Transportation Research Board
84th Annual Meeting

Doctoral Student Research in Transportation Geotechnics

Sunday, January 9, 2005
1:30 p.m. – 5:00 p.m.
McKinley Room
Marriott Wardman Park Hotel

The workshop is cosponsored by TRB sections: A2K00, Soil Mechanics, A2L00, Geology and Properties of Earth Materials, and A2J00, Geomaterials

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Organizer: Sarah L. Gassman, *University of South Carolina*
Moderator: Jean-Louis Briaud, *Texas A&M University*

The primary objective of this new workshop series initiated at the 2001 Annual Meeting is to integrate recent and upcoming geotechnical PhD's into the TRB research community by providing them with an opportunity to showcase their research at the Annual Meeting. The workshop will consist of reports on geotechnical engineering research related to transportation facilities that will be of interest to both practitioners and researchers.

1:30 pm - 1:35 pm	**Introduction** Jean-Louis Briaud, *Texas A&M University*
1:35 pm – 1:50 pm	**Design and Performance of Sheet Pile Walls in Peat** Yong Tan, *University of Massachusetts-Lowell*
1:55 pm - 2:10 pm	**Mechanics of Biocell Landfill Settlements** Chamil Hiroshan Hettiarachchi, *New Jersey Institute of Technology*
2:15 pm - 2:30 pm	**Mechanistic Modeling of Asphalt Concrete with Application to Reflection Cracking in Pavements** Nelson H. Gibson, *University of Maryland at College Park*
2:35 pm – 2:50 pm	**Seismic Site Response of Deep Soil and Embankment in the New Madrid Seismic Zone** Wanxing Liu, *University of Missouri-Rolla*
2:55 pm - 3:10 pm	**Mitigation of the Impacts of Chromium Ore Processing Residue on Transportation Facilities** James Tinjum, *University of Wisconsin-Madison*
3:15 pm - 3:30 pm	**BREAK**
3:30 pm - 3:45 pm	**Permanent Deformation Behavior of Airport Pavement Base and Subbase Courses** In Tai Kim, *University of Illinois at Urbana-Champaign*
3:50 pm - 4:05 pm	**Mechanisms of Earthquake Induced Deformation in Slopes and Embankments** A. S. M. Nasim, *Drexel University*
4:10 pm - 4:25 pm	**Evaluation of Soil Suction as an Indicator of Sample Quality for a Saturated Marine Clay** Steven Poirier, *University of Massachusetts-Amherst*
4:30 pm - 4:45 pm	**Evaluation of EPS Geofoam as a Subbase/Subgrade Material in Pavement Structures** Xiaodong Huang, *Syracuse University*
5:00 pm	**ADJOURN**

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Abstracts:

Title: Mechanistic Modeling of Asphalt Concrete with Application to Reflection Cracking in Pavements

Author: Nelson H. Gibson, *University of Maryland*

Abstract:
Currently, practical prediction of highway performance using fully mechanistic principles is beyond the state-of-the-art, but recent advances in material characterization and computing allow fully mechanistic levels to be approached, at least for critical and special pavement conditions. This research will take some exploratory steps in numerically modeling asphalt concrete pavements that are needed to obtain such capabilities.

The Schapery viscoelastic continuum damage theory has been applied to model the nonlinear viscoelastic properties of asphalt concrete due to growing damage in the microstructure. A viscoplastic extension has been added to capture irrecoverable deformations that occur. Both models are augmented with an extended time-temperature superposition principle that both significantly simplifies material characterization efforts and allows the nonlinear viscoelastic and viscoplastic responses to be predicted at multiple temperatures. The models have been satisfactorily validated under a wide range of uniaxial loading rates and temperatures with a limited validation under confined conditions. Some additional refinements are to be added to the viscoplastic extension for enhanced multiaxial capability and accuracy. The models will then be implemented into a finite element program where a set of reflection cracking scenarios will be analyzed using the advanced material models to demonstrate the capabilities of a mechanistic pavement simulation.

