Determination of Uniaxial Compressive Strength Using Point Load Index of High Grade Metamorphic Rocks from Western Sri Lanka

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Abstract: This research is focused on finding the correlation of unconfined compressive strength (UCS) with Point load Index (PLI) of gneissic rocks, and to propose proper correlating value, based on a study carried out for Sri Lankan Gneissic rocks. There has been an increasing use of the PLI as a measure of rock strength since its introduction in 1972. The small size and the simplicity of the point load tester have led to its use on site in many projects. The rock samples were obtained from three rock quarries in the Western Province. Using the results of laboratory testing of gneissic rocks under point loading as well as in Uniaxial Compression, and statistical analysis, different conversion factors relating UCS and PLI are determined for each quarry. The sample preparation and testing are conducted according to the ASTM code. Exactly 206 individual test results, from 35 distinct rock units were used. The conversion factor between UCS and PLI of the study is found to be between 9 and 14. The results of the study are useful to find the strength of rocks conveniently through point load testing.

Keywords: Conversion factor, Correlation factor, Gneissic rocks, Point load index

1. Introduction

Sri Lanka is composed of Precambrian metamorphic rocks having a ragged terrain concentrated on central hilly areas, which has given rise to a long history of construction developments with high grade metamorphic rock such as gneiss. In construction it is important to investigate rock properties and characteristics applicable for Sri Lanka in order to

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facilitate better design of rock related structures.

Designing a structure in weak rock involves some difficulties. Rock strength is one of the important factors which determine the design of the underground structure. If an investigation reveals that the location consists of weak rocks, the whole designing process has to be re-evaluated to suit the conditions.

The point load test (PLT) is an accepted testing procedure in rock mechanics, used to determine a rock strength index. This index can be used to estimate other rock strength parameters (Hoek .E 1977). The focus of this paper is to present the data analysis used to correlate the point load test index (Is_{50}) with the uniaxial compressive strength (UCS), and to propose appropriate Is_{50} to UCS conversion factors for high grade metamorphic rocks, found in Western Province of Sri Lanka.

2. Material and methods

2.1 Field studies and observations

Three locations of the Western Province were chosen for the study, as indicated in Figure 1. Site locations selected to collect samples were as follows:

i) Metal Mix Quarry- Kalutara district.
ii) Kyang Nam Quarry- Colombo district.
iii) Hovel Quarry- Gampaha district.

Field studies were carried out for an extended period and key areas were located and visited prior to collecting samples. Samples were obtained for laboratory testing and Geological data were gathered from the above three locations.

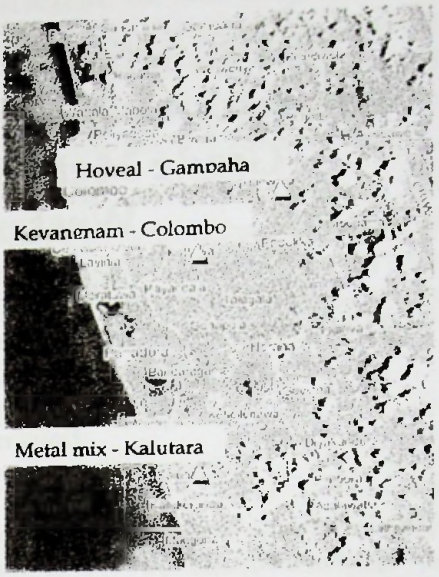

Figure 1. Collecting locations of samples

2.2 Sampling

Between 11 to 13 boulders of size 6"x9"(0.1524mx0.2286m) were collected from each quarry. These boulders had resulted from rock blasting at each site. Both types of Biotite Gneiss (dark) and Felsphatic Gneiss (light) samples were collected randomly. Samples which seemed to be fresh, slightly weathered and moderately weathered were collected.

2.3 Sample preparation

Field samples collected (in the form of rock pieces or boulders) were brought to the Rock Mechanics laboratory of the Earth Resources Engineering Department, and cored with core drilling machine to the size of NX (54 mm) for both UCS and PLI tests. End surfaces were prepared according to the test standards (length-11cm) by using cutting and polishing machines, for UCS tests.

