# CEE 595F – Geotechnical Seminar – ONLINE

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# Volume Change of Unsaturated Soils: A Recommendation for a Unified Approach

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**Speaker Bio**: Sandra Houston, PhD, PE, D.GE, is Emeritus Professor in the School of Sustainable Engineering and the Built Environment, Ira A. Fulton Schools of Engineering, Arizona State University. Professor Houston's contributions to the field of geotechnical engineering focus on unsaturated soils, including advancement of methodologies for dealing with unsaturated soils and arid region problem soils, particularly collapsible and expansive soils. Sandra has served in numerous leadership positions in the American Society of Civil Engineers (ASCE), Geo-Institute (GI), and the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE). She is a recipient of the ASCE Terzaghi Award and the William H. Wisely American Civil Engineer Award, and has provided service through her past roles including president of the Geo-Institute, chair of the ASCE Board-level Committee on Diversity and Inclusion, chair of the GI Unsaturated Soils Committee, and USA representative on the ISSMGE Committee on Unsaturated Soils.

**Abstract:** Volume change response of unsaturated soils highlights the critical importance of use of two separate stress state variables, net total stress and matric suction, in constitutive modeling. Early laboratory-based research on unsaturated soils revealed complex volume-change response, wherein low to high plasticity soils exhibit collapse or expansion in response to reduction of soil suction, depending on density and the applied confining stress. State surface approaches were developed that accommodate soil expansion or collapse due to wetting under load. Nonetheless, expansive and collapsible soils are often viewed separately in research and practice, resulting in development of numerous constitutive models specific to the direction of volume change resulting from suction decrease. In addition, several elastoplastic models, developed primarily for collapse or expansion, are modified by add-on, such as multiple yield surfaces, to accommodate a broader range of soil response. Our tendency to think of unsaturated soils as either expansive or collapsible (or, sometimes, stable), has likely contributed to lack of development of a unified approach to unsaturated soil volume change. The Modified State Surface Approach (MSSA) of Zhang and Lytton (2009) represents a unifying elastoplastic framework that accommodates complex volume change response of unsaturated soil, whether the soil exhibits collapse, expansion, or both. It is not always necessary or desirable to use the most comprehensive and complete elastoplastic constitutive model for solving routine unsaturated soil volume change problems due to time, expense and feasibility of obtaining required soil parameters. It could be argued that simpler volume change models, requiring commonly-performed and relatively inexpensive laboratory tests, are most appropriate for routine application of unsaturated soil mechanics, provided adherence to appropriate unsaturated soil theory can be ensured. In the arena of routine practice-based approaches for unsaturated soil volume change problems, the surrogate path method (SPM), an oedometer/suction-based approach, is demonstrated to be consistent with the MSSA framework (Houston and Zhang, 2021; Houston and Houston, 2018). The SPM is broadly applicable for use with expansive and collapsible soils, and yields results consistent with measured field stress-path soil response. The SPM approach requires only simple and relatively inexpensive additions to typical geotechnical investigations- additions which can lead to substantial improvement in the characterization of unsaturated soil sites. In particular, performance of response to wetting tests (e.g. ASDTM D4546, Method B) and measurement of index properties, throughout the potential depth of suction change, aids in the identification of potentially problematic moisture sensitive soils and to the development of cost-effective geotechnical engineering solutions.