GROUND IMPROVEMENT FOR LIQUEFACTION MITIGATION AT EXISTING HIGHWAY BRIDGES

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Dissertation submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
in
Civil Engineering

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July 13, 2000
Blacksburg, VA

Keywords: Liquefaction, remediation, ground improvement, bridges, numerical modeling, earthquakes

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ABSTRACT

The feasibility of using ground improvement at existing highway bridges to mitigate the risk of earthquake-induced liquefaction damage has been studied. The factors and phenomena governing the performance of the improved ground were identified and clarified. Potential analytical methods for predicting the treated ground performance were investigated and tested.

Key factors affecting improved ground performance are the type, size, and location of the treated ground. The improved ground behavior is influenced by excess pore water pressure migration, ground motion amplification, inertial force phasing, dynamic component of liquefied soil pressure, presence of a supported structure, and lateral spreading forces.

Simplified, uncoupled analytical methods were unable to predict the final performance of an improved ground zone and supported structure, but provided useful insights. Pseudostatic stability and deformation analyses can not successfully predict the final performance because of their inability to adequately account for the transient response. Equivalent-linear dynamic response analyses indicate that significant shear strains, pore water pressures and accelerations will develop in the improved ground when the treated-untreated soil system approaches resonance during shaking. Transient seepage analyses indicate that evaluating pore pressure migration into a three-dimensional improved zone using two-dimensional analyses can underestimate the pore pressures in the zone.

More comprehensive, partially-coupled analyses performed using the finite difference computer program FLAC provided better predictions of treated ground performance. These two-dimensional, dynamic analyses based on effective stresses incorporated pore pressure generation, non-linear stress-strain behavior, strength reduction, and groundwater flow. Permanent

movements of structures and improved soil zones were predicted within a factor of approximately two. Predictions of ground accelerations and pore water pressures were less accurate.

Dynamic analyses were performed with FLAC for an example bridge pier and stub abutment on an approach embankment supported on shallow foundations and underlain by thick, liquefiable soils with and without improved ground zones. Ground improvement that restricted movements of the pier and stub abutment to tolerable levels included improved zones of limited size extending completely through the underlying liquefiable soils and formed through densification by compaction grouting or cementation by chemical grouting or jet grouting. A buttress fill at the abutment was unsuccessful.

ACKNOWLEDGEMENTS

Throughout this research work, numerous people have provided support and encouragement. I would like to extend my sincere thanks to my advisor and Ph.D. committee chair, Dr. James K. Mitchell, for his enthusiasm, insights, and support for this work over the last six years. Likewise, I appreciate the interest and insights of my committee members: Drs. J. Michael Duncan, Mahendra P. Singh, Thomas L. Brandon, and James R. Martin. Other faculty members providing useful suggestions and information included Drs. George M. Filz, T. Kuppusamy, and Richard M. Barker.

In the process of performing the numerical analyses for this research using the computer program FLAC, several people shared their knowledge and offered advice. I would like to thank Dr. Peter M. Byrne of the University of British Columbia, Vancouver, Canada, for providing the soil model UBCSAND. Dr. Byrne and graduate student Michael Beaty of UBC also provided useful insights and suggestions regarding dynamic analyses with FLAC and UBCSAND. Dr. Peter Cundall and the Itasca Consulting Group offered valuable technical support for FLAC, helping to address issues regarding use of the program for this work.

My graduate work would not have been possible without the generous financial support of several organizations. Funding for this work was primarily provided by the Federal Highway Administration through the Multidisciplinary Center for Earthquake Engineering Research in Buffalo, New York, under FHWA Contract DTFH61-92-C-00106, Seismic Vulnerability of Existing Highway Construction. Support also came from a nine-month fellowship for earthquake hazards reduction research from the Federal Emergency Management Agency through the Earthquake Engineering Research Institute in Oakland, California. The Center for Geotechnical Practice and Research at Virginia Tech generously provided a one-semester fellowship to allow completion of my research.

During the course of my graduate studies at Virginia Tech, I had the good fortune of working and becoming friends with other students and visiting scholars. Graduate student Jennifer Schaeffer made contributions to this research through her Master’s degree project and report on excess pore water pressure migration into improved ground zones. Numerous other students shared their knowledge and good humor with me. I particularly would like to thank graduate students Chris and Diane Baxter and Carmine Polito for their encouragement and support from the beginning of my studies. I am also grateful to Dr. Moussa Wone for his understanding, advice, humor and friendship over the last three years.

My family has been a constant source of love, encouragement, and support throughout my graduate studies and my life. I am grateful to my mother Dorothy, sister Kathy, and brother-in-law Steve for their love, patience, and understanding over the last six years. Likewise, I am grateful to my father, Harry, who was a source of love, joy, and wisdom in my life and in our family.

I would like to express my gratitude to my family at Christ Episcopal Church in Blacksburg for the love and encouragement they have offered during my time at Virginia Tech. Above all, praise and thanks to a gracious and loving God, for the strength, hope, and mercy provided throughout my life.

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