Wednesday, 3/15/2017

8–9:30 a.m.

Fiber Optic and Remote Sensing

Chairs: Assaf Klar, Technion–Israel Institute of Technology; Ashley MacMillan, Geocomp

Performance Evaluation of Multi-span Geosynthetic Reinforced Soil–Integrated Bridge System (GRS-IBS)

Ashley H. MacMillan and Martin Hawkes, Geocomp; Joey Goode, Shannon & Wilson

Nearly all states nationwide have implemented Geosynthetic Reinforced Soil – Integrated Bridge System (GRS-IBS) technology. This construction method has proven to save time and money over traditional abutment construction. The I-70 over Smith Road in Aurora, CO multi-span bridge included design methodology changes that were classified as "experimental features" and thus additional project funds were included for evaluation. In an attempt to understand the geostructural performance of the multi-span GRS-IBS, the abutment was instrumented with a vertical chain of accelerometers, vertical and horizontal pressure cells and geotextiles with embedded fiber optic strain sensors. All of the data is remotely accessed combining traditional geotechnical monitoring strategies with a cutting edge fiber optic technology. Data has been collected over the past 18 months and analyzed to identify the importance of each monitoring element and to assess the performance of the GRS-IBS. An excavation along the toe of the abutment occurred towards the end of the project which induced additional stresses. The performance of the structure during this excavation stage is discussed. Since GRS-IBS has typically been implemented for single-span bridges, the results of this monitoring program can be used in the development of future GRS-IBS technology.

Wireless Subsurface Sensors Supporting Remote Roadway Management

Ramprasad Balasubramanian, Heather Miller, Benjamin Viall, Somayeh Eftekhari, and Philip Igoe, University of Massachusetts, Dartmouth

Roadways subject to seasonal load restrictions are located in remote areas where collection and transmission of real-time subsurface data is problematic. A demonstration project used wired underground sensors connected via cell/satellite transmissions. The present project developed radio frequency wireless sensors and transmission systems to measure subsurface data. A major advantage with wireless is installation simplicity, eliminating the need to trench out the roadway for cables from the sensors to a roadside data collection and transmission system. Real-time wireless sensor data and environmental data are integrated into a Decision Support System designed to assist state Department of Transportation (DOT) officials in setting winter weight premiums (WWP) and seasonal load restrictions (SLR). WWP and SLR decisions are made using forecasting models using computed environmental and subsurface parameters. Collected and computed information are displayed on a web browser, alerting Maine and New Hampshire DOTs when critical threshold values are reached.

Quantifying Streambank Erosion Using Unmanned Aerial Systems at the Site-specific and River Network Scales

Scott D. Hamshaw, University of Vermont; Thomas Bryce, University of Vermont; Jarlath O'Neil-Dunne, Donna Rizzo, Jeff Frolik, Tayler Engel, and Mandar Dewoolkar, University of Vermont

Streambank erosion is an important component of geomorphic responses to channel changes that affect a wide range of physical, ecological, and socio-economic issues in the fluvial environment including water quality and on- and near-stream infrastructure. A number of direct (e.g., longitudinal surveys, erosion pins, remote sensing) and indirect (e.g. process-based models) methods have been used to quantify streambank erosion. These methods are not only very resource intensive, but many are feasible and appropriate only for site-specific studies and not suitable or practical for erosion estimates at larger scales. Recent developments in Unmanned Aircraft Systems (UAS) provide opportunities for rapidly and economically quantifying streambank erosion and deposition at variable scales (from site-specific to river network), and is the focus of this paper. At the site-specific scale, the capability of UAS to quantify streambank erosion was assessed by comparing it to terrestrial laser scanning (TLS) and RTK (real time kinematic) GPS for validation. At the individual site level, the estimation of bank erosion using UAS was within 4% of the actual erosion at a surveyed cross-section. At the river network-level scale, initial results indicate even bank retreats of less than a meter can be detected, provided banks are not completely obscured by dense vegetation.

