Research Project Highlight

Remediation of Liquefaction Effects on Embankments Using Soil-Cement Reinforcements

Project # 1120-NCTRBU

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Start-End Dates:
10/1/2014-12/30/2015

Abstract
This research project facilitated performing two centrifuge tests on the 9-m radius centrifuge at UC Davis as part of a PEER-based collaborative effort to develop design procedures for use of soil-cement grid and panel reinforcements for mitigating liquefaction-induced ground deformations for embankments and other transportation infrastructure. The centrifuge tests provided the first available physical modeling data regarding how crack initiation and progression in soil-cement grids and panels during earthquake shaking affects their ability to mitigation potential ground deformations for embankment. The results of these tests filled a high-priority research need for developing and validating liquefaction remediation strategies. The archived data provide a basis for evaluating numerical modeling procedures, which was beyond the scope of this specific project. Nonetheless, this collaborative research effort completed both experimental and numerical efforts by leveraging research efforts of individuals from three institutions.

Deliverables
Archived experimental data reports, conference papers, and journal papers describing the experiments, numerical analyses, and recommendations regarding the use of soil-cement grids/panels for remediating liquefaction effects on embankments and other transportation infrastructure.

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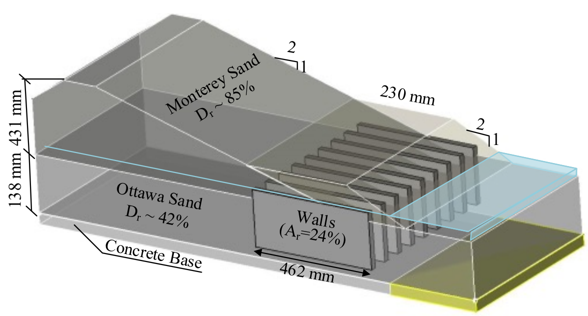
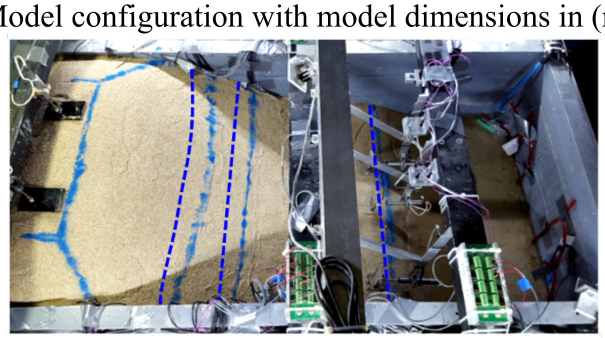
Research Impact

Centrifuge tests and two-dimensional nonlinear dynamic analyses were performed for an embankment on a liquefiable foundation layer treated with soil-cement walls. The model corresponded to a 28 m tall embankment underlain by a 9 m thick saturated loose sand layer. Soil-cement walls were constructed through the loose sand layer over a 30 m long section near the toe of the embankment with a replacement ratio of 24%. The model was shaken with scaled earthquake motions having peak horizontal base accelerations of 0.26 g and 0.54 g. The experimental data were archived as a lasting resource for validation of numerical modeling procedures. Nonlinear deformation analyses were performed using the platform FLAC with the user-defined constitutive model PM4Sand for the liquefiable materials and area-averaged properties for the treatment zone. The numerical simulations were in reasonable agreement with the recorded dynamic responses, including the triggering of liquefaction in the loose sand layer during both events. The simulations reasonably approximated the observed deformation magnitudes and patterns, and correctly predicted that the soil-cement walls would shear through their full length in the second event. The results of these comparisons provide support for the use of these numerical modeling procedures, including the representation of the treatment zone with area-weighted properties, for analyses of embankments with soil-cement treatment of liquefiable soils in their foundations.

Project Images



a) Model configuration with model dimensions in (mm)



b) Photograph of the model surface after completion of the second shaking event; dashed blue lines show location of the blue colored sand markers prior to shaking

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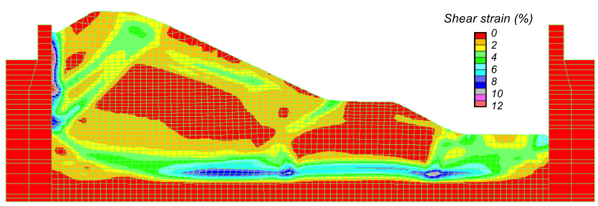
c) Photograph of soil-cement walls during model excavation after testing; embankment toe was to the left side of photo



d) Contours of shear strain on the deformed mesh after the second shaking event

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