David Potyondy – ITASCA Minneapolis

Senior Geomechanics Engineer

Expertise

Computational Structural Mechanics, Rock Mechanics, Fracture Mechanics, Continuum and Discontinuum Numerical Methods, Software Development

Education

Ph.D. (Civil Engineering), 1993
M.S. (Civil Engineering), 1990
Cornell University

B.S. (Civil Engineering), 1987
University of Minnesota

Professional Affiliations

Member: American Rock Mechanics Association, American Society of Civil Engineers, International Society of Rock Mechanics

Honors

American Rock Mechanics Association 2024 Best Paper Award for the paper: Potyondy, D.O., & Fu. W. A 3D Subspring Network Breakable Voronoi Model for Rock: Laboratory-Scale Behavior. In Proceedings, 58th U.S. Rock Mechanics / Geomechanics Symposium (ARMA, Golden, Colorado, June 2024). ARMA 24-493.

University of Minnesota Center for Transportation Studies 2018 Research Partnership Award for Geogrid Reinforced Aggregate Base Pavement Design, which includes a series of projects from the early 2000s to present (team member, 2012–2018).

American Rock Mechanics Association 2005 Award for Research in Rock Mechanics for the paper: A Bonded-Particle Model for Rock. *Int. J. Rock Mech. Min. Sci.*, *41*(8), 1329-1374 (2004).

NASA 1996 Group Achievement Award, to Fuselage Structural Integrity Analysis Team at Langley Research Center (team member, 1990-1993)

Graduate Research Assistant Award, 1991-1993, NASA Airframe Structural Integrity Program

Graduate Fellowship, 1987-1990, National Science Foundation

National Winner: SAMPE Scholarship, 1985 and 1986, Society for the Advancement of Material and Process Engineering; ACEC Scholarship, 1985 American Consulting Engineers Council

Professional Experience

	ITASCA Minneapolis
2005 – Present	Senior Geomechanics Engineer
2004 – 2005	Associate
1994 – 2003	Project Engineer, Director of Software Development
1983, 1985 – 1986	Engineering Software Consultant

2004 – 2005	University of Toronto, Department of Civil Engineering, Canada Assistant Professor
1993 – 1994	Georgia Institute of Technology, Postdoctoral Fellow
1990 – 1993	Fracture Analysis Consultants, Inc., Ithaca, New York Engineering Software Consultant
1990 – 1993	Cornell University, Graduate Research Assistant
1988 – 1990	Cornell University, Research Assistant
1985 – 1986	University of Minnesota Department of Civil and Mineral Engineering Summer Academic Intern

Project Experience

Dr. Potyondy has developed and applied both continuum and discontinuum models to represent damage and flow processes on both a macro- and a micro-scale. His research focus is on microstructural modeling of rock fracture using discrete-element methods. He developed the bonded-particle modeling methodology along with Peter Cundall and continues to develop this methodology. He has directed development of the PFC codes, given more than 45 PFC training courses, developed the structural-element logic in the FLAC3D code, and developed novel techniques for applying micro-mechanical discontinuum models to fracture-related boundary-value problems that are not limited to rock-mechanics applications.

Research and Development

Discontinuum Modeling — University of Minnesota Center for Transportation Studies 2018 Research Partnership Award to Geogrid Reinforced Aggregate Base Pavement Design, which includes a series of projects from the early 2000s to present (team member, 2012–2018). These projects led to design procedures and modified construction specifications that better utilize a geogrid reinforcement for flexible pavements to build financially effective roadways. Through the projects, a Geogrid (Gain) factor was also created for modeling and understanding the best use of the material throughout Minnesota. ITASCA developed the commercial software framework (pavement-design package within PFC3D) that embodies the methodology.

Research and development projects to support ongoing development of novel techniques for applying micro-mechanical discontinuum models (PFC2D and PFC3D), which represent a solid as a bonded assembly of circular/spherical particles, to fracture-related boundary-value problems. Fundamental research was funded by Atomic Energy of Canada Limited as part of the Thermal-Mechanical Stability Study (1995-2001), one aim of which has been to improve fundamental understanding of short- and long-term rock-mass behavior around underground openings at ambient and elevated temperatures. The result of this work has been the development and verification of the PFC Model for Rock — a mechanistically based numerical model for predicting excavation-induced rock-mass damage and long-term strength (based on a stress-corrosion mechanism) in Lac du Bonnet granite. Model enhancements (funded by Svensk Kärnbränslehantering AB, SKB) include breakable, deformable polygonal grains joined by cement.

Developed a PFC model of lithophysal tuff and used this model to better understand the effect of lithophysae (hollow, bubble-like voids) on the mechanical properties of this rock, including the time-dependent damage processes induced by stress corrosion. These studies address the tunnel-stability issues in the license application for a monitored geological repository for high-level radioactive waste at Yucca Mountain in Nevada.

