Constitutive Modelling Of Granular Materials

Studies in Applied Mechanics, Volume 7: Mechanics of Granular Materials: New Models and Constitutive Relations provides information pertinent to the fundamental aspects of the mechanics of granular materials. This book presents the theoretical and experimental studies of quasi-static deformations of granular materials. Organized into 30 chapters, this volume begins with an overview of the results on the description of a macroscopic stress measure and measures of the fabric of granular masses that support external loads through frictional contact. This text then introduces some quantities for the macroscopic description of mechanical and graphical characteristics of granular materials. Other chapters consider particle rolling, which appears to be a major microscopic deformation mechanism when interparticle friction is large. This book discusses as well the stress-induced anisotropy of granular materials that have initially strong anisotropic fabric. The final chapter deals with the interpretation of linear instabilities of voidage disturbances in fluidized beds. This book is a valuable resource for scientists, theoreticians, and experimentalists.

Constitutive modeling of granular material behavior has generally been based on global response of laboratory-size specimens or larger models with little understanding of the fundamental mechanics that drive the global response. Many studies have acknowledged the importance of micro-scale and meso-scale mechanics on the constitutive behavior of granular materials. However, much knowledge is still missing to develop and improve robust micromechanical constitutive models. The research in this dissertation contributes to this knowledge gap for many potential applications using novel experimental techniques to investigate the three-dimensional (3D) behavior of granular materials. Critical micromechanics measurements at multiple scales are investigated by combining 3D synchrotron micro-computed tomography (SMT), 3D image analysis, and finite element analysis (FEA). At the single particle level (micro-scale), particle fracture was examined at strain rates of 0.2 mm/min and 2 m/s using quasi-static unconfined compression, unconfined mini-Kolsky bar, and x-ray imaging techniques. Surface reconstructions of particles were generated and exported to Abaqus FEA software, where quasi-static and higher rate loading curves and crack propagation were simulated with good accuracy. Stress concentrations in oddly shaped particles during FEA simulations resulted in more realistic fracture stresses than theoretical models. A nonlinear multivariable statistical model was developed to predict force required to fracture individual particles with known internal structure and loading geometry. At the meso-scale, 3D SMT imaging during in-situ triaxial testing of granular materials were used to identify particle morphology, contacts, kinematics and interparticle behavior. Micro shear bands (MSB) were exposed during pre-peak stress using a new relative particle displacement concept developed in this dissertation. MSB for spherical particles (glass beads) had larger thickness (3d50 to 5d50) than that of angular sands (such as F35 Ottawa sand, MSB thickness of 1d50 to 3d50). Particle morphology also plays a significant role in the onset and growth of shear bands and global fabric evolution of granular materials. More spherical particles typically exhibit more homogeneous internal anisotropy. Fabric of particles within the shear band (at higher densities and confining pressures) exhibits a peak and decrease into steady-state. Also, experimental fabric produces more accurate strength and deformation predictions in constitutive models that incorporate fabric evolution.

Microscopic re-examination of geomaterials consisting of aggregates can shed light on macroscopic behaviour, including compressibility, anisotropy, yielding, creep, cyclic liquefaction and shear rupture. As a result of this process of examination, new methods of material characterization emerge, leading to a greater degree of accuracy in the specification of new constitutive models with physically-meaningful parameters. The impetus behind this development is an increasing awareness on sustainability, leading to the more efficient use of recycled materials for geotechnical applications. The characteristics of recycled materials, such as compressibility and self-hardening, may differ significantly from those of natural materials, and it is crucial that evaluation is made from a specifically particulate perspective.

The Application of a Constitutive Model for Granular Materials to True Triaxial Conditions and Stress Rotations
Constitutive Modelling of Granular Materials

Advances in Spatio-Temporal Analysis
Applications and developments of Barodesy

This monograph contains original results in the field of mathematical and numerical modeling of mechanical behavior of granular materials and materials with different strengths. It proposes new models helping to define zones of the strain localization. The book shows how to analyze processes of the propagation of elastic and elastic-plastic waves in loosened materials, and constructs models of mixed type, describing the flow of granular materials in the presence of quasi-static deformation zones. In a last part, the book studies a numerical realization of the models on multiprocessor computer systems. The book is intended for scientific researchers, lecturers of universities, post-graduates and senior students, who specialize in the field of the deformable materials mechanics, mathematical modeling and adjacent fields of applied and calculus mathematics.

