

Selected Papers from the Proceedings of the
Fourth Geo-China International Conference

Geotechnical Special
Publication No. 258



Advances in Pavement Engineering and Ground Improvement

Edited by

Hadi Khabbaz, Ph.D.

Zahid Hossain, Ph.D.

Boo Hyun Nam, Ph.D.



This is a preview. [Click here to purchase the full publication.](#)

GEOTECHNICAL SPECIAL PUBLICATION NO. 258

GEO-CHINA 2016

ADVANCES IN PAVEMENT ENGINEERING AND GROUND IMPROVEMENT

SELECTED PAPERS FROM THE PROCEEDINGS OF THE FOURTH
GEO-CHINA INTERNATIONAL CONFERENCE

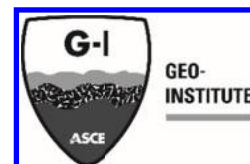
July 25–27, 2016
Shandong, China

SPONSORED BY

Shandong University
Shandong Department of Transportation
University of Oklahoma
Chinese National Science Foundation
Geo-Institute of the American Society of Civil Engineers

EDITED BY

Hadi Khabbaz, Ph.D.
Zahid Hossain, Ph.D.
Boo Hyun Nam, Ph.D.
Xianhua Chen, Ph.D.



Published by the American Society of Civil Engineers

This is a preview. [Click here to purchase the full publication.](#)

Published by American Society of Civil Engineers
1801 Alexander Bell Drive
Reston, Virginia, 20191-4382
www.asce.org/publications | ascelibrary.org

Any statements expressed in these materials are those of the individual authors and do not necessarily represent the views of ASCE, which takes no responsibility for any statement made herein. No reference made in this publication to any specific method, product, process, or service constitutes or implies an endorsement, recommendation, or warranty thereof by ASCE. The materials are for general information only and do not represent a standard of ASCE, nor are they intended as a reference in purchase specifications, contracts, regulations, statutes, or any other legal document. ASCE makes no representation or warranty of any kind, whether express or implied, concerning the accuracy, completeness, suitability, or utility of any information, apparatus, product, or process discussed in this publication, and assumes no liability therefor. The information contained in these materials should not be used without first securing competent advice with respect to its suitability for any general or specific application. Anyone utilizing such information assumes all liability arising from such use, including but not limited to infringement of any patent or patents.

ASCE and American Society of Civil Engineers—Registered in U.S. Patent and Trademark Office.

Photocopies and permissions. Permission to photocopy or reproduce material from ASCE publications can be requested by sending an e-mail to permissions@asce.org or by locating a title in ASCE's Civil Engineering Database (<http://cedb.asce.org>) or ASCE Library (<http://ascelibrary.org>) and using the “Permissions” link.

Errata: Errata, if any, can be found at <http://dx.doi.org/10.1061/9780784480014>

Copyright © 2016 by the American Society of Civil Engineers.
All Rights Reserved.
ISBN 978-0-7844-8001-4 (PDF)
Manufactured in the United States of America.

Preface

This Geotechnical Special Publication (GSP) contains 18 papers that were accepted and presented at the 4th GeoChina International Conference on Sustainable Civil Infrastructures: Innovative Technologies for Severe Weathers and Climate Changes, held in Shandong, China on July 25-27, 2016. Major topics covered in this GSP are:

- Engineering Issues in Ground Subsidence
- Geophysical Testing in Civil and Geological Engineering
- Ground Improvement, and Chemical / Mechanical Stabilization for Pavement and Geotechnical Applications
- Asphalt Mix-Design, HMA Testing, & Material Property Characterization

The overall theme of the GSP is advances in pavement engineering and ground improvement and all papers address different research findings of this theme. It provides an effective means of shearing recent technological advances, engineering applications and research results among scientists, researchers and engineering practitioners.

Acknowledgements

The editors would like to thank the many individuals who assisted in reviewing the abstracts and papers. Without their efforts we would not have had high quality papers included in this publication.

