A 3D generalized rigid particle contact model for rock fracture

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Abstract

Purpose – The rigid spherical particle models proposed in the literature for modeling fracture in rock have some difficulties in reproducing both the observed macroscopic hard rock triaxial failure enveloped and compressive to tensile strength ratio. The purpose of this paper is to obtain a better agreement with the experimental behavior by presenting a 3D generalized rigid particle contact model based on a multiple contact point formulation, which allows moment transmission and includes in a straightforward manner the effect of friction at the contact level.

Design/methodology/approach – The explicit formulation of a generalized contact model is initially presented, then the proposed model is validated against known triaxial and Brazilian tests of Lac du Bonnet granite rock. The influence of moment transmission at the contact level, the number of contacts per particle and the contact friction coefficient are assessed.

Findings – The proposed contact model model, GCM-3D, gives an excellent agreement with the Lac du Bonet granite rock, strength envelope and compressive to tensile strength ratio. It is shown that it is important to have a contact model that: defines inter-particle interactions using a Delaunay edge criteria; includes in its formulation a contact friction coefficient; and incorporates moment transmission at the contact level.

Originality/value – The explicit formulation of a new generalized 3D contact model, GCM-3D, is proposed. The most important features of the model, moment transmission through multiple point contacts, contact friction term contribution for the shear strength and contact activation criteria that lead to a best agreement with hard rock experimental values are introduced and discussed in an integrated manner for the first time. An important contribution for rock fracture modeling, the formulation here presented can be readily incorporated into commercial and open source software rigid particle models.

Keywords Fracture, Volcanic rocks, Modelling, Granite, Friction, Tensile strength, Discrete element, Particle model, Contact model

Paper type Research paper

1. Introduction

Detailed rigid particle models have been introduced in the study of fracture of continuous media such as concrete and rock in the early 1990s (Meguro and Hakuno, 1989; Potyondy and Cundal, 1996; Schlangen and Garboczi, 1997; Bolander and Saito, 1998). More recently 3D rigid spherical particle models have been proposed for geomaterials like rock (Matsuda and Iwase, 2002; Potyondy and Cundall, 2004) and concrete (Lilliu and Van Mier, 2003; Hentz *et al.*, 2004; Cusatis *et al.*, 2006). Models based on the rigid block spring method adopting 3D Voronoi polyhedral shape have also been developed for concrete (Nagai *et al.*, 2005; Berton and Bolander, 2006).