

Rock Mechanics Theory And Applications With Case Histories

Traditional textbooks on rock mechanics often fail to engage students in the learning process as such books are packed with theory that students are unlikely to use in their future employment. In contrast, this book delivers the fundamentals of rock mechanics using a more practical and engaging project-based approach which simulates what practitioners do in their real-life practice. This book will be of great help to those who would like to learn practical aspects of rock mechanics and better understand how to apply theory to solve real engineering problems. This book covers geology, rock mechanics principles, and practical applications such as rock falls, slope stability analysis and engineering problems in tunnels. Throughout the whole book, the reader is engaged in project-based work so that the reader can experience what rock mechanics is like and clearly see why it is an important part of geotechnical engineering. The project utilizes real field and laboratory data while the relevant theory needed to execute the project is linked to each project task. In addition, each section of the book contains several exercises and quiz questions to scaffold learning. Some problems include open-ended questions to encourage the reader to exercise their judgement and develop practical skills. To foster the learning process, solutions to all questions are provided to allow for learning feedback.

Rock mechanics is a first course in the field of mining and geotechnical engineering. Over the last decades, the concepts and applications of rock mechanics have evolved tremendously for understanding the stability and safety of structures made of/on the rock masses. This book elaborates the fundamental concepts of rock mechanics for designing and analysis of structures and excavations for a variety of applications. The text includes a fine blend of theory and worked-out examples and applications, and also emphasises the basics of stress and strain analysis, volume–weight relationship, rock mass classification systems, in situ stress measurements, stresses around underground opening, pillar and support design, subsidence, slope stability, rock failure criteria and behaviour of jointed rock mass. Numerical analysis procedures and interaction between rock bolts and rock masses are also introduced emphasising the mechanics and applications in rock engineering. Besides undergraduate and postgraduate students of civil (including geotechnical), mining and petroleum engineering, the book will also benefit the practicing engineers and researchers, who wish to acquaint themselves with state-of-the-art techniques of rock mechanics and its applications. Overall, this textbook is useful for both elementary as well as advanced learning.

This book thoroughly describes a theory concerning the yield and failure of materials under multi-axial stresses – the Unified Strength Theory, which was first proposed by the author and has been frequently quoted since. It provides a system of yield and failure criteria adopted for most materials, from metals to rocks, concretes, soils, and polymers. This new edition includes six additional chapters: General behavior of Strength theory function; Visualization of the Unified Strength Theory; Equivalent Stress of the UST and Comparisons with other criteria; Economic Signification of the UST; General form of failure criterion; Beauty of Strength Theories. It is intended for researchers and graduate students in various fields, including engineering mechanics,

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material mechanics, plasticity, soil mechanics, rock mechanics, mechanics of metallic materials and civil engineering, hydraulic engineering, geotechnical engineering, mechanical engineering and military engineering.

The two-volume set *Rock Mechanics and Rock Engineering* is concerned with the application of the principles of mechanics to physical, chemical and electro-magnetic processes in the upper-most layers of the earth and the design and construction of the rock structures associated with civil engineering and exploitation or extraction of natural resources in mining and petroleum engineering. Volume 2, *Applications of Rock Mechanics – Rock Engineering*, discusses the applications of rock mechanics to engineering structures in/on rock, rock excavation techniques and in-situ monitoring techniques, giving some specific examples. The dynamic aspects associated with the science of earthquakes and their effect on rock structures, and the characteristics of vibrations induced by machinery, blasting and impacts as well as measuring techniques are described. Furthermore, the degradation and maintenance processes in rock engineering are explained. *Rock Mechanics and Rock Engineering* is intended to be a fundamental resource for younger generations and newcomers and a reference book for experts specialized in *Rock Mechanics and Rock Engineering* and associated with the fields of mining, civil and petroleum engineering, engineering geology, and/or specialized in Geophysics and concerned with earthquake science and engineering. The two-volume set *Rock Mechanics and Rock Engineering* is concerned with the application of the principles of mechanics to physical, chemical and electro-magnetic processes in the upper-most layers of the earth and the design and construction of the rock structures associated with civil engineering and exploitation or extraction of natural resources in mining and petroleum engineering. Volume 1, *Fundamentals of Rock Mechanics*, discusses rock-constituting elements, discontinuities and their behavior under various physical and chemical actions in nature. The governing equations together with constitutive laws and experimental techniques and the solution techniques are explained and some examples of applications are given. A number of chapters are devoted to possible new directions in rock mechanics. *Rock Mechanics and Rock Engineering* is intended to be a fundamental resource for younger generations and newcomers and a reference book for experts specialized in *Rock Mechanics and Rock Engineering* and associated with the fields of mining, civil and petroleum engineering, engineering geology, and/or specialized in Geophysics and concerned with earthquake science and engineering.