Contents

Downdrag Behavior of Piled Foundations Caused by Deep Water Pumping: A Forensic Study of a Damaged HSR Viaduct	1
Jin Hung Hwang, Yuan Chang Deng, Teng Ruei You, and Hao Shiang Hsu	
Study on the Settlement of an Expressway Foundation with Cement Mixing Piles in the Yellow River Alluvial Plain	10
Zhanyong Yao, Kai Yao, Xiaomeng Zhang, Xiuguang Song, Teng Ma, and Xianghong Pan	
Pressures Needed to Suppress Expansion in Clayey Soils	18
E. Mutaz and M. Dafalla	
Numerical Analysis of Heat Transfer on a Concrete Retaining Wall with Defects	26
Ting-Qiang Zhou and Jian-Gong Chen	
On the Response of Ibese Shale to Coconut and Rice Husk Ash Treatment	36
Oyediran Ibrahim Adewuyi and Fadamoro Oluwafemi Festus	
Evaluation of Optimal Compaction Frequencies for Granular Materials	44
Wynand Steyn and Greg Reynolds	
Hydraulic Conductivity of Compacted Lime-Treated Expansive Soils	52
Tamer Y. Elkady, Abdullah Shaker, and Mosleh Al-Shamrani	
Three-Dimensional Simulation of a Load Transfer Mechanism for Frictional and End Bearing CMC Supported Embankments on Soft Soil	60
Hamed Mahdavi, Behzad Fatahi, Hadi Khabbaz, Michal Krzeminski, Roger Santos, and Michael Marix-Evans	
Evaluating the Behavior of a Column-Supported Embankment Founded on Soft Ground	68
Mohsen Mousivand, Hesam Aminpour, Mehran Kardooni Naseri, and Amir Mohamad Amiri	
Experimental Study on an Ideal Compaction Grouting into Sand	77
Shanyong Wang, Qiong Wang, Xinyu Ye, Scott William Sloan, and Daichao Sheng	

Compaction and Strength Characteristics of Modified Waste Expanded Polystyrene (EPS) Mixed with a Standard Sand	85
Oluwapelumi O. Ojuri and Salami A. Ademola	
Impact of Quicklime and Fly Ash on the Geotechnical Properties of Expansive Clay	93
Hayder Hasan, Hadi Khabbaz, and Behzad Fatahi	
Periodogram-Based Numerical Analysis on Pavement Stochastic Roughness	101
Rui He, Shuhua Wu, and Wenfei Wu	
Performance Improvement of Granular Pavement Materials Using a Polyacrylamide-Based Additive	108
Romel Georges, Rayya Hassan, Robert Evans, and Piratheepan Jegatheesan	
Geotechnical Characterisation of Soft Clay Treated with a Bottom and Fly Ash Mixture	118
Swamy K. Ranga	
Evaluating the Rutting Performance of a Polymer-Modified Binder Containing WMA Additives Using Different Rheological Parameters	126
Aniket V. Kataware and Dharamveer Singh	
Different Approaches to Develop Permeability Specifications of Asphalt Pavements	135
Rafiqul A. Tarefder and Mohiuddin Ahmad	
Evaluation of an HMA Stiffness Modulus Based on Indirect Tensile Testing	143
José Neves and António Gomes-Correia	

Downdrag Behavior of Piled Foundations Caused by Deep Water Pumping: A Forensic Study of a Damaged HSR Viaduct

Jin Hung Hwang¹; Yuan Chang Deng²; Teng Ruei You³; and Hao Shiang Hsu⁴

¹Professor, Dept. of Civil Engineering, National Central Univ., No. 300, Jhongda Rd., Jhongli, Taoyuan, Taiwan. E-mail: jinhunghwang@gmail.com

²Ph.D. Candidate, Dept. of Civil Engineering, National Central Univ., No. 300, Jhongda Rd., Jhongli, Taoyuan, Taiwan. E-mail: ben210253@hotmail.com

³Ph.D. Candidate, Dept. of Civil Engineering, National Central Univ., No. 300, Jhongda Rd., Jhongli, Taoyuan, Taiwan. E-mail: 943202029@cc.ncu.edu.tw

⁴Master, Dept. of Civil Engineering, National Central Univ., No. 300, Jhongda Rd., Jhongli, Taoyuan, Taiwan. E-mail: eminemshow28@gmail.com

Abstract: One of the viaducts of the High Speed Railway in Taiwan has suffered significant structural cracks in its piers. This has raised serious public concern. The damage was conjectured to have resulted from ground settlement due to regional water pumping. The paper proposed a practical methodology to investigate the downdrag behavior of the pile foundations of the viaduct. A fictitious settlement controlled layer beneath the pile foundation was used to control the ground surface settlement due to deep water pumping. A three-dimensional finite difference mesh including the soil profile and the pile foundation was established with the geotechnical investigation report and design data. By varying the ground surface settlement, the variations of the pile settlement, ground settlement, and downdrag force with depth for each pile can be reasonably simulated. The results show an obvious pile group effect, which shows the minimum downdrag force in the interior pile and maximum force in the corner pile. There also exists a critical surface ground settlement at which the drag force reaches the maximum value. The simulated differential settlement was close to the measured value, however this was not enough to have caused the structural cracks in the piers. The cracks are more likely caused by other engineering events.

INTRODUCTION

The Taiwan High Speed Railway (HSR) was constructed along Taiwan's western coastal alluvial plain in 2006 and began operating in 2007. Figure 1 shows its route and the site under study. Nowadays, it is a very important transportation artery. The western coastal plain has suffered from regional ground subsidence for many years owing to

pumping water for use in agriculture irrigation and aquaculture fisheries. The most serious subsidence area is Yunlin County. Figure 2 shows the accumulated settlement contour of the county during 2002-2011 and the routes of HSR and the No. 78 highway.

