CORRELATION BETWEEN UNIAXIAL COMPRESSIVE STRENGTH AND POINT LOAD STRENGTH INDEX OF GRANITE SAMPLE

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DEDICATION

This project report is dedicated to those who have been there for me through all the tough times with no regret and judgement.

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ABSTRACT

Uniaxial compressive strength (UCS) of rocks is an important parameter in geotechnical structure designs. Being difficult to obtain proper sample and the UCS test itself is expensive, indirect methods of estimating UCS were developed such as point load test. In this study, an attempt has been made to correlate the point load strength index ($I_{s(50)}$) with the UCS for local granite. The $I_{s(50)}$ is widely used to determine the rock strength by estimating the UCS using conversion factor, κ. The $I_{s(50)}$ value is known to correlate well with UCS. Various studies have come out with correlation between UCS and $I_{s(50)}$. It is found that the index-to-strength conversion factors are rock dependent. This study presents the correlation between UCS and $I_{s(50)}$ of granite rock samples originating from a site located at Seremban, Negeri Sembilan. Seven granite rock samples underwent uniaxial compressive test. A correlation between these two parameters was generated from the graph giving an equation of UCS = 4.8231 $I_{s(50)}$ + 25.201. From the results obtained and the observation made in this study, it is suggested that future study to employ a well-designed laboratory works considering factors such as larger sample size, diversity of rock type and better rock quality to ensure a more reliable correlation can be produced.

ABSTRAK

Kekuatan mampatan satu paksi (UCS) batuan merupakan parameter yang penting dalam rekaan struktur geoteknik. Kesukaran mendapatkan sampel yang berkeadaan baik dan kajian makmal UCS itu sendiri yang lebih mahal menjadikan kaedah ujian tidak langsung seperti ujikaji beban titik direka untuk mengukur UCS. Dalam kajian ini, satu langkah telah dibuat untuk menghasilkan faktor pekali hubungkait di antara UCS dan kekuatan beban titik ($I_{s(50)}$) bagi batuan granit tempatan. Umum mengetahui $I_{s(50)}$ digunakan secara meluas untuk mengukur UCS menggunakan faktor penukaran, κ. Nilai $I_{s(50)}$ mempunyai hubungkait yang baik dengan UCS. Pelbagai kajian mengenai hubungkait antara UCS and $I_{s(50)}$ telah dijalankan. Diketahui bahawa faktor penukaran indeks-kepada-kekuatan adalah sangat berkait rapat dengan batuan itu sendiri. Kajian ini membentangkan hubungkait antara UCS dan $I_{s(50)}$ batuan granit yang berasal dari Seremban, Negeri Sembilan. Tujuh sampel batuan granit telah melalui ujian makmal UCS dan $I_{s(50)}$. Persamaan hubungkait antara kedua-dua parameter ini telah dihasilkan daripada graf dengan UCS = 4.8231 $I_{s(50)}$ + 25.201. Daripada hasil kajian yang diperolehi dan pemerhatian yang dibuat, adalah dicadang kepada kajian akan datang, agar ujian makmal dirancang dengan lebih baik mengambil kira faktor seperti jumlah saiz sampel batuan yang lebih besar, kepelbagaian jenis batuan serta batuan yang lebih berkualiti bagi memastikan persamaan hubungkait yang lebih baik boleh dihasilkan.

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LIST OF ABBREVIATIONS

UCS	-	Uniaxial Compressive Strength
ISRM	-	International Society for Rock Mechanics
RMR	-	Rock Mass Rating
LVDT	-	Linear Variable Differential Transformers
L	-	Length
W	-	Width
D	-	Diameter
F	-	Correction Factor

LIST OF SYMBOLS

κ	-	Correlation Factor
$I_{s(50)}$	-	Corrected Point Load Strength Index
%	-	Percent
σ	-	Compressive Stress
A_0	-	Cross-sectional Area
P	-	Maximum Load
E	-	Young's Modulus
v	-	Poisson's Ratio
ε_a	-	Axial Strain
ε_d	-	Diametral Strain
Δl	-	Change in Measure Axial Length
l_0	-	Original Measured Axial Length
Δd	-	Change in Diameter
d_0	-	Original Undeformed Specimen Diameter
E_t	-	Tangent Modulus
E_{av}	-	Average Modulus
E_s	-	Secant Modulus
${D_e}^2$	-	Equivalent Core Diameter
E_s	-	Secant Modulus
R^2	-	Correlation Coefficient

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Uniaxial compressive strength (UCS) of rock is the most sought-after geotechnical information in engineering practices. It is widely used in the design and analysis of geotechnical problems such blasting, excavation and underground engineering works including rock tunnelling projects and the design of rock-socketed piles.

