Wednesday, 3/15/2017

1:30–3 p.m.

Sinkholes

Chairs: Charles Schwartz, University of Maryland; Boo Hyun Nam, University of Central Florida

Sinkhole Early Detection System

Matthew Dettman and Ron Rizzo, Western Kentucky University

A pilot study was performed to determine the viability of a permanently installed sinkhole detection device for use in both commercial and residential applications. The current state of the practice methods for sinkhole detection provide only a single snapshot in time of subsurface conditions. The theory investigated was the concept that if a sinkhole is forming underneath an existing structure, the void forming could be detected mechanically by a falling weight causing a trigger to alert occupants. The device would be installed through the existing floor and at a depth such that the sinkhole void could be detected prior to any damage to the structure. Prototypes were constructed and tested in various environmental conditions for durability and in simulated sinkhole conditions in the field. While impediments to widespread use exist, the device appears capable of serving as a sinkhole early detection system.

Development of Sinkhole Hazard Mapping for Central Florida

YongJe Kim, Han Xiao, Dingbao Wang, and Boo Hyun Nam, University of Central Florida; Yeon Woo Choi, Seoul Metropolitan Government

Sinkholes are one of the most frequent hydrogeological hazards in the Central Florida region. The risks related to sinkholes pose a significant threat to humans, infrastructure, and natural resources. It is important to identify the sinkhole-prone areas in order to mitigate or prevent damage and losses caused by sinkholes. The main objective of this study is to develop sinkhole hazard mapping for Central Florida region with a GIS technique. A sinkhole hazard map was generated by using Frequency Ratio (FR) model that analyzes the relationship between the sinkhole occurrence and sinkhole-affecting factors. Various hydrogeological factors that potentially contribute to the sinkhole formation in the region were identified and used for the analysis. The Sinkhole Hazard Index (SHI) values for the entire study area were determined using the developed hazard model, and then used to produce the sinkhole hazard map of the Central Florida region. The developed sinkhole hazard map shows a strong correlation with the reported sinkhole.

Sinkhole Risk Evaluation by Subsurface Cone Penetration Test

Ryan Shamet and Boo Hyun Nam, University of Central Florida; Kathy Gray, Florida Department of Transportation

As Florida's population is expanding and greater fluctuations in groundwater levels are being recorded, Central Florida has been experiencing a higher frequency of sinkhole occurrences than ever before. Sinkholes are formed when the soluble limestone bedrock weathers and creates cavities at its interface with the overburden finer-grained soils. The overburden soil then erodes into the limestone fissures, thus weakening the strength and holding capacity of the soil above. This initial stage of a sinkhole is referred to as soil raveling and is the most effective time to perform soil improvement measures, such as grouting, to mitigate further expansion of the subterranean void. Geotechnical engineers and scientists use subsurface exploration techniques such as Standard Penetration Test (SPT) and Cone Penetrometer Test (CPT) to stratify soils and estimate soil properties. These in-field tests can be implemented to detect and evaluate areas of soil raveling which may be a sign of a potential sinkhole. In this study, the authors present the current practice to assess the risk of sinkhole by using SPT and CPT as well as the Raveling Index (RI). Additionally, a 2D CPT imaging technique is presented to estimate the dimension of raveled soil zone and its engineering applications are discussed.

Numerical Investigation of the Geomechanics of Sinkhole Formation and Subsidence

Kishor Rawal and Liangbo Hu, University of Toledo; Zhongmei Wang, Guizhou University

Sinkholes are a devastating and widespread geo-hazard which poses a significant threat to the environment, infrastructure, and human lives. Many practices involved in the sinkhole assessment are generally of a qualitative nature and largely based on geological characteristics of the karst terrains. This paper aims to present a quantitative analysis of the deformation involving the various behaviors of the geo-materials and interplay of multiple mechanisms involved during the development of sinkholes. It is primarily focused on the influence of rapid and slow drawdown of water scenarios, studied via a coupled hydromechanical model. Rapid drawdown at a higher rate of head drop causes much higher deformation than the slower drawdown which may lead to fast creation of sinkhole. A parametric study of various properties responsible for the sinkhole development is undertaken which involves influence of cohesion, permeability and ground water flow time. The results shows that the higher permeability and higher ground water flow time causes rapid formation of sinkhole. The resistance to the sinkhole formation in the limestone zone is a function of the tensile strength of the rock while the cohesion and friction angle are responsible for the resistance in the clay soil.

Development of a Large Warehouse Complex Overlying Slag, a Landfill, and Karst

Eric Backlund, Kleinfelder

Work is underway to develop a 465-acre site to include six large warehouse facilities. The site was an industrial facility in the past, and portions of the site had been used as a disposal area for steel slag and industrial debris. The subsurface conditions include historical fills, buried underground structures, and an unregulated industrial waste landfill in addition to alluvial, glacial, and residual soils. This case study reviews Kleinfelder's site exploration, geo-hazards encountered onsite, and how the project team addressed these geo-hazards. Kleinfelder's site exploration program primarily used borings and test pits to evaluate subsurface conditions and supplemented those with selectively located air probes and geophysics to provide a better understanding in certain areas. Hazards considered in the development of the site include karst geology, potentially expansive slag fill, and building over an industrial landfill.

Limit State Sinkhole Risk Assessment

Michael Perlow, Engineering Knowledge Management LLC; Max William Perlow, Pennoni Associates; Josh Wagner, DiGioia Gray & Associates

A unique sinkhole limit state risk assessment methodology has been developed that incorporates: (1) an evaluation of primary triggering mechanisms; (2) assessment of key risk factors (past failure history, soil-bedrock type, groundwater flow, and hydrology); (3) an evaluation of human activities (site development, drainage changes, construction activities); and (4) and most importantly, the impacts of extreme weather (precipitation, temperature, flash flooding, erosion). Baseline load and resistance parameters for a given karst area or site are analyzed for normal pre-failure or typical failure limit states.

Various load and critical resistance factors are then applied to determine possible failure limit states. A simple graph or map of each critical load or resistance factor with time or location is developed for key parameters such as sinkhole failure history, precipitation, groundwater fluctuations-flow, surface runoff, drainage changes, and any relevant activity by man. The average normal range, upper and lower damage-failure thresholds are identified along with the upper and lower extremes that are associated with major failures and disasters. By overlaying the various load-resistance factors, critical limit states and sinkhole risk are determined for any given area and combinations of loading-resistance conditions. The use of the sinkhole limit state risk assessment methodology is presented for a PA33-Tatamy Road Pennsylvania sinkhole case study.