Limits of Applicability of the Finite Element Explicit Joint Model in the analysis of Jointed Rock Problems

A. Riahi, R.E. Hammah,
J.H. Curran
Rocscience Inc., Toronto, Canada

Abstract

Discontinuities within a material are surfaces that represent a sudden jump in the displacement field, and result in the following secondary effects: discontinuity in stress and strain fields, reduced elastic and strength properties, and sometimes a significant freedom in the displacement of individual bodies. Also, when discontinuities are prevalent within a material, they form a microstructure or fabric, and give rise to scale effects related to the sizes of discrete blocks or grains.

This paper compares the formulation of continuum-based numerical methods, which use an interface element, to that of discrete-based techniques, when both are applied to jointed rock problems. It intends to show the similarities and differences between these formulations, and to provide guidelines on how to choose between discontinuous techniques (namely, the distinct element method, discontinuous deformation analysis) and continuum-based techniques with interface elements in the analysis of jointed rock.

The governing equations, kinematics, and fundamental solutions of both continuum and discrete methods are discussed. Using a number of benchmark problems, the performance of the discrete and continuum-based numerical methods are compared with a primary focus on mechanism of deformation, scale effects, and accuracy of results.

Finally, the predictions of both methods for a number of typical geotechnical problems (including slope stability) involving various failure mechanisms, are compared and discussed.

From the comparison of the formulations, the paper concludes that the FEM with interface elements is equivalent to discrete element models with constant (fixed) points of contact. If input geometry and the assumptions on the deformability of intact material are similar in both models, they yield the same result, provided that the contacts between elements remain unchanged throughout the solution process. If the contacts change, then discrete element techniques provide more realistic results.

For practical geotechnical modelling, the FE-interface model is more desirable because of its ability to quickly analyze several models with varying network geometries and material properties. This feature allows engineers to explore the effects of parameter uncertainty on potential mechanisms, and to develop more robust slope designs and stability measures.

Keywords: discrete element method, finite element method, interface element, contact technology, distinct element method, discontinuous deformation analysis, internal length scale, microstructure