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M.I. Beltek[1], Phd student
N.A. Evpak[1], student
[1]Department of Geoengineering
Igor Sikorsky Kyiv Polytechnic Institute

RESULTS OF MODELING THE EXPLOSION OF A BOREHOLE CHARGE IN A FRACTURED ROCK MASSIF IN ANSYS AUTODYN

Abstract: *The expediency of using Ansys Autodyn software package for modeling the action of a borehole explosive charge explosion in a naturally disturbed rock massif is substantiated. Computer modeling of dynamic destruction of rock massif by explosion is carried out to determine the volume and size of the zone, which is disturbed by the action of a borehole charge explosion, at different values of the strength reduction factor.*

The graphical dependence of change of kinetic energy of explosion in time for different values of strength of naturally disturbed rock massif is established. Calculations show that the kinetic energy of the explosion action is generally exhausted within 1.0...1.5 ms.

The fracture zone for the massif with full strength is obtained and the character of its distribution is established.

Keywords: *Ansys Autodyn; fracture zone; borehole charge; naturally disturbed rock massif; strength index; degree of massif disturbance.*

Introduction. The action of detonation of a borehole explosive charge in a naturally disturbed rock massif is characterized by the complexity of the dynamic fracture process. Numerical modeling of such explosive rapid processes is recommended in order to gain more knowledge about complex physical phenomena that cannot be obtained by experimental research methods. Problems of high-speed dynamic impact, penetrating action of explosion and other nonstationary phenomena with high strain rates are usually solved using an explicit approach to the equations of continuum mechanics.

Purpose and Objectives. The purpose of the presented article is to study the possibility of modeling the action of the explosion of a borehole explosive charge in a fractured rock massif in the Ansys Autodyn software package.

The task of the study is to establish the relationship between the overall strength of the rock massif and the result of the action of the explosion of a borehole charge in it.

Material and results of the study. Ansys Autodyn is a modeling tool for solving problems of significant deformation or fracture of materials that has multiple models to represent complex physical phenomena such as fluid, solid, and gas interactions, material phase transitions, and shock wave propagation. The main features of the program allow it to be used to predict fragmentation in rock explosions. The combined use of Eulerian and Lagrangian reference frames in ANSYS AUTODYN software is particularly useful for modeling explosive fields [1].

The Eulerian reference frame is best suited for representing explosive detonations because the material flows through a geometrically constant mesh that can easily handle the large deformations associated with gas and fluid flows. Rocks are modeled using a Lagrangian reference frame, which is best suited for fragmented solids because the mesh moves with the material and allows realistic deformation and collapse. These two reference frames are coupled in the ANSYS AUTODYN program so that energy is easily transferred between them to accurately simulate the entire explosion process. A compelling feature of ANSYS AUTODYN

is the inclusion of these features in the 3D simulation, making the program the only logical choice for modeling and analyzing rock blasting.

To determine the volume and size of the zone, which was formed by the action of the explosion of the borehole charge, at different values of the strength reduction factor, computer modeling of the dynamic destruction of the rock massif by explosion was carried out. To compare the simulation results, 10 models were analyzed, in which the strength characteristics were changed with the strength reduction factor K_{sp} [2], with a step of 0,1 of the initial strength.

The model configuration as well as the location of the observation points are shown in Fig. 1.