This practical and design-oriented book focuses on ground characterization and structural calculation, as part of the active structural design methodology. With a focus on rock tunnelling it offers a comprehensive rather than a topic-based perspective, deriving sound tunnel design criteria and methods from basic principles. Ground characterization includes excavations, site investigation, and in situ stress determination, culminating in geotechnical classifications. The book then deals with various construction methods and their appropriate calculations, which range from constitutive models for the stress-strain behaviour of an excavation and tunnel support elements to a full stress–strain analysis methodology. The heavily practical approach of the book draws on the authors' twenty years of tunnelling experience in Spain and South America. It will help any young or established professional who wants to develop a career in the underground field across both civil engineering and geology. As it

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incorporates the very fundamentals of tunneling design, it can be used as a support for tunneling courses or as a textbook for master's and PhD courses. Benjamín Celada was Chief Tunnel Engineer at Hunosa and Potasas de Navarra S.A. before founding Geocontrol S.A. He has also worked for twenty years as Professor of Underground Works at the Polytechnic Mining University in Madrid, Spain. Z. T. Bieniawski directed the Rock Mechanics Department of the Council for Scientific and Industrial Research in Pretoria, then taught at the Pennsylvania State University for twenty years.

Rock dynamics studies the response of rock materials and rock masses under dynamic loading conditions. In the last a couple of decades, the development of experimental and computational techniques has been able to capture the progress of fracturing in microsecond steps, allowing the exploration on how the fracture is initiated, propagated and branched

Although theoretical in character, this book provides a useful source of information for those dealing with practical problems relating to rock and soil mechanics - a discipline which, in the view of the authors, attempts to apply the theory of continuum to the mechanical investigation of rock and soil media. The book is in two separate parts. The first part, embodying the first three chapters, is devoted to a description of the media of interest. Chapter 1 introduces the main argument and discusses the essence of the discipline and its links with other branches of science which are concerned, on the one hand, with technical mechanics and, on the other, with the properties, origins, and formation of rock and soil strata under natural field conditions. Chapter 2 describes mechanical models of bodies useful for the purpose of the discourse and defines the concept of the limit shear resistance of soils and rocks. Chapter 3 gives the actual properties of soils and rocks determined from experiments in laboratories and in situ. Several tests used in geotechnical engineering are described and interconnections between the physical state of rocks and soils and their rheological parameters are considered. The second part of the book considers the applications of various theories which were either first developed for descriptive purposes in continuum mechanics and then adopted in soil and rock mechanics, or were specially developed for the latter discipline. Chapter 4 discusses the application of the theory of linear viscoelasticity in solving problems of stable behaviour of rocks and soils. Chapter 5 covers the use of the groundwater flow theory as applied to several problems connected with water movement in an undeformable soil or rock skeleton. Chapter 6 is a natural expansion of the arguments put forward in the previous chapter. Here the movement of water is regarded as the cause of deformation of the rock or soil skeleton and the consolidation theory developed on this basis is presented in a novel formulation. Some new engineering solutions are also reported. The seventh chapter is devoted to the limit state theory as applied to the study of the mechanical behaviour of soils and rocks. It presents some new solutions and methods which include both static and kinematic aspects of the problem, and some original effective methods for investigating media of limited cohesion. The final chapter gives a systematic account of the mechanics of highly dispersed

soils, commonly called clays.

This congress proceedings provides recent research on leading-edge manufacturing processes. The aim of this scientific congress is to work out diverse individual solutions of "production at the leading edge of technology" and transferable methodological approaches. In addition, guest speakers with different backgrounds will give the congress participants food for thoughts, interpretations, views and suggestions. The manufacturing industry is currently undergoing a profound structural change, which on the one hand produces innovative solutions through the use of high-performance communication and information technology, and on the other hand is driven by new requirements for goods, especially in the mobility and energy sector. With the social discourse on how we should live and act primarily according to guidelines of sustainability, structural change is gaining increasing dynamic. It is essential to translate politically specified sustainability goals into socially accepted and marketable technical solutions. Production research is meeting this challenge and will make important contributions and provide innovative solutions from different perspectives.

