Liquefaction Of Soils During Earthquakes

There have been numerous examples of damage to buildings due to the effects of soil liquefaction or cyclic softening in recent significant earthquake events. Of these examples, shallow-founded buildings on level ground atop shallow liquefiable soils have often been impacted by partial or complete bearing failures, loss of foundation soils due to eroded sediment ejecta, and vertical settlements that have been exacerbated by soil-structure-interaction (SSI). While significant progress has been made in recent years towards understanding these deformation mechanisms, there is still no widely-accepted simplified method by which engineering practitioners can reliably estimate the settlement of buildings due to liquefaction or cyclic softening. Rollins and Seed (1990) pointed out that the liquefaction potential below a building was often evaluated by treating the soil as if it were in the free-field. Two decades later, Bray and Dashti (2010) found that liquefaction-induced building settlements are still often estimated using empirical procedures developed to calculate post-liquefaction, one-dimensional, consolidation settlements in the free-field (e.g., Tokimatsu and Seed, 1987; Ishihara and Yoshimine, 1992). These free-field procedures do not capture important shear-induced and localized volumetric-induced building deformation mechanisms. Therefore, these procedures can significantly underestimate building settlements. Improvements are required to advance the state-of-the-art in liquefaction engineering. The primary objective of this research effort is to advance the understanding of the seismic performance of buildings subjected to soil liquefaction or cyclic softening. This objective is achieved through the performance of a geotechnical centrifuge experiment and through the documentation and interpretation of a number of field performance case histories. Well-documented field and physical model case history data are essential to advancing the profession's understanding of the effects of liquefaction or cyclic softening on building performance. The field and laboratory studies are also critical to the development and calibration of simplified empirical procedures and advanced analytical procedures. Therefore, while the primary objective of the work presented herein is to advance the understanding of liquefaction-induced building settlements, an additional significant objective is to provide high quality and well-interpreted field and physical model case history data that can be used to develop, evaluate, and calibrate analytical procedures and design methods. A sophisticated geotechnical centrifuge model of shallow-founded model structures atop shallow liquefiable soils was designed, constructed, and subjected to several realistic earthquake motions of varying intensity and duration as part of this work. This experiment was designed to build on previous centrifuge experiments described by Hausler (2002) and Dashti (2009). There were many design similarities between this model and the models described by Dashti (2009), and the findings were generally consistent. However, an additional key objective of this model was to evaluate the effects of building adjacency on the observed performance of the model structures. It was found that placing a baseline model structure next to an identical model structure did not significantly impact the building settlement of either building during the test. Placing the baseline model structure next to a taller, heavier shallow-founded model structure illustrated that it is erroneous to always expect a heavier shallow-founded structure to settle more than a lighter shallow-founded structure when subjected to shallow liquefaction. For some ground motions, less cyclic softening occurred under the heavier structure, so it settled less than the adjacent lighter baseline structure. The seismic demand on the building's foundation soils is directly related to the ground motion and both the building's weight and its dynamic response. In addition, the adjacent model buildings generally tilted and displaced laterally away from one another. These observations suggest that the physical presence of the adjacent building kinematically constrained ground movements under the structures on the sides nearest the adjacent buildings relative to the ground movements that occurred under the sides away from the adjacent building. Also, the confining stresses under the sides of closely-spaced adjacent buildings are lower under the side away from the neighboring building than the side closest to the neighboring building. Consequently, with all other things equal, one would expect a lower liquefaction resistance in the foundation soils on the sides away from the adjacent building, and therefore, relatively more cyclically-induced deformation to occur on that side during shaking Building performance evaluations of select buildings in Christchurch, New Zealand during the 2010-2011 Canterbury earthquake sequence were also performed. Many multi-story buildings were heavily damaged by liquefaction-induced ground movements during the 22 February 2011 Mw 6.2 Christchurch earthquake, but not by other significant earthquakes. Conventional CPT-based liquefaction triggering evaluations were generally conservative for these field case histories, and this conservatism led to post-liquefaction free-field ground settlement estimates that were generally similar for the 4 September 2010 Mw 7.1 Darfield, 13 June 2011 Mw 6.0, and 22 February 2011 Mw 6.2 Christchurch earthquakes. Variability in the shallow subsurface conditions over relatively short distances was sometimes a critical factor in the seismic performance of the ground and buildings. Ground loss due to eroded sediment ejecta was found to be an important foundation settlement mechanism in several cases of shallow-founded buildings with shallow liquefiable foundation soils. In addition, two shallow-founded, tall buildings settled and tilted due to relatively deeper liquefaction or cyclic softening during the Christchurch event. Though these tall structures were founded at least 3 m above materials that were judged to have liquefied, the liquefied materials were well within the depth range with a significant vertical strain influence using the settlement approach developed by Schmertmann (1978) for rigid footings on sand. Therefore, cyclically-induced deformation of these materials due to increased pore water pressures likely led to the observed building settlements and tilts. In summary, there are important physical constraints caused by building adjacency that can affect the seismic performance of buildings subjected to soil liquefaction or cyclic softening. The performance of a building is also significantly affected by the earthquake motion, the ground beneath its foundation, and its dynamic response, including SSI effects such as superstructure rocking. Consequently, the combined effects of all these factors are difficult to judge a priori. Additional studies are warranted to develop insights and improved methods.

