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Research Paper

Using the Core Strangle Test for Determining Uniaxial Compressive Strength of Intact Rock by an Indirect Method

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Abstract: Uniaxial Compressive Strength (UCS) of rock material is one of the most important and effective parameters in geotechnical and mining projects. Direct evaluation of UCS is expensive and time-consuming, therefore indirect tests such as point load, Schmidt hammer and sound wave velocity tests have been developed, among which the point load test is very commonly used, simple and economic. However, this method has limitations such as the effect of loading direction, the application of load to a small part of the rock and the high dependency of the results on the dimensions of the sample. In 2009, the Core Strangle Test (CST) was developed, which has the advantage of applying load through a circle perpendicular to the core axis. In this paper, the results of designing and manufacturing a CST machine, which has been performed for the first time in Iran, are described in order to estimate the UCS of rocks with high accuracy and low cost. The design and construction of the machine were done in the rock mechanics laboratory of Yazd University. In order to calibrate the machine, 70 standard rock and concrete samples with lengths of 20, 10 and 5 cm and a diameter of 54 mm were prepared. In addition to CST, point load and direct UCS tests were performed on these 70 specimens. Then, the relationship between UCS obtained by direct, CST and point load methods was investigated. Calculations showed that the relationship between UCS and machine oil pressure at the moment of failure in the CST method is a linear relationship with a correlation coefficient of 0.78 and the relationship between UCS and point load index is also linear with a correlation coefficient of 0.63.

Keywords: Rock mechanics, Uniaxial compressive strength, Point load test, Core, Core strangle test.

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INTRODUCTION

The strength of intact rocks is the most important parameter in rock mechanics studies. The existing methods for determining UCS are divided into two categories: direct and indirect methods. In direct methods, cylindrical samples having a height to diameter ratio of 2.5–3.0 and a diameter of preferably 45 mm are needed. The ends of the samples must be flat to 0.02 mm. In many cases, core specimens with these dimensions cannot be obtained due to the rock mass properties. For this reason, many indirect testing methods, such as point load, Schmidt hammer, sonic velocity, shore test, etc., have been proposed. In most indirect tests, the force is applied by the device in a very small area of the rock sample, which leads to errors in the estimation of UCS. In order to overcome this shortcoming, the Core Strangle Test (CST) method and apparatus has been developed by Yilmaz in 2009 [1]. In this test, the rock is loaded through as a circle line instead of a point consequently, the effect of the heterogeneity and/or anisotropy is decreased. In this article, the results of the design, construction and calibration of the CST device are explained using rock samples from different parts of Iran as well as concrete samples. In addition, the accuracy of the method in measuring the UCS of rock and concrete is investigated by this method.

METHODS

The CST testing machine consists of four main parts [1] (Figure 1):

- Hydraulic unit: the pressure required to load the specimen produces by a gear pump
- Load measuring gauge
- Load transfer unit
- Loading unit