Important developments in the progress of the theory of rock mechanics during recent years are based on fractals and damage mechanics. The concept of fractals has proved to be a useful way of describing the statistics of naturally occurring geometrics. Natural objects, from mountains and coastlines to clouds and forests, are found to have boundaries best described as fractals. Fluid flow through jointed rock masses and clusterings of earthquakes are found to follow fractal patterns in time and space. Fracturing in rocks at all scales, from the microscale (microcracks) to the continental scale (megafaults), can lead to fractal structures. The process of diagenesis and pore geometry of sedimentary rock can be quantitatively described by fractals, etc. The book is mainly concerned with these developments, as related to fractal descriptions of fragmentations, damage and fracture of rocks, rock burst, joint roughness, rock porosity and permeability, rock grain growth, rock and soil particles, shear slips, fluid flow through jointed rocks, faults, earthquake clustering, and so on. The prime concerns of the book are to give a simple account of the basic concepts, methods of fractal geometry, and their applications to rock mechanics, geology, and seismology, and also to discuss damage mechanics of rocks and its application to mining engineering. The book can be used as a textbook for graduate students, by university teachers to prepare courses and seminars, and by active scientists who want to become familiar with a fascinating new field. This new edition has been completely revised to reflect the notable innovations in mining engineering and the remarkable developments in the science of rock mechanics and the practice of rock engineering that have taken place over the last two decades. Although "Rock Mechanics for Underground Mining" addresses many of the rock mechanics issues that arise in underground mining engineering, it is not a text exclusively for mining applications. Based on extensive

professional research and teaching experience, this book will provide an authoritative and comprehensive text for final year undergraduates and commencing postgraduate students. For professional practitioners, not only will it be of interests to mining and geological engineers, but also to civil engineers, structural mining geologists and geophysicists as a standard work for professional reference purposes.

The analysis of crack problems through fracture mechanics has been applied to the study of materials such as glass, metals and ceramics because relatively simple fracture criteria describe the failure of these materials. The increased attention paid to experimental rock fracture mechanics has led to major contributions to the solving of geophysical problems. The text presents a concise treatment of the physics and mathematics of a representative selection of problems from areas such as earthquake mechanics and prediction, hydraulic fracturing, hot dry rock geothermal energy, fault mechanics, and dynamic fragmentation.

The expansion of unconventional petroleum resources in the recent decade and the rapid development of computational technology have provided the opportunity to develop and apply 3D numerical modeling technology to simulate the hydraulic fracturing of shale and tight sand formations. This book presents 3D numerical modeling technologies for hydraulic fracturing developed in recent years, and introduces solutions to various 3D geomechanical problems related to hydraulic fracturing. In the solution processes of the case studies included in the book, fully coupled multi-physics modeling has been adopted, along with innovative computational techniques, such as submodeling. In practice, hydraulic fracturing is an essential project component in shale gas/oil development and tight sand oil, and provides an essential measure in the process of drilling cuttings reinjection (CRI). It is also an essential measure for widened mud weight window (MWW) when drilling through naturally fractured formations; the process of hydraulic plugging is a typical application of hydraulic fracturing. 3D modeling and numerical analysis of hydraulic fracturing is essential for the successful development of tight oil/gas formations: it provides accurate solutions for optimized stage intervals in a multistage fracking job. It also provides optimized well-spacing for the design of zipper-frac wells. Numerical estimation of casing integrity under stimulation injection in the hydraulic fracturing process is one of major concerns in the successful development of unconventional resources. This topic is also investigated numerically in this book. Numerical solutions to several other typical geomechanics problems related to hydraulic fracturing, such as fluid migration caused by fault reactivation and seismic activities, are also presented. This book can be used as a reference textbook to petroleum, geotechnical and geothermal engineers, to senior undergraduate, graduate and postgraduate students, and to geologists, hydrogeologists, geophysicists and applied mathematicians working in this field. This book is also a synthetic compendium of both the fundamentals and some of the most advanced aspects of hydraulic

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fracturing technology.

This book focuses on the fundamentals of rock mechanics as a basis for the safe and economical design and construction of tunnels, dam foundations and slopes in jointed and anisotropic rock. It is divided into four main parts: - Fundamentals and models - Analysis and design methods - Exploration, testing and monitoring - Applications and case histories. The rock mechanical models presented account for the influence of discontinuities on the stress-strain behavior and the permeability of jointed rock masses. This book is for: - Civil- and Mining-Engineers - Geologists - Students in the related fields

Principles is the first volume of the five-volume set Rock Mechanics and Engineering and contains twenty-four chapters from key experts in the following fields: - Discontinuities; - Anisotropy; - Rock Stress; - Geophysics; - Strength Criteria; - Modeling Rock Deformation and Failure. 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 wideranging 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 worldrenowned 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.