The first book of its kind, providing over thirty real-life case studies of ground improvement projects selected by the worlds top experts in ground improvement from around the globe. Volume 3 of the highly regarded Elsevier Geo-engineering book series coordinated by the Series Editor: Professor John A Hudson FREng. An extremely reader friendly chapter format. Discusses wider economical and environmental issues facing scientists in the ground improvement. Ground improvement has been both a science and art, with significant developments observed through ancient history. From the use of straw as blended infill with soils for additional strength during the ancient Roman civilizations, and the use of elephants for compaction of earth dams during the early Asian civilizations, the concepts of reinforced earth with geosynthetics, use of electrokinetics and thermal modifications of soils have come a long way. The use of large and stiff stone columns and subsequent sand drains in the past has now been replaced by quicker to install and more effective prefabricated vertical drains, which have also eliminated the need for more expensive soil improvement methods. The early selection and application of the most appropriate ground improvement techniques can improve considerably not only the design and performance of foundations and earth structures, including embankments, cut slopes, roads, railways and tailings dams, but also result in their cost-effectiveness. Ground improvement works have become increasingly challenging when more and more problematic soils and marginal land have to be utilized for infrastructure development. This edited compilation contains a collection of Chapters from invited experts in various areas of ground improvement, who have illustrated the basic concepts and the applications of different ground improvement techniques using real projects that they have been involved in. The case histories from many countries ranging from Asia, America, Australia and Europe are addressed.

Seismic Design of Industrial Facilities demands a deep knowledge on the seismic behaviour of the individual structural and non-structural components of the facility, possible interactions and last but not least the individual hazard potential of primary and secondary damages. From 26.-27. September 2013 the International Conference on Seismic Design of Industrial Facilities firstly addresses this broad field of work and research in one specialized conference. It brings together academics, researchers and professional engineers in order to discuss the challenges of seismic design for new and existing industrial facilities and to compile innovative current research. This volume contains 50 contributions to the SeDIF-Conference covering the following topics with respect to the specific conditions of plant design: · International building codes and guidelines on the seismic design of industrial facilities · Seismic design of non-structural components · Seismic design of silos and liquid-filled tanks - Soil-structure-interaction effects · Seismic safety evaluation, uncertainties and reliability analysis · Innovative seismic protection systems

· Retrofitting The SeDIF-Conference is hosted by the Chair of Structural Statics and Dynamics of RWTH Aachen University, Germany, in cooperation with the Institute for Earthquake Engineering of the Dalian University of Technology, China.

