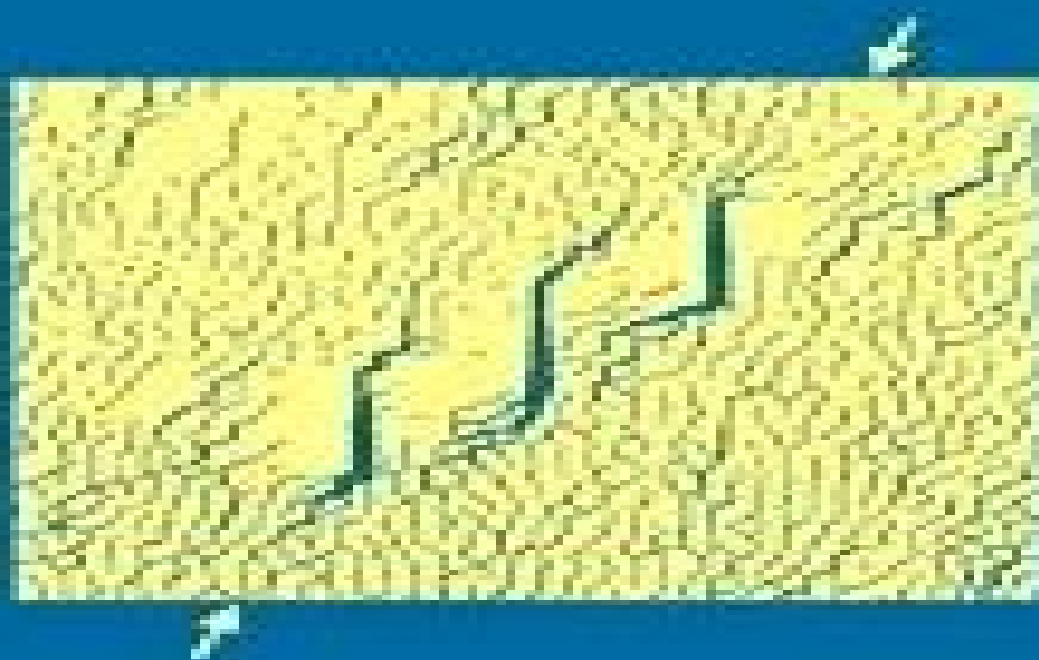


Numerical Modelling and Analysis of Fluid Flow and Deformation of Fractured Rock Masses

KING ZHANG AND DAVID J. SANDERSON



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Numerical Modelling And Analysis Of Fluid Flow And Deformation Of Fractured Rock Masses

**Y.M. Cheng, J. H. Wang, L. Liang, W. H.
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Numerical Modelling And Analysis Of Fluid Flow And Deformation Of Fractured Rock Masses:

Numerical Modelling and Analysis of Fluid Flow and Deformation of Fractured Rock Masses Xing Zhang, D.J.

Sanderson, 2002-05-14 Our understanding of the subsurface system of the earth is becoming increasingly more sophisticated both at the level of the behaviour of its components solid liquid and gas as well as their variations in space and time The implementation of coupled models is essential for the understanding of an increasing number of natural phenomena and in predicting human impact on these The growing interest in the relation between fluid flow and deformation in subsurface rock systems that characterise the upper crust has led to increasingly specialized knowledge in many branches of earth sciences and engineering A multidisciplinary subject dealing with deformation and fluid flow in the subsurface system is emerging While research in the subject area of faulting fracturing and fluid flow has led to significant progress in many different areas the approach has tended to be reductionist i e involving the isolation and simplification of phenomena so that they may be treated as single physical processes The reality is that many processes operate together within subsurface systems and this is particularly true for fluid flow and deformation of fractured rock masses The aim of this book is to begin to explore how advances in numerical modelling can be applied to understanding the complex phenomena observed in such systems Although mainly based on original research the book also includes the fundamental principles and practical methods of numerical modelling in particular distinct element methods This volume explores the principles of numerical modelling and the methodologies for some of the most important problems in addition to providing practical models with detailed discussions on various topics The Initiation, Propagation, and Arrest of Joints and Other Fractures John W.

