

# Geo-Congress 2023

GSP 343

## Geotechnical Systems from Pore-Scale to City-Scale

Selected Papers from Geo-Congress 2023
Los Angeles, California • March 26–29, 2023

*Edited by*
Ellen Rathje, Ph.D., P.E.
Brina M. Montoya, Ph.D., P.E.
Mark H. Wayne, Ph.D., P.E.

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# GEO-CONGRESS 2023

## *GEOTECHNICAL SYSTEMS FROM PORE-SCALE TO CITY-SCALE*

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The Geo-Institute of the
American Society of Civil Engineers

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# Preface

This is the sixth volume of six Geotechnical Special Publications (GSPs) containing papers from the 2023 Geo-Congress: Sustainable Infrastructure Solutions from the Ground Up, held in Los Angeles, California on March 26–29, 2023. These six volumes contain over 350 contributions that span 22 topic areas of the ASCE Geo-Institute's standing technical committee as well as 11 special topics unique to Geo-Congress 2023.

This volume includes contributions associated with geotechnical systems – from pore-scale to city scale. The geotechnical systems addressed in this volume include embankments/dams/slopes, unsaturated soil systems, pavements, underground construction, major projects, ports/harbors, and spatially distributed infrastructure.

This publication culminates two years of effort by the technical planning committee whose focus has been to continue the success of the previous Geo-Congress conference series. Many individuals are responsible for the content of this volume, all of whom served in the efforts to maintain the standard set by previous proceedings. An international call for papers and a rigorous peer review process yielded more than 350 accepted technical papers, that were presented in a wide range of technical sessions, in addition to invited keynote presentations. Papers were reviewed in accordance with ASCE GSP standards. Accordingly, each paper was subjected to technical review by two or more independent peer reviewers. Publication requires concurrence by at least two peer reviewers.

The Editors would like to express their appreciation for having been provided the opportunity to be a part of this Congress' organization, their sincere thanks to the numerous session chairs and reviewers, and we hope that these proceedings will be of use to the geotechnical engineering community for many years to come.

**The Editors,**

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# 2D and 3D Probabilistic Slope Stability Analysis of a Levee with Relief Wells

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## ABSTRACT

Relief wells are commonly used to reduce the pore water pressure on the river-side of levees which will eventually reduce the risk of levees and embankments failure. Two-dimensional slope stability analyses, which are commonly used, tend to smear the three-dimensional relief well water influence. Two-dimensional (2D) analyses assume that relief wells have infinite length normal to the 2D plane of the model. Three-dimensional (3D) analysis more accurately captures the seepage flow around the relief wells and considers the spacing effects of these wells on the overall groundwater analysis. This study considers a full 2D and 3D steady state finite element seepage analyses of a typical levee with different relief well setups. The pore water pressure distributions of these cases were used for 2D and 3D limit equilibrium analyses to find the slope factor of safety and probability of failure. A full comparison of the effect of relief wells is presented for the 2D and 3D models for cases with and without relief wells.

## INTRODUCTION

Relief wells can be installed near levees to reduce buildup of porewater pressures underground (Gebhart, 1973). In the case of flooding, levees near rivers can protect the landside as an earthen embankment. However, seepage of water through the layers of the levee from the water side to the landward side can cause the buildup of porewater pressure. If relief wells are not installed, the safety of the structure can be threatened.

The effect of adding relief wells to reduce the pore water pressure with regards to slope stability near levees has been studied in various research (Zur, 2000; Walberg et al. 2013). It requires first conducting a groundwater seepage analysis to calculate the porewater pressure. To accomplish this, the Finite Element Method (FEM) is typically recommended. The use of FEM seepage analysis results as an input to a slope stability problem has been adopted extensively (Gofar and Asof, 2006; Pham et al., 2013; Andreea, 2016).

The analysis of relief wells towards slope stability is more accurately completed in 3D rather than in 2D, because the spacing of the relief wells results in a 3D variation to the pore pressure which cannot easily be represented in 2D. A 2D model assumes an infinite extrusion, whereas the 3D geometrical effects of a slope on the seepage flow, and subsequently its stability can only be fully realized in 3D. The most common approach for 3D slope stability analysis remains limit equilibrium method (LEM), which is usually an extension of the various 2D methods (Huang and Tsai, 2002; Cheng and Yip, 2007). These methods incorporate asymmetry and complex slopes along with the sliding direction and forces between the soil columns.

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