CGS-SOS February 2021 Workshops
Numerical Modeling in Geotechnical Engineering

SCHEDULE
Feb. 4-25, 2021

Thursday
Feb. 4, 2021
12:00-1:30 pm EST

Presentation 1 : Juan Pestana
A -The Role of Numerical Modeling in Current Geotechnical Engineering Practice
B - The Behavior of Crushable Granular Materials

A. The development of a final design often requires that we evaluate the performance of numerous alternatives in terms of the constructability, performance, cost and the risk of failure (among other aspects). This presentation will give a brief introduction of numerical modeling and as well as applicability for feasibility, detail design stages and forensic investigations.

B. As crushing occurs, potentially large increases in the specific surface area (appearance of fines and changes in particle size distribution) will cause a rapid decrease of hydraulic conductivity that cannot be explained by changes in density alone. Crushing is a time dependent phenomenon enhanced by increases in temperature. This presentation will discuss these mechanisms and the proposed constitutive model to describe the variation of mechanical and flow properties with stress and temperature.

Tuesday
Feb. 9, 2021
12:00-1:30 pm EST

Presentation 2 : Katerina Ziotopoulou/Jack Montgomery
Numerical Modeling of Geosystems: Background, Constitutive Modeling & Problem-Specific Validation

Numerical modeling is a powerful tool to understand the expected behavior of geosystems (e.g., dams, foundations, tunnels, landslides) and to identify factors that control system performance. This presentation will give attendees an overview of some of the important considerations when creating numerical models of geosystems, including identifying behaviors of interest, building a model, selection and calibration of a constitutive model, and interpretation of results.

Thursday
Feb. 11, 2021
12:00-1:30 pm EST

Presentation 3 : Katerina Ziotopoulou/Jack Montgomery
Using Numerical Modeling to Interpret Case Histories

This presentation will introduce the use of numerical models for interpreting case histories. Examples of applying numerical models to case histories of landslides and ground failure will be presented along with a discussion on the importance of considering uncertainties.

Tuesday
Feb. 16, 2021
12:00-1:30 pm EST

Presentation 4: Omid Mahabadi
Numerical Modelling of Rock Fracturing Processes

The finite-discrete element method (FDEM) overcomes the limitations of the finite element method and discrete element method and makes it possible to study the failure of rock masses with incorporation of complex kinematic mechanisms. A number of practical case studies in mining and civil engineering are presented. These applications demonstrate that large displacements and fracturing in discontinuous rock masses can be simulated without using complex constitutive models.

Thursday
Feb. 18, 2021
12:00-1:30 pm EST

Presentation 5: Michael Beaty
Challenges and Solutions in Geotechnical Numerical Analyses

Not all numerical analyses are equal. Many factors can influence the reliability and usefulness of a numerical analysis program or may create unexpected challenges to the analyst. These factors often include the site characterization, approximating that characterization in a numerical model, ensuring the appropriate behaviors and mechanics are addressed, identifying and addressing uncertainties and sensitivities, validating and verifying the model, and interpreting the estimated system response in a way that provides a sound basis for engineering judgment.

Tuesday
Feb. 23, 2021
12:00-1:30 pm EST

Presentation 6: Itasca/Rocscience

Abstract will be updated upon availability

Thursday
Feb. 25, 2021
12:00-1:30 pm EST

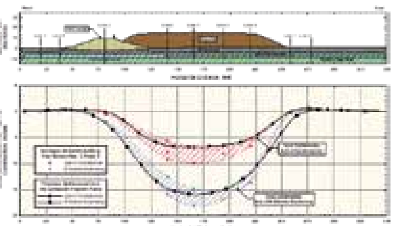
Presentation 7: Geoslope/Bentley

Abstract will be updated upon availability

CGS-SOS February 2021 Workshops
Numerical Modeling in Geotechnical Engineering
Feb. 4th Presentation

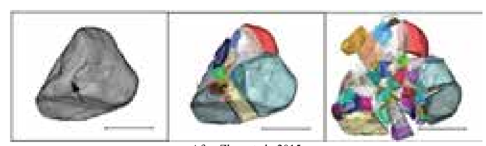
The Role of Numerical Modeling in Current Geotechnical Engineering Practice

Numerical Modeling for Geotechnical Engineering Practice is the process by which we construct a simplified mathematical reality from a more complex physical reality using numerical methods (or tools) to study the performance of systems variable levels of abstraction. Although, the previous sentence is quite general, it does contain for the most part the spirit of the field at present time. Complexities of the physical system (i.e., natural geological materials) as well as complex designs or complex construction processes are common and becoming more and more important. The development of a final design often requires that we evaluate the performance of numerous alternatives in terms of the constructability, performance, cost and the risk of failure (among other aspects). The speaker will give a brief introduction of numerical modeling and as well as applicability for feasibility, detail design stages and forensic investigations. Key elements of material response are introduced and described within the context of Constitutive Modeling. Application of Numerical Modeling in Geotechnical Engineering is illustrated through geotechnical case histories