Barodesy is a constitutive model for granular materials such as sand and clay. It is based on the asymptotic behaviour of granular media at a constant deformation rate. In this work the existing sand version of Barodesy is improved. For this purpose, the underlying scalar equations are simplified using different concepts from soil mechanics. The improved version is also compared with laboratory tests and different elastoplastic and hypoplastic constitutive relations. Also the stability of slopes and advanced stress paths such as the rotation of the princple stresses are investigated with these models.

Granular or particulate materials arise in almost every aspect of our lives, including many familiar materials such as tea, coffee, sugar, sand, cement and powders. At some stage almost every industrial process involves a particulate material, and it is usually the cause of the disruption to the smooth running of the process. In the natural environment, understanding the behaviour of particulate materials is vital in many geophysical processes such as earthquakes, landslides and avalanches. This book is a collection of current research from some of the major contributors in the topic of modelling the behaviour of granular materials. Papers from every area of current activity are included, such as theoretical, numerical, engineering and computational approaches. This book illustrates the numerous diverse approaches to one of the outstanding problems of modern continuum mechanics.

Practice of Constitutive Modelling for Saturated Soils
Mathematical Modeling in Mechanics of Granular Materials
Physically-based Constitutive Modeling of Granular Materials
Numerical Implementation of an Advanced Constitutive Model for Granular Materials

Granular Materials

Modern continuum mechanics is the topic of this book. After its introduction it will be applied to a few typical systems arising in the environmental sciences and in geophysics. In large lake/ocean dynamics peculiar effects of the rotation of the Earth will be analyzed in linear/nonlinear processes of a homogenous and inhomogenous water body. Strong thermomechanical coupling paired with nonlinear rheology affects the flow of large ice sheets (such as Antarctica and Greenland) and ice shelves. Its response to the climatic forcing in an environmental of greenhouse warming may significantly affect the life of future generations. The mechanical behavior of granular materials under quasistatic loadings requires non-classical mixture concepts and encounters generally complicated elastic-plastic-type constitutive behavior. Creeping flow of soils, consolidation processes and ground water flow are described by such theories. Rapid shearing flow of granular materials lead to constitutive relations for the stresses which incorporate rate independent behavior of Mohr-Coulomb type together with dispersive stress contributions due to particle collisions. Rockfalls, sturzstroms, snow and ice avalanches, but also debris flow and sea ice drifting can be described with such formulations.

Constitutive modelling of granulate materials has achieved significant progress in recent times although some challenging problems still remain to be solved. Many of the 35 contributions in this volume are devoted to modelling but there are also papers investigating the phenomena to be modelled. For instance, there are reviews on several aspects of the behaviour of granulates which are mere material properties while other aspects are related to the ill-posedness of the corresponding boundary value problems.

The work provides a comprehensive and up to date treatise on the theory of plasticity in granular materials, together with a great number of solution methods and applications. The volume is intended for researchers and practising engineers who wish to enhance their knowledge in this rapidly expanding field.

Developments in Geographic Information Technology have raised the expectations of users. A static map is no longer enough; there is now demand for a dynamic representation. Time is of great importance when operating on real world geographical phenomena, especially when these are dynamic. Researchers in the field of Temporal Geographical Information Systems (TGIS) have been developing methods of incorporating time into geographical information systems. Spatio-temporal analysis embodies spatial modelling, spatio-temporal modelling and spatial reasoning and data mining. Advances in Spatio-Temporal Analysis contributes to the field of spatio-temporal analysis, presenting innovative ideas and examples that reflect current progress and achievements.