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This book treats the mechanics of porous materials infiltrated with a fluid (poromechanics), focussing on its linear theory (poroelasticity). Porous materials from inanimate bodies such as sand, soil and rock, living bodies such as plant tissue, animal flesh, or man-made materials can look very different due to their different origins, but as readers will see, the underlying physical principles governing their mechanical behaviors can be the same, making this work relevant not only to engineers but also to scientists across other scientific disciplines. Readers will find discussions of physical phenomena including soil

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consolidation, land subsidence, slope stability, borehole failure, hydraulic fracturing, water wave and seabed interaction, earthquake aftershock, fluid injection induced seismicity and heat induced pore pressure spalling as well as discussions of seismoelectric and seismoelectromagnetic effects. The work also explores the biomechanics of cartilage, bone and blood vessels. Chapters present theory using an intuitive, phenomenological approach at the bulk continuum level, and a thermodynamics-based variational energy approach at the micromechanical level. The physical mechanisms covered extend from the quasi-static theory of poroelasticity to poroelastodynamics, poroviscoelasticity, porothermoelasticity, and porochemoelasticity. Closed form analytical solutions are derived in details. This book provides an excellent introduction to linear poroelasticity and is especially relevant to those involved in civil engineering, petroleum and reservoir engineering, rock mechanics, hydrology, geophysics, and biomechanics.

This book provides a comprehensive coverage of the theory and principle of the Hoek-Brown (HB) failure criterion, methods or guidelines for estimating the HB input parameters, and the methodology of application of the HB criterion in rock engineering projects. It aims to help researchers, engineers and research students who work in the area of rock mechanics and mining engineering.

Academics can quickly obtain an overview of the state of the art of the theory and principle of the Hoek-Brown criterion by reading the book before they advance their researches on the topics related to rock failure criteria. Geotechnical engineers can select appropriate Hoek-Brown input parameters for the design and analysis of rock engineering projects with the help of the principles introduced in this book. Research students may use the book as a textbook to learn the principle of rock mechanics related to rock mass properties.

Engineering Rock Mechanics Part II: Illustrative Worked Examples can be used as an independent book or alternatively it complements an earlier publication called Engineering Rock Mechanics: An Introduction to the Principles by the same authors. It contains illustrative worked examples of engineering rock mechanics in action as the subject applies to civil, mining, petroleum and environmental engineering. The book covers the necessary understanding and the key techniques supporting the rock engineering design of structural foundations, dams, rock slopes, wellbores, tunnels, caverns, hydroelectric schemes and mines. There is a question and worked answer presentation with the question and answer sets collated into twenty chapters which match the subject matter of the first book.

Much of the research on fracture of rocks or rock-like materials conducted over the past two decades may be considered as "academic studies" of the general phenomenon of fracture. Yet, the understanding of this phenomenon is fundamental if a material is used in any engineering design, whether the aim is to prevent failure of the structure or to promote it. Fracture theories existing are generally empirical and derived from experimental results of laboratory test with

simple boundary conditions. Because of the basic weakness of rock intension and because in general the environmental stresses in rock mechanics are compressive most of these theories consider fracture under compressive stress conditions. The Coulomb-Navier-, the Mohr-, the Griffith and the McClintock and Walsh criteria are typical examples and will be considered in the following. In addition the tendency during the past was in making accurate experiments under conditions of homogeneous stresses. To obtain information about the fracture behaviour with unequal principal stresses systems have to be used which involve inhomogeneous stresses. This case is of particular interest, since in practical rock mechanics we may expect conditions of highly inhomogeneous stresses. However, a consideration of such situations involve additional assumptions like the applicability of the theory of elasticity for calculating the stress field, which may be open to question. A distinction has to be made between fracture initiation and fracture propagation, since a detailed observation of the total fracture process in rock was possible by means of "stiff" and "servo-controlled" loading systems.