Title: Mechanics of Biocell Landfill Settlements

Author: Chamil Hiroshan Hettiarachchi, *New Jersey Institute of Technology*

Abstract:
Settlement prediction is one of the main concerns in design and maintenance of a bioreactor landfill. Accurate prediction is essential for design of piping systems used for the delivery of re-circulated leachate and collection of gases. Though the major component of settlement is due to the decomposition of municipal solid waste over several years, considerable amount of settlement takes place during the initial construction stage too, which is usually unnoticeable as it happens during construction. A comprehensive model for settlement analysis of a bioreactor landfill should be able to demonstrate not only the settlements due to biodegradation but also the settlements that occur due to mechanical compression during initial construction stage. Often an overall compressibility index is defined similar to that of clays, to explain compressibility of waste, but not much attention has been paid to the settlement behavior during the initial stage or during construction. This research describes a procedure to compute settlements due to mechanical reasons in a bioreactor landfill by separating that from the biodegradation. Then a new conceptual framework is proposed to numerically predict the settlements using time dependant waste properties and landfill geometry.

Title: Evaluation of EPS Geofoam as a Subbase/Subgrade Material in Pavement Structures

Author: Xiaodong Huang, *Syracuse University*

Abstract:
EPS Geofoam has been widely used in the past decades. Design methods related to pavement performance have been developed in Europe. In the United States, the design method is mainly based on elastic modulus of geofoam. The focus of this research is to determine the mechanical properties specified in the conventional pavement design methods, such as resilient modulus, modulus of subgrade reaction, and CBR values of EPS geofoam. By determining these properties, the difference between EPS geofoam and conventional subbase/subgrade materials can be studied. Design methods of EPS geofoam in pavement structures can be proposed with least modification from the current design methods.

Title: Permanent Deformation Behavior of Airport Pavement Base and Subbase Courses

Author: In Tai Kim, *University of Illinois at Urbana-Champaign*

Abstract:
This thesis mainly focuses on characterizing and predicting the permanent deformation behavior of airport pavement granular base/subbase layers constructed and tested at the FAA's National Airport Pavement Test Facility (NAPTF) in the United States. The P209/P154 aggregate materials were used in the construction and testing of the NAPTF flexible pavement test sections with variable thickness base and subbase courses. The laboratory testing results on the P209/P154 aggregate materials will be presented for both constant and variable type confining pressure conditions applied in triaxial testing. Such a comprehensive experimental program was designed with the purpose of developing rutting prediction models for the airport base and subbase materials to fully account for the dynamic effects under moving wheel load conditions. Based on the results of the FAA NAPTF testing, the performances of the developed rutting models will be evaluated for predicting the field accumulation of permanent deformation.

Title: Seismic Site Response of Deep Soil and Embankment in the New Madrid Seismic Zone

Author: Wanxing Liu, *University of Missouri-Rolla*

Abstract:
Three different field tests have been used to study the maximum shear modulus and damping of the upper 60 m soil deposits at two bridge locations in the New Madrid Seismic Zone: seismic cone penetration, cross-hole, and spectral analysis of surface wave (SASW). In addition, dynamic laboratory tests including cyclic triaxial and resonant column testing were performed to obtain the dynamic soil properties. The hyperbolic model with extended Masing rules (Kramer 1996) was modified to account for the deep soil effect and implemented into a one-dimensional program, SUMDES (Li et al.,1992). The built-in nonlinear hypoplasticity model (SUMDES) and the implemented modified hyperbolic model were used to analyze the deep soil seismic site response. A shaking table test was conducted on a physical model of the approach embankment to MoDOT bridge A1466 to analyze the response of highway embankment in accordance with the similitude theory. The modified hyperbolic model with Masing rules was developed and implemented in the FLAC computer code, which was calibrated using the 1971 failure of Upper San Fernando Dam. Then it was used to determine the earthquake-induced deformation of the study sites. Liquefaction analysis of the study sites was evaluated using both conventional analysis and the modified hyperbolic model implemented in FLAC.

Title: Mechanisms of Earthquake Induced Deformation in Slopes and Embankments

Author: A. S. M. Nasim, *Drexel University*

Abstract:
This project uses numerical and experimental methods to investigate the mechanisms of earthquake induced deformations in slopes. Numerical analyses examine the transition of deformations from being highly distributed to becoming localized under earthquake loading. Constitutive models, ranging from simple equivalent-linear elastic to more complex plasticity formulations, are tested under various earthquake loading conditions (duration, intensity, frequency content) to assess their ability to capture different deformation mechanisms using finite difference program FLAC (Fast Lagrangian Analysis of Continua).