Structure Mapping through Spatial and Temporal Deformation Monitoring using Persistent Scatterer Interferometry and Geographic Information Systems

El Hachemi Y. Bouali, Thomas Oommen, and Rudiger Escobar-Wolf, Michigan Technological University

Many engineering professions have adopted asset management procedures to properly construct, monitor, maintain, and support physical assets through the full service life-cycle of all assets within a network. All asset management programs, whether structural, geotechnical, or transportation, have one common goal: to achieve life-cycle performance goals (e.g., safety, preservation, economic and environmental sustainability, etc.) by cost-effectively managing physical structures. Monitoring deformation rates across an asset can be used as an indirect method of obtaining initial condition assessment information, which is vital for understanding an asset's current life-cycle stage. Persistent Scatterer Interferometry (PSI), an Interferometric Synthetic Aperture Radar remote sensing stacking technique, is capable of measuring displacement rates at 1 mm/year accuracy on anthropogenic infrastructure not undergoing immediate, catastrophic failure. Geographic Information Systems (GIS) allows storing, processing, analyzing, and displaying geographic data. By combining PSI and GIS capabilities, this paper will illustrate how these techniques can be utilized to spatially and temporally map deformation rates on a variety of assets, and how an initial condition assessment can be made on each asset. Structure mapping can be conducted in four steps: (1) digitization of geographic location for all structures; (2) processing of radar imagery, which results in displacement rate data for all viewable structures; (3) spatially analyzing displacement rates and assigning PS points to individual structures; (4) producing maps, including both spatial and temporal information (e.g., displacement-time series analyses). This procedure will be demonstrated using 40 COSMO-SkyMed satellite radar data, 3 m resolution images acquired between July 2012 and September 2014, over urban infrastructure in San Pedro, California.

The Use of Unmanned Aerial Vehicles (UAVs) and Structure from Motion (SfM) to Measure Volume Change at a Deep Dynamic Compaction Site

Kevin W. Franke, Christopher W. Bender, Derek Wolfe, John D. Hedengren, and Brandon Reimschiissel, Brigham Young University; Thang Van Nguyen and Lisheng Shao, Hayward Baker Inc.

A small unmanned aerial vehicle (sUAV) is used with structure from motion (SfM) computer vision (Marr and Nishihara 1978; Snavely et al. 2008) to measure the amount of settlement that is induced by deep dynamic compaction at a site of a new casino near Lake Havasu City, AZ. Details of the project and field operations are provided, and comparisons are made between induced settlement measurements from traditional techniques and induced settlement measurements from the new sUAV/SfM approach. Results of the study show that the sUAV/SfM approach estimates an average induced settlement of 38 cm across the site, which straddles within 2.5 cm of the average induced settlements that were measured with other traditional techniques. Additionally, the sUAV/SfM technique is shown to provide significant detail of the distribution of induced settlements across the site. This distribution of settlements could be indicative of the distribution of subsurface soils that were more affected by the DDC such as looser or cleaner sands. Implications of the findings of this study are briefly discussed.

Monitoring and Modeling of Peat Decomposition in Sacramento Delta Levees

Amr Helal, North Carolina State University; Victoria Bennett, Rensselaer Polytechnic Institute; Mohammed Gabr, North Carolina State University; Roy Borden, North Carolina State University; Tarek Abdoun, Rensselaer Polytechnic Institute

The integrity and reliability of levees are essential components of homeland safety. The failure of such systems due to a natural or manmade hazard can have monumental repercussions, sometimes with dramatic consequences on human life, property and the country's economy. This paper presents some results of integrated monitoring and modeling to assess the performance-based response of a levee section. The modeled levee is part of the Whale's Mouth section on Sherman Island where satellite images and in-ground global positioning system (GPS) sensors are used for displacement measurements. The Whale's Mouth levee is modeled using the large deformation option of the finite element program PLAXIS 2D. The model is used to establish a deterministic performance response under maximum water level loading and to investigate the effect of peat decomposition on the deformation response of the levee section. The remote sensing and in situ data are used to calibrate the numerical model. The results are compared to the pre-defined limit state and illustrate how the peat layer decomposition affects the modeled levee section performance. The concept of performance limit states of these critical structures provides a means to quantitatively assess the functionality of an earth structure under severe storm loading events. The probability of exceeding a prescribed limit state is defined based on the strain or gradient levels in potential emerging failure zones. The variation in strength properties and hydraulic conductivity of the levee embankment, as well as the rate of rising water level and duration of flooding, may lead to the progression of the structure state from a low probability of exceeding adequate functionality to the probability of exceeding a high limit state (i.e., imminent failure). The displacement data collected during these loading and unloading events is used to establish the levee condition assessment on the basis of the performance limit states.