Continuum Modeling — Assisted in developing an analysis methodology and software infrastructure (FRANC3D) at Cornell University. The methodology is based on solid modeling principles, interactive computer graphics and automatic mesh generation and supports arbitrary-directional, discrete crack-growth simulation in both solid and thin-shell structures utilizing both finite- and boundary-element analysis techniques.

Developed the stiffened, thin-shell capabilities of the FRANC3D code by coupling it with STAGS, a geometrically non-linear finite-element code as part of the NASA Airframe Structural Integrity Program (ASIP) in collaboration with researchers at NASA Langley Research Center and Lockheed Palo Alto Research Laboratory; verified the approach for simulating growth of long cracks in pressurized fuselage structures by comparing with full-scale pressurized-panel tests conducted by Boeing Commercial Airplane Group; co-facilitated the FRANC3D User's Group Workshop to train ASIP and industry personnel in use of the code.

Supervised a Master's student (Georgia Institute of Technology) in the development of a finite-element-based methodology for computing non-linear fracture parameters of a bulging crack in a pressurized fuselage structure incorporating material non-linear behavior.

Software Development — Directed of all aspects of development and provision of training courses for the Particle Flow Codes (PFC2D and PFC3D). Developed, implemented and documented the structural-element logic in the FLAC3D, 3DEC, and PFC codes, which provides shell, beam, pile, cable, geogrid and liner elements that can interact with the finite-difference based continuum grid. The implementation utilizes various shell and beam finite elements and includes logic to support non-linear grid interaction including slip and separation. The beams and shells can have plastic material models. The structural-element logic is used by 3DEC and PFC3D

Consulting

Fracture of a Discontinuum — Served as a consultant to clients interested in applying the PFC codes to a multitude of problems. In these projects, PFC2D and PFC3D were applied to simulate pull-out tests in reinforced concrete, ice-structure interaction, tool-rock interaction during rock cutting, blade-hair interaction during shaving and acoustic emissions during chalk compaction, and to predict borehole breakout, excavation damage in hard rock, stability of undercut backfill, density gradients in powder-compacted specimens and dense-phase pneumatic conveying. Served as a consultant to Sandia National Laboratories in evaluating the spallings conceptual model used in performance assessment of the Waste Isolation Pilot Plant to predict surface release arising from human intrusion via drilling into a pressurized waste panel.

Fracture of a Continuum — Applied FRANC3D to simulate three-dimensional, non-planar fatigue crack growth in a turbine blade root and compared results with laboratory data; installed FRANC3D and provided user training to simulate hydraulically induced fracture for reservoir stimulation for Schlumberger Cambridge Research Laboratory; installed FRANC2D and provided user training for Grumman Aerospace and GTE Laboratories, for Fracture Analysis Consultants, Inc.

Teaching

Graduate Student Advisement — Mentor to 18 different students via the ITASCA Educational Partnership, served on 5 graduate student thesis committees, and First Opponent for two PhD defenses at Norwegian University of Science and Technology.

Software Training Courses — Taught 45 PFC training courses (4-day course) to various research groups in industry and academia focusing on simulating the fracture and flow of brittle rock-like materials via bonded-particle modeling. Taught 8 FLAC3D training courses focusing on Structural Element logic.

Short Courses

Co-taught ARMA 2018 Short Course "Microstructural Modeling of Rock Fracture: Bonded-Particle Modeling with PFC and Bonded-Block Modeling with *3DEC*" with Tryana Garza-Cruz at the 52nd U.S. Rock Mechanics/Geomechanics Symposium, Seattle, USA, 17–20 June 2018.

PFC Short Course (August 24, 2008) at the First International *FLAC*/DEM Symposium on Numerical Modeling, Minneapolis, MN. Focus: new features in PFC 4.0, bonded-particle modeling, applications of smooth-joint logic, and fluid-flow capability.

University Courses — Taught two courses at the University of Toronto during the 2004–2005 academic year.

Developed and taught graduate course (in 2004): *Micromechanical Modeling Using Discrete Element Methods*. Discrete-element methods (DEM) allow one to simulate the movement and mechanical interaction of tens of thousands of discrete bodies. The macroscopic behavior of such models is an emergent property of the system that arises from a small set of microproperties for the particles and the particle-particle interactions. These models provide a scientific tool to investigate the micro-mechanisms that combine to produce complex macroscopic behaviors and have been used to study the mechanical behavior of many materials and systems that cannot be expressed adequately by existing continuum theories. After introducing the formulation of the general DEM and reviewing current applications areas, the focus will shift to bonded-particle models applied to study damage processes in rock or other brittle materials. This type of modeling is in its infancy compared to continuum modeling, and thus it is important to develop a proper modeling methodology that involves careful numerical experimentation and qualitative comparison with physically observed micro- and macro-mechanisms as well as quantitative comparison with measured properties. This will be achieved through a balance of lectures, case studies and hands-on modeling exercises using a flexible DEM code with an embedded programming language that provides circular particles with simple bonding schemes. As a final project, students will develop and implement a methodology by which the code could be applied to a research area of their choosing.

