Comparison of Tensile Strength Values of Rocks Determined by Point Load and Direct Tension Tests

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1. Introduction

A number of methods exist to fail rock in tension: among them samples are loaded either by directly induced tension, as in the direct test for tension (Hawkes et al., 1973) or by indirectly induced tension via compression, as in the Brazilian test (Fairhurst, 1964) and Point Load test (Brock and Franklin, 1972). In general the experimental results obtained by these different methods e.g. direct tension, point load, etc. differ, and it is not known how to quantitatively compare them other than by empiricism, even to obtain a value for tensile strength. Thus, at present, these simple and very useful tests which measure strength indirectly have their values considered only as an index of strength.

In this note a new approach is given which could enable a comparison of these results to be made and so enhance the usefulness of these tests: it is based on the force at failure and the initial geometrical area of failure rather than upon the ratio of force and area, i.e. stress. For this purpose, published data on sandstones, marble and granite are used.

2. Background

In 1993 Butenuth et al. (1993) reported the results of a series of tests conducted on specimens of sandstone and marble. The samples were in the shape of hoops: the height of the hoops was constant, the inner and the outer diameters of the hoops varied. Two hemi-cylindrical rigid platens were placed within the central hole of such hoops and separated by a jack so extending the hoop in the direction of the load line of the jack, until failure of the hoop in extension occurred. The force at failure, $F$, when plotted against the cross sectional area of the hoop specimen (i.e. its height multiplied by two times its width), $A$, plotted as a straight line; Fig. 1. The slope of this line, $\Delta F/\Delta A$ seemed to agree closely with the value of tensile strength, $\sigma_t$, for the sandstone and marble tested, as defined by tests of direct tension (Butenuth et al., 1993; Butenuth and
de Freitas, 1995). These results suggested that a plot of $\Delta F/\Delta A$ may provide a rational means of comparing the results of tests on rock failed in extension: note that as can be seen from Fig. 1, $\Delta F/\Delta A$ is not the same as $F/A$. To test this hypothesis published results of work by others were reviewed: two excellent data sets for this purpose are those produced by Wijk et al. (1977) and Brook (1977).

3. Experimental Results

Wijk and his co-workers investigated the strength of a range of sample sizes using direct tension as well as point load tests. The samples were cut from the Bohus Granite in Sweden: compositional and textural details are given in Table 1. The samples for the point load test were prepared in such a way that their core length was always either greater or equal to twice their diameter, which ranged from about 8 to 62 mm. The stress at failure of the point load test “is defined as

$$\sigma_{PLT} = \frac{F}{d^2},$$

(1)

where $F$ is the averaged force at the moment the core is split” (Wijk et al., 1977) and $d$ is equal to the original core diameter. For each diameter a set of 15 to 20 samples were tested. Figure 2 (redrawn from Wijk’s paper) shows the values and the “experimental scatter in terms of the standard deviation on each side of the average value of $\sigma_{PLT}$”, the stress at failure calculated using Eq. (1), vs. the sample diameters. From this figure the mean values were extracted in terms of $\sigma_{PLT}$ and $d$, and with the use of Eq. (1) the force at failure, $F_{PLT}$, and the area $d^2$ was back calculated.