Technical Note

The Effect of Specimen Size and Stress Rate for the Brazilian Test — A Statistical Analysis

By

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Summary

The Brazilian test is a widely accepted method for the determination of the tensile strength of intact rock. Specifications for the Brazilian tensile strength test have been established by the American Society for Testing and Materials (ASTM), ASTM D 3967-86 and a suggested approach is provided by the International Society for Rock Mechanics (ISRM). The ASTM and ISRM allow a relatively wide range of values for specimen geometry defined in terms of length to diameter ratio and loading rates defined as either time to failure or stress rate.

A statistical study was carried out on a coal measure sandstone to determine whether the tensile strength determined by the Brazilian test is independent of the specimen geometry and the stress rate.

1. Introduction

The Brazilian indirect tensile strength test was proposed independently by Caneiro (1947) and by Akazawa (1953). The test was developed as an alternative to the direct tensile strength test which requires extensive specimen preparation and a more rigorous testing procedure. The Brazilian test results are commonly used for evaluating roof stability in underground excavations, particularly in horizontally bedded strata. Since the failure plane in the test specimens is typically perpendicular to the bedding planes, the Brazilian test closely models the expected failure mode of “roof beams” in the field. In the author’s experience, an exception may occur in thinly bedded shales, where failure initiates from the edge of the specimen along the bedding planes.
Specifications for specimen preparation and the testing procedure have been established by the ASTM (ASTM D 3967-86) and a suggested method is proposed by the ISRM (ISRM, 1981). The test procedures of both organizations are similar. However, there are certain notable differences. The ISRM suggests a testing apparatus to hold the specimen, while ASTM recommends that cardboard or plywood be placed between the platens and the specimen to reduce the stress concentration at the loading points. The procedures recommended by the ASTM and those suggested by the ISRM are shown for comparison in Table 1.

Table 1. Comparison of the ASTM Specifications and the ISRM Recommendations for the Brazilian Indirect Tensile Strength Test

<table>
<thead>
<tr>
<th></th>
<th>ASTM Specifications</th>
<th>ISRM Suggested method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>Length to diameter ratio</td>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>Test duration (min)</td>
<td>1.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Stress rate (psi/min)</td>
<td>500</td>
<td>3000</td>
</tr>
<tr>
<td>Loading rate (lb/min)</td>
<td>No standard</td>
<td></td>
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</tbody>
</table>

The purpose of this study is to investigate, through an analysis of variance (AOV), whether the recommended ranges for specimen geometry and stress rate cause a statistically significant difference in the test results.

2. Analysis of Variance

Analysis of variance (AOV) is a statistical method used to compare the means of two or more samples to determine if the samples come from populations with identical means. This method is widely used in the design of experiments and has been previously applied in rock mechanics investigations (Greminger, 1982) and for geologic classification systems (Rouleau and Gale, 1985).

In an AOV, the $F$, or Fisher test, is used to compare the variance of the means of the sample to the mean of the sample variances (Mattson, 1981). In this study the effect of two parameters, the sample geometry ($L/D$ ratio) and the loading rate or stress rate on the indirect tensile strength was investigated. For each group of specimens with an identical geometry or loading rate, a mean tensile strength and variance can be calculated. Similarly, for the aggregate of all specimens the mean tensile strength and variance can be determined. The primary question is whether the variance of the mean in the individual groups, for example $L/D = 0.50$, is significantly different from the variance of the mean for other groups, say $L/D = 1.00$, and for all groups irrespective of the $L/D$ ratio or the loading rate. Since the calculations associated with the $F$ test can be found in...