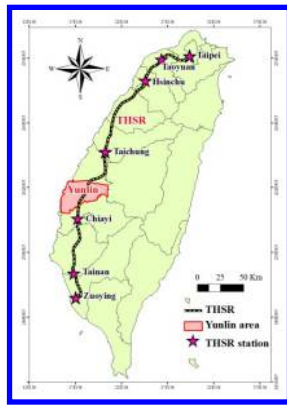


FIG. 1 The route of THSR and study site

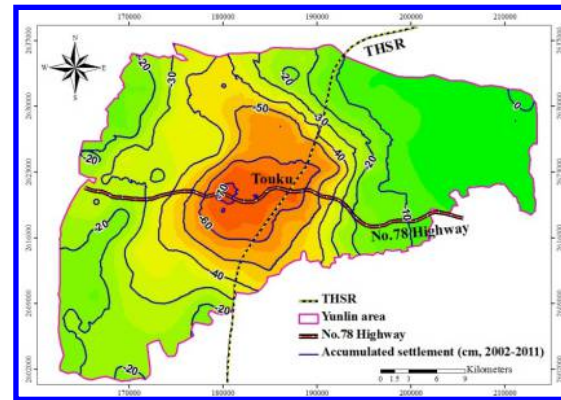


FIG. 2 Settlement contour of Yunlin County during 2002-2011

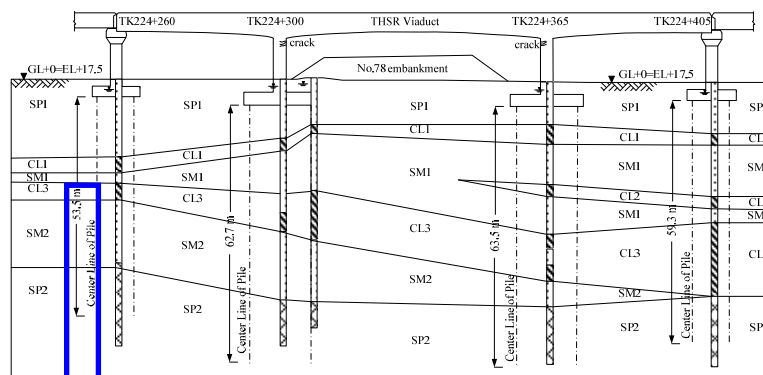


FIG. 3 The 3-span viaduct, the cracked piers, and the pile foundations

Two bridge piers of one HSR viaduct at the intersection of the HSR and No.78 highway have been found to have serious structural cracks at the top of the pier. Figure 3 shows the 3-span viaduct, the cracked piers, and the pile foundations. Figure 4 displays the cracks that occurred at the top of the damaged pier. Based on the settlement records during 2003-2010

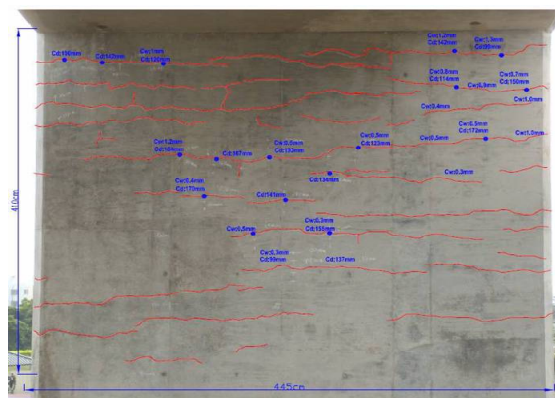


FIG.4 The cracks at the top of pier

(Sinotech 2012), the accumulated settlement at the intersection of the HSR and No. 78 Highway has reached a maximum of approximately 62 cm. Thus, the damage to the piers caused great concern in the public about the safety of the HSR. Most people attributed the damage to the settlement of the region due to pumping water. This background led to this study aiming to understand the influence of the regional settlement on the pile foundations of the HSR.

METHODOLOGY AND ANALYSIS MODEL

The purpose of this study is to investigate the effect of deep pumping water on the pile foundations of the HSR. The analysis procedure included (1) establishing an analysis model, (2) summarizing the parameters needed from the soil profile, (3) a simplified method to simulate deep water pumping, and (4) performing numerical simulations. Originally, the whole viaduct structure and foundation ground (full model) were included in the analysis model. However, the full model was unacceptable due to the following three factors. First, the element number was enormous, second was the very complicated soil profile, and the last was that the dewatering depth reached down to a depth of 300 m. All these made the analysis domain too large. The study finally selected one pile foundation and its surrounding ground as the analysis domain to save computational time and cost. The complicated soil layers were simplified into several horizontal soil layers. A novel idea was to use a controlled bottom layer to replace the large soil domain below the bottom of pile foundation. The settlement of the former was controlled to equal to that of the latter. Thus, the computational effort can be greatly reduced. Based on this idea, a practical methodology was successfully developed for analyzing the effect of deep water pumping on the pile foundation.

