Technical Note
Estimating Rock Strength with the Equotip Hardness Tester

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INTRODUCTION

Unconfined compressive strength is the most widely used parameter for the classification and characterisation of rock material. However, the need for accurate preparation of the test specimen and complex and heavy test equipment makes the test expensive and difficult to execute in the field. Consequently, much time and effort has been expended in the past to developing portable equipment to provide an indication of rock strength. The best known index test in this context is probably the Point Load Test [1]. For this test even small irregular lumps of rock can be used, but, while attempts have been made to develop truly portable test equipment [2] the test is generally confined to a specific field set up. The equipment for another widely used test, the Schmidt hammer [3], is truly portable, but the high impact energy of the hammer makes it is less suitable for weak rock and for testing core samples. The Shore Scleroscope [3] delivers less energy, but its use is limited by the fact that the impacting hammer falls under gravity alone so that it can be used only vertically with obvious limitations for field use. The Equotip Hardness Tester is a relatively new product in the field of hardness testing by rebound and the Section of Engineering Geology of Delft University of Technology is presently investigating its use as an index test. This Technical Note reports preliminary results of this work.

THE EQUOTIP HARDNESS TESTER

A few years ago, Proseq SA (the company which manufacturers the Schmidt Hammer) introduced the Equotip Hardness Tester [4] (Figs 1 and 2). The Equotip is developed to measure the hardness of metallic materials. It is a small electronic, battery operated, spring-loaded device. A 3 mm dia. spherical shaped tungsten carbide test tip is mounted in an impact body and impacts under spring force against the test surface from which it rebounds. Impact and rebound velocities are measured and processed into the hardness value \( L \) which is shown on the digital display. The basic type D impact device delivers an impact

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energy of 11 Nmm. Impact devices with an impact energy of 3 Nmm (type C) and 90 Nmm (type G) are available.

EXPERIMENTS AND RESULTS

Equotip tests, using the impact device D, were performed on a series of rock samples prepared for the unconfined compressive strength test. During testing, the rock samples were placed on a table with a 10 cm thick rock table top. For tests across the diameter of the cores, the rock core was put in the V-notch in a 15 kg metal block (as used for the ISRM laboratory Schmidt Hammer test [3]) placed on the rock table. The rock cores used were mostly of limestone but granitic, sandstone and man-made gypsum and building-stone were also tested. The cores tested were mostly of 30 and 40 mm dia. and 60 and 80 mm long, respectively, but for a few weaker rock types samples of 50 mm dia. and 100 mm length were prepared. For each sample, a total of 10 Equotip rebound values were taken, 5 on each loading surface of the sample; the average of the 10 readings was expressed as the hardness number L. The same samples were used to measure the unconfined compressive strength. If more than one specimen was tested from the same rock type, average results were used for correlation.

The results of the Equotip L number against the unconfined compressive strength are shown in Fig. 3, which shows a reasonable relation between the two

<table>
<thead>
<tr>
<th>Sample</th>
<th>Dia. (mm)</th>
<th>Equotip value</th>
<th>UCS (MPa)</th>
<th>E-modulus (GPa)</th>
<th>tan 50% UCS</th>
<th>Unit weight (kN/m²)</th>
<th>Porosity (%)</th>
<th>Rock type</th>
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<td>254.7</td>
<td>8</td>
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<td>6</td>
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<td>56.1</td>
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</table>

ND = not determined.
parameters. Only sample C1, a dolomite with a high porosity, gave an L-value which did not fall within the general trend of correlation. This correlation is as good as may be expected, since the volume of sample tested by Equotip rebound is much smaller than that tested by the compression of the rock core. Thus, a flaw in the UCS sample, outside the volume influenced by the rebound test, may cause the sample to fail at strengths lower than those assessed by rebound. Further information about the rock specimens used is given in Table 1.

SURFACE ROUGHNESS OF TEST AREA

It is generally accepted that surface roughness of the test specimen will affect results in rebound testing. The Users Manual for the Equotip specifies that, for testing metals, the roughness of the testing surface should not exceed 10 μm (ISO 4287 [5]) and the arithmetical average roughness should not exceed 2 μm = N7 (N7 = roughness classification according to ISO/R 1302 [6]). To determine the influence of rock surface roughness on Equotip L-values, tests were performed on three types of limestone, each with 4 different surface treatments to give grades of roughness.

These were:

1. A rough surface on a large block sample (about 20 kg) treated with a small grinding stone in a battery operated hand-held drilling machine.
2. A sawn plane perpendicular to the axis of a 60 mm diameter rock core.
3. As 2, but after sawing the surface was lapped.
4. As 3 but after lapping the surface was polished.

The results are shown in Fig. 4. No major difference was found between the measurements taken on the different surface treatments.
SAMPLE DIMENSIONS

Despite the small mass of the impact body and the low impact energy, a relatively large impact force of short duration is generated at the moment the impacting body hits the measuring surface. This suggests that very small and light samples would give results relating more to the background material than the rock. To examine the influence of specimen size, three types of limestone were tested in cores of varying size. Cores 150 mm long with diameters of 100, 60 and 30 mm were axially and radially tested. Results are given in Figs 5 and 6. Axial tests were also performed on cores of 60 mm dia. with lengths of 150, 50 and 25 mm. Results are given in Fig. 7. From these results, it may be concluded that tests performed on rock cores with a diameter of 30 mm gave L-values lower than tests on cores with diameters of 60 and 100 mm. Axial tests on cores with a length of 25 mm give lower L-values than tests on core lengths greater than 50 mm.

CONCLUSIONS

The Equotip seems to be a convenient portable tool for estimating the unconfined compressive strength of rock material. The possibility to make diametral measurements on rock cores makes the Equotip very useful for core logging.

If the test area shows some excessive roughness, as it may do in the field, it appears sufficient to grind the test spot with a small grinding stone in a (battery operated) hand-held drilling machine before testing. Although the results in Fig. 3 are based on core samples with a diameter of 30, 40 and 50 mm, tests on samples with dimensions below 50 mm seem to give lower results than larger samples. Further investigation is necessary to confirm this and perhaps it is possible to find a correction factor for testing small samples, although this is unlikely to prove a handicap in core logging because most cores taken are larger than the N size (54 mm). The influence of larger than usual mineral grains in rock samples has yet to be investigated.

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REFERENCES


