

Research Article

Discontinuous Deformation Analysis Enriched by the Bonding Block Model

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The discontinuous deformation analysis (DDA) has been extensively applied in geotechnical engineering owing to its salient merits in the modeling of discontinuities. However, this method assumes a constant stress field within every block and hence cannot provide reliable estimation for block deformations and stresses. This paper proposes a novel scheme to improve the accuracy of the DDA. In our method, advanced subdivision is introduced to represent a block as an assembly of triangular or quadrilateral elements, in which overlapped element edges are separated from each other and are glued together by bonding springs. The accuracy and the effectiveness of the proposed method are illustrated by three numerical experiments for both continuous and discontinuous problems.

1. Introduction


The discontinuous deformation analysis (DDA) [1, 2] is developed for the modeling of the statics and dynamics problems in geological engineering. This method represents a jointed rock mass as an assembly of blocks with constantly changing deformations and contact status. At every contact point, a normal spring and a shear spring are applied. Such contact springs must satisfy no tension in an open contact and no penetration in a close contact, which are fulfilled through repeated open-close iterations. In the literature [3–8], the augmented Lagrangian method is also introduced into the DDA to increase the accuracy for contact computation. The DDA uses an incremental procedure to solve block movements and deformations on a given time mesh. In every time step, the simultaneous equilibrium equations are formed by the submatrices derived from minimizing all sources of potential energies. Due to the above unique merits, this method has been extensively applied in the analysis of seismic landslides [9–11], crack propagations [12–14], and hydraulic fractures [15, 16].

However, the DDA employs the first-order polynomial to approximate block displacements, and hence the stress within every block keeps invariable. Such assumption leads to the difficulty to implement this method to simulate block cracks, which require accurate stress estimation. In order to improve the accuracy of the DDA, a multitude of methods have been developed. A direct way is to use second- or higher-order polynomial functions to approximate block displacements [17–22]. But the accuracy of this method is only adequate for regularly shaped blocks. Another way is the so-called subblock DDA [3, 13, 16, 23], which subdivides blocks into smaller ones by preassumed artificial joints and applies contact springs along the interfaces to prevent the relative movements. Since contact detections and open-close iterations are also required for the contacts between subblocks, the computational burden of this method is very heavy, especially when adopting finer subdivisions.

The accuracy of the DDA can also be improved by coupling with the FEM. In the literature [24, 25], the DDA and the FEM codes are integrated into a computer program to alternately figure out block deformations and contact forces.

Block System Modeling By Discontinuous Deformation Analysis Topics In Engineering

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and also the Discrete Fracture Network DFN approach for fluid flow and solute transport simulations The latter is actually also a discrete approach of importance for rock mechanics and rock engineering In addition brief introductions to some alternative approaches are also provided such as percolation theory and Cosserat micromechanics equivalence to particle systems which often appear hand in hand with the DEM in the literature Fundamentals of the particle mechanics approach using DEM for granular media is also presented Presents the fundamental concepts of the discrete models for fractured rocks including constitutive models of rock fractures and rock masses for stress deformation and fluid flow Provides a comprehensive presentation on discrete element methods including distinct elements discontinuous deformation analysis discrete fracture networks particle mechanics and Cosserat representation of granular media Features constitutive models of rock fractures and fracture system characterization methods detailing their significant impacts on the performance and uncertainty of the DEM models **Understanding the Discrete Element Method** Hans-Georg Matuttis, Jian

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Advanced Computational Methods and Geomechanics Shenghong Chen,2023-01-01 The aim of this book is intended through parallel expounding to help readers comprehensively grasp the intrinsic features of typical advanced computational methods These methods are created in recent three decades for the understanding of the post failure of geo materials accompanied with discontinuous and finite deformation dislocation as well as the violent fluid structure interaction accompanied with strong distortion of water surface The strong points and weak points of the formalisms for governing equations the discretization schemes the nodal interpolation approximation of field variables and

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web for example if a company has 10 product lines and each line has 3 products then length is 10 3 30 length of the product mix refers to the total number of products in the mix if a company has 5 product lines and 10 products under each product lines the length of the mix will be 50 5 x 10 product mix consistency

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web according to philip kotler a product line can be defined as a group of products that are closely related because they function in a similar manner and sold to the same customer groups are marketed through these same types of outlets fall within given price range

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product lines or depth i.e product variations within lines contraction a company narrows its product mix to eliminate lower performing products or lines or to simplify remaining products or lines

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web nov 1 2023 a product line is a range of similar products or services introduced and sold by the same company to make it clear simultaneously a product mix also called product assortment is considered the full assortment of all products introduced to its clients hence both product lines and individual products will form a product mix

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web nov 2 2023 the different elements of a product mix strategy a product mix can be broken into the following three elements width this represents the total number of product lines in your portfolio for example three of apple s product lines are mobile personal computing and music length here you consider the number of products

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web in simple words the product mix is the amalgamation of all the product lines a firm has under it the deeper and wider a product mix is the more products a company can offer which will ultimately lead to more reach but what exactly is the difference between a product line product mix

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web a product line is a set of products that are similar or complementary for example domino s sells crunchy thin handmade pan brooklyn style and gluten free crust along with its hand tossed pizza crust as a part of a product line a product mix contains all the products that a company sells

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