Soil liquefaction during past earthquakes has caused extensive damage to buildings, bridges, dam, pipelines and other elements of infrastructure. Geotechnical engineers use empirical observations from earthquake case histories in conjunction with soil mechanics to predict the behavior of liquefiable soils. However, current empirical databases are insufficient to evaluate the behavior of soils subject to long-duration earthquakes, such as a possible Mw = 9.0 Cascadia Subduction Zone earthquake. The objective of this research is to develop insight into the triggering and effects of liquefaction due to long-duration ground motions and to provide recommendations for analysis and design. Recorded ground motions from 21 case histories with surficial evidence of liquefaction showed marked differences in soil behavior before and after liquefaction was triggered. In some cases, strong shaking continued for several minutes after the soil liquefied, and a variety of behaviors were observed including dilation pulses, continued softening due to soil fabric degradation, and soil stiffening due to pore pressure dissipation and drainage. Supplemental field and laboratory investigations were performed at three sites that liquefied during the 2011 Mw = 9.0 Tohoku earthquake. The recorded ground motions and field investigation data were used in conjunction with laboratory observations, analytical models, and numerical models to evaluate the behavior of liquefiable soils subjected to long-duration ground motions. Observations from the case histories inspired a framework to predict ground deformations based on the differences in soil behavior before and after liquefaction has triggered. This framework decouples the intensity of shaking necessary to trigger liquefaction from the intensity of shaking that drives deformation by identifying the time when liquefaction triggers. The timing-based framework promises to dramatically reduce the uncertainty in deformation estimates compared to conventional, empirically-based procedures.

Estimating Losses from Future Earthquakes

Effects of Long-duration Ground Motions on Liquefaction Hazards

The Effects of Band-limited White Noise Excitation on Liquefaction Potential in Large-scale Tests

A Review of the Five-Year Reconstruction Efforts

A Critical State Approach, Second Edition

Design of Pile Foundations in Liquefiable Soils

Earthquake-induced soil liquefaction (liquefaction) is a leading cause of earthquake damage worldwide. Liquefaction is often described in the literature as the phenomena of seismic generation of excess porewater pressures and consequent softening of granular soils. Many regions in the United States have been witness to liquefaction and its consequences, not just those in the west that people associate with earthquake hazards. Past damage and destruction caused by liquefaction underline the importance of accurate assessments of where liquefaction *is likely and of what the consequences of liquefaction may be. Such assessments are needed to protect life and safety and to mitigate economic, environmental, and societal impacts of liquefaction in a cost-effective manner. Assessment methods exist, but methods to assess the potential for liquefaction triggering are more mature than are those to predict liquefaction consequences, and the earthquake engineering community wrestles with the differences among the various assessment methods for both liquefaction triggering and consequences. State of the Art and Practice in the Assessment of Earthquake-Induced Soil Liquefaction and Its Consequences evaluates these various methods, focusing on those developed within the past 20 years, and recommends strategies to minimize uncertainties in the short term and to develop improved methods to assess liquefaction and its consequences in the long term. This report represents a first attempt within the geotechnical earthquake engineering community to consider, in such a manner, the various methods to assess liquefaction consequences.*

The Fukushima and Tohoku Disaster: A Review of the Five-Year Reconstruction Efforts covers the outcome of the response, five years later, to the disasters associated with the Great East Japan earthquake on March 11, 2011. The 3.11 disaster, as it is referred to in Japan, was a complex accident, the likes of which humans had never faced before. This book evaluates the actions taken during and after the earthquake, tsunami, and nuclear accident, for which the Japanese government and people were not prepared. The book also provides recommendations for preparing and responding to disasters for those working and living in disaster-prone areas, making it a vital resource for disaster managers and government agencies. Includes guidelines for governments, communities and businesses in areas where similar complex disasters are likely to occur Provides information, propositions, suggestions and advice from the people that were involved in making suggestions to the Japanese government Features case studies (both pre- and post-disaster) of three simultaneous disasters: the Great East Japan earthquake, the resulting tsunami, and the Fukushima Nuclear Power Plant disaster