Analysis Model

The 3-span (40m-65m-40m) damaged viaduct has four pile foundations. The inner pile foundations with cracked piers were used to set up the analysis model. The analyzed pile foundation had a cap with dimensions of 18 m \times 18 m \times 3 m, and 12 bored piles (all casing piles) with 2 m diameters and 62 m of length. The ultimate axial bearing capacity of each single pile is about 52.4MN with a frictional capacity of 43MN (82%). The plan layout of the pile foundation and the pier is shown in Figure 5. The pile was meshed by hexadecagonal solid elastic elements. The ground was meshed by hexagonal solid elastoplastic elements with finer mesh sizes in the foundation area and gradually coarser mesh sizes from the foundation edge towards the boundaries. The ground water table has been

lowered down to a depth of 300 m. Thus, a large numerical model with a depth of 300 m was required to simulate the real conditions. However, the computational time was unacceptable for such a model. To overcome the problem, a 10 m thick controlled soil layer was used to replace the 230 m thick one below the bottom of the pile foundation by requiring the settlement of the former layer to be equal to that of the latter layer. Thus, the original model size of 112 m \times 112 m \times 300 m was reduced to a 112 m \times 112 m \times 80 m concept of the settlement-controlled layer. The final mesh of the analysis model had 1,920,000 elements, as shown in Figure 6.

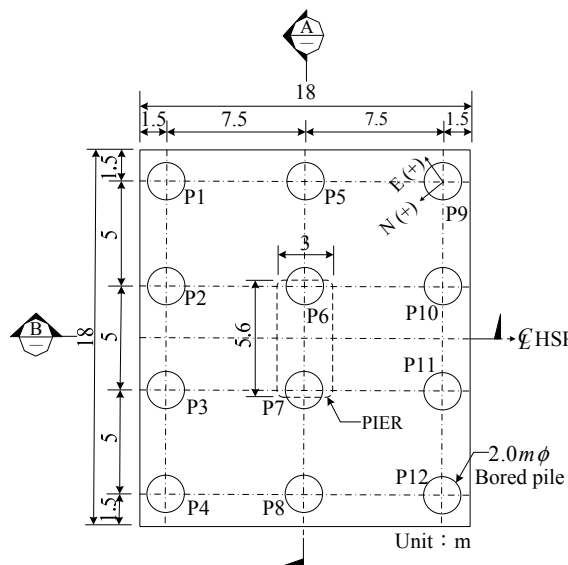


FIG. 5 The plan layout of pile foundation

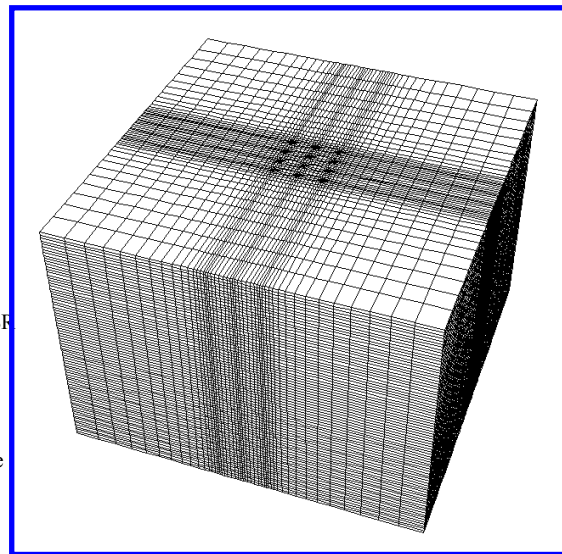


FIG. 6 The mesh of analysis model

Geotechnical Parameters

Based on the geotechnical investigation report for this site, there were data from one borehole at the position of each pier in the design stage. An additional boring hole was performed at a position near to the interior pier. The borehole depths ranged from 65 m to 69 m and the ground water tables ranged from 1.7 m to 2.7 m. The site consists of interbedded sandy and clayey soils down to at least 1000 m. The soil formation is very complicated. The simplified soil profile and the geotechnical parameters for analysis are summarized in Table 1. It consists of three sandy soils and two clayey soil layers. The pile bottom is located in the last sandy layer. Below that is the settlement-controlled layer for modelling the effect of deep soil formation beneath the pile foundation. The ground water table was assumed to be at a 2 m depth for the analysis. The pile is assumed to be an elastic material. The soils are elastic-perfectly plastic materials that follow the Mohr-Coulomb failure criterion.