Taught undergraduate course (in 2004): *APS106, Fundamentals of Computer Programming*, taken by all first-year students in Civil, Mechanical, Chemical and Materials Engineering programs. The APS106 course is designed to introduce first-year engineering students to computer programming. Students will learn how to design and implement algorithms using the C programming language.

Invited Lectures

Five invited lectures on PFC Modeling. Tongji University (Shanghai, China, 30 October to 9 November 2024). Host is Fengshou Zhang. (1) "3D Subspring Network Breakable Voronoi Model for Rock," Tongji University (Shanghai, China, 8 November 2024); (2) "Potyondy, Itasca and BPM," Itasca China Office (Hangzhou, China, 6 November 2024); (3) "3D Subspring Network Breakable Voronoi Model for Rock," Chengdu University of Technology (Chengdu, China, 4 November 2024 — host is Prof. Haiyan Zhu); (4) "Simulating Perforation Damage with a Flat-Jointed Bonded-Particle Material," Southwest Petroleum University (Chengdu, China, 4 November 2024 — host is Prof. Liuke Huang); (5) "Bonded-Particle Modeling: What It is, Why It Matters," Session of Early Career Forum at China Rock 2024, Chinese Society for Rock Mechanics and Engineering (Chengdu, China, 3 November 2024).

Four invited lectures on PFC Modeling. Tongji University (Shanghai, China, 21 May 2019). Host is Fengshou Zhang. (1) "The Bonded-Particle Model as a Tool for Rock Mechanics Research and Application," Departmental Lecture (21 May 2019); (2) "Simulating Perforation Damage with a 2D Flat-Jointed Bonded-Particle Material,"

Departmental Lecture (21 May 2019); (3) "Simulating Spalling with a 3D Flat-Jointed Bonded-Particle Material," Departmental Lecture (21 May 2019). Keynote lecture for PFC Workshop put on by HydroChina – ITASCA R&D Center (Hangzhou, China). Host: Weijiang Chu "River". "PFC (Particle Flow Code): Historical Development and Engineering Applications," Keynote Lecture (23 May 2019).

Three invited lectures at University of Tennessee (Knoxville), Civil Engr. Dept. (22–23 March 2018). Host is Khalid Alshibli. (1) "PFC Pavement-Design Package," Tennessee Department of Transportation, Materials and Tests Division (Knoxville, TN, March 22, 2018); (2) "PFC (Particle Flow Code): Historical Development and Engineering Applications," Departmental Seminar, University of Tennessee (Knoxville), CE Department (Knoxville, TN, March 22, 2018); (3) "Discrete-Element Modeling of Rock Fracture for Nuclear-Waste Isolation: Predicting the Effect of Lithophysae on the Properties of Volcanic Tuff," ASCE Technical Seminar, Knoxville ASCE Branch (Oak Ridge, TN, March 23, 2018).

Four invited lectures on Bonded-Particle Modeling. Tsinghua University, Civil Engr. Dept. (Beijing, China, 12-16 October 2015). Host is Zhihong Zhao. (1) "The Bonded-Particle Model as a Tool for Rock Mechanics Research and Application," Graduate Lecture (13 October 2015); (2) "PFC (Particle Flow Code): Historical Development and Engineering Applications," General Seminar (14 October 2015); (3) "Simulating Perforation Damage with a Flat-Jointed Bonded-Particle Material," General Seminar (14 October 2015); (4) "Discrete-Element Modeling of Rock Fracture: Predicting the Effect of Lithophysae on the Properties of Volcanic Tuff," Workshop on DEM in Geotechnical Engineering (16 October 2015).

"The Bonded-Particle Model as a Tool for Rock Mechanics Research and Application: Current Trends and Future Directions," Keynote Lecture at 7th Asian Rock Mechanics Symposium — ARMS7 (Seoul, Korea, 16 October 2012).

"Bonded-Particle Modeling of Excavation Response," Lecture for Online Certificate in Tunneling Course, University of Texas at Austin, July 2010.

"Discrete Element Modeling of Rock Fracture for Nuclear-Waste Isolation: Predicting the Effect of Lithophysae on the Properties of Volcanic Tuff," State of the Art Lecture, 13th Annual George F. Sowers Symposium, Georgia Institute of Technology, Atlanta, May 11, 2010.