Monday 3/13/2017

12:15–1:45 p.m.

Slope Stability and Stabilization 2

Chairs: Binod Tiwari, California State University, Fullerton; Beena Ajmera, California State University, Fullerton

Ultimate Bearing Capacity Near Slopes: Transition from a Bearing Capacity Problem to a Slope Stability Problem

Yonggui Xie and Ben Leshchinsky, Oregon State University

Evaluating the bearing capacity adjacent or near slopes is an important issue as it effects design criteria not only for shallow foundations, but walls and highway structures. Past research has evaluated bearing capacity near slopes often using analytical models using a projected, two-sided failure mechanism that is based on punching or shear failure of strip footings; however, the failure mechanism for bearing capacity may transition into a one-sided slope failure when the influence of the slope is significant. This analysis evaluates both bearing capacity near slopes and coupled slope failure using a parallelized limit equilibrium procedure, evaluating not only the ultimate bearing capacity, but also the associated mechanism for failure. The proposed model is verified against both known bearing capacity equations for horizontal ground, but also compared to numerical analyses, showing good agreement. A subsequent parametric analysis is performed to evaluate the effects of slope angle, setback and friction angle of soil, presented in convenient design charts.

Mining in a landslide, is it possible? Geotechnical investigation and analysis

Chrysanthos Steiakakis, Geosysta Ltd.; Zacharias Agioutantis, University of Kentucky; Evangelia Apostolou, Geosysta Ltd.; Georgia Papavgeri, Geosysta Ltd.

This paper presents a case study of a large open pit lignite mine excavation taking place on a moving landslide. The Mavropigi mine in Northern Greece has reached depths of more than 120m from the ground surface and produces a substantial amount of lignite for an adjacent power plant. The lignite is important for the power supply of Greece and the mine must constantly operate. The southwest slopes of the mine started moving after 2011 and large tension cracks appeared in the ground surface. The landslide has reached displacement values of more than 8m until today. This paper presents the geotechnical investigation conducted for the evaluation of the sliding mass, which consisted of boreholes, inclinometers, survey measurements, inSAR and geophysical investigation. Based on the information gathered from the investigation a detailed geological – geotechnical – kinematic model of the sliding mass was proposed and validated with the execution of limit equilibrium back analysis. The verified model was then used to provide the appropriate excavation balance between the toe and the crest for the mine to continue operation even with moving slopes but with controlled displacements.

A Note on Deep-seated Failure in Supported Vertical Cuts in Sands below the Groundwater Table by a Coupled Numerical-Analytical Method

Mehdi Veiskarami, Shiraz University; Sina Fadaie, University of Guilan

Stability of supported excavations in sands and other granular matters against deep failure is of particular importance as different modes of failure are often probable. Among all, the active/passive earth pressure failures, failure of supports and braces, hydraulic failures due to the ground heaving or

piping and the bearing capacity or deep seated failure can be pointed out. In some staged-construction procedures, a sheet-pile may not be previously extended below the final level of the cut or the extended length can be insufficient to prevent such failures. In this research, the stability of vertical cuts against such failures has been studied. In particular, when the sand is below the groundwater table, a rather steady state flow of water will form towards the bottom of the cut and together with the weight of the surcharge in the proximity of the cut, it can cause several kinds of failure. For such a problem, a semi-analytical approach is implemented comprising of the solution of the flow field by complex analysis and the stress field (stability analysis) by the slip lines method. Whereas the first analytical procedure works as a background solution, the foreground numerical solution of the stress field can be used for stability analysis. A number of analyses revealed that the deep seated failure may precede the piping and/or heaving failures. Also, in absence of the groundwater seepage, a deep failure is probable. The results are presented in terms of some measure of stability, defined as a factor of safety.

Importance of Side Resistance in 3D Stability Analysis
Timothy D. Stark, University of Illinois at Urbana-Champaign; Kamran Akhtar, National University of Sciences and Technology
Present 3D limit equilibrium (LE) methods do not incorporate shear resistance from near vertical sides parallel to the direction of slide movement. Consequently, the computed 3D factor of safety (FS) is underestimated and the shear strength parameters from an inverse analysis are overestimated. The present study uses continuum mechanics to calculate the magnitude of side shear resistance along near vertical sides of a translational slide mass. Results of the parametric study show use of an earth pressure coefficient (K_τ) that is in-between at-rest (K_0) and active (K_A) earth pressure and Mohr-Colombo strength criteria provides a reasonable estimate of the side shear resistance and 3D/2D FS ratios that are in agreement with finite element (FE) and finite difference (FD) a continuum analyses. Based on these findings, charts showing the influence of shear resistance on 3D/2D FS ratios for various slope inclinations and geometries are presented herein.

Effect of Soil Relative Density and Inclination Angle on Impact Force from a Granular Sliding Mass on a Rigid Obstruction
Amir Ahmadipur and Tong Qiu, Pennsylvania State University
The impact force from a granular sliding mass on a rigid obstruction can be used to gain insights into the granular flow; however, such data is remarkably scarce in the literature. In this study, a two-dimensional soil flume was constructed and utilized to measure the impact force from a granular sliding mass on an obstruction instrumented with dynamic load cells in order to systematically study the effects of different factors on the impact force. In this paper, the effects of initial soil density and inclination angle on the impact force were investigated. Results from these experiments showed that in gentle slopes (i.e., low inclination angle) as the initial density increases the impact force decreases. However, in steep slopes (i.e., high inclination angle) when densely packed granular mass flows downslope with high velocity, the flow is similar to the sliding of a less-deformable block and the impact force increases as the initial density increases.

Consequences of seismic excitation on slopes in soils with tensile strength cutoff
Dowon Park, Zhijie Wang, and Radoslaw L Michalowski, University of Michigan
The yield criterion typically employed in slope stability analyses is the Mohr-Coulomb function with

internal friction angle and the cohesion as the two strength parameters. The implication of this yield function is the presence of the tensile strength. However, it is doubtful whether geotechnical design should rely on the existence of tensile strength in soils, and models such as Cam clay do not allow uniaxial tensile strength in soils. It is demonstrated that eliminating tensile strength from the yield condition leads to a reduction in the stability factor. This is because the absence of tensile strength allows a larger variety of admissible failure surfaces. Seismic excitation produces the load that amplifies adverse consequences of the absence of the tensile strength. Two types of mechanisms are considered: translational and rotational. Examples of analyses with both types of collapse mechanisms are presented using the kinematic approach of limit analysis.