Offer the equations required to measure the compressive strength of rocks and concretes, using the new "Twist-off" test and compare it with standard methods

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Abstract

In engineering works, especially in geological sciences, civil engineering and mining engineering, before or after the construction of structures, there are cases where it is necessary to determine the strength of stone or concrete. In this regard, changes in the use of the structure (change in load), unfavorable operating conditions, lack of time, lack of access to laboratory equipment and structural damage are among the reasons for assessing the strength of materials in situ. There are several methods for testing materials that are either destructive or have expensive and imported equipment. In this paper, using the new "Twist-off" test, the strength of 9 different types of stone and concrete with eight different strength classes has been measured. Also, while comparing the results with standard methods, calibration diagrams and equations required to convert the results of the "Twist-off" test to the compressive strength of the mentioned materials are presented. According to the results, to measure the compressive strength of ordinary concrete using twist-off test, the relationship $y = 19.27x^{0.67}$ with a coefficient of determination of about 0.95 can be used. Also, for the rocks used in this research, by using the equation $y = 27.87x^{0.52}$, the compressive strength of the mentioned rocks can be determined by using the twist-off test with an accuracy of 94%.

Keywords: *"Twist-off" method, Insitu strength, Stone, Concrete, calibration diagram.*

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Extended Abstract:

1. Introduction

Recently, the use of non-destructive tests to evaluate the characteristics and behavior of materials in various industries has expanded significantly. Non-destruction of samples and non-damaging as well as preserving their integrity is the most important factor in the increasing development of these tests in engineering experiments, especially in geotechnical engineering, civil engineering and mining engineering. Many methods have been invented to test materials in the structure, which are divided into three groups, non-destructive, semi-destructive and destructive, based on the possibility of damaging the structure. One of the existing methods invented by Naderi is the "Twist-off" method, which is considered in the realm of semi-destructive tests, or rather with partial damage (Naderi, 2007). Considering the need to measure the compressive strength of materials in situ and at the site of the structure, therefore, in this research, the compressive strength of 9 types of stone and 8 classes of concrete has been measured using the modern torsion test. Then, by comparing the results of the torsion test with the results of standard tests, calibration diagrams were drawn and the required equations were presented to convert the results of the torsion test to the compressive strength of the material. The stones used in this research are rhyolite, marble, crystalline green tuff, andesite, granite, stone green tuff, travertine, basalt and lime. Concretes with resistances of 15 to 50 MPa have also been used. As a result, by carrying out this research, it is possible to measure the compressive strength of stones and concretes with a high correlation coefficient in the form of a small failure and a simple twisting device.

2. Materials and methods

The materials used to make concrete are Portland cement type 2 produced by Abik Cement Factory, sand from Shahriar mines, drinking water from Qazvin province, sand from Qazvin mines, two-component epoxy glue and polyolefin-type acting materials. Aggregates were graded according to ASTM C136, 2006. The amount of water absorption of sand according to ASTM C127, 2012 and ASTM C128, 2015 standards was found to be 2.3% and 2.6%, respectively. In the torsion test, a metal cylinder with a diameter of 50 mm is glued on the surface of the test site using epoxy glue. After attaching the cylinder, as shown in Figure 2, using a conventional manual torsion tester, a torsional anchor is inserted into the metal cylinder until the test object fails. The equipment used in the "twisting" test is very simple, cheap and accessible compared to other corresponding tests. The damage caused by the "twisting" test is very minor and superficial, and by causing failure in the object itself, it determines its resistance directly and without any other factor. To perform the uniaxial compressive strength test of stones according to the ASTM D4543 standard, the load on the test piece must be continuously applied at a constant pressure rate of one megapascal per second, and the maximum load must be recorded at approximately 10 kilonewtons. In Figure 7-a, the sample placed under the jack is shown. In Figure 7-b, cores taken from different stones can be seen. ASTM C805, 2018 standard was also used to perform the Schmidt hammer test. The hammer used is type N. The manufacturer's recommendations regarding the use of the device and the reading of the results were fully followed. When using this method, its limitations should be considered. This method cannot be used as a substitute for the standard compression test, but it is a method to determine the uniformity of materials or to compare the quality of materials at different points.

To evaluate the resistances obtained from the "twisting" test and the compressive strength, cubic samples were made with compressive strengths in the range of 15 to 50 MPa. For the concrete mixing plan, the step-by-step method of the national concrete mix plan has been used (BHRC, 2008). The mixture ratios of concrete samples are presented in Table 2. The water absorption percentage of the aggregates was also calculated and added to the mixing plan water. Also, the flow rate and air percentage of fresh concrete can be seen in the above table.

3. Results

According to Table 4, it can be seen that with the increase in the compressive strength of concrete, the results of the torsion test have also increased. The compressive strength of concrete ranges from 18.7 MPa to 51.3 MPa and the value of the torsion test results varies from 136 Nm to 290 Nm. It can be seen from Table 7 that with the increase in the compressive strength of the stones, the value of the torsional moment resulting from the torsion test has also increased. But since the Schmidt hammer test is highly dependent on the surface of the sample and the presence of surface holes and cracks on the stones leads to wrong readings from the Schmidt hammer test, it is possible that stones with lower resistance but with a smooth and polished surface will give the results higher than similar stones but with a rough and rough surface. An example of this is the number read for granite compared to basalt. Also, for the torsion test, the diameter of the cylinder and the height of the stones can have a direct effect on the results.

4. Conclusion

The "twisting" test with wide application and high accuracy can be used to measure the compressive strength of ordinary concrete and various stones. The damage resulting from this test is very minor and can be applied in any situation.

Considering the coefficient of determination equal to 0.95 between the results of the torsion test and the compressive strength of concrete, therefore, by using the calibration chart and the equation $y=19.27x^{0.67}$, it is easy to measure the compressive strength of concrete by applying the torsion test. took action

Considering the correlation coefficient equal to 0.94 between the results of the torsion test and the compressive strength of stone cores, it is possible to measure the compressive strength of stones using the equation $y=27.87x^{0.52}$, by placing the results of the torsion test.

By comparing the results of the torsion test with the Schmidt hammer test for measuring the compressive strength of stones, it was observed that the torsion test has a higher accuracy for evaluating the compressive strength of stones.

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