in a ground massif or rock; 2) the calculation of seismic explosive waves under the explosion of the group cylindrical charges at instantaneous or short-delay demolition; 3) the calculation of the wave interaction of the falling seismic explosive waves with the base of a protected object.

The task is selected in the main window of program (Fig. 1).

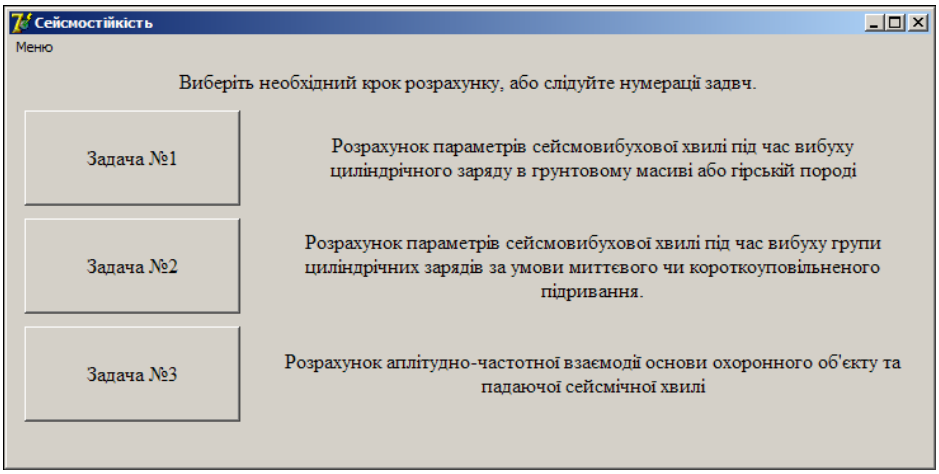


Fig. 1. The main window of the work program

In first task camouflet explosion of cylindrical charge explosive substance in the ground mass is numerically calculated. Thus the motion of ground and detonation products are studied in the framework of mechanics of continuous medium. Selection of medium model is carried out depending on the soil kind in which explosion occurs. For the rocks relation between stress and deformation is investigated on the basis of the incremental theory of plasticity. The generalized Hooke's law for isotropic material is valid in an elastic zone. In the case of plastic deformation connection with the corresponding stress is recorded with using of the energy conditions of strength. Soil is simulated by solid porous visco-plastic medium [1]. Selection of medium is carried out in entry window (fig. 2) and set by pressing the «task №1» in the main program window or using the drop-down menu of the main window Menu → Task №1.

The input data are the physical and mechanical characteristics of the soil near the source of the explosion, the detonation characteristics of explosives, the parameters of the charge’s structure. As a result of numeral experiment we receive an array of the basic parameters of seismic explosive waves (stresses, velocity, time of wave coming, time of the maximum impulse coming and duration), which depend on the time and the relative distance. In a software implementation results in form of

arrays of data are saved in separate files and processed by the least squares method for obtaining analytical dependences that are needed to solve the second task.

At this stage the input parameters are: the number of charges, the distance between them and to the free surface, the delay interval. There is a possibility of simultaneous demolition or introduction of the delay interval, which is different for each charge.

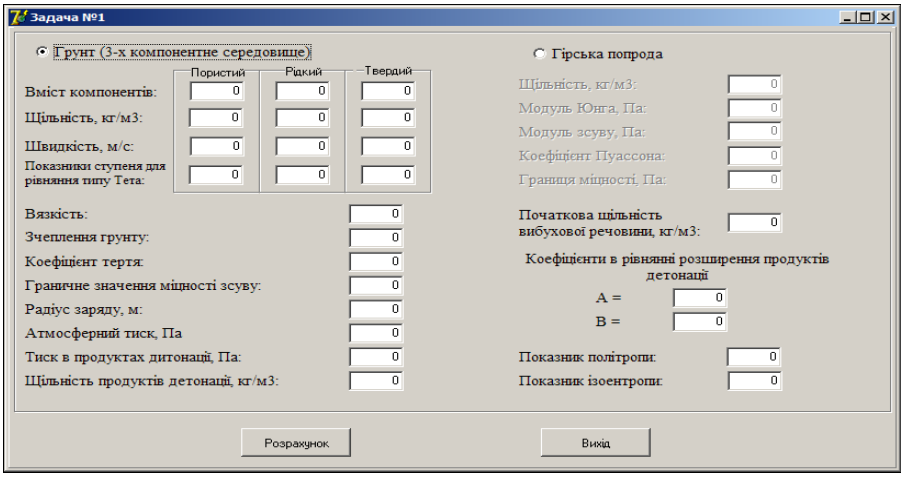


Fig. 2. The window of data entry for task about the explosion of the cylindrical charge in a soil massif

Moreover it is necessary to set the time moment of the output of the wave process parameters and the grid size covering the computational domain. Fig. 3 shows the data entry window.