2.4 Lab testing

Prepared core samples were first tested with diemeterial test method (Bienawski Z.T 1975) by using point load testing machine; and thereafter tested for compressive strength by using UCS Testing Machine. It was assumed that the several rock samples cored from a given boulder had similar properties. It was often possible to get several PLI values from a core barrel, and a separate prepared core barrel from the same boulder was used to get the UCS values by UCS machine (www.geotechsystem.com).

Figure 2. UCS test

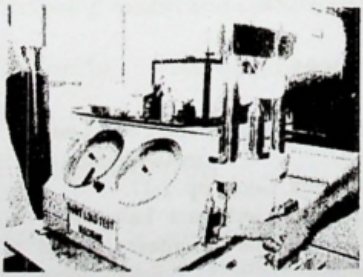

Figure 3. Point load test

2.5 Data analysis

The test data were analysed to find the correlation factor between UCS and PLI by drawing graphs between those values obtained from the tests (Basu.A, Aydin .A 2006). These correlation values can be used to evaluate the Uniaxial compressive strength of the rock through point load test easily and can be used in the designing of various structures involving rock masses.

3. Results

The test results for UCS and PLI of the rock samples tested are summarised in Table -1. It also shows the correlation factor (UCS/PLI) based on regression analysis of the test data shown in figure 4.

Table 1. Universal Compressive Strength (UCS) and Point Load Index (PLI) and their correlation in the selected quarries

Strength / Quarry	Avg: UCS value (MPa)	Avg: PLI value (MPa)	Correlation factor (UCS/PLI)
Metal mix	98.24	6.73	13.42
Keangnam	60.29	5.41	10.75
Hovel	63.51	5.76	9.95
All samples	73.23	5.94	11.59

Figure 4 was obtained by regression analysis (using Minitab software) and the conversion factor was found to be 11.59. The desired final correlation is given in eqn (1):

$$UCS = 11.59 \times PLI \quad \text{..... (1)}$$

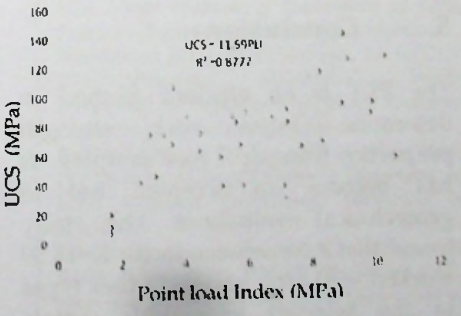

Figure 4. Relationship between Point Load Index (PLI) and Uniaxial Compressive Strength (UCS).

4. Discussion

Rock characteristics exhibit regional variations. Using the correlation developed here UCS of the rock can be determined easily at the site by having the point load tester, because direct measurement of UCS is costly and time consuming. Thus this research assists the industry to find UCS economically. The UCS is frequently used in pillar designs, design of supports in underground mines, many underground civil engineering structures and to determine quality of aggregates in the construction industry.

One disadvantage of the study was that the number of PLT tests that could be performed was about 3 per unit. Therefore it was not possible to follow the method suggested by ISRM (1985) for determining the mean value, which involves deleting the two highest and two lowest Is_{50} values from a set of at least 10 tests. The point load test allows the determination of the uncorrected point load strength index (Is). It must be corrected to the standard equivalent diameter (De) of 50 mm. However when the core being tested is 50 mm in diameter (such as NX core), the correction is not necessary.

5. Conclusions

The PLT is an efficient method to determine intact rock strength properties from drill core samples. It has become an accepted test in geotechnical evaluations. This study found that a conversion factor K=11.59 worked well for a variety of rock types in the selected geographic region. There is some indication that K decreases for lower strength rocks, but the tendency was not very pronounced. Geological and engineering judgment should be used when converting PLT results to UCS. It must be remembered that both tests can only be used to estimate intact rock strength and not rock mass strength.

The point load test provides for full utilization of data that can be gained from exploration drilling programs. Intact rock strength information can be acquired for use in geotechnical evaluations and design work through numerical modelling and rock mass classification systems. The cost of point load testing is minimal when compared to the overall exploration expense.

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