Constitutive Behaviour of Granular Materials

Constitutive Models for Rapidly Deforming Granular Materials

High Stress Flow Behaviour and Constitutive Modeling of Dry Granular Materials

Neural Network-based Constitutive Modeling of Granular Material

Fundamentals and Applications

The science of complex materials continues to engage researchers from a vast range of disciplines, including physics, mathematics, computational science, and virtually all domains of engineering. This volume presents a unique multidisciplinary panorama of the current research in complex materials. The contributions explore an array of problems reflecting recent developments in four main areas: characterization and modeling of disordered packings, micromechanics and continuum theory; discrete element method; statistical mechanics. The common theme is the quest to unravel the connection between the microscopic and macroscopic properties of complex materials. Sample Chapter(s). Chapter 1: Foam as granular matter (2,433 KB). Contents: Foam as Granular Matter (D Weaire et al.); Delaunay Simplex Analysis of the Structure of Equal Sized Spheres (A V Anikeenko et al.); On Entropic Characterization of Granular Materials (R Blumenfeld); Mathematical Modeling of Granular Flow-Slides (I Vardoulakis & S Alevizos); The Mechanics of Brittle Granular Materials (I Einav); Stranger than Friction: Force Chain Buckling and Its Implications for Constitutive Modelling (A Tordesillas); Investigations of Size Effects in Granular Bodies During Plane Strain Compression (J Tejchman & J Grski); Granular Flows: Fundamentals and Applications (P W Cleary); Fine Tuning DEM Simulations to Perform Virtual Experiments with Three-Dimensional Granular Packings (G W Delaney et al.); Fluctuations in Granular Materials (R P Behringer); Statistical Mechanics of Dense Granular Media (M Pica Ciamarra et al.); Compaction of Granular Systems (P Richard et al.). Readership: Physicists, material scientists, soil engineers and applied mathematicians.

Granular Materials at Meso-scale: Towards a Change of Scale Approach proposes a new way

for developing an efficient change of scale—considering a meso-scale defined at the level of local arrays of particles. The change of scale is known to be a very interesting way to improve the modelling of mechanical behavior granular materials. In the past, studies have been proposed using a micro-scale at the grain level to perform change of scale, but limitations have been proven for these approaches. Definition and analysis of the phases are detailed, constituted by sets of meso-domains sharing the same texture characteristics. The authors propose a local constitutive model for the phases, allowing the constitutive model of the representative elementary volume to be definied from a change-of-scale approach and, finally, presenting the validation of obtained modeling on cyclic loadings. Proposes a new way for developing an efficient change of scale—considering a meso-scale Explores local meso-domains and texture characteristics Defines meso-strain and stress Analyzes the evolution of these variables and texture characteristics in relation to the applied loading

Particulate discrete element analysis is becoming increasingly popular for research in geomechanics as well as geology, chemical engineering, powder technology, petroleum engineering and in studying the physics of granular materials. With increased computing power, practising engineers are also becoming more interested in using this technology for analysis in industrial applications. This is the first single work on Discrete Element Modelling (DEM) providing the information to get started with this powerful numerical modelling approach. Written by an independent author with experience both in developing DEM codes and using commercial codes, this book provides the basic details of the numerical method and the approaches used to interpret the results of DEM simulations. Providing a basic overview of the numerical method, Particulate Discrete Element Modelling discusses issues related to time integration and numerical stability, particle types, contact modelling and boundary conditions. It summarizes approaches to interpret DEM data so that users can maximize their insight into the material response using DEM. The aim of this book is to provide both users and prospective users of DEM with a concise reference book that includes tips to optimize their usage. Particulate Discrete Element Modelling is suitable both for first time DEM analysts as well as more experienced users. It will be of use to professionals, researchers and higher level students, as it presents a theoretical overview of DEM as well as practical guidance on running DEM simulations and interpreting DEM simulation data.

Granular and Complex Materials

Constitutive Equations for Granular Materials

A Constitutive Model for Non-linear Granular Materials

A Fabric Related Constitutive Model for Granular Materials

Constitutive Models for Granular Materials Including Quasi-static Frictional Behaviour

This book presents a complete and comprehensive analysis of the behaviour of granular materials including the description of experimental results, the different ways to define the global behaviour from local phenomena at the particle scale, the various modellings which can be used for a D.E.M. analysis to solve practical problems and finally the analysis of strain localisation. The concepts developed in this book are applicable to many kinds of granular materials considered in civil, mechanical or chemical engineering.

This textbook compiles reports written by about 35 internationally recognized authorities, and covers a range of interests for geotechnical engineers. Topics include: fundamentals for mechanics of granular materials; continuum theory of granular materials; and discrete element approaches.

These basic results regarding the microscopic grain-interactions are generic to granular media and have important consequences for constitutive modeling. In particular we show that kinetic theories, which assume binary collisions, only apply below the network transition. In this regime we show that Enskog kinetic theory agrees with data from the simulations. We then proceed to introduce two analytical theories that use the observed microscopic grain-interactions to make predictions. First we propose a new constitutive model--the Force-Network model--that quantitatively predicts constitutive relations using properties of the force-networks for all values of xi. Second we demonstrate that STZ theory, which predicts constitutive relations by assuming certain dynamical correlations in amorphous materials, is in agreement with both the microscopic motion of grains and measured constitutive relations for large xi.