Cosgrove, Terry Engelder, 2004 This volume is a state of the art look at our understanding of joint development in the crust Answers are provided for such questions as the mechanisms by which joints are initiated the factors controlling the path they follow during the propagation process and the processes responsible for the arrest of joints Many of the answers to these questions can be inferred from the geometry of joint surface morphology and joint patterns Joints are a record of the orientation of stress at the time of propagation and as such they are also useful records of ancient stress fields regional and local Because outcrop and subsurface views of joints are limited statistical techniques are required to characterize joints and joint sets Finally joints are subject to post propagation stresses that further localize deformation and are the focus for the development of new structures *Fractures, Fluid Flow and Mineralization* Ken McCaffrey, Lidia Lonergan, Jamie

Wilkinson, 1999 Hydrothermal mineralization is usually structurally controlled so it is important to understand the role of faulting and fracturing in enhancing rock permeability and facilitating fluid flow and mass transfer This is the main theme of this interdisciplinary volume and the papers included are intended to provide an overview of current ideas at the interfaces of structural geology fluid flow and mineralization research **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 their connectivity via support domains covers or enrichments the basic algorithms etc are clarified Being aware of that the differences in these methods are not so large as at the first glance this book will help readers to select appropriate methods to improve the methods for their specific purpose and to evaluate the reliability applicability of the outcomes in the hazard evaluation of geotechnical hydraulic structures beyond extreme work situation This book may be looked at as an advanced continuation of Computational Geomechanics and Hydraulic Structures by the author 2018 Springer Verlag ISBN 978 981 10 8134 7 which elaborates the fundamental computational methods in geomechanics for the routine design of geotechnical hydraulic engineering

Numerical Methods and Implementation in Geotechnical Engineering - Part 2 Y.M. Cheng,J. H. Wang,L. Liang,W. H. Fung Ivan,2020-04-20 Numerical Methods and Implementation in Geotechnical Engineering explains several numerical methods that are used in geotechnical engineering The second part of this reference set includes more information on the distinct element method geotechnical optimization analysis and reliability analysis Information about relevant additional numerical methods is also provided in each chapter with problems where applicable The authors have also presented different computer programs associated with the materials in this book set which will be useful to students learning how to apply the models explained in the text into practical situations when designing structures in locations with specific soil and rock settings This reference book set is a suitable textbook primer for civil engineering students as it provides a basic introduction to different numerical methods classical and modern in comprehensive readable volumes

Numerical Methods and Implementation in Geotechnical Engineering - Part 1 Y.M. Cheng,J. H. Wang,L. Liang,W. H. Fung Ivan,2020-04-01 Numerical Methods and Implementation in Geotechnical Engineering explains several numerical methods that are used in geotechnical engineering The first part of this reference set includes methods such as the finite element method distinct element method discontinuous deformation analysis numerical manifold method smoothed particle hydrodynamics method material point method plasticity method limit equilibrium and limit analysis plasticity slope stability and foundation engineering optimization analysis and reliability analysis The authors have also presented different computer programs associated with the materials in this book which will be useful to students learning how to apply the models explained in the text into practical situations when designing structures in locations with specific soil and rock settings This reference book set is a suitable textbook primer for civil engineering students as it provides a basic introduction to different numerical methods classical and modern in comprehensive readable volumes

Rock Mechanics: Meeting Society's Challenges and Demands, Two Volume Set Erik Eberhardt,Doug Stead,Tom

