The Donald M. Burmister Lecture

Department of Civil Engineering and Engineering Mechanics
Columbia University

An Investigation Into Why The Earthquake Liquefaction Charts Work So Well

Professor Ricardo Dobry

Institute Professor
Rensselaer Polytechnic Institute, Troy, New York

November 9, 2011 (4:00-5:00 PM) 535 Mudd

The lecture explores why the field sand liquefaction charts based on Seed and Idriss' Simplified Procedure work so well. These are state-of-practice (SOP) empirical charts based on case histories of liquefaction and no liquefaction during actual earthquakes. The charts use either the Standard Penetration Test (SPT), the Cone Penetration Test CPT, or shear wave velocity measured in the field to characterize the soil. There is a disconnect between the State-of-the-Art (SOA), which relies mostly on laboratory measurements and correlations with void ratio and relative density of the sand, and this SOP based on field measurements of penetration resistance or shear wave velocity coupled with empirical correlations. This gap slows down further progress in both SOP and SOA, and understanding why the liquefaction charts work is an important first step to close the gap.

This exploration of why the charts work is accomplished through: a literature review of relevant aspects of the SOA including factors influencing threshold shear strain and pore pressure buildup during cyclic strain-controlled tests; a discussion of factors influencing field penetration resistance and shear wave velocity; and a discussion of the meaning of the curves in the liquefaction charts separating liquefaction from no liquefaction, helped by recent full-scale and centrifuge results. It is concluded that the charts are curves of constant cyclic strain at the lower end (V_{s1} < 160 m/s), with this strain being about 0.03 to 0.05% for earthquake magnitude, $M_w \approx 7$. It is also concluded, in a more speculative way, that the curves at the upper end probably correspond to a variable increasing cyclic strain and K_o, with this upper end controlled by overconsolidated and preshaken sands, and with cyclic strains needed to cause liquefaction being as high as 0.1 to 0.3%. These conclusions have been validated by application to case histories corresponding to $M_w \approx 7$, mostly in the San Francisco Bay Area of California during the 1989 Loma Prieta earthquake.

About The Speaker: Professor Ricardo Dobry is Civil Engineer from the University of Chile, after which he obtained his Master of Science at UNAM, and Ph.D at MIT. Since 1977 he has been faculty at Rensselaer Polytechnic Institute (RPI), currently being the Director of the Center for Earthquake Engineering Research that includes one of the state-of-the-art NEES geotechnical centrifuges. Dr. Dobry's research interests include soil dynamics, geotechnical earthquake engineering and geotechnical dynamic centrifuge testing. He was an active member of the group that performed the new seismic provisions on local site amplification, recently incorporated in U.S. building codes. He is one of the authors of the visionary 20-year research plan in earthquake engineering prepared in 2003 by the Earthquake Engineering Research Institute for NSF. Since 2000 he has leaded at RPI the geotechnical centrifuge experimental site of the Network for Earthquake Engineering Simulation (NEES), one of 15 interconnected experimental nodes funded by NSF to revolutionize earthquake engineering research in the U.S. Dr. Dobry has published more than 200 technical papers and research reports and has advised 40 PhD and MS theses at Rensselaer.

Prof. Dobry has served as consulting expert and member of consulting boards of important and prestigious civil engineering projects, including offshore oil platforms in Venezuela and Australia, earth dams and dikes in California, Puerto Rico and South America, seismic retrofitting of large bridges in NYC, seismic guidelines for design of new bridges in NYC, and the design of the new Rion-Antirion bridge in Greece. Dr. Dobry has been invited as a state-of-the-art and keynote speaker at international meetings in U.S., Mexico, South America, Europe, Japan and Australia. He earned the J. James Croes Medal of the American Society of Civil Engineers in 1985, and was elected member of the National Academy of Engineering in 2004, for his fundamental contributions to geotechnical earthquake engineering. In 2011, Prof. Dobry delivered the Ishihara Lecture at the 5th International Conference on Earthquake Geotechnical Engineering in Chile.

The late Prof. Donald M. Burmister (1895-1981) is one of the pioneers in the field of Soil Mechanics and Geotechnical Engineering. He established the Soils Laboratory at Columbia University in 1933. He was a faculty member for 34 years before retiring in 1963. During his tenure at Columbia University, he investigated earthworks and foundations for over 400 projects. Most notably among these were the Brookhaven National Laboratory, the Throgs Neck, Tappan Zee and Verrazano Narrows Bridges, the First New York World Fairs at Flushing Meadows, and the reconstruction of the White House in 1950. He has developed several soil testing methods and his soil classification system is still widely used. He also contributed to the first use of digital computer in conjunction with his theory of the layered pavement system.