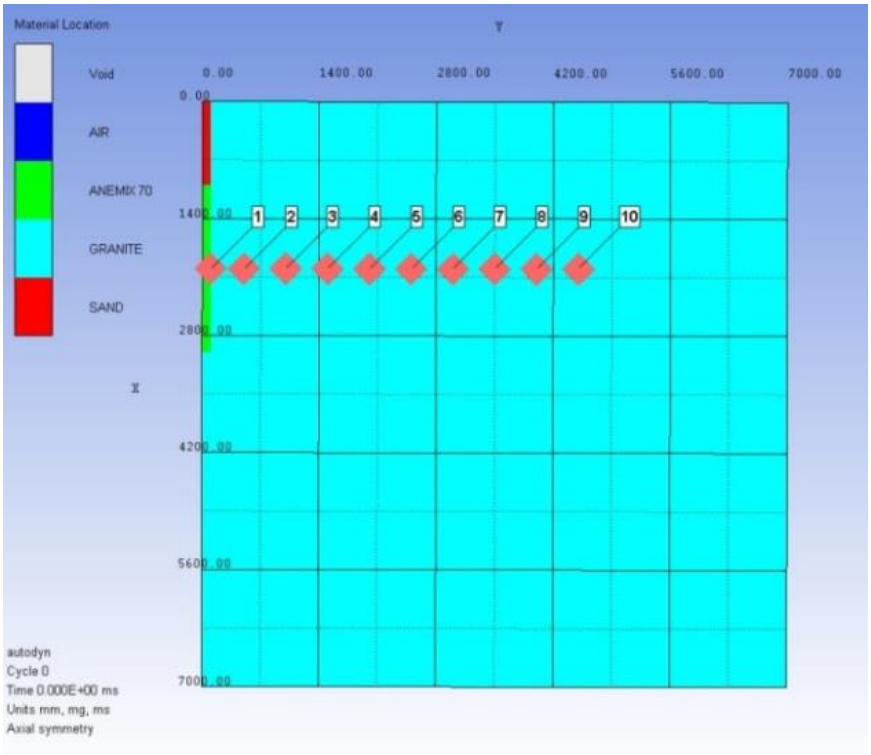

Figure 1 – Model configuration and location of observation points

The monitoring points were added to the model to determine the time variation of parameters such as pressure and rock fracture. All monitoring points are located on the same horizontal line in the middle of the explosive charge. Point 1 is located at the boundary between the explosive charge and the rock mass and is intended to determine the change in pressure of the explosion gases over time, points 2-10 are located every 0,5 m, their task is to observe the degree of destruction of the massif.

Calculations show that the kinetic energy of the explosive charge is exhausted in 1,0...1,5 ms (Fig. 2). However, under the action of accumulated loads and inertia, the massif continues to deform in some places and to undergo greater crack propagation.

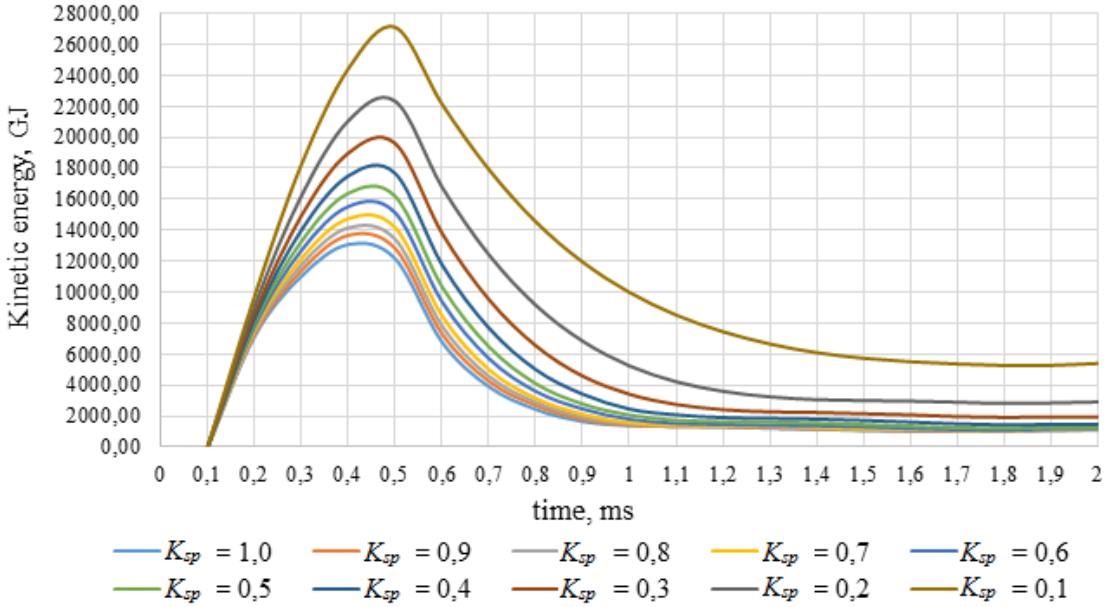

Figure 2 – Variation of kinetic energy in time

As a result of modeling, the character of fracture distribution for the array with full strength was obtained (Fig. 3).