Morrison, 2007-05-17 Ore extraction through surface and underground mining continues to involve deeper excavations in more complex rock mass conditions. Communities and infrastructure are increasingly exposed to rock slope hazards as they expand further into rugged mountainous terrains. Volume 1 presents papers describing new technologies, ideas and insights concerning fundamental rock mechanics, while the second volume comprises a collection of rock engineering case histories relevant to the major themes of the symposium: rock slope hazards, geotechnical infrastructure, surface and underground mining and petroleum exploitation. Frontiers of Discontinuous Numerical Methods and Practical Simulations in Engineering and Disaster Prevention Guangqi Chen, Yuzo Ohnishi, Lu Zheng, Takeshi Sasaki, 2013-08-12 Analysis of large deformation, rigid body movement and strain or stress for discontinuous materials is often required for project designs and plans in the fields of engineering and disaster prevention. Many numerical simulation and analysis methods have been developed for the requirement from science and technology people since the 1970s. Among them D *Rock Mechanics and Engineering Volume 3* Xia-Ting Feng, 2017-04-21 Analysis, Modeling, Back Analysis, Risk Analysis, Design and Stability Analysis, Overviews, Design and Stability Analysis, Coupling Process Analysis, Design and Stability Analysis, Blast Analysis and Design, Rock Slope Stability Analysis and Design, Analysis and Design of Tunnels, Caverns and Stopes. The five volume set *Comprehensive Rock Engineering* which was published in 1993 has had an important influence on the development of rock mechanics and rock engineering. Significant and extensive advances and achievements in these fields over the last 20 years now justify the publishing of a comparable new compilation. *Rock Mechanics and Engineering* represents a highly prestigious multi-volume work edited by Professor Xia Ting Feng with the editorial advice of Professor John A. Hudson. This new compilation offers an extremely wide-ranging and comprehensive overview of the state of the art in rock mechanics and rock engineering and is composed of peer-reviewed dedicated contributions by all the key experts worldwide. Key features of this set are that it provides a systematic global summary of new developments in rock mechanics and rock engineering practices as well as looking ahead to future developments in the fields. Contributors are world-renowned experts in the fields of rock mechanics and rock engineering, though younger talented researchers have also been included. The individual volumes cover an extremely wide array of topics grouped under five overarching themes: Principles Vol 1, Laboratory and Field Testing Vol 2, Analysis, Modelling and Design Vol 3, Excavation Support and Monitoring Vol 4, and Surface and Underground Projects Vol 5. This multi-volume work sets a new standard for rock mechanics and engineering compendia and will be the go-to resource for all engineering professionals and academics involved in rock mechanics and engineering for years to come. **Rock Dynamics: From Research to Engineering** Haibo Li, Jianchun Li, Qianbing Zhang, Jian Zhao, 2016-04-19 *Rock Dynamics: From Research to Engineering* is a collection of the scientific and technical papers presented at the Second International Conference on Rock Dynamics and Applications RocDyn 2, Suzhou, China, 18-19 May 2016. The book has four sections. The first section contains 8 keynote papers covering a wide range of dynamic issues related to rock. Fluid Dynamics in Complex

Fractured-Porous Systems Boris Faybishenko, Sally M. Benson, John E. Gale, 2015-06-15 Despite of many years of studies predicting fluid flow heat and chemical transport in fractured porous media remains a challenge for scientists and engineers worldwide This monograph is the third in a series on the dynamics of fluids and transport in fractured rock published by the American Geophysical Union Geophysical Monograph Series Vol 162 2005 and Geophysical Monograph No 122 2000 This monograph is dedicated to the late Dr Paul Witherspoon for his seminal influence on the development of ideas and methodologies and the birth of contemporary fractured rock hydrogeology including such fundamental and applied problems as environmental remediation exploitation of oil gas and geothermal resources disposal of spent nuclear fuel and geotechnical engineering This monograph addresses fundamental and applied scientific questions and is intended to assist scientists and practitioners bridge gaps in the current scientific knowledge in the areas of theoretical fluids dynamics field measurements and experiments for different practical applications Readers of this book will include researchers engineers and professionals within academia Federal agencies and industry as well as graduate undergraduate students involved in theoretical experimental and numerical modeling studies of fluid dynamics and reactive chemical transport in the unsaturated and saturated zones including studies pertaining to petroleum and geothermal reservoirs environmental management and remediation mining gas storage and radioactive waste isolation in underground repositories Volume highlights include discussions of the following Fundamentals of using a complex systems approach to describe flow and transport in fractured porous media Methods of Field Measurements and Experiments Collective behavior and emergent properties of complex fractured rock systems Connection to the surrounding environment Multi disciplinary research for different applications

