Abstract

The understanding of the mechanical behavior of rocks under tensile and compressive stresses is crucial in rock engineering. There are two fundamental aspects to the characterization of rock materials. First, the selected laboratory test must be appropriate and valid. The specimen geometry and loading configuration should yield reliable and meaningful data. Second, the laboratory specimens must represent the geology and test configurations should reasonably simulate field-like stress conditions, particularly where multiple lithologies interact.

Assessment of the indirect tensile testing of rocks shows that the conventional Brazilian test has several shortcomings which lead to the development of alternative tests like flattened Brazilian disc (FBD) and ring tests that are not incorporated in the common standards (e.g. ISRM, ASTM etc.). Although these methods have been studied largely through numerical analyses, comprehensive experimental comparisons of their strength, deformation behavior and applicability remain less-explored. Therefore, first part of the thesis addresses this issue by investigating the tensile behavior of some rocks from India (Barakar sandstone, Raniganj sandstone and Malanjkhand granite) using these testing methods. Comparative analysis of the two Gondwana sandstones demonstrates that the marked differences in their indirect tensile strengths are primarily governed by microstructural characteristics, including grain size, texture, and mineralogical composition. For both the Gondwana sandstones, the ratio of ring tensile strength to Brazilian tensile strength increases for weaker/less compact rock materials. The results further indicate that the ring tensile strengths capture rock heterogeneity more effectively than those obtained from Brazilian and FBD tests proving the ring test to be practically more efficient in assessing the indirect tensile strength of rock materials.

Limited studies have examined how the tensile strength derived from FBD and ring specimens varies with quasi-static strain rates or deformation rates. To address this gap, FBDs and ring specimens of Malanjkhand granite are tested at deformation rates of 0.5 mm/min, 1.5 mm/min and 5.5 mm/min. The indirect tensile strength is found to be dependent on both the deformation rate and the geometry of the different specimens. Furthermore, a detailed strain analysis is executed for ring specimens of granite, where the tensile Tangent Deformation Modulus (D_v) and the ratio of the horizontal strain to vertical strain, coined as Ring Strain Ratio (RSR), are estimated from the tensile stress and vertical-horizontal strain data. A finite element analysis performed in Abaqus corroborates the experimental stress distribution in ring tests.

In compression testing, single rock cylindrical specimens for uniaxial compressive strength and triaxial compressive strength tests are well-established and effective for characterizing intact rock materials. However, intact specimens do not always represent complex and layered geology. To address this limitation, the second part of the thesis employs cylindrical composite specimens that better simulate natural geological configurations. A bi-layered composite of weathered quartzite and quartz-mica schist rocks, collected from the Singhbhum Copper Belt of India, is prepared, where these rocks are found in conjunction with each other in the hanging wall of the Chaibasa Formation. The composites are assembled in three volumetric proportions of quartzite to schist: 75-25, 50-50 and 25-75. The specimens are tested under uniaxial and triaxial compression (5, 10 and 15 MPa) at a deformation rate of 0.6 mm/min and photomicrographic analyses are performed. The results show that the layer interface influences the strength and deformation moduli of the composites differently for different volumetric proportions of rock component, with the 50-50 composite showing the most pronounced reduction. The increase in confinement has an increasing effect on the strength of quartzite and schist dominated composite up to a critical point, beyond which the effect of the weaker, weathered foliated schist prevails. The deformation moduli of each component of the composites have also been analyzed and the plausible reasons for their variations are explained.

Keywords: *Indirect tensile strength, Brazilian test, Flattened Brazilian test, Ring test, Sandstone, Granite, Uniaxial and triaxial compression, Quartzite-mica schist composite, Deformation modulus, Failure pattern*