EFFECT OF LAMINATION ON ROCK PROPERTIES UNDER UNIAXIAL LOADING

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ABSTRACT

The objective of this study is to determine the effect of lamination on rock properties under uniaxial compression loading. Rocks are often anisotropic with regard to their mechanical behaviour, and this property is usually associated with sedimentary and metamorphic rocks. The properties of such rocks vary with direction of loading. The anisotropy of sedimentary rocks such as sandstone is due to mineral arrangement and termed as lamination. Other related properties like Young's Modulus and Poisson's ratio also vary with respect to lamination. In this study, a series of uniaxial compressive tests on samples with different lamination orientation were undertaken using 3000 kN Tinius Olsen servo-controlled testing machine. The stress-strain curve of samples will be obtained through the laboratory testing. Stress-strain curve serves as the fundamental tool in understanding of the deformational behavior and engineering properties of rocks. Representative data on the fundamental rock properties like Poisson's ratio, Young's Modulus and strain at failure, particularly for sedimentary rocks that possess anisotropy behaviour, is essential for safe and economical design of civil engineering structures (i.e. tunnels, dams and slopes) associated with these type of rocks.

ABSTRAK

Tujuan kajian ini adalah untuk mengkaji pengaruh laminasi atas parameter batu di bawah beban mamapatan satu paksi. Batu sering kali bersifat anisotropi disebabkan oleh kelakuan mekanikalnya dan sifat ini lazimnya mempunyai hubungan dengan batu yang berkeladak dan batu metamorfik. Parameter bagi batu-batuan jenis ini berubah menurut arah bebanan yang dikenakan. Sifat anisotropi bagi batu yang berkeladak seperti batu pasir adalah disebabkan oleh susunan mineral dan dipanggil laminasi. Parameter-parameter lain yang berkenaan seperti kekenyalan modulus Young dan nisbah Poisson juga berubah menurut laminasi. Dalam kajian ini, sesiri ujian mampatan satu paksi dijalankan pada sampel-sampel yang mempunyai orientasi laminasi yang berlainan dijalankan dengan menggunakan mesin ujian '*servo-controlled*' Tinius Olsen berkapasiti 3000 kN. Graf tegasan-terikan akan diperoleh melalui ujian makmal. Graf tegasan-terikan memainkan peranan sebagai peralatan asas dalam memahami sifat-sifat ubah bentuk dan parameter kejuruteraan batu-batuan. Data bagi parameter asas batu seperti nisbah Poisson, kekenyalan modulus Young dan terikan pada kegagalan, terutamanya batu yang berkeladak yang mempunyai sifat anisotropi, adalah penting dari segi keselamatan dan keekonomian bagi rekaan struktur kejuruteraan awam (i.e. terowong, empangan, dan cerun) yang berkenaan dengan batuan jenis ini.

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CHAPTER I

INTRODUCTION

1.1 Introduction

Rock as a material has been ingrained in human culture since the beginning of history and now has been developed to become the “working material” in geotechnical and rock engineering. As a consequence of the development of today’s construction, the designing and constructing in rock of underground tunnels, underpinnings of structures, massive dams, and other civil engineering structures require the turning over of an enormous amount of rockworks under various and difficult geologic conditions.

Basically, rock can be categorized into three groups which are igneous, metamorphic and sedimentary. Sedimentary rock had become a concern in civil engineering because of the numerous foundation and slope stability problems with which they are commonly associated with. Sedimentary rocks such as shale and sandstone are among the complex, problematic and the least understood geological material. The main difficulties in assessing and predicting the engineering behavior sedimentary rocks can be attributed to two unique features; their transitional strength between rock and soil exhibiting both "soil like" and "rock like" behaviors, and their tendency to progress from rock-like to soil-like material in relatively short periods.

Most sedimentary and metamorphic rocks are anisotropic with regard to their mechanical behavior. The anisotropy of sedimentary rocks such as shale is due to partial alignment and arrangement of its platy clay minerals which is termed as *lamination*. Normally sedimentary rocks exhibit higher compressive strength in the direction perpendicular to the lamination. Other related properties like Young's Modulus and Poisson's ratio also vary with respect to lamination. The anisotropic behavior of sedimentary rocks is considered to be of major importance in the design of civil engineering structures like tunnel, dam and slopes as the structures are associated with loading of rock mass.

The deformation and failure of rock is one of the basic rock mechanics subjects to which great attention has been paid for the last few decades. For safe and economical design of structure on and in rock, adequate cognition about deformation behaviors and engineering properties of rock is indispensable. With regard to the study on the deformational behavior and related engineering properties of rocks, the stress-strain curve forms the fundamental tool. The stress-strain curve illustrates the behaviors of the rock samples under compression, the pre- and post failure regime, the peak compressive strength, strain-softening behaviour, and finally the residual strength region. Through the studies of the stress-strain curve, several engineering properties (i.e. Uniaxial compressive strength, Young's modulus, and Poisson's ratio) regarding the tested rock samples can be determined.

1.2 Problem statement

The anisotropic behavior of sedimentary rocks is considered to be of major importance in designing civil engineering structures such as tunnels, dams and slopes. This is mainly due to the distinctive laminations (mineral arrangement) exhibited by these rocks that will lead to some variations of strengths and properties, depending on the loading configuration with respect to prevailing lamination. Therefore, for safe and economical design of structures in sedimentary rock, knowledge on deformation behaviors and engineering properties of these rocks is essential. Thus the study of stress-strain of rock samples is essential in understanding the deformation behaviours of rock and obtaining the relevant engineering properties.

1.3 Objectives

This study is geared towards achieving the following objectives:

1. To verify any variation of rock properties due to variation of lamination direction with respect to the loading axis.

2. To verify the uniaxial compressive behavior of sandstone when loaded at different direction with respect to orientation of lamination.

3. To obtain essential rock engineering properties based on data obtained from uniaxial compression strength test on sandstone.

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