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CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION
TRANSFORMING IDEAS INTO SOLUTIONS

Research Results

Next Generation Liquefaction (NGL) Models for Predicting Triggering and Manifestation of Liquefaction

This research aims to enhance liquefaction triggering models by utilizing the recently created Next Generation Liquefaction (NGL) database.

Geotechnical/ Structures

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Project Title: Next Generation Liquefaction (NGL) Models for Predicting Triggering and Manifestation of Liquefaction

Task Number: 4418

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WHAT WAS THE NEED?

Soil liquefaction has caused significant bridge damage during past earthquakes. Liquefaction weakens soil layers beneath bridge foundations, leading to settlement and potentially causing horizontal ground movement that exerts lateral loads on the foundation, increasing the risk of the bridge superstructure becoming unseated. Accurately assessing the potential for liquefaction or severe strength loss in soil is crucial in geotechnical seismic hazard assessments for bridge design. Current liquefaction triggering models continue to face uncertainty regarding the influence of Fines Content (FC) in sandy soils on penetration resistance and cyclic soil behavior. Additionally, traditional intensity measures such as peak ground acceleration and earthquake magnitude may not be the most reliable predictors of liquefaction potential, as suggested by recent laboratory studies. Alternative intensity measures, such as Peak Ground Velocity (PGV), Arias Intensity (IA) and Cumulative Absolute Velocity (CAV), could be more effective. However, the depth-independence of these measures is not yet fully understood and requires further investigation.

WHAT WAS OUR GOAL?

This project aimed to develop an FC correction that separately accounts for its effects on penetration resistance and cyclic strength. Additionally, it sought to evaluate the effectiveness of ground motion intensity measures beyond peak acceleration and magnitude in predicting liquefaction triggering and manifestation.

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WHAT DID WE DO?

This project was conducted to update liquefaction triggering models by addressing two key areas of uncertainty:

1. Effect of fines in sandy soils on cyclic resistance ratio and penetration resistance: The research team investigated the influence of FC on the cyclic resistance ratio (CRR) and cone tip resistance. They analyzed cyclic laboratory test data to identify the transition from sand-dominated behavior (FC < 5%) to fines-dominated behavior at higher FC. For intermediate FC values, a logistic function was developed for interpolation. To assess CRR based on both drained and undrained tip resistance, correction factors were developed using the soil behavior type index (Ic).
2. Triggering models using alternative intensity measures: By analyzing liquefaction history data from the NGL database in relation to cone tip resistance, the research team computed alternative intensity measures such as PGV and IA to distinguish cases with and without liquefaction.

WHAT WAS THE OUTCOME?

A new FC correction was developed for liquefaction triggering, uniquely formulating the influence of FC on penetration resistance and cyclic resistance separately, representing a departure from existing corrections. This approach utilized variable rate cone penetration test data to quantify drained tip resistance and cyclic laboratory test data to quantify cyclic resistance, successfully interpolating between clean sand liquefaction and fine-grained soil cyclic softening frameworks. Additionally, this study evaluated alternative intensity measures, with preliminary findings indicating that measures such as IA and PGV do not exhibit improved predictive capability compared to peak ground acceleration and earthquake magnitude.

WHAT IS THE BENEFIT?

This research clarifies the role of fines in sandy soils on liquefaction triggering, enabling more accurate and reliable assessments. By improving the understanding of how earthquake intensity measures vary with depth, the project enhances seismic hazard evaluations and strengthens bridge resilience to liquefaction-related risks.

LEARN MORE

Final report online access is forthcoming.

IMAGES

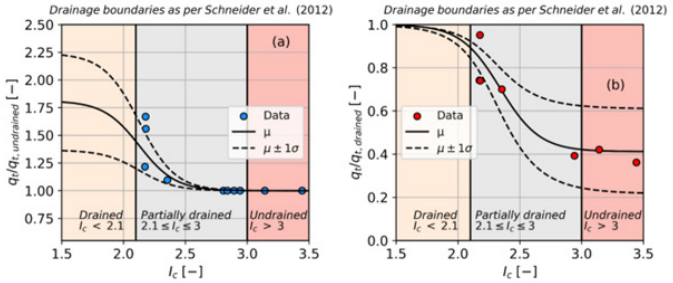

Image 1: Proposed Model for (a) the ratio of measured tip resistance (qt) to drained tip resistance (qt,undrained) versus soil behavior type index (Ic) and (b) the ratio of qt to drained tip resistance (qt,drained) versus Ic
Reference: Schneider, J. A., J. N. Hotstream, P. W. Mayne, and M. F. Randolph. (2012). "Comparing CPTU Q–F and Q–Δu2/σv0'soil classification charts." Géotechnique Lett., 2 (4): 209–215. ICE Publishing. https://www.emerald.com/jgele/article-abstract/2/4/209/1125365/Comparing-CPTU-Q-F-and-Q-u2-v0-soil-classification?redirectedFrom=fulltext