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Geotechnics of Natural Hazards

Selected Papers from Geo-Congress 2024
Vancouver, British Columbia, Canada | February 25–28, 2024

Edited by

T. Matthew Evans, Ph.D.
Nina Stark, Ph.D.
Susan Chang, Ph.D., P.E.

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GEOTECHNICS OF NATURAL HAZARDS

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Preface

This Volume is the second of six Geotechnical Special Publications (GSPs) containing papers from Geo-Congress 2024: Bridging Government, Industry, and Academia for Resilient Mega-Communities, held in Vancouver, British Columbia, Canada on February 25-28, 2024. Notably, this was the first Geo-Congress held outside of the United States, and the Canadian Geotechnical Society and Vancouver Geotechnical Society served as partnering organizations. The conference hosted the Terzaghi, Peck, Seed, and Prakash Lectures, numerous invited presentations on selected topics addressing the state of the art and practice in geotechnical engineering, and many technical sessions, panel sessions, short courses, and student competitions.

The call-for-papers was distributed internationally and resulted in 885 submissions. Several strong technical themes were observed in the submissions. These included cold regions engineering, machine learning and artificial intelligence, and sustainability, in addition to other traditionally strong tracks such as deep foundations, geosystems, and geoenvironmental engineering. We see these tracks as a reflection of both the location of the Geo-Congress and the topics currently at the forefront of geotechnical research and practice.

This volume includes a collection of papers in the fields of Earthquake Engineering and Soil Dynamics, Soil Erosion, Landslide Hazards, and Risk Assessment and Management. Each paper was subjected to a rigorous technical assessment by two or more independent peer reviewers. Acceptance required concurrence by at least two peer reviewers, and final decisions were made only after review coordinators confirmed that authors satisfactorily addressed any reviewer comments on their original submission. Ultimately, this resulted in acceptance of 366 papers in total, 76 of which are in this volume. All accepted papers are presented at the conference as posters or technical talks and are eligible for applicable ASCE Awards.

The success of this conference and proceedings would not have been possible without the participation and collaboration of many individuals, including the tireless staff at the Geo-Institute: Barbara Curtis, Lucy King, Krystina Scott, Sean Herpolsheimer, and Brad Keelor. We would also like to extend our gratitude to the Session Chairs and Reviewers, who provided thorough reviews and assessments of the submissions in a timely manner.

The Editors,

T. Matthew Evans, Ph.D.
Nina Stark, Ph.D.
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Static Liquefaction Triggering and Post-Liquefaction Strengths of Coarse Oil Sand Tailings

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ABSTRACT

Saturated oil sands tailings can be susceptible to static liquefaction if deposited loosely. The occurrence of static liquefaction can thus pose a major risk to an oil sands tailings dam. This study presents the results of a series of monotonic undrained and drained triaxial compression tests on moist-tamped specimens of coarse oil sands tailings. The experiments were conducted on specimens subjected to isotropic and laterally confined (K_0) consolidation loads to assess the effect of stress anisotropy and initial shear stress on the liquefaction behavior of oil sands tailings. The triggering and post-liquefaction undrained strengths normalized by the major consolidation stress were observed to decrease with decreasing relative density or increasing void ratio. A significant effect of anisotropic consolidation was observed, causing higher liquefaction triggering strengths in K_0-consolidated specimens than those mobilized in isotropically consolidated specimens. This was, however, diminished at large strains resulting in similar post-liquefaction undrained strength ratios.

INTRODUCTION

Liquefaction is a phenomenon wherein a saturated or partially saturated cohesionless soil loses a substantial percentage of its shear strength due to excess pore water pressure generation (Castro, 1969). In the past decades, considerable efforts have been made to better understand liquefaction susceptibility and stress-strain properties of saturated cohesionless soils using experimental and numerical studies. Substantial economic losses, human fatalities, and environmental damages have resulted from failures related to static liquefaction.

Tar Island dike is an example of oil sands liquefaction flow failure in northern Alberta. The dike was constructed using the upstream method to contain tailings waste from the extraction of bitumen. The Tar Island dike experienced four liquefaction-induced flow slides between 1972 and 1974 in submerged beach sands. The rapid fill placement caused an increase in pore water pressure in loose sand below the starter dike (Olson, 2001). More recently the Fundao (Morgenstern, et al., 2016) and the Brumadinho (Robertson, et al., 2019) iron mine tailings dams underwent flow failures following lateral extrusion of soft compressible slimes, rise of the phreatic surface due to a heavy rainfall, and liquefaction of overlying loose sand tailings.

Canadian oil sands deposits are concentrated mainly in Alberta including the Athabasca, Cold Lake, and Peace River deposits. The Athabasca oil sands are the largest and most accessible reserves of bitumen, spanning an area of about 75,000 km^2. The main resources of mineable oil sands are located north of Fort McMurray, which can be found close to the surface. The Cold Lake basin extends for about 22,000 km^2 in the east-central of Alberta. Following the extraction of oil, the residual tailings are often stored behind large dams. Oil sands tailings are

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