DRISI

CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

TRANSFORMING IDEAS INTO SOLUTIONS

Research Results

Validation of Design for Liquefaction-Induced Downdrag on Piles

Investigating Validation of Design for Liquefaction-Induced Downdrag on Piles.

Geotechnical/ Structures

October 2022

Project Title: Validation of Design for Liquefaction-Induced Downdrag on Piles

Task Number: 3168

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WHAT WAS THE NEED?

Downdrag loads on pile foundations can be an important design consideration when earthquake-induced liquefaction is expected to cause ground settlements. Despite significant research progress on the effects of liquefaction on structures, and the seismic response of piles, there is still a knowledge gap in the assessment of liquefaction-induced downdrag loads on piles. The interrelationships between mechanisms affecting negative skin friction (pore pressure generation and dissipation patterns, the sequencing of settlements and reconsolidation of liquefied soils, as well as gapping and softening of soils around the piles) are not accounted for in current practice. Hence, the inability to confidently account for liquefaction-induced downdrag may lead to overly-conservative or unsafely designed piles. A verified and more rational approach to account for downdrag forces on piles is needed.

WHAT WAS OUR GOAL?

This proposal had one specific goal: to develop centrifuge-based design guidelines for the assessment of liquefaction-induced downdrag loads on piles. This goal was met by satisfying two objectives: (i) to perform centrifuge model tests that will systematically illuminate the mechanisms affecting negative skin friction for a variety of situations wherein liquefaction takes place around piles and evaluate the downdrag loads and ground settlements, and (ii) to figure out how to revise existing procedures to better and cost effectively design piles to perform satisfactorily in the event of liquefaction of some layers along the length of the pile.

Caltrans

DRISI provides solutions and knowledge that improves California's transportation system

WHAT DID WE DO?

The California Department of Transportation (Caltrans), in partnership with the University of California, Davis Department of Civil and Environmental Engineering, developed and completed the research including seven interrelated tasks as part of an integrated experimental and numerical research program designed to improve Caltrans ability to properly account for liquefaction-induced downdrag loads on piles. The experimental work serves to provide time history data of how the key mechanisms are evolving for representative scenarios. The experimental work is essential for understanding the time dependency of the phenomena. The numerical work utilized the experimental data to develop guidelines for the design of piled foundations in liquefiable deposits.

WHAT WAS THE OUTCOME?

The end-product of this project were recommendations for a revised design procedure and the final report, which would provide the technical backup and data required to support the revised design procedure. Centrifuge data reports are available for future researchers. At least one conference paper and one journal paper was published to disseminate the results of the research to the broader bridge engineering community.

WHAT IS THE BENEFIT?

This project directly serves the goals set forward for bridges and structures that are safe, cost effective, and well-built. New data was incorporated or verified per current Caltrans design guidelines for downdrags on piles, used and openly and transparently shared for the transportation community to embrace and follow, and subsequently integrate into design and planning. The proposed research was aligned with the broader objective of ensuring reliability and structural integrity of bridges with pile foundations in liquefiable deposits. The strategy adopted is that of optimizing the design service life of such bridges by developing performance-based design and construction criteria for factors such as anticipated service life, and most importantly post-earthquake serviceability.

LEARN MORE

View Final Report: https://escholarship.org/uc/item/7c0205nw

IMAGES

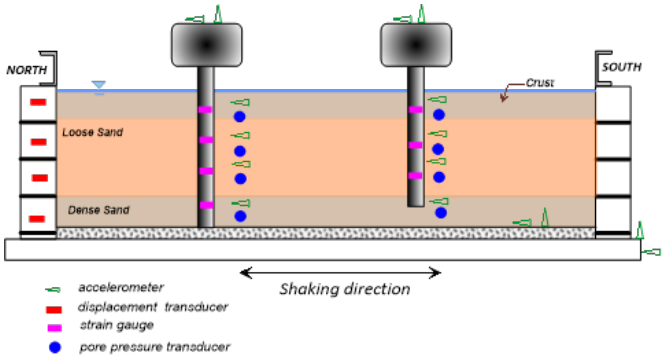

Image 1: Centrifuge Testing model

Image 2: Centrifuge testing machine at UC Davis