Accepted Manuscript

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PII: S0191-8141(18)30198-6

DOI: 10.1016/j.jsg.2018.04.007

Reference: SG 3626

To appear in: *Journal of Structural Geology*

Received Date: 14 October 2017

Revised Date: 21 March 2018

Accepted Date: 6 April 2018

Please cite this article as: Labuz, J.F., Zeng, F., Makhnenko, R., Li, Y., Brittle failure of rock: A review and general linear criterion, *Journal of Structural Geology* (2018), doi: 10.1016/j.jsg.2018.04.007.

Brittle failure of rock: a review and general linear criterion

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Abstract

A failure criterion typically is phenomenological since few models exist to theoretically derive the mathematical function. Indeed, a successful failure criterion is a generalization of experimental data obtained from strength tests on specimens subjected to known stress states. For isotropic rock that exhibits a pressure dependence on strength, the simplest failure criterion is a linear equation in major and minor principal stresses, independent of the intermediate principal stress. A general linear failure criterion called Paul-Mohr-Coulomb (PMC) contains all three principal stresses with three material constants: friction angles for axisymmetric compression ϕ_c and extension ϕ_e and isotropic tensile strength V_0. PMC provides a framework to describe a nonlinear failure surface by a set of planes "hugging" the curved surface. Brittle failure of rock is reviewed and multiaxial test methods are summarized. Equations are presented to implement PMC for fitting strength data and determining the three material parameters. A piecewise linear approximation to a nonlinear failure surface is illustrated by fitting two planes with six material parameters to form either a 6- to 12-sided pyramid or a 6- to 12- to 6-sided pyramid. The particular nature of the failure surface is dictated by the experimental data.

Keywords: Failure criteria, failure surface, friction angle, intermediate stress effect, multiaxial testing, triaxial compression, triaxial extension, true triaxial testing