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The Influence of Water Content on Strength Characteristic of Sandstone Subject to Triaxial Test

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ABSTRACT

It has been well accepted that water content significantly changes the physical and mechanical properties of rocks. Experimentation data of Uniaxial Compressive Strength (UCS), Modulus of Elasticity (E) and Brazilian Tensile Strength (UTS) of sandstone showed that increasing water content from oven dried to saturated condition will decrease their values. Ultrasonic tests carried out together with the UCS tests also indicated that the sonic wave traveled faster as rock specimen became saturated.

During triaxial tests, the sonic velocity changed with the applied load. It was found that constitutive behavior of dried rock specimen was dependent on the confining pressure, whereas saturated rock specimen did not seem to be dependent on the confining pressure. Dependency of failure criteria such as Mohr-Coulomb, Bieniawski and Hoek & Brown on the water content was confirmed as well.

In order to show the influence of water content on the stability of an underground opening, a numerical modeling, based on finite element method, was carried out. The model was run using the mentioned failure criteria.

INTRODUCTION

Over the last two decades there has been an unprecedented increase in the development of open pit coal mines. In the near future the open pit coal mines will face highwalls, and subsequently underground mines will be developed. Furthermore, a significant coal deposit at Ombilin, West Sumatra, of PT. Bukit Asam will be mined by longwall method at level down to 800 m below surface, which is referred to Ombilin III. In order to anticipate the geomechanical problems encountered at that great depth, gathering data on the known effects of water on strength properties of coal bearing strata becomes essential. As sandstone being one of the coal bearing strata that carries water, this paper therefore describes the influence of water content on the strength characteristic of sandstone under uniaxial and triaxial conditions.

Underground stability assessment is often done through failure criteria analysis. The most commonly used failure criteria so far have been the Mohr-Coulomb, Bieniawski (1974) and Hoek & Brown (1980). These criteria were exercised for sandstone specimens under wet and dry conditions. Hence, for the purpose of this particular research a Von Karmon type triaxial cell was designed and manufactured in house.

REVIEW OF THE PREVIOUS WORKERS ON THE INFLUENCE OF WATER CONTENT ON INTACT ROCK STRENGTH

Many rock strata in situ are fully saturated by water, or have at least a high water content. In spite of this, testing of rocks in the laboratory is often performed on dry specimens or specimens with uncontrolled water content. This change of environmental condition may greatly influence the strength characteristics and constitutive behaviour of rocks as reported by many authors (Broch, 1974; Mimuro et al, 1991; and Van Eeckhout, 1976).

It has been reported elsewhere that UCS and UTS are also influenced by water content (Burshtein, 1969; Mimuro et al, 1991; Dube & Singh, 1972; Price, 1960). Price (1960) reported that the UCS of sandstone specimen decreases as water content increases (saturated, natural, dry). The same phenomenon was also found by Feda (1966) for schist and gneiss rock specimens. Using five types of sandstone, Dube and Singh (1972) stated that non-linear correlation between UTS and water content was found. It can therefore be said that water content would reduce the UCS and UTS of rock specimens.

A study on the behaviour of rock specimen under triaxial condition was conducted by Griggs (1938). At his test the specimen, that was not covered up with jacket sleeve, led to a condition that pore pressure was equal to the confining pressure. In 1950, Griggs and Handin then carried out similar test using jackcted rock specimen, so that pore pressure was considered zero. These two studies indicated that mechanical properties of rocks would be dependent on pore pressure.