Geomechanics from Micro to Macro Kenichi Soga, Krishna Kumar, Giovanna Biscontin, Matthew Kuo, 2014-08-26 Geomechanics from Micro to Macro contains 268 papers presented at the International Symposium on Geomechanics from Micro and Macro IS Cambridge UK 1 3 September 2014 The symposium created a forum for the dissemination of new advances in the micro macro relations of geomaterial behaviour and its modelling The papers on experimental investigati

Notes on Numerical Modeling in Geomechanics William G. Pariseau, 2022-03-31 This book is an introduction to numerical analysis in geomechanics and is intended for advanced undergraduate and beginning graduate study of the mechanics of porous jointed rocks and soils Although familiarity with the concepts of stress strain and so on is assumed a review of the fundamentals of solid mechanics including concepts of physical laws kinematics and material laws is presented in an appendix Emphasis is on the popular finite element method but brief explanations of the boundary element method the distinct element method also known as the discrete element method and discontinuous deformation analysis are included Familiarity with a computer programming language such as Fortran C or Python is not required although programming excerpts in Fortran are presented at the end of some chapters This work begins with an intuitive approach to interpolation over a triangular element and thus avoids making the simple complex by not doing energy

minimization via a calculus of variations approach so often found in reference books on the finite element method The presentation then proceeds to a principal of virtual work via the well known divergence theorem to obtain element equilibrium and then global equilibrium both expressed as stiffness equations relating force to displacement Solution methods for the finite element approach including elimination and iteration methods are discussed Hydro mechanical coupling is described and extension of the finite element method to accommodate fluid flow in porous geological media is made Example problems illustrate important concepts throughout the text Additional problems for a 15 week course of study are presented in an appendix solutions are given in another appendix

Hydraulic Fracture Modeling Yu-Shu Wu, 2017-11-30 Hydraulic Fracture Modeling delivers all the pertinent technology and solutions in one product to become the go to source for petroleum and reservoir engineers Providing tools and approaches this multi contributed reference presents current and upcoming developments for modeling rock fracturing including their limitations and problem solving applications Fractures are common in oil and gas reservoir formations and with the ongoing increase in development of unconventional reservoirs more petroleum engineers today need to know the latest technology surrounding hydraulic fracturing technology such as fracture rock modeling There is tremendous research in the area but not all located in one place Covering two types of modeling technologies various effective fracturing approaches and model applications for fracturing the book equips today s petroleum engineer with an all inclusive product to characterize and optimize today s more complex reservoirs Offers understanding of the details surrounding fracturing and fracture modeling technology including theories and quantitative methods Provides academic and practical perspective from multiple contributors at the forefront of hydraulic fracturing and rock mechanics Provides today s petroleum engineer with model validation tools backed by real world case studies

Seismic Fracture Characterization Enru Liu, 2013-12-06 During the last three decades seismic anisotropy has evolved from a purely academic research topic into applications in the mainstream of applied geophysics Today nobody doubts that the earth is anisotropic and most if not all hydrocarbon reservoirs are anisotropic Since shale accounts for 70% of sedimentary basins and fractures exist in all reservoirs seismic anisotropy may be even more extensive than we think Taking anisotropy into account in seismic processing has improved the quality of seismic images even though it makes seismic processing more challenging since additional parameters are needed At the same time fracture characterization using the concept of seismic anisotropy has added value in reservoir characterization reservoir management and has increased recovery and optimized well locations This book and the associated course provide an introduction to the fundamental concepts of seismic fracture characterization by introducing seismic anisotropy equivalent medium representation theories of fractured rock and methodologies for extracting fracture parameters from seismic data We focus on practical applications using extensive field data examples Includes case studies demonstrating the applicability workflow and limitations of this technology Contains physical laboratory 3D experiments where fracture distributions are known a Middle East fractured

carbonate reservoir and a fractured tight gas reservoir Builds discrete fracture network models incorporating all data These models should not only be geologically consistent but also geophysically and geomechanically consistent so that the models can be used to forecast the behaviour and performance of fractured reservoirs **Rock Stress and Earthquakes** Furen