A Constitutive Model for Granular Materials with Grain Crushing

Modern Approaches to Plasticity

New Models and Constitutive Relations

Granular Materials at Meso-scale

From Discrete Element Modelling to Data-driven Forecasting

In view of its extreme complexity the mathematical description of the mechanical behaviour of granular materials is an extremely difficult task. Today many different models compete with each other. However, the complexity of the models hinders their comparison, and the potential users are confused and, often,

disencouraged. This book is expected to serve as a milestone in the present situation, to evaluate the present methodes, to clear up the situation, to focus and encourage for further research activities.
Landslides include various forms of geological mass movements such as falls, slides and flows under the force of gravity. Predictions of landslide kinematics and dynamics require knowledge of flow behaviour and mathematical modeling. Research into the flow behaviour of granular materials has revealed the existence of rate-dependent collisional behaviour at high shear rates and void ratios as well as rate-independent frictional behaviour at low shear rates and void ratios. However, the results of high stress shear experiments on small particles indicate that shear rate has no effect on flow behaviour. Following this finding, most geotechnical analyses of landslides have considered mainly frictional flow behaviour. Since the collisional behaviour of granular materials depends on particle inertia, both shear rate and particle mass (or particle density and diameter) are equally important in its occurrence. In this research, the relevance of rate-dependent collisional behaviour at high stress was re-investigated using simulation experiments on large size particles. The results indicate that rate-dependent flow behaviour is more likely to occur in rapid-flow landslides involving large particles, such as debris avalanches and rock avalanches. The critical state framework which captures the frictional behaviour was extended to capture rate-dependent collisional behaviour by adding shear rate as an additional state variable, based on the pioneering work of Campbell. The extended framework was used for flow classification, study of flow progress, and constitutive modeling. The effect of particle shape on granular flow behaviour and the extended critical state framework was reviewed using simulation experiments. Selected unified constitutive models proposed by Savage and Louge were evaluated using the extended critical state framework. In this research, new unified constitutive model is developed. The new model combines the frictional and collisional stress contributions using weighting functions called stress coefficients to determine the total stress. The stress coefficients are interdependent and are determined using empirical equations and detailed theoretical analyses. The new model is used to predict the extended critical state framework and implemented in the numerical model for inclined flows. The model performs well in capturing the extended framework and flow profiles of dense granular inclined flows on flat-frictional and rough bases.

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Geomechanics and Geotechnics of Particulate Media

Continuum Mechanics in Environmental Sciences and Geophysics

Behaviour of Granular Materials

Toward a Thermodynamic Theory of Plasticity

This book describes the development of a constitutive modeling platform for soil testing, which is one of the key components in geomechanics and geotechnics. It discusses the fundamentals of the constitutive modeling of soils and illustrates the use of these models to simulate various laboratory tests. To help readers understand the fundamentals and modeling of soil behaviors, it first introduces the general stress–strain relationship of soils and the principles and modeling approaches of various laboratory tests, before examining the ideas and formulations of constitutive models of soils. Moving on to the application of constitutive models, it presents a modeling platform with a practical, simple interface, which includes various kinds of tests and constitutive models ranging from clay to sand, that is used for simulating most kinds of laboratory tests. The book is intended for undergraduate and graduate-level teaching in soil mechanics and geotechnical engineering and other related engineering specialties. Thanks to the inclusion of real-world applications, it is also of use to industry practitioners, opening the door to advanced courses on modeling within the industrial engineering and operations research fields.

Granular materials play an important role in many industries. Continuous ingenuity and advancement in these industries necessitates the ability to predict the fundamental behaviour of granular materials under different working environments. With contributions from international experts in the field Granular Materials; Fundamentals and Applications details recent advances made in theoretical computational and experimental approaches in understanding the behaviour of granular materials including industrial applications. Topics covered include: * key features of granular plasticity * high temperature particle interactions * influence of polymers on particulate dispersion stability: scanning probe microscopy investigations * in-process measurement of particulate systems Presented by world renowned researchers this book will be welcomed by scientists and engineers working across a wide spectrum of engineering disciplines.

Scientists involved with geomaterial modeling honor the retirement of distinguished colleague Frank L. DiMaggio (civil engineering and engineering mechanics, Columbia U.) by offering contributions representing recent advances in the modeling of sand, clay, and concrete. DiMaggio contributed to the d

Nachricht von der in ... Hildburghausen ... errichteten Academie

Theory and Numerical Implementation

A Geomechanics Perspective

Particulate Discrete Element Modelling

Towards a Change of Scale Approach