Application of Quasiconformal Mapping Methods to the Investigation of the Explosive Processes Impact on the Environment

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Abstract— **The mathematical models used to study explosive processes are given. A class of problems investigating the influence of explosive processes on the environment by the quasiconformal mappings numerical methods are outlined and their practical application are described.**

Keywords— explosion processes, quasiconformal mappings, mathematical modelling, numerical methods.

I. INTRODUCTION

The rapid progress of scientific and technological progress, the acceleration of the rhythm of life of modern society, and the tendency to migrate of a significant number of workers from the industrial spheres to non-production ones, necessitates the use of new technologies in the production, which allow to automate part of the production process, to accelerate it or to reduce the cost.

One such technology is the use of explosive energy. Explosive processes are widely used in the buildings construction (for foundation pit construction and for the underground or semi-underground structures). Another area that makes extensive use of explosive processes is the extraction of minerals, especially those that lie at great depths and to gain access to them, it is necessary to remove a thick layer of soil. Explosions are also used to destroying and crushing rocks, to construction underground transport infrastructure, in particular, subways and tunnels under water bodies (for example, under the English Channel). Explosive processes are also used to provide materials with the necessary engineering properties (for example, compression of the soil to give it the required strength). Explosive energy is also used by a number of other industries, though to a lesser extent than by those mentioned above.

II. MATHEMATICAL MODELS OF EXPLOSION PROCESSES

The huge energy released by an explosion can significantly speed up production work and, at the same time, can cause significant damage to production and the environment (including human casualties) in the case of incorrect calculation of the explosion parameters, therefore, the using of an explosive process requires careful a priori modeling of the process and a clear definition of its consequences.

Exploration of explosion geodynamics is devoted to a number of works by both Ukrainian and foreign scientists who use different mathematical models to study the explosive process. All existing models can be divided into 2 types: those that study the dynamics of rocky (fragile) rocks and the dynamics of compressible rocks (which include soils) [1]. There is also a so-called middle group of mediums - semi-rocky ones. Environments where the explosion takes place are divided into cohesive, non-cohesive, special-state environments (such as frozen soil), sedimentary rocks (clay), etc. [2].

Depending on the environment being studied, one or another mathematical model is selected and appropriate methods are applied. Given the sophisticated mathematical apparatus required to modelling the explosion process and its impact on the environment, the analytical solution of the corresponding boundary value problem is only possible for certain, quite close, cases of input data, so the vast majority of mathematical models that describes the given processes are based on numerical methods.

III. MATHEMATICAL MODELLING OF EXPLOSION PROCESSES IN THE SOILS

One of the mathematical models used for mathematical modeling of explosive processes occurring in compressible rocks (particularly soils) is a fluid one based on modeling the investigated environment as an ideal fluid [3, 4]. The "classical" fluid model for the study of the impact of the explosion process on the environment is based on the use of conformal mappings numerical methods. The authors modified the fluid model by using quasiconformal mapping numerical methods instead of the conformal ones to simulate the explosion process and to take into account the mutual impact of characteristics of environmental and the explosive process.

The basic idea of described approach is to model the environment under investigation in the form of a two-bounded domain, the inner contour of which is the charge contour. The purpose of the study is to determine the contours of the crater, pressed and undisturbed sections of soil formed by the explosion process (Figure 1).
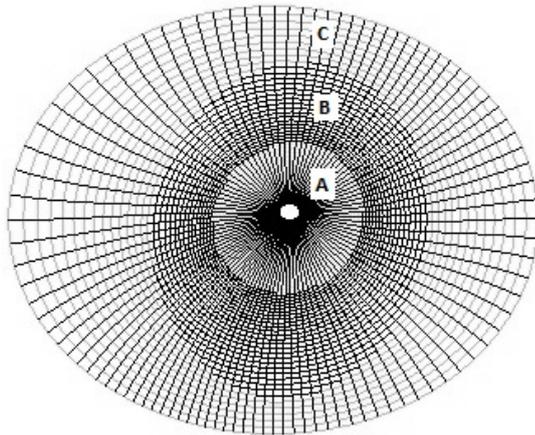
Figure 1. The distribution of crated, pressed an unperturbed zones of soil

Figure 1 shows an example of the distribution of a crater (A), the pressed (B), and undisturbed (C) sections of the soil formed in the investigated medium by the explosion process.

Using numerical quasiconformal mapping methods, a wide variety of problems of significant theoretical and practical importance are already solved for today.

In particular, the boundaries of the crater, the pressed and unperturbed zones formed in the environment by the explosion, are determined for the cases of the isotropic media and the anisotropic one [5].

It is established which outer contour of the mathematical domain under study is sufficient to consider the correct resulting distribution of the formed zones [6].

The boundaries of the crater, pressed and unperturbed sections of the soil formed in the study domain for the cases of synchronous and asynchronous explosion of two charges were determined [7], as well as a comparative analysis of the impact on the environment of synchronous and asynchronous explosions of two charges having the same characteristics.

The optimum bookmark location and the explosive performance of charge required to form a crater of the maximum size are established, while maintaining the integrity of certain two [8] and three [9] objects within the possible impacted zone of the soil.

The described model for the two-dimensional mathematical domain is generalized to the spatial case and the boundaries of the crater, pressed and unperturbed soil zones for the three-dimensional domain are established [10].

IV. CONCLUSIONS

Numerical quasiconformal mapping methods are a powerful tool for investigating the impact of explosive processes on the environment, in particular on the soil. A wide range of problems of great theoretical and practical importance have already been solved with their use. However, a number of problems remain unsolved for today.

In the long term is solving problems in the study of the impact of the explosion process on the environment, where one or more fixed objects are allocated in the area of destruction, the setting the parameters of the explosion required for the displacement or destruction of fixed objects, the study of relevant spatial cases, the application of the proposed methods of modeling the impact of the explosive process on the environment to the modeling of social processes (in particular, the movement of crowds in emergency situations, the definition of the so-called "hot" and "safe" zones etc.).

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