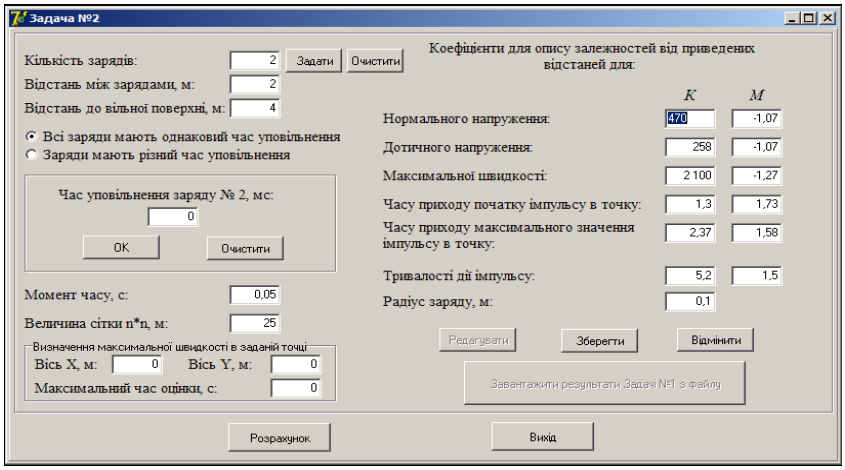


Fig. 3. The entry window of data for the explosion group cylindrical charges in soil massif task

Figure 4 shows the output window of the results for this task, which contain four insets: for stresses and velocity of two components. Maximum values of all the calculated values is shown in the upper part of the window. The fields of the output values are represented as colored areas that are limited by isolines. Color and number of isolines can be set in the main window in the tab of menu «Configuration».

Functional dependence of falling seismic wave which interacts with the protected object is recorded based on the obtained dependence of the maximum velocity (horizontal components) on a distance. Oscillation of the object is regarded as motion a homogeneous solid body in rectangular form which is placed in an elastic medium by the action of falling seismic wave. The task is limited by consideration only translational motion of the body. Motion of a solid rectangular body is described by center of mass displacement, ground motion is determinated by dynamic Lame's equation.

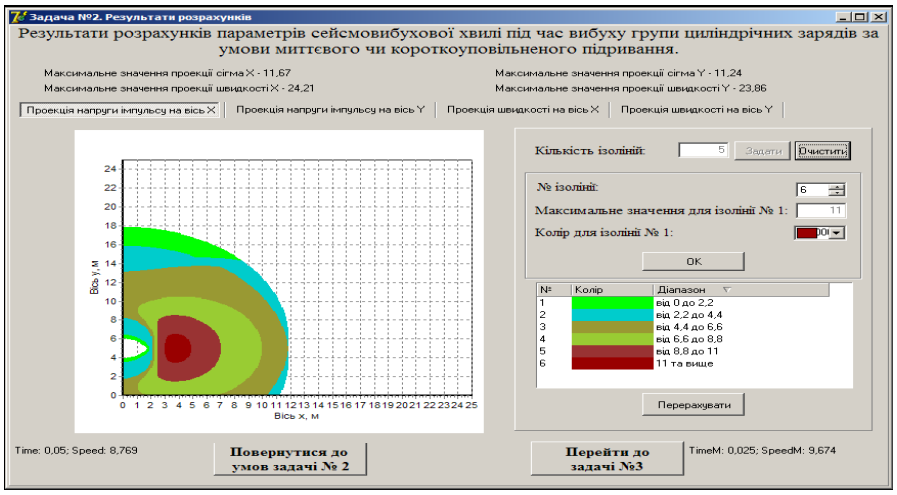


Fig. 4. The output window of the results for the task about the explosion of cylindrical charge group in soil massif

For the numerical solution of the task ordinary differential equation is obtained, which is solved by the fourth order Runge-Kutta method.

The input parameters are the linear size of the object, its inertial characteristics, soil's physical and mechanical properties, the angle of a falling wave, the distance to the epicenter of the explosion.

