A STUDY ON STRESS-STRAIN BEHAVIOUR OF GRANITE AND SANDSTONE USING CLOSED-CIRCUIT SERVO-CONTROLLED TESTING MACHINE

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ABSTRACT

The objective of this study is to adopt a fundamental approach towards understanding the behaviour of granite and sandstone under uniaxial compression. The study is based on the complete stress-strain curve that represents the rock deformation under loading at a constant strain rate. Indeed, the complete stress-strain curve covers the behaviour of rock both at pre- and post-peak failure phases. To obtain the curve, the compression test need to be carried out using closed-circuit servo-controlled testing machine, or machine of high stiffness. In this study, a series of unaxial compressive tests on samples of granite and sandstone were undertaken using 3000 kN Tinius Olsen servo-controlled testing machine. Based on the complete stress-strain curves obtained, the deformation behaviour for both rock types are compared. Parameters being compared include peak strength, strain at failure and deformational behaviour at pre- and post-peak stages. Study on post failure behaviour of rock is particularly important in designing excavation, where rock materials may have been highly fractured or display certain degree of failure.

ABSTRAK

Tujuan kajian ini adalah untuk menyediakan asas ke arah pemahaman sifat-sifat granit dan batu pasir di bawah mampatan satu paksi. Kajian ini adalah berdasarkan graf tegasan-terikan lengkap yang menjelaskan ubah bentuk batu di bawah pembebanan pada kadar terikan yang tetap. Sesungguhnya, graf tegasan-terikan lengkap ini meliputi sifat-sifat batu di bawah fasa pra- dan pasca-kegagalan. Bagi memperolehi graf tegasan-terikan lengkap ini, ujian mampatan perlu dijalankan di bawah kadar terikan yang tetap dengan menggunakan mesin '*closed-circuit servo-controlled'* atau mesin dengan pengukuhan yang tinggi. Di dalam kajian ini, satu siri ujian mampatan satu paksi pada sampel-sampel granit dan batu pasir dijalankan dengan menggunakan mesin ujian '*servo-controlled'* Tinius Olsen dengan kapasiti 3000 kN. Berdasarkan graf tegasan-terikan lengkap yang diperolehi, sifat-sifat ubah bentuk pada kedua-dua jenis batu tersebut dikenalpasti dan dibandingkan. Parameter-parameter tersebut temasuklah kekuatan puncak, terikan pada kegagalan dan sifat-sifat ubah bentuk pada fasa pra- dan pasca-kegagalan. Kajian pasca kegagalan pada batu adalah penting di dalam mereka-bentuk kerja-kerja pengorekan, di mana sifat-sifat batu yang berkemungkinan mempunyai rekahan atau menunjukkan darjah kegagalan yang tertentu.

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σ	-	Compressive stress.
ε_a	-	Axial strain.
P	-	Compressive force.
A_o	-	Initial cross-sectional area.
Δl	-	Change in measured axial length.
l_o	-	Axial length of specimen prior to loading.
E_{av}	-	Average Young's modulus.
UCS	-	Uniaxial compressive strength.

CHAPTER I

INTRODUCTION

1.1 Introduction.

The design of excavations in rocks requires knowledge on strength and deformation characteristics of the rock in immediate vicinity of any excavation face. The most fundamental approach in understanding the deformation behaviour of fractured rock is by understanding the complete stress-strain curve of rock sample. The terms complete stress-strain curve refers to the behaviour of the specimen end from initial loading, through the linear elastic pre-peak region, through the peak compressive strength, and into post-peak failure region, and eventually residual strength.

However, several problems arise in obtaining the complete stress-strain curve. Since most rocks exhibit brittle behaviour, they fail violently and uncontrollable when tested on conventional testing machines. The violent collapse of a compressed specimen is not an intrinsic characteristic but due to the rapid release of strain energy from the machine components (e.g. loading columns) after the maximum load bearing capacity of the specimen has been exceeded. Therefore, the attention must be given to the possibility of reducing energy stored in the loading

system, i.e. by increasing the rigidity of the testing frame, and more recently, the use of the servo-controlled system have been successfully used to determine the complete stress-strain curve for rock specimens deforming under compression until reaching the post-failure.

1.2 Research significant.

The complete stress-strain curve reflects the actual deformation behaviour of rock under compressive loading. It covers the loading history of the rock sample throughout the phases at pre- and post-peak. Study on the post failure behaviour is particularly important in designing excavation where rock materials may have been highly fractured. By understanding of the post failure phase of rock sample, it would help to reduce any potential hazards and contribute to the economic advantages of the constructions.

1.3 Research objectives.

The main objectives of this study are:

1. To understand the underlying principles and characteristic of complete stress-strain curve for the purpose of studying the deformation behaviour of rock.

2. To undertake laboratory uniaxial compression tests on samples of granite and sandstone using servo-controlled testing machine and to obtain the complete stress-strain curve for each rock type.

3. To identify the deformation behaviour of granite and sandstone such as the failure characteristics and other related parameters.

4. To compare the differences between the complete stress-strain curve of granite and sandstone.

1.4 Research scope.

The scopes of this study will cover the following aspects:

1. The deformation behaviour of rock samples based on complete stress-strain curves.

2. The rock samples being studied consist of granite and sandstone.

3. Laboratory test conducted is uniaxial compression test under constant strain rate using servo-controlled testing machine.

4. To compare the differences between the deformation behaviour of granite and sandstone. Parameters being compared include peak strength, strain at failure and deformational behaviour at pre- and post-peak.

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