The Behavior of Crushable Granular Materials

For estimating settlements, cohesionless soils are generally treated as incompressible (i.e., negligible reduction of void ratio with increasing confining stress) and with little or no time dependency (e.g., secondary compression is usually ignored). In addition, changes in temperature are not considered and flow properties are described by a constant hydraulic conductivity that is controlled primarily by the particle size distribution of the material and to a lesser extent by density. While all these observations are nearly all true at low confining stresses, they are found to be invalid at high confining stresses such as the ones experienced in oil reservoirs and other important applications. At these stresses, increases in normal or shear stresses results in crushing of the grains and rearrangement of the particles, thus reducing the void ratio. As crushing occurs, potentially large increases in the specific surface area (appearance of fines and changes in particle size distribution) will cause a rapid decrease of hydraulic conductivity that cannot be explained by changes in density alone. Crushing is a time dependent phenomenon enhanced by increases in temperature. The speaker will discuss these mechanisms and the proposed constitutive model to describe the variation of mechanical and flow properties with stress and temperature.



After Zhao et al., 2015

Speaker Bio

Juan Pestana Ph.D., P.E., Senior Principal
(Geosyntec Consultants)

Prior to joining Geosyntec, he spent 23 years as a professor in the Civil and Environmental Engineering Department at the University of California at Berkeley where he taught and conducted research in Computational Geomechanics, Geotechnical, Geotechnical Earthquake and Offshore Engineering. Dr. Pestana has authored or coauthored more than 150 research publications. His research awards include the National Science Foundation CAREER award on modeling cyclic behavior of cohesionless soils, the ASCE Arthur Casagrande Award for contributions to constitutive modeling of soil behavior, the ASCE Walter L. Huber Civil Engineering Research Prize for contributions to constitutive and numerical modeling in Geotechnical Engineering, and the Shamsher Prakash Research Prize for significant contributions to Geotechnical Earthquake Engineering.

Dr. Pestana has worked extensively on the numerical analysis of levees and dams as well as ground improvement techniques for stability and mitigation of settlements and limiting ground deformations in soft ground conditions and liquefaction prone soils. He performed/supervised numerical modeling to estimate ground deformations and stability for sensitive levees in California and he led the UC Berkeley team performing numerical evaluations of the performance of levees in New Orleans following Hurricane Katrina. He has performed numerical modeling and optimization of ground improvement, using Cement Deep Soil Mixing (CDSM) techniques, for LNG facilities that saved the client tens of millions of dollars. He has conducted research on the use of stone columns and vertical drains for liquefaction mitigation and ground control in soft and liquefaction prone soils He has provided advice on construction sequence (stage-construction) and interim stability as well as provide guidance on expected ground deformations resulting for construction activities such as excavation and associated dewatering. He recently worked in the modeling of hydraulic fracturing of an earth dam from grouting injections performed during the remediation and construction of a vertical cut-off system. He has participated in over 40 professional courses worldwide over the last 20 years on the use of numerical tools to model geotechnical problems and he is recognized as a world expert in soil behavior and its modeling. He has extensive consulting experience in difficult construction projects and provides expert services for litigation support.

Feb. 9th Presentation

Numerical Modeling of Geosystems: Background, Constitutive Modeling & Problem-Specific Validation

Numerical modeling is a powerful tool to understand the expected behavior of geosystems (e.g., dams, foundations, tunnels, landslides) and to identify factors that control system performance. Validation is a key part of any numerical modeling effort in order to demonstrate that the tools, engineering procedures and numerical modeling protocols followed are capable of reasonably approximating key aspects of the problem under consideration. This presentation will give attendees an overview of some of the important considerations when creating numerical models of geosystems, including identifying behaviors of interest, building a model, selection and calibration of a constitutive model, and interpretation of results. The finite difference numerical platform FLAC and the constitutive model PM4Sand will be used as examples, but the procedures and lessons are transferable to any combination of tools. The presentation will also discuss approaches for validating numerical models at both the material and system level to check that the model is providing reasonable results. While the presentation will focus on

Feb. 11th Presentation

Using Numerical Modeling to Interpret Case Histories

Many areas of geotechnical engineering rely on well-documented case histories to understand behaviors that may be difficult or impossible to recreate in the lab, including the effects of spatial variability and hydro-mechanical interactions. Interpreting case histories is often complicated by uncertainties in both the site characterization and loading conditions, and the lack of instrumentation. Numerical modeling can be used to help with the interpretation of case histories by allowing the modeler to examine different aspects of the problem, identify controlling behaviors, and draw conclusions with regards to the capabilities and limitations of sets of advanced tools and procedures to replicate the observations. This presentation will introduce the use of numerical models for interpreting case histories. Examples of applying numerical models to case histories of landslides and ground failure will be presented along with a discussion on the importance of considering uncertainties.