This volume addresses the multi-disciplinary topic of engineering geology and the environment, one of the fastest growing, most relevant and applied fields of research and study within the geosciences. It covers the fundamentals of geology and engineering where the two fields overlap and, in addition, highlights specialized topics that address principles, concepts and paradigms of the discipline, including operational terms, materials, tools, techniques and methods as well as processes, procedures and implications. A number of well known and respected international experts contributed to this authoritative volume, thereby ensuring proper geographic representation, professional credibility and reliability. This superb volume provides a dependable and ready source of information on approximately 300 topical entries relevant to all aspects of engineering geology. Extensive illustrations, figures, images, tables and detailed bibliographic citations ensure that the comprehensively *defined contributions are broadly and clearly explained. The Encyclopedia of Engineering Geology provides a ready source of reference for several fields of study and practice including civil engineers, geologists, physical geographers, architects, hazards specialists, hydrologists, geotechnicians, geophysicists, geomorphologists, planners, resource explorers, and many others. As a key library reference, this book is an essential technical source for undergraduate and graduate students in their research. Teachers/professors can rely on it as the final authority and the first source of reference on engineering geology related studies as it provides an exceptional resource to train and educate the next generation of practitioners.*

To provide a general view of liquefaction, some of the larger earthquakes occurring in the alluvial plains of Japan are discussed as case history studies. Among the subjects discussed are the sand deposits in the lowland areas, and the damage directly associated with the liquefaction of this loose sand deposits, the upward movement of underground structures such as storage tanks, sewage conduits and septic tanks, the volcanic ejection of water and sand, and the like; also discussed are structural damages to modern bridges, and the importance of the study of liquefaction as a potential hazard, especially sandy areas.

Case Histories

A Critical State Approach

Soil Liquefaction during Recent Large-Scale Earthquakes

Final Report

Earthquake Geotechnical Engineering for Protection and Development of Environment and Constructions

Handbook of Seismic Risk Analysis and Management of Civil Infrastructure Systems

Earthquakes are natural calamities that occur as a result of sudden release of strain energy stored in fault planes. Earthquakes have been observed to cause huge damage to infrastructures and lives. Earthquakes result in development of fissures, abnormal or unequal movement of foundations, and loss of strength and stiffness of the soils. Liquefaction is attributed as a major cause for the loss of strength and stiffness of soil during earthquakes. In the past, liquefaction was attributed only to coarse-grained to medium-grained sand and was extensively studied but the fine-grained soils were generally considered as non-liquefiable. However, from observations during recent earthquakes, fine-grained soils having low plasticity (plasticity index (PI)

Innovative Earthquake Soil Dynamics deals with soil dynamics in earthquake engineering and includes almost all aspects of soil behavior. Both generally accepted basic knowledge as well as advanced and innovative views are accommodated. Major topics are (i) seismic site amplification, (ii) liquefaction and (iii) earthquake-induced slope failure. Associated with the above, basic theories and knowledge on wave propagation/attenuation, soil properties, laboratory tests, numerical analyses, and model tests are addressed in the first part of the book. A great number of earthquake observations in surface soil deposits as well as case histories with new findings are addressed in the later chapters, together with associated laboratory test data. Most of the research results originate from Japan, which is rich in earthquake records and case histories, although mostly isolated from the outside world because of the language barrier. Another important feature characterizing this book is an

energy perspective in addition to the force-equilibrium perspective, because it is the author's strong belief that energy is a very relevant index in determining seismic failures, particularly of soils and soil structures. Innovative Earthquake Soil Dynamics is written for international readers, graduate students, researchers, and practicing engineers, interested in this field.
Aims to validate reliable procedures of analysis in geotechnical engineering practice. Specifically, the work discusses one area which has seen substantial development of numerical computer codes for analysis and design - the liquefaction of soils during earthquakes.
During earthquakes, ground movement can cause soils to lose strength or stiffness resulting in structures settling and embankments sliding. A phenomenon contributing to this loss in strength and subsequent failures is called soil liquefaction. This title, however, does not refer to a single well-defined event, but rather to a complex set of interrelated phenomena which contribute to the occurrence of damage and and failures during an earthquake. Numerous investigators have tried to model and predict the potential and probability of liquefaction occurring in soils. Since the early 1960's considerable attention has been given to the development of laboratory testing procedures to provide improved methods of characterizing the liquefaction properties of soils. Various test apparatus have been designed or modified in an attempt to provide an accurate representation of the stress state generated in-situ by earthquakes. To this end a number of experimental devices including the cyclic triaxial, and cyclic simple shear with repeatable representation of conditions in-situ during an actual earthquake.