The field of rock mechanics and rock engineering utilizes the basic laws of continuum mechanics and the techniques developed in computational mechanics. This book describes the basic concepts behind these fundamental laws and their utilization in practice irrespective of whether rock/rock mass contains discontinuities. This book consists of nine chapters and six appendices. The first four chapters are concerned with continuum mechanics aspects, which include the basic operations, definition of stress and strain tensors, and derivation of four fundamental conservation laws in the simplest yet precise manner. The next two chapters are the preparation for computational mechanics, which require constitutive laws of geomaterials relevant to each conservation law and the procedures for how to determine required parameters of the constitutive laws. Computational mechanics solves the resulting ordinary and partial differential equations. In Chapter 7, the methods of exact (closed-form) solutions are explained and they are applied to ordinary/partial differential equations with solvable boundary and initial conditions. In Chapter 8, the fundamentals of approximate solution methods are explained for one dimension first and then how to extend them to multi-dimensional problems. The readers are expected to learn and clearly understand how they are derived and applied to various problems in geomechanics. The final chapter involves the applications of the approximate methods to the actual problems in practice for geomechanical engineers, which cover the continuum to discontinuum, including the stress state of the earth as well as the ground motions induced by earthquakes. Six appendices are provided to have a clear understanding of continuum mechanics operations and procedures for how to deal with discontinuities/interfaces often encountered in rock mechanics and rock engineering.

Rock Dynamics – Experiments, Theories and Applications is a collection of scientific and technical papers presented at the Third International Conference on Rock

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Dynamics and Applications (RocDyn-3, Trondheim, Norway, 26-27 June 2018). The papers in the book reflect the recent developments in experiment and theory as well as engineering applications of rock dynamics. Rock dynamics studies the response of rock and rock masses under dynamic loading and during the state transition from static loading to kinetic movement. It also includes the study of engineering countermeasures to dynamic instability of rock and rock masses. The topics in the book include: - Dynamic theories - Numerical simulation - Propagation of stress waves - Dynamic tests of rock - Stability of underground openings under dynamic loading - Rockburst - Seismic monitoring - Dynamic rock support - Blasting - Earthquake-related rock structure damage, etc. Applications, such as rockburst, dynamic rock support, seismic monitoring, blasting and earthquake-related rock structure damage, are paid special attention in Rock Dynamics – Experiments, Theories and Applications. The papers, from specialists both from mining and tunnelling branches, discuss commonly interested dynamic issues. Their experience and knowledge in the application of rock dynamics are extremely valuable for all academics, engineers and professionals who work with rock dynamics.

Rock dynamics has become one of the most important topics in the field of rock mechanics and rock engineering. The spectrum of rock dynamics is very wide and it includes the failure of rocks, rock masses and rock engineering structures such as rockbursting, spalling, popping, collapse, toppling, sliding, blasting, non-destructive testing, geophysical explorations, science and engineering of rocks and impacts. The book specifically covers fundamentals of rock dynamics, constitutive models, numerical analysis techniques, dynamic testing procedures, the multi-parameter responses and motions of rocks during fracturing or slippage in laboratory experiments, earthquakes and their strong motion characteristics and their effect on various rock structures such as foundations, underground structures, slopes, dynamic simulation of loading and excavation, blasting and its positive utilization in rock engineering, the phenomenon of rockburst in rock excavations, non-destructive testing of rockbolts and rock anchors and impacts by meteors or projectiles. The main goal of this book is to present a unified and complete treatise on Rock Dynamics and to represent a milestone in advancing the knowledge in this field and in leading to new techniques for experiments, analytical and numerical modelling as well as monitoring of dynamics of rocks and rock engineering structures.

The book introduces the reader to the fundamentals of rock mechanics and to its application to economic construction in rock. Models describe the mechanical properties and the permeability of rock. Numerical methods for evaluating the stability of structures in rock are given to solve special problems related to tunnels, caverns, pressure tunnels, dam foundations and slopes. Methods for testing the rock mechanical properties are described. A number of case histories enable the reader to make use of the content in his or her own work.

This volume presents the proceedings of a symposium on rock mechanics, held in the USA in 1995. Topics covered include: rock dynamics; tool-rock interaction; radioactive waste disposal; underground mining; fragmentation and blasting; theoretical and model studies; hydrology; and rock creep.

