

**CORRELATION BETWEEN UNIAXIAL COMPRESSIVE
STRENGTH AND POINT-LOAD INDEX STRENGTH**

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I hereby dedicate my project report to the best father a child could ever ask for,
Mr. S. Sundara, to my lovely mother Madam S. Mageswary,
and to my elder brother Mr. S. Jeevanantham.

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ABSTRACT

In verifying the material properties of rock, laboratory test need to be carried out to ensure a safe design of structures. Among the most common rock properties verified in laboratory are uniaxial compressive strength test (UCS) and point-load index strength test ($I_{s(50)}$). These two rock properties are often correlated for ease of evaluating rock properties particularly during preliminary design stage. The focus of this study is to verify correlation factor between UCS and $I_{s(50)}$ and to compare with established correlation. Rock types investigated are granite collected from Tumpat, Kelantan and limestone from Pandan Indah, Kuala Lumpur. The samples of granite and limestone are in fresh state (grade 1). Literature review shows that the conversion factor, K for correlating between UCS and $I_{s(50)}$ lies between 16-29. From this study, verification of laboratory test data shows that there is no clearly good correlation between UCS and $I_{s(50)}$. Variation on test data has been observed. This is expected for natural material like rock. The insignificance relationship of strength signifies that there is possibility of insufficient data of rock samples. Although there are some trends that correlate UCS and $I_{s(50)}$ for the rock types investigated, however due to significant variation of data and limited number of samples tested, the correlation obtained is not clearly present good linear relationship between the two properties. To improve this more samples should be verified for both properties.

ABSTRAK

Untuk memerhatikan sifat batu terutamanya kekuatan batu, kajian makmal perlu dijalankan supaya kualiti rekaan struktur dalam aktiviti pembinaan terjamin. Laizmnya mampatan satu paksi (UCS) dan beban titik (I_{s50}) adalah antara ujian yang digunakan untuk mengkaji sifat kekuatan batu. Kedua-dua ujian ini mempunyai persamaan dan boleh dikaitkan sesama sendiri untuk mengenal pasti kekuatan batu dengan tujuan untuk memudahkan rekaan awal rancangan pembinaan. Fokus utama kajian ini adalah untuk mengenal pasti faktor pekali perhubungan di antara UCS dan I_{s50} selain membandingkan dengan perhubungan yang sedia ada. Batu yang berlainan jenis digunakan dalam kajian ini adalah batu granit dari Tumpat, Kelantan dan batu kapur dari Pandan Indah, Kuala Lumpur. Kesemua sampel batu ini digolongkan dalam keadaan segar (gred 1). Menurut kajian sebelum ini, faktor pekali itu berubah-ubah dalam 16-29. Untuk kajian ini, keputusan faktor pekali, K tidak jelas untuk kedua-dua batu kapur dan granit. Pembezaan hubungkait yang tidak jelas menunjukkan bahawa perlu ada penambahan data kekuatan dalam batu yang dikaji. Keputusan ini sudah dijangkakan untuk bahan asli seperti batu. Pada dasarnya, keputusan yang diperoleh ada bentuk hubungkait antara UCS dan I_{s50} walaupun terdapat variasi dalam data sampel yang tidak banyak. Penambahan batu sampel perlu dibuat supaya hubungkait ini lebih terjawab.

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LIST OF SYMBOLS

kN	-	Kilo Newton
mm	-	Milimeter
MPa	-	Mega Pascal
P	-	Compressive Force
I_s	-	Point-load index strength
I_{s50}	-	Corrected point-load index strength
F	-	Size correction factor
D	-	Depth
W	-	Width
mm^2	-	Milimeter per squared
m^2	-	Meter per squared
A_o	-	Initial cross sectional area
σ	-	Compressive stress
D_e	-	Equivalent core diameter

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The extent to which the strength properties of a rock mass may coincide with the result of laboratory tests on samples of rock material is a matter of major concern in engineering structures. Rock strength is an important property since it requires for the design of rock engineering structures. The degree of accuracy of rock strength is often questionable in way of designing structures since it is not always possible to control the strength and it varies among different types of rock.

A qualitative measurement of rock strength is required at both *in-situ* and laboratory. Civil engineer ought to know practical application of rock strength toward any rock engineering structure. Without a proper understanding of rock behavior and strength, there is a tendency for rational design of the foundations of rock engineering structures to collapse.

In reviewing the material properties of rock strength, laboratory test need to be carry out to ensure a quality design and structures. Among the most essential rock properties especially in testing of rock strength in laboratory are uniaxial compressive strength test and point-load index strength test. These two rock properties are often correlated for ease of evaluating rock properties particularly during preliminary design stage.

Point-load index strength test is often replacing the uniaxial compressive strength test because it is reliable in simple manner and quick to measure. Apparently, a reasonable estimation of the uniaxial compressive strength of the rock can be obtained by means of the point-load index strength test. This has been tailored by the previous researcher using an established correlation whereby the correlation between uniaxial compressive strength (UCS) and point-load index strength (I_s) can be obtained by using an equation below and conversion factor, K was 24.

$$UCS = (K) I_s = 24 I_s \quad (1.1)$$

Although the equation relating the I_s and UCS was most commonly accepted, however studies have shown that there is a tendency for the conversion factor, K to change in subject to different types of rock. To acquire best result in determining of rock strength, a study has been done on correlation between uniaxial compressive strength and point-load index strength and find out the suitable conversion factor for the established correlation above.

1.2 Problem of statement

Point-load index strength test is one of the indirect strength tests in rock testing. It has been used widely in practice due to its simple nature of testing; portable, simplicity of specimen preparation and possible of field applications. However, data collected from this indirect strength test is not suitable for detailed design purpose. Uniaxial compressive strength (UCS) is one of the most fundamental properties of rock that is required in designing rock engineering structures. However to determine UCS of rock, it requires complex testing and sample preparation procedures. It has been a common practice to estimate UCS using point-load index strength (I_s) using established correlation. However, the reliability of the correlation is depends on the location, weathering grade and specific rock type. This study is to establish a correlation between UCS and I_s for specific rock type and weathering grade. Such correlation is essential for quick estimation on UCS particularly in area where the samples of the rock are collected.

1.3 Objectives

This study is geared towards achieving the following objectives:

1. To review the existing correlation between point-load index strength (I_s) and uniaxial compressive strength (UCS) for various rock types.
2. To determine the point-load index strength (I_s) and uniaxial compressive strength (UCS) of rock samples namely limestone and granite.
3. To verify correlation between point-load index strength (I_s) and uniaxial compressive strength (UCS) and to establish conversion factor for the established correlation.

1.4 Scope of study

Basically, the scope of this study will include several aspects as below:

1. The laboratory tests undertaken in the study are point-load index strength test and uniaxial compressive strength test.
2. The rock samples being studied are granite and limestone of fresh state (grade 1).
3. Correlation factor between point-load index strength corrected to a specimen diameter of 50 mm (I_{s50}) and its uniaxial compressive strength (UCS) are being investigated.
4. Samples of limestone were collected from Pandan Indah, Kuala Lumpur and samples of granite were collected from Tumpat, Kelantan.

1.5 Significance of the study

Appropriate correlation factor between direct strength and index strength for specific rock, weathering grade and locality is important in design of rock engineering structure. The correlation factor enables direct strength (UCS) of rock to be established using simple index test such as point-load test.