Innovative Earthquake Soil Dynamics

Hazard Analysis of Seismic Soil Liquefaction

Proceedings of the International Conference, Davis California, 17-20 October 1993

Physics and Mechanics of Soil Liquefaction

Proceedings of the 7th International Conference on Earthquake Geotechnical Engineering, (ICEGE 2019), June 17-20, 2019, Rome, Italy

Seismic Design of Industrial Facilities

The Loma Prieta earthquake struck the San Francisco area on October 17, 1989, causing 63 deaths and $10 billion worth of damage. This book reviews existing research on the Loma Prieta quake and draws from it practical lessons that could be applied to other earthquake-prone areas of the country. The volume contains seven keynote papers presented at a symposium on the earthquake and includes an overview written by the committee offering recommendations to improve seismic safety and earthquake awareness in parts of the country susceptible to earthquakes.
The destructive force of earthquakes has stimulated human inquiry since ancient times, yet the scientific study of earthquakes is a surprisingly recent endeavor. Instrumental recordings of earthquakes were not made until the second half of the 19th century, and the primary mechanism for generating seismic waves was not identified until the beginning of the 20th century. From this recent start, a range of laboratory, field, and theoretical investigations have developed into a vigorous new discipline: the science of earthquakes. As a basic science, it provides a comprehensive understanding of earthquake behavior and related phenomena in the Earth and other

terrestrial planets. As an applied science, it provides a knowledge base of great practical value for a global society whose infrastructure is built on the Earth's active crust. This book describes the growth and origins of earthquake science and identifies research and data collection efforts that will strengthen the scientific and social contributions of this exciting new discipline.

Despite advances in the field of geotechnical earthquake engineering, earthquakes continue to cause loss of life and property in one part of the world or another. The Third International Conference on Soil Dynamics and Earthquake Engineering, Princeton University, Princeton, New Jersey, USA, 22nd to 24th June 1987, provided an opportunity for participants from all over the world to share their expertise to enhance the role of mechanics and other disciplines as they relate to earthquake engineering. The edited proceedings of the conference are published in four volumes. This volume covers: Constitutive Relations in Soil Dynamics, Liquefaction of Soils, and Experimental Soil Dynamics. With its companion volumes, it is hoped that it will contribute to the further development of techniques, methods and innovative approaches in soil dynamics and earthquake engineering.

Earthquakes represent a major risk to buildings, bridges and other civil infrastructure systems, causing catastrophic loss to modern society. Handbook of seismic risk analysis and management of civil infrastructure systems reviews the state of the art in the seismic risk analysis and management of civil infrastructure systems. Part one reviews research in the quantification of uncertainties in ground motion and seismic hazard assessment. Part twi discusses methodologies in seismic risk analysis and management, whilst parts three and four cover the application of seismic risk assessment to buildings, bridges, pipelines and other civil infrastructure systems. Part five also discusses methods for quantifying dependency between different infrastructure systems. The final part of the book considers ways of assessing financial and other losses from earthquake damage as well as setting insurance rates. Handbook of seismic risk analysis and management of civil infrastructure systems is an invaluable guide for professionals requiring understanding of the impact of earthquakes on buildings and lifelines, and the seismic risk assessment and management of buildings, bridges and transportation. It also provides a comprehensive overview of seismic risk analysis for researchers and engineers within these fields. This important handbook reviews the wealth of recent research in the area of seismic hazard analysis in modern earthquake design code provisions and practices Examines research into the analysis of ground motion and

seismic hazard assessment, seismic risk hazard methodologies
Addresses the assessment of seismic risks to buildings, bridges, water supply systems and other aspects of civil infrastructure
Geotechnical Earthquake Engineering
Liquefaction Potential in the Central Mississippi Valley
Practical Lessons from the Loma Prieta Earthquake
Tectonics, Hazard and Risk Mitigation
Panel Report
Soil Dynamics and Earthquake Geotechnical Engineering