There are two general types of rock strength which are compressive strength and tensile strength. Compressive strength is the compressive force axially directed on rock that has the capacity to withstand it. It is the maximum load applied to a solid material to sustain from being fractured. When rock fails in compression, it means that the compressive stress has exceeded the compressive strength of the rock. On the other hand, tensile strength is the maximum tensile stress a rock material can bear. An assumption of zero tensile strength is usually taken since the result is usually extremely low.

Uniaxial compressive strength (UCS) is the strength parameter of rock that is commonly tested and shall be obtained from direct laboratory test. Uniaxial compressive strength test or UCS test looks on to the maximum axial compressive stress that a right-cylindrical sample of rock materials can withstand before failing. It is a direct test with a special set up equipment in the laboratory that gives direct measure to rock strength. It is a method that is known to be more expensive than the indirect test. In addition, UCS test is more time consuming considering that the rock samples are required to be well prepared.

Indirect test is an index test serve as a prediction to the strength of rock (JahanGer, 2013). Indirect tests are simpler, faster and more economical. Sample preparation is very minimal making the tests easier to be carried out. Apart from testing in a laboratory setting, indirect tests use less sophisticated equipment in which such testing can be performed on site (Kahraman, 2001). The term, correlation factor (κ), is normally referred to the index value used to predict the UCS. Among the well-known indirect test that is commonly used for UCS prediction is the point load test.

The correlation factor (κ) between UCS and point load strength index ($I_{s(50)}$) were studied by various researchers previously. Many studies had produced correlation between these two parameters on various types of rocks. Among the most renowned study was by Broch and Franklin (1972) giving a correlation factor of 24 $I_{s(50)}$. According to the International Society of Rock Mechanics (1985), the correlation factor recommended is between 20 $I_{s(50)}$ to 24 $I_{s(50)}$. The difference in the index value is due to the rock samples origin. Akram et al. (2007) mentioned that the index-to-strength conversion factors are found to be rock dependent considering that UCS is site-specific. Previous researches have shown many correlation factors or equations emerged as a results of studying rocks at various location.

1.2 Problem Statement

Uniaxial compressive strength (UCS) test is the fundamental properties of rock in geotechnical engineering design. However, UCS test requires samples to be prepared accordingly as suggested by ISRM with laboratory procedure that is more stringent. Unlike UCS test, point load test is more convenient requiring simple preparation and testing procedure that is less demanding. In condition where obtaining UCS through direct laboratory procedure is not an option, it has been a common practice by engineers to use $I_{s(50)}$ resulted from point load test to predict the UCS using the suggested correlation factor by ISRM.

With rock being site-dependent, the suggested correlation factor may be less reliable. As can be seen today, further research on the relationship between UCS and

$I_{s(50)}$ has been studied for different rock types and origins which resulted in various correlation factors being established. This indirectly strengthen the idea that there is possibility of different location, rock types and weathering grade of rock samples will bring about different correlations. The effort of researchers on the study of relationship between UCS and $I_{s(50)}$ is seen necessary where it could provide professionals with a 'shortcut' way of obtaining the UCS as the fundamental parameter for geotechnical design with the establishment of correlation factor.

1.3 Research Objectives

This study aims to achieve the objectives as follows:

1. To evaluate the point load index of granite samples.
2. To evaluate the uniaxial compressive strength of granite samples.
3. To establish the correlation between point load strength index and uniaxial compressive strength of granite samples.

1.4 Scope of Study

This research is limited the following aspects as below:

1. There are seven fresh granite samples available for testing.
2. The samples were obtained from a secondary source originated from a site in Seremban, Negeri Sembilan.
3. The samples will undergo uniaxial compression test and point load index strength test.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter will discuss on the outcome of the methodology as planned. The data obtained are to be recorded and analysed. To carry out the analysis, thorough methods and proper equations involved are utilised to achieve the objectives.

For this project, the standard laboratory procedure of point load test and uniaxial compression test by ISRM has been conducted. The maximum load causing samples to fail was recorded for each sample. With formulas given by ISRM, the point load strength and uniaxial compressive strength were calculated and evaluated. Apart from that, the vertical displacement measured from the use of LVDT during UCS test was also recorded to determine the axial strain and calculate the Young's Modulus.

4.2 Uniaxial Compressive Strength

Seven granite rock were prepared for uniaxial compression test. The calculation for the to determine the UCS. Table 4.1 until Table 4.7 show the before and after uniaxial compressive strength (UCS) test with calculation to determine the UCS, axial strain and Young's modulus. From the results obtained, a graph of uniaxial compressive strength against the axial strain is plotted as shown in Figure 4.1. The summary of test results is tabulated in Table 4.8.