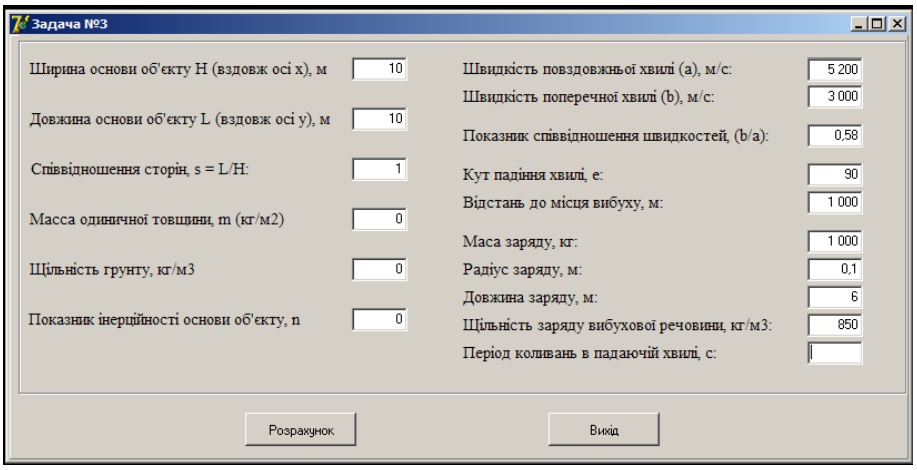
The results of calculation are graphical dependences of displacement and vibration velocity of the object base on the time. By the resulting graph the maximum speed of vibrations and compared with those given in the window of program acceptable standard values vibration speed can be determined. Fig. 5 a, b shows data entry and output of results windows respectively.

It is possible to give recommendations to increase or decrease the scale of explosion work depending on the results of the comparison and repeat calculation of seismic stability of the object for the new selected parameters.Thus it is possible to vary parameters of charge, type explosives, detonation conditions. It should be noted that it will be necessary to recalculate only the second and third tasks.

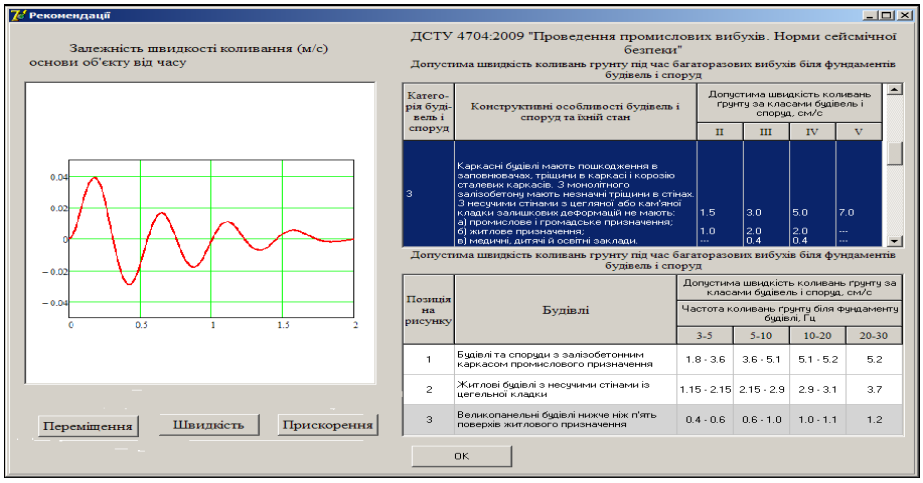
The algorithm for calculating the seismically safe parameters of explosion is repeated until there will not be achieved the necessary rational values of them.

Conclusions

Thus the developed methodology and software package for the numerical experiment to establish the seismically safe parameters of explosion work near protected objects has a number of advantages over the natural experiment. Firstly it is less resource-intensive and costly. Secondly it allows to obtain results for different initial conditions quickly and can be used for mining enterprises that use explosive technology and located close to protected buildings.



a)



b)

Fig. 5. Data entry window (a) and output of results solution of the task about the interaction of seismic explosive waves with the protected object basis window (b)

References

1. Luchko I.A. Mathimatical simulation of the explosive action in the grounds and rocks / I.A. Luchko, N.S. Remez, A.I. Luchko. K.: NTUU “KPI”, 2011. - 264 p. [in Ukrainian]

2. Remez N.S. Estimation of seismic safety from data of simulation of waves interaction processes at the short slow explosing of cylindrical charges / N.S. Remez, V.V. Boyko, Yu.S. Yaschenko // Problems of labour protections. – 2009. - Is. 17. – P. 41–48. [in Russian]

3. Remez N.S. Simulation of processes of wave fields interaction at cylindrical charges explosions in rocks / N.S. Remez, V.V. Boyko, Yu.S. Yaschenko // Announcer of National technical university of Ukraine "KPI", serya "Mountain business". – 2009 –№18. – P. 10–17. . [in Russian]

4. Remez N.S. Seismic firmness of the guarded building at interaction of superficial seismo-explosive wave with his foundation // Announcer of National technical university of Ukraine "KPI", serya "Mountain business". – 2011 –№20. – P. 86–92. . [in Russian]

Стаття надійшла до редакції 28.06.2013 р.