Soil liquefaction is a major concern in areas of the world subject to seismic activity or other repeated vibration loads. This book brings together a large body of information on the topic, and presents it within a unified and simple framework. The result is a book which will provide the practising civil engineer with a very sound understanding of

Based on the graduate course in Earthquake Hydrology at Berkeley University, this text introduces the basic materials, provides a comprehensive overview of the field to interested readers and beginning researchers, and acts as a convenient reference point.

This book is devoted to diverse aspects of earthquake researches, especially to new achievements in seismicity that involves geosciences, assessment, and mitigation. Chapters contain advanced materials of detailed engineering investigations, which can help more clearly appreciate, predict, and manage different earthquake processes. Different research themes for diverse areas in the world are developed here, highlighting new methods of studies that lead to new results and models, which could be helpful for the earthquake risk. The presented and developed themes mainly concern wave's characterization and decomposition, recent seismic activity, assessment-mitigation, and engineering techniques. The book provides the state of the art on recent progress in earthquake engineering and management. The obtained results show a scientific progress that has an international scope and, consequently, should open perspectives to other still unresolved interesting aspects.

Soil Liquefaction during Recent Large-Scale Earthquakes contains selected papers presented at the New Zealand – Japan Workshop on Soil Liquefaction during Recent Large-Scale Earthquakes (Auckland, New Zealand, 2-3 December 2013). The 2010-2011 Canterbury earthquakes in New Zealand and the 2011 off the Pacific Coast of Tohoku Earthquake in Japan have caused significant damage to many residential houses due to varying degrees of soil liquefaction over a very wide extent of urban areas unseen in past destructive earthquakes. While soil liquefaction occurred in naturally-sedimented soil formations in Christchurch, most of the areas which liquefied in Tokyo Bay area were reclaimed soil and artificial fill deposits, thus providing researchers with a wide range of soil deposits to characterize soil and site response to large-scale earthquake shaking. Although these earthquakes in New Zealand and Japan

caused extensive damage to life and property, they also serve as an opportunity to understand better the response of soil and building foundations to such large-scale earthquake shaking. With the wealth of information obtained in the aftermath of both earthquakes, information-sharing and knowledge-exchange are vital in arriving at liquefaction-proof urban areas in both countries. Data regarding the observed damage to residential houses as well as the lessons learnt are essential for the rebuilding efforts in the coming years and in mitigating buildings located in regions with high liquefaction potential. As part of the MBIE-JSPS collaborative research programme, the Geomechanics Group of the University of Auckland and the Geotechnical Engineering Laboratory of the University of Tokyo co-hosted the workshop to bring together researchers to review the findings and observations from recent large-scale earthquakes related to soil liquefaction and discuss possible measures to mitigate future damage. Soil Liquefaction during Recent Large-Scale Earthquakes will be of great interest to researchers, academics, industry practitioners and other professionals involved in Earthquake Geotechnical Engineering, Foundation Engineering, Earthquake Engineering and Structural Dynamics.

State of the Art and Practice in the Assessment of Earthquake-Induced Soil Liquefaction and Its Consequences
Ground Improvement
(With CD-ROM)
The Fukushima and Tohoku Disaster
Soil Liquefaction During Earthquakes
IGC 2016 Volume 3

The workshop aims to provide a fundamental understanding of the liquefaction process, necessary to the enhancement of liquefaction prediction. The contributions are divided into eight sections, which include: factors affecting liquefaction susceptibility and field studies of liquefaction.