This proceedings volume contains over 300 papers on rock mechanics and engineering with contributors from all over Asia and many other parts of the world. Seven keynote

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papers summarize the state-of-the-art in rock engineering including topics such as underground rock caverns. The technical papers cover a wide range of rock mechanics and engineering topics: rock tunnels, caverns, mining, rock slopes and dams, rock blasting, rock burst and failure, rock properties, rock mass, rock joints, and block theory. Numerous valuable rock engineering case studies are also reported. This volume should serve as a useful reference for the engineers and researchers in rock mechanics and rock engineering. Sample Chapter(s). Chapter 1: Forensic Engineering for Underground Construction (244 KB). Contents: Tunnelling; Rock Caverns; Mining; Blasting and Dynamics; Support and Reinforcement; Rock Mass; Rock Properties; Discontinuities; Block Theory and DDA; Failure, Fracture and Burst; Dams and Slopes; Other Applications. Readership: Graduate students, academics and researchers in civil engineering and engineering mechanics.

An Ideal Source for Geologists and Others with Little Background in Engineering or Mechanics Practical Rock Mechanics provides an introduction for graduate students as well as a reference guide for practicing engineering geologists and geotechnical engineers. The book considers fundamental geological processes that give rise to the nature of rock masses and control their mechanical behavior. Stresses in the earth's crust are discussed and methods of measurement and prediction explained. Ways to investigate, describe, test, and characterize rocks in the laboratory and at project scale are reviewed. The application of rock mechanics principles to the design of engineering structures including tunnels, foundations, and slopes is addressed. The book is illustrated throughout with simple figures and photographs, and important concepts are illustrated by modern case examples. Mathematical equations are kept to the minimum necessary and are explained fully—the book leans towards practice rather than theory. This text: Addresses the principles of rock mechanics as it applies to both structural geology and engineering practice Demonstrates the importance of and methods of geological characterisation to rock engineering Examines the standard methods of rock mechanics testing and measurement as well as interpretation of data in practice Explains connections between main parameters both empirically as well as on the basis of scientific theory Provides examples of the practice of rock mechanics to major engineering projects Practical Rock Mechanics teaches from first principles and aids readers' understanding of the concepts of stress and stress transformation and the practical application of rock mechanics theory. This text can help ensure that ground models and designs are correct, realistic, and produced cost-effectively.

This book presents some fundamental concepts behind the basic theories and tools of discrete element methods (DEM), its historical development, and its wide scope of applications in geology, geophysics and rock engineering. Unlike almost all books available on the general subject of DEM, this book includes coverage of both explicit and implicit DEM approaches, namely the Distinct Element Methods and Discontinuous Deformation Analysis (DDA) for both rigid and deformable blocks and particle systems, 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

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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

Provides practical solutions to the challenge of modeling and analyzing rock masses

Consolidates a wealth of previously published technical papers on the subject and introduces previously unseen material This authoritative title is a key reference for any Geo-engineer.

Rock masses differ considerably from man-made materials, and their properties can vary with location, direction and time. As a result there is a critical need to capture these variations via modeling and analysis. Zhu and Zhao provide an expert introduction to the techniques and analytical methods needed for studying underground excavations in fractured rock masses.

The book brings together previously published and new material to provide a comprehensive and up-to-date reference. Provides practical solutions to the challenge of modeling and analyzing rock masses Consolidates a wealth of previously published technical papers on the subject and introduces previously unseen material

The development of constitutive relations for geotechnical materials, with the help of numerical models, have increased notably the ability to predict and to interpret the mechanical behaviour of geotechnical works. This work covers rock excavations, soil excavations, earth fills and dams.

This book contains probabilistic analyses and reliability-based designs (RBDs) for the enhancement of Eurocode 7 (EC7) and load and resistance factor design (LRFD) methods. An intuitive perspective and efficient computational procedure for the first-order reliability method (FORM, which includes the Hasofer–Lind reliability index) is explained, together with discussions on the similarities and differences between the design point of EC7/LRFD and RBD-via-FORM. Probability-based designs with respect to the ultimate and serviceability limit states are demonstrated for soil and rock engineering, including shallow and deep foundations, earth-retaining structures, soil slopes, 2D rock slopes with discontinuities, 3D rock slopes with wedge mechanisms, and underground rock excavations. Renowned cases in soil and rock engineering are analyzed both deterministically and probabilistically, and comparisons are made with other probabilistic methods. This book is ideal for practitioners, graduate students and researchers and all who want to deepen their understanding of geotechnical RBD accounting for uncertainty and overcome some limitations and potential pitfalls of the evolving LRFD and EC7. Solutions for the book's examples are available online and are helpful to acquire a hands-on appreciation: <https://www.routledge.com/9780367631390>.

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