A physical modeling-based experimental study (1-g shaking table and centrifuge) is being conducted in parallel with the numerical simulations. Cohesive slopes constructed from laboratory prepared clay (a saturated kaolinite-bentonite mix) are being tested using a shaking table. Identical earthquake loading conditions as used in numerical analyses are employed to gradually increase the level of deformation in the slopes before they undergo catastrophic failure, thereby capturing the physical phenomenon causing transformation from highly diffuse to localized deformations. Similar approach is employed to test small scale granular embankments using a centrifuge. Physical model test results are also being used to calibrate and validate the numerical results.

Existing design procedures are reviewed considering the test results and recommendations are made regarding their adequacy for practice.

Title: Evaluation of Soil Suction as an Indicator of Sample Quality for a Saturated Marine Clay

Author: Steven Poirier, *University of Massachusetts-Amherst*

Abstract:
Researchers have struggled with the evaluation of sample disturbance effects on geotechnical laboratory test results for many years. Despite advances in the sophistication of laboratory testing, the quantification of sample disturbance of natural soil samples remains a largely unresolved issue.

This research involved developing a portable suction probe and technique for measuring soil suction in saturated fine grained soils. Project work included obtaining soil samples of various quality (split spoon, free piston, fixed piston, and Sherbrooke Block) from a site consisting of a marine clay, extensive laboratory testing and soil property assessment of these samples, and advancing suction measurement technology and its application to sample disturbance evaluation.

The suction probe was used to perform field and laboratory measurements of the negative pore pressure that develops within soft clay samples due to stress relief and mechanical disturbance during sampling. The use of soil suction for evaluating sample disturbance was investigated by correlating suction values to measured engineering properties (e.g., yield stress, undrained shear strength) for the different quality samples collected. These data were compared to other techniques of sample disturbance evaluation such as volumetric strain during laboratory reconsolidation and shear wave velocity.

Title: Design and Performance of Sheet Pile Walls in Peat

Author: Yong Tan, *University of Massachusetts-Lowell*

Abstract:
A relocation of state highway No. 44 in Carver, Massachusetts required the construction of sheet pile walls, fills and embankments through cranberry bogs and ponds containing deep peat deposits. Peat is an organic complex soil, well known for its high compressibility and low stability. These properties result in difficulties assessing the interaction between the sheet piles and the supporting peat.

The ability to measure the earth pressure distribution and deformation along a sheet pile wall is important for design and for the understanding of wall-soil interaction. For the moment very limited data are available regarding lateral soil stress measurements on sheet piles and practically none is known to exist in peat.

In this project, the interaction between the sheet piles and the peat was monitored via field instrumentation. Five road sections were instrumented with total pressure cells and inclinometers. Additionally, a surveying monitoring program was conducted throughout the site at different construction stages. The instrumentation design, construction and installation are described. A long term instrumentation monitoring including the sheet pile wall behavior during the fill compaction is presented and conclusions are drawn. Finally, a finite element analysis was conducted to model the sheet pile performance in peat during different construction stages, and the modeling results are compared to the field measurements. Design parameters for sheet piles in peat are developed and presented.

Title: Mitigation of the impacts of Chromium Ore Processing Residue on Transportation Facilities

Author: James Tinjum*, University of Wisconsin-Madison*

Abstract:
Transportation facilities, including ports and rail corridors in Maryland and New Jersey, contaminated by highly alkaline chromium ore processing residue (COPR) is a large environmental and redevelopment problem along the mid-Atlantic seaboard. This waste fill poses a serious threat because of the leaching potential of toxic hexavalent chromium in addition to unpredictable swelling caused by chemical weathering, which causes damage to overlying transportation infrastructure (e.g., pavements, storm sewers, and abutments). One proposed in situ remediation technique involves introduction of ferrous iron and acidic compounds that neutralize COPR's alkalinity and bind reduced trivalent chromium to insoluble mineral compounds. An experimental program was undertaken to investigate the chemical and mineralogical factors that control the leaching characteristics and effectiveness of this remediation technique. Results from the study indicate that acid neutralization is effective at reducing COPR alkalinity, although significant buffering must be overcome. Combined with addition of ferrous iron compounds, which largely reduce aqueous concentrations of hexavalent chromium, and sulfate compounds, which compete for chromate ion adsorption sites, the treatment strategy effectively forces chromate into the aqueous phase, where reduction and precipitation mechanisms come into play and/or where pump and treat strategies may be fruitful.