UTC Project Information	
Project Title	MPC-548 – Development of Models for the Prediction of Shear Strength of Swelling Clays
University	North Dakota State University
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Total Project Cost	$200,000
Agency ID or Contract Number	69A3551747108
Start and End Dates	November 20, 2017 to July 31, 2022
Brief Description of Research Project	Accurate prediction of the shear strength of swelling clays is critical for the design of roads, railway infrastructure, foundations, embankments, slopes, canals, erosion control, retaining walls, etc. The damage caused by swelling clays to the U.S. infrastructure is estimated to be of the order of about $13 billion per year (2009)[1]. Swelling clays are found in various parts of the United States[2] and the world. In Fig. 1, the red and blue colored regions contain soils with high swelling potential and orange, and green colored regions contain soils with moderate to low swelling potential. Portions of North and South Dakota contain soils that have high swelling potential. Overestimation of strength parameters can lead to failures and underestimation can lead to significant increase in the cost of the project. Shear strength of soils with high swelling clay content can vary from high values when swelling is restrained to significant degradation in strength or even complete loss of strength due to swelling. The change in shear strength can also be seasonal. Fundamental strength parameters that define strength properties of soils are related to a variety of factors that include soil type,

	microstructural characteristics, fluid properties, mineralogy, saturation, etc. Reliable predictive tools that can accurately predict the shear strength of swelling clays are lacking. Our prior work on clays demonstrates the key role of molecular interactions on the evolution of microstructure and the macroscopic properties such as permeability, consolidation, and swelling pressure[3]. This is a continuing funding request for year 2 and year 3 funding. The earlier proposal contained tasks for all three years. The previous proposal has been modified to include tasks accomplished in year 1 and the tasks to be accomplished in year 2 and 3. The research needs and year 2 and year 3 research tasks and methodology included here are from our previous proposal. Research Objectives: 1. Construction of multiscale computational simulations test-beds for swelling clays to evaluate the role of molecular interactions and microstructure to macroscale shear strength properties of swelling clays. 2. Development of experimental techniques to evaluate the swelling clay-fluid interactions and mechanical properties at various length scales: molecular scale to macroscale.
Describe Implementation of Research Outcomes (or why not implemented) Place Any Photos Here	The research results are published and presented at conferences. The implementation will occur upon completion of the research project.
Impacts/Benefits of Implementation (actual, not anticipated)	The major outcome of this basic research will be a multiscale computational framework for swelling clays to evaluate the mechanical response of swelling clay to external loading. The models incorporate the molecular scale clay-fluid interactions and the evolution of microstructure during swelling, the two critical factors that influence the mechanical properties of swelling clays. These simulation testbeds will provide insight into the mechanisms that affect the mechanics of swelling clays. The innovative experiments developed in this research would not only serve as model development and verification tools but could lead to the introduction of new experimental techniques for swelling clays.
Web Links • Reports • Project Website	https://www.ugpti.org/resources/reports/details.php?id=987