The Donald M. Burmister Lecture

Department of Civil Engineering and Engineering Mechanics
Columbia University

Modeling the Time- and Temperature-Dependent Response of Cohesive Soils in a Generalized Bounding Surface Framework

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ABSTRACT The concept of a bounding surface in stress space was originally introduced to describe the monotonic and cyclic behavior of metals. The prominent features of a bounding surface formulation are a) the existence of inelastic deformations for stress states within an outer ("bounding") surface, and b) the existence of a smoothly varying plastic modulus. These features represent definite advantages over classical rate-independent yield surface elastoplastic formulations, especially for "softer" materials such as cohesive soils.
Since the late 1970's, the bounding surface concept has been successfully used to simulate the response of cohesive soils. Initially, bounding surface models for such soils were developed in the context of rate-independent isotropic soil elastoplasticity. This was subsequently extended to include anisotropy and then time- and rate-dependence.
The predictive capabilities of bounding surface models for cohesive soils have been assessed by comparing numerical results with data obtained from standard laboratory tests, physical centrifuge models, as well as some field results.
Typically, previous models for cohesive soils were based on the concept of a bounding surface in stress space have improved upon earlier versions of such models, enhanced the predictive capabilities of earlier models by expanding the model's features, or accomplished both of these tasks. Missing from the earlier development of bounding surface models for cohesive soils was any attempt to *synthesize* the many previous forms of these models. Such a synthesis was realized through the Generalized Bounding Surface Model (GBSM) for cohesive soils, which not only synthesizes many previous forms of the bounding surface model for cohesive soils, but also improves upon many aspects of these forms.
In its most general form, the GBSM for cohesive soils is a microscopically inspired, fully three-dimensional, time-dependent model that accounts for both inherent and stress induced anisotropy. In addition, to better simulate the behavior of cohesive soils exhibiting softening, the model employs a non-associative flow rule. Finally, the rotational hardening rule and the shape hardening function associated with the GBSM were chosen after a thorough review of past modeling practices; in both cases, the selected functional form simplified earlier versions of the bounding surface model without compromising the GBSM's predictive capabilities.
In this lecture, the GBSM will be briefly outlined. Simulations of time-independent and time-dependent response will next be presented. Finally, the extension of the model to thermo-hydro-mechanical analyses will be outlined.

About the Speaker Dr. Victor N. Kaliakin is a Professor in the Department of Civil and Environmental Engineering at the University of Delaware. He received his Ph.D. degree in Civil Engineering from the University of California, Davis in 1985. His research has focused on the computational geomechanics (development of robust continuum and interface elements; model implementation; simulation of field problems) and the constitutive modeling of cohesive soils, of "transition" silt-clay soils, and of geosynthetics. Prof. Kaliakin has supervised or been a member of more than 40 doctoral dissertation committees at the University of Delaware as well as other universities. He is the sole author of two books (*Approximate Solution Techniques, Numerical Modeling and Finite Element Methods*, published in 2001 by Marcel Dekker, and *Soil Mechanics: Calculations, Principles, and Methods*, published in 2017 by Butterworth-Heinemann) and has published more than 250 peer-reviewed book chapters, journal artices and conference papers. Prof. Kaliakin is a member of the ASCE Geo-Institute Soil Properties and Modeling Committee and the ASCE EMI Poromechanics Committee. He serves as an associate editor for Geosynthetics International. Prof. Kaliakin has been invited to give keynote/invited lectures and short courses in several countries. Prof. Kaliakin has been active in the organization of numerous syposia and workshops throughout the world..

The late Prof. Donald M. Burmister (1895-1981) is one of the pioneers in the field of Soil Mechanics and Geotechnical Engineering. He established the Soils Laboratory at Columbia University in 1933. He was a faculty member for 34 years before retiring in 1963. During his tenure at Columbia University, he investigated earthworks and foundations for over 400 projects. Most notably among these were the Brookhaven National Laboratory, the Throgs Neck, Tappan Zee and Verrazano Narrows Bridges, the First New York World Fairs at Flushing Meadows, and the reconstruction of the White House in 1950. He has developed several soil testing methods and his soil classification system is still widely used. He also contributed to the first use of digital computer in conjunction with his theory of the layered pavement system.