Xie,2010-07-29 The evaluation of in situ rock stress is not only important in the exploration and engineering involving rock masses for mining hydropower tunneling oil and gas production and stone quarrying but also in the geodynamics and earthquake prediction The methods of determining these stresses for shallow crust in the engineering practice including

XAFS for Everyone Scott Calvin,2013-05-20 XAFS for Everyone provides a practical thorough guide to x ray absorption fine structure XAFS spectroscopy for both novices and seasoned practitioners from a range of disciplines The text is enhanced with more than 200 figures as well as cartoon characters who offer informative commentary on the different approaches used in XAFS spectroscopy The book covers sample preparation data reduction tips and tricks for data collection fingerprinting linear combination analysis principal component analysis and modeling using theoretical standards It describes both near edge XANES and extended EXAFS applications in detail Examples throughout the text are drawn from diverse areas including materials science environmental science structural biology catalysis nanoscience chemistry art and archaeology In addition five case studies from the literature demonstrate the use of XAFS principles and analysis in practice The text includes derivations and sample calculations to foster a deeper comprehension of the results Whether you are encountering this technique for the first time or looking to hone your craft this innovative and engaging book gives you insight on implementing XAFS spectroscopy and interpreting XAFS experiments and results It helps you understand real world trade offs and the reasons behind common rules of thumb **Analysis and Design Methods** Catherine

Fairhurst,2014-06-28 Analysis and Design Methods *Developments in Hydraulic Conductivity Research* Oagile

Dikinya,2011-02-28 This book provides the state of the art of the investigation and the in depth analysis of hydraulic conductivity from the theoretical to semi empirical models perspective as well as policy development associated with management of land resources emanating from drainage problem soils A group of international experts contributed to the development of this book It is envisaged that this thought provoking book will excite and appeal to academics engineers researchers and University students who seek to explore the breadth and in depth knowledge about hydraulic conductivity Investigation into hydraulic conductivity is important to the understanding of the movement of solutes and water in the terrestrial environment Transport of these fluids has various implications on the ecology and quality of environment and subsequently sustenance of livelihoods of the increasing world population In particular water flow in the vadose zone is of fundamental importance to geoscientists soil scientists hydrogeologists and hydrologists and allied professionals **Distinct Element Modelling in Geomechanics** K.R. Saxena,2018-12-20 Linear mathematical assumptions for procedures in other branches of engineering have little relevance for geoengineering which must accommodate non linear behaviors Contributors

to eight papers apply the breakthrough numerical modeling Distinct Element Method Cundall late 1960s The design philosophy for structures or excavations in geotechnical engineering is different from that followed for fabricated materials like steel and concrete The designer has little data both with regard to geological weaknesses and strength and deformation characteristics of materials before finalizing the designs Also these characteristics vary from place to place In situ stresses due to gravity and tectonics and transient forces imposed due to rainfall and earthquakes make the matter more complicated The pore waters carry the load initially before passing it on to the solids For the analytical procedure to be realistic it should account for large displacements and non linear behaviour including strain softening Because of these considerations the designers have followed procedures based on simplifying assumptions such as linear small strain elastoplastic behaviour Numerical procedures based on such assumptions though very popular in other branches of engineering have made little impact in geo engineering An attempt has been made in this book to compile the recent use of distinct element codes for solutions of some of the problems in geomechanics particularly those involving excavations It is hoped that it will provide an opportunity for the fraternity of geotechnical engineers to appreciate the opening of new frontiers in the use of computers for solving more challenging geotechnical problems

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