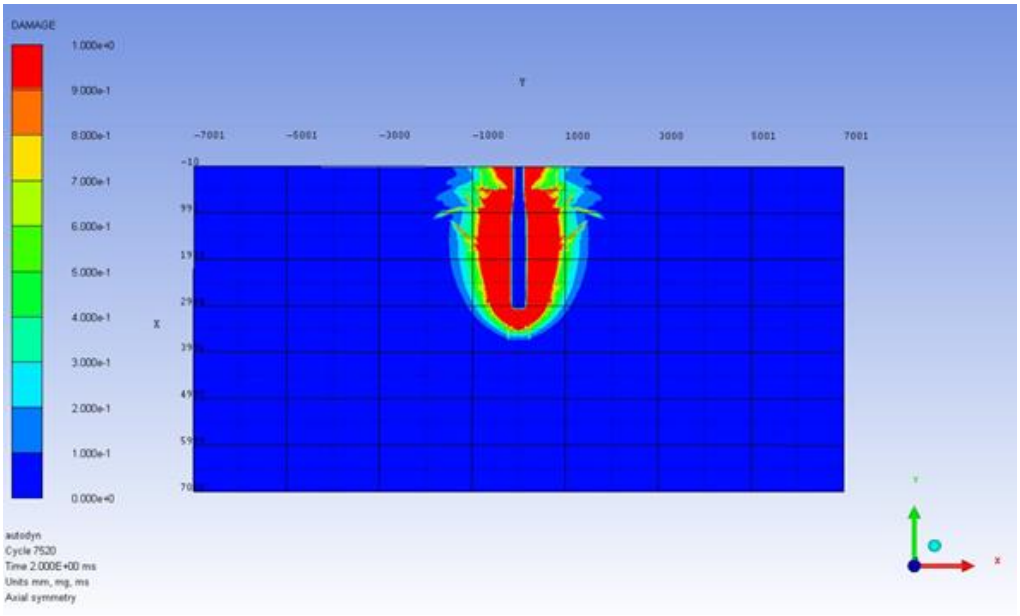

Figure 3 – Fracture diagram of a rock massif that has full strength

The fracture results make it possible to conclude that the volumes and radii of fracture zones increase with decreasing strength.

The conducted theoretical studies have shown that the explosive fracture of rocks is significantly affected by the fracturing of the rock massif. To confirm the effectiveness of the proposed method of assessing the explosive destruction of naturally disturbed rock massifs, experimental studies are required. When conducting them, it is necessary to take into account the characteristics of explosives and properties of disturbed rock massifs.

References

1. Hryshanova I. A., Zghurovska L. P., Kyrychuk Yu. V. Rozviazok zadach proiektuvannia pryladiv ta system z vykorystanniam ANSYS i MATHCAD: pidruchnyk. Kyiv: Vyd-vo «Politekhnika» KPI im. Ihoria Sikorskoho, 2022. 180 s.

2. Beltek M.I. Yevpak N.A., Frolov O.O. Doslidzhennia zminy mitsnosti skelnoho hirskoho masyvu zalezhno vid stupeniu yoho trishchynuvatosti. Suchasni problemy hirnytstva ta budivnytstva: tezy Vseukrainskoi naukovo-praktychnoi konferentsii, m. Zhytomyr, 23 lystopada 2023 roku. Zhytomyr: Zhytomyrska politekhnika, 2023. S.13-15.

Scientific advisor: Dr. of Engineering, Prof. Oleksandr Frolov

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М.І. Бельтек[1], аспірант
Н.А. Євпак[1], магістрант
[1]Кафедра Геоінженерії
КПІ ім. Ігоря Сікорського

РЕЗУЛЬТАТИ МОДЕЛЮВАННЯ ВИБУХУ СВЕРДЛОВИННОГО ЗАРЯДУ У ТРІЩИНУВАТОМУ МАСИВІ ГІРСЬКИХ ПОРІД В ANSYS AUTODYN

Анотація: *Обгрунтована доцільність застосування програмного комплексу Ansys Autodyn для моделювання дії вибуху свердловинного заряду вибухової речовини в природно порушеному масиві гірських порід. Проведено комп'ютерне моделювання динамічного руйнування масиву гірських порід вибухом для визначення об'єму і розмірів зони, яка порушена дією вибуху свердловинного заряду, за різних значень коефіцієнту зниження міцності.*

Встановлена графічна залежність зміни кінетичної енергії вибуху в часі для різних значень міцності природно порушеного гірського масиву. Розрахунки показують, що кінетична енергія дії вибуху в даних умовах в цілому вичерпується впродовж 1,0…1,5 мс.

Отримана зона руйнування для масиву з повною міцністю та встановлено характер її розподілу.

Ключові слова: *Ansys Autodyn; зона руйнування; свердловинний заряд; природно порушений гірський масив; показник міцності; ступінь порушеності масиву.*

Список використаних джерел

1. Гришанова І. А., Згуровська Л. П., Киричук Ю. В. Розв'язок задач проєктування приладів та систем з використанням ANSYS і MATHCAD: підручник. Київ: Вид-во «Політехніка» КПІ ім. Ігоря Сікорського, 2022. 180 с.

2. Бельтек М.І. Євпак Н.А., Фролов О.О. Дослідження зміни міцності скельного гірського масиву залежно від ступеню його тріщинуватості. *Сучасні проблеми гірництва та будівництва*: тези Всеукраїнської науково-практичної конференції, м. Житомир, 23 листопада 2023 року. Житомир: Житомирська політехніка, 2023. С.13-15.

Науковий керівник: докт. техн. наук, професор Фролов О.О.

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