Probabilistic Back-Analysis of Liquefied Shear Strength from Case Histories

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Abstract: Liquefaction, where loose cohesionless soils lose a considerable amount of shear strength, is a major cause of earthquake damage. A critical parameter involved in assessing the potential for liquefaction and in designing against the harmful effects of liquefaction is the liquefied shear strength. One method to determine the liquefied shear strength is by back-analysis of cases where flow failure has occurred in soil deposits and embankments. However, estimates of liquefied shear strength from case histories are based on limited data, utilize deterministic procedures, and do not provide sufficient details for choosing appropriate strengths. Determination of the appropriate liquefied shear strength is an important decision in the cost-effective, safe and reliable design of structures on potentially liquefiable soils. The presentation provides methods to effectively analyze and design against the catastrophic effects of liquefaction within a risk-based framework. Probabilistic liquefied shear strength criteria are developed using the First-Order Reliability Method (FORM), Monte Carlo Simulations (MCS), and Bayesian Mapping (BM). Probabilistic slope stability analyses were conducted on field case histories of natural slopes and engineered embankments. MCS was used to account for the variability in soil material properties, represented by a Probability Distribution Function (PDF), in the estimates of the potential statistical range of the liquefied shear strength. In addition, the spatial variability of the liquefied shear strength is investigated to demonstrate how the spatial distribution of material properties can affect probability of failure estimates. FORM and BM are used to aggregate the results of the MCS and to correlate the liquefied shear strength with the minimum SPT blowcount. The result is a probabilistic relationship between liquefied shear strength and the SPT blowcount that can be used not only an estimate of the factor of safety against flow liquefaction but also probability of flow failure.

Bio: Dr. Marte Gutierrez is the James R. Paden Distinguished Professor at the Department of Civil and Environmental Engineering of Colorado School of Mines. Prior to joining CSM in 2008, he was Post-doctoral Fellow, Senior Engineer and Program Leader at the Norwegian Geotechnical Institute, and Associate Professor/Professor at Virginia Tech. He has held visiting professorship and researcher positions in China, Chile, France, Japan and South Korea and UAE. He has published more than 210 papers in book chapters, journals and conference proceedings, and has given keynote and invited lectures at a number of conferences. He is a member of the Editorial Board of four International Journals. He is the recipient of the 2011 Geotechnical Research Medal from UK's Institute of Civil Engineers and Peter A. Cundall Honorable Mention Award. Dr. Gutierrez's main research interests are in Geomechanics, and Energy and Environmental Sustainability. Dr. Gutierrez obtained his Ph.D. from the University of Tokyo under the supervision of Dr. Kenji Ishihara.