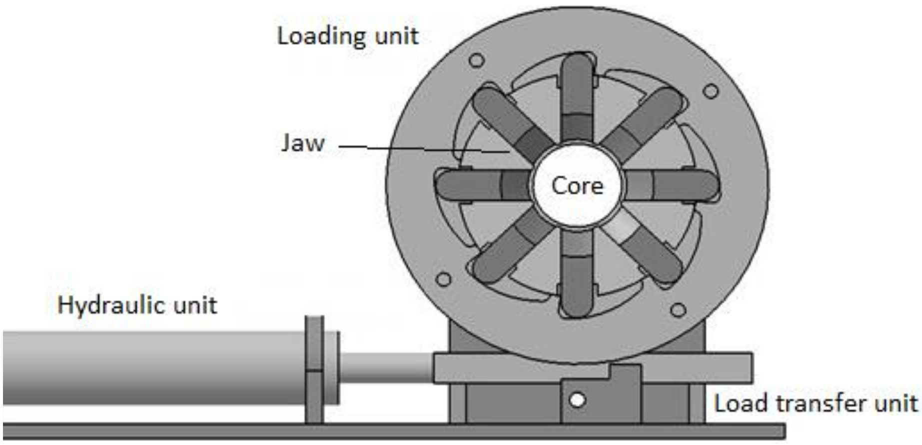

Figure 1. A view of the main components of the CST device

A rock sample in the form of an NX core having a length of 25 mm or more is placed inside the testing machine between the jaws. As the load increases, the taws move towards the sample and the load is applied through a circle perpendicular to the core axis. When the specimen is broken into two parts, the load (PF) is recorded. There is a strong relationship between breakage load and UCS [1,2].

FINDINGS AND ARGUMENT

In this section, in order to calibrate the device and also compare the results of this method with the point load test, 70 NX samples including rock and concrete samples were prepared. Direct uniaxial compressive strength, point load and CST were performed on all samples. The relationship between the pressure at the moment of failure (PF) in terms of the bar and the UCS of the specimens in terms of MPa is shown in Figure 2.

This relationship is given as follows:

$$UCS = 0.92 \times PF - 54 \qquad (R^2 = 0.78) \tag{1}$$

Also, in order to compare the results CST with the point load test, the relationship between UCS and point load index was also investigated, the results of which are shown in Figure 3.

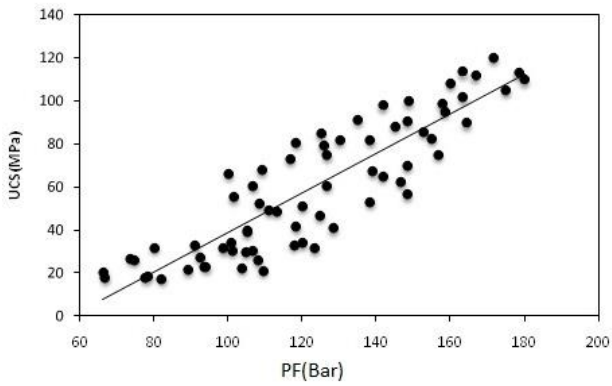

Figure 2. The relationship between the pressure at the moment of failure (PF) and the UCS

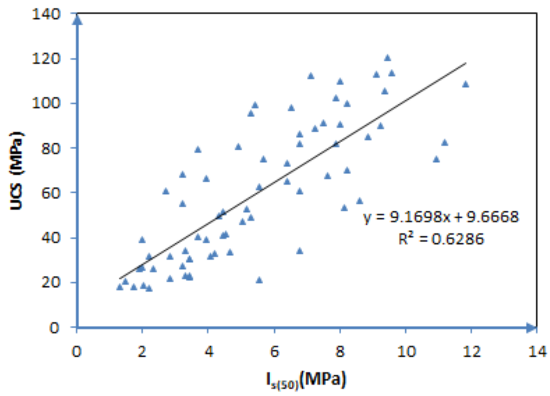

Figure 3. The relationship between UCS and point load index

The comparison of the results shows that the correlation between the results in the CST test is higher than the correlation in the point load test.

CONCLUSIONS

In this article, the details of the CST were explained as an indirect method for determining the UCS of rock material. In this test, the load is applied radially and vertically along the core and on its circumference. By increasing the load, the sample is broken into two parts and using the pressure value at the moment of failure, it is possible to obtain the uniaxial compressive strength of the rock material with a high correlation coefficient. The comparison of the results obtained from this test with the point loading test indicated that the correlation coefficient in this test is higher than the point loading test. Conducting this test on cores with lengths of 20, 10 and 5 cm showed that the effect of the length of the samples on the test results is very small and negligible. Also, the conditions at the beginning and end of the samples have no effect on the results of this test. In addition, this test can be performed on cores with different diameters and not necessarily 54 mm, in which case it is necessary to apply the diameter correction factor.

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