Katerina Ziotopoulou Ph.D., P.E.
(UC Davis)

Speaker Bio

Katerina Ziotopoulou joined the Department of Civil and Environmental Engineering at University of California at Davis in August of 2016. Prior to this appointment, she was an Assistant Professor at the Charles E. Via Jr. Department of Civil and Environmental Engineering at Virginia Tech for two years. She received her PhD and MS degrees in Civil Engineering from the University of California at Davis, and her undergraduate Diploma degree in Civil Engineering from the National Technical University of Athens, Greece. Currently, her research focuses on the numerically and experimentally studying ground failure due to earthquake-induced liquefaction and its mitigation. Her goals are to: (a) improve our understanding of the response of liquefiable soil-structure systems, (b) perform reliable numerical simulations, and develop and deliver usable numerical simulation tools, and through those (c) facilitate advances in the performance-based design across a range of geosystems. Her work is currently funded from the National Science Foundation, the Center for Biomediated and Bioinspired Geotechnics, Caltrans, and the California Strong Motion Instrumentation Program. In parallel, she is also working on developing mentoring practices and tools focused on promoting and supporting underrepresented groups. She is the recipient of the 2021 Arthur Casagrande Professional Development Award of ASCE, and the 2017 Greek International Woman in Science.

Jack Montgomery Ph.D.
(Auburn University)

Speaker Bio

Dr. Jack Montgomery is an Assistant Professor at Auburn University, where he focuses his research and teaching on geotechnical earthquake engineering, landslides, dam engineering, and advanced site characterization. He received his bachelor's degree in Civil Engineering from California Polytechnic State University, San Luis Obispo and his master's and Ph.D. in Civil Engineering from the University of California, Davis. Some of his recent research projects include modeling the effects of spatial variability on liquefaction, using geophysics to investigate sinkholes and landslides, and evaluating cyclic softening of clays.

Feb. 16th Presentation

Numerical Modelling of Rock Fracturing Processes

Numerical modelling of rock deformation and failure poses major challenges, including: presence of heterogeneities and discontinuities (joints, faults), non-linear stress-strain response, and confinement-dependent behaviour. Numerical methods commonly used in practice either ignore stress and deformation (e.g. limit equilibrium method), assume the rock to be continuous (e.g. traditional finite element methods), or represent the rock mass as complete blocks (e.g. discrete element method). The finite-discrete element method (FDEM) overcomes these limitations and makes it possible to study the failure of rock masses with incorporation of complex kinematic mechanisms. At the core of FDEM is the fracture model that uses the cohesive element approach to capture tensile, shear, and mixed-mode fracturing in intact rock and along pre-existing joints/faults. Contact detection and interaction formulations resolve interactions of discrete bodies (either pre-existing or created via fracturing). To show the application of FDEM, a number of practical case studies in surface and underground mining as well as civil engineering are presented. These applications demonstrate that large displacements and fracturing in discontinuous rock masses can be simulated without using complex constitutive models.

Omid Mahabadi Ph.D., P.Eng.
(Geomechanica)

Speaker Bio

Omid Mahabadi is the president, CEO and a co-founder of Geomechanica. He holds a PhD degree in rock mechanics (civil engineering) from the University of Toronto. Omid specializes in development and application of advanced numerical simulation tools to solve rock engineering problems in civil, mining, and petroleum engineering. Omid was the lead developer of Y-Geo FDEM code and the sole developer of Y-GUI and GeoLab DAQ codes. He has authored or co-authored over 40 articles in peer-reviewed journals and conferences and acts as reviewer for many technical international journals and funding agencies in Canada.

Feb. 18th Presentation

Challenges and Solutions in Geotechnical Numerical Analyses

Nonlinear numerical analyses for estimating pore pressures, stresses and displacements are an essential tool for assessing the potential response of complex geotechnical systems. Performance based design may require estimates of soil or structural displacements due to prescribed loading conditions or load histories, and the most rational method for estimating these displacements at unique sites is often a numerical analysis. But not all numerical analyses are equal. Many factors can influence the reliability and usefulness of a numerical analysis program or may create unexpected challenges to the analyst. These factors often include the site characterization, approximating that characterization in a numerical model, ensuring the appropriate behaviors and mechanics are addressed, identifying and addressing uncertainties and sensitivities, validating and verifying the model, and interpreting the estimated system response in a way that provides a sound basis for engineering judgment.

Dr. Beaty will discuss aspects of good analytical practices and potential pitfalls, illustrated using case history examples. Although an emphasis will be placed upon analyses of embankment dams and seismic loading, many of the topics and approaches will be equally relevant to other applications.

Michael Beaty Ph.D., P.E., G.E.
(Beaty Engineering LLC)

Speaker Bio

Michael Beaty is an independent engineering consultant with 35 years of experience, primarily in geotechnical and earthquake engineering, numerical analysis, and soil-structure interaction. His projects include embankment dams, foundations, ground remediation, transportation, buried pipelines, and slopes. Many of these projects include assessing the occurrence and effects of liquefaction in sands, gravels, and low-plasticity silts. His use of the finite difference technique to analyze liquefaction and the resulting deformations includes co-authoring the UBCSAND constitutive model for the analysis program FLAC. Michael has degrees from UC Berkeley, UC Davis, and the University of British Columbia and has worked extensively in the Lower Mainland of BC. Michael currently provides geotechnical and seismic analyses, peer review, site characterization, and technical guidance for public, commercial, and international clients. He is Principal Engineer at Beaty Engineering LLC located in Beaverton, Oregon.