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EXTENDED ABSTRACT

Assessment of Bomb Penetration into the Rocks with RMR> 90

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1. Introduction

To design a safe underground structure, it is necessary to construct this structure at the optimal depth to be completely safe due to having sufficient overburden. Therefore, knowing the penetration depth of the bunker buster bombs in which the explosion will eventually occurs is essential in the design of defensive structures. The depth of penetration, in addition to the characteristics of the projectile and the speed of its impact, depends on the geomechanical characteristics of the rock mass. In this research, the penetration depth of GBU-28 bomb is modeled by Abaqus software in rocks with RMR> 90 (three types of granite, sandstone and lime). This laser-guided bomb is a type of penetrating bomb that penetrates several meters into the ground, rock or concrete before exploding and then explodes.

2. Methodology

First, the geomechanical parameters of three types of rocks (granite, sandstone and limestone) with RMR> 90 are determined by RocData library and software studies. Then the depth of bomb penetration in all three types of rocks is obtained by modeling using the FEM-based software package, Abaqus. Since the rock elastic and strength parameters with specific RMR are not unique, the sensitivity analysis was performed on the rock mass elastic and strength parameters. In addition, since presence of joints and discontinuities significantly affects the mechanical behavior of rock mass the effect of joint/discontinuity angle as wells as the amount of joints in the model was investigated.

Determining boundary conditions is always one of the key challenges in dynamic and geomechanical modeling, which are often determined by geotechnical structure, tectonic and geological conditions in boundary areas. In this study, the boundary conditions of the model are defined as follows:

- he lower border of the model is closed in all directions
- The upper limit of the model is free
- There is no normal displacement in the lateral borders of the model

3. Results and discussion

The depth of bomb penetration in all three types of rocks was obtained by modeling and then sensitivity analysis was performed on the bomb impact speed, formation geomechanical properties and discontinuities angle. Empirical relationships (despite the existing simplification assumptions) were used to verify the penetration depth values obtained from numerical modeling.

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Results of previous studies on projectile penetration depth relationships show that the relationship of ACE Army Engineering Group has more coordination and similarity with the curves obtained from laboratory results and therefore exhibit better performance and accuracy than other relationships.

Comparison of the penetration depth obtained from modeling with the penetration depth obtained from ACE relationship shows that the penetration depth values obtained from the modeling are in good agreement with the penetration depth values obtained from this experimental relationship.

4. Conclusions

Numerical modeling by finite element software shows that the penetration depth in rocks with RMR> 90 granite, sandstone and limestone are 4.33, 4.80 and 5.37 meters, respectively. In addition, the stress concentration is higher in granite although the plastic area in limestone is larger.

Increasing any of the elastic/strength parameters (young modulus, poisson's ratio, friction angle and etc.) of the rock mass such results in reduction of the bomb penetration depth. On the other hand, the presence of joints and discontinuities significantly affects the mechanical behavior of the rock mass so that the depth of penetration of the bomb will increase.

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