Liquefaction of Soils During EarthquakesNational AcademiesLiquefaction of Soils During EarthquakesLiquefaction of Soils During EarthquakesFinal Report

This book, whose primary aim is to describe liquefaction processes and their implications for marine structures such as pipelines, sea outfalls, quay walls and caisson breakwaters, discusses the subject of soil liqeufaction in the marine environment. In addition, the physics of liquefaction (including examples illustrating the catastrophic consequences of soil liquefaction with regard to marine structures) are described, and the mathematical modelling of liqeufaction is treated in detail. Also, carefully selected numerical examples support the discussion of assessing liquefaction potential, and benchmark cases such as buried gas pipelines and their floatation, caisson breakwaters, cover stones and their interaction with liquefied soil along with counter measures are investigated. Contents:Introduction and Physics of LiquefactionBiot Equations and Their SolutionsResidual LiquefactionMomentary LiquefactionFloatation of Buried

PipelinesSinking of Pipelines and Marine ObjectsLiquefaction Under Standing WavesLiquefaction at Gravity StructuresStability of Rock Berms in Liquefied SoilImpact of Seismic-Induced LiquefactionCounter Measures Readership: Professionals and researchers in the area of coastal, ocean and marine civil engineering; graduate and post graduate students. Key Features:Physics of liquefactionMathematical modellingAssessment of liquefaction potential, supported by numerical examplesBenchmark cases such as buried gas pipelines, caisson structures, etc.Keywords:Soil Liquefaction;Marine Environment;Mathematical Modelling;Pipelines;Caisson BreakwatersReviews: “This is a well-written and comprehensive book describing the physics and processes of seabed liquefaction around marine structures. Overall, this book is highly recommended for all professionals and researchers interested in seabed soil liquefaction and the stability of marine structures, and is indeed suitable as a textbook for graduate/postgraduate students in this field.” J. Ocean Eng. Mar. Energy

The vulnerability of waterfront facilities to earthquake-induced soil liquefaction has been demonstrated during several recent earthquakes. A liquefaction threat analysis conducted by the Navy has suggested, however, that reliable procedures for precisely evaluating the extent of this hazard to waterfront structures are not currently available. As a part of a program to remedy this problem, the earthquake-induced liquefaction potential at a coastal Naval installation was evaluated by means of cyclic triaxial testing of undisturbed soil samples. This study shows that for the particular sensitive soil tested, the resistance to liquefaction as determined by laboratory testing of undisturbed samples is considerably larger than that determined using correlations with in situ penetration resistance tests. Both dynamic split spoon driving resistance and quasi-static friction cone resistance were measured in the tests. Field evaluation techniques are discussed, and those considered most promising are noted. Several total stress and effective stress computer codes are discussed, with particular attention to those incorporating pore water dissipating mechanisms. Several example solutions from the literature are presented. (Author).

Liquefaction Around Marine Structures

Earthquakes

Earthquakes and Water

Soil Dynamics and Liquefaction

Verification of Procedures for the Analysis of Soil Liquefaction Problems

Seismic Soil Liquefaction at the Waterfront

Soil liquefaction, a hazardous ground failure induced by strong motion earthquakes, can cause catastrophic damage to structures such as dams, bridges, power plants, and water-front structures and may involve great losses of life. Examples of liquefaction and resulting damage were observed during the Alaska (1964), Niigata, Japan (1964), and Tangshan, China (1976), earthquakes. Ground failure due to earthquake-induced soil liquefaction may manifest itself as excessive settlement, loss of bearing capacity, sand boiling, and flow slides. The liquefaction potential of clean sands has been studied extensively for the last two decades. However, case histories revealed that liquefied sands were seldom clean. They may contain various percentages of silt or clay or both. In fact, the Chinese observation in the Tansghan earthquake indicated that some cohesive soils may have liquefied. If this indeed had happened, then structures underlain by fine-grained soils, with a marginal safety factor based on the liquefaction criteria normally applied to sands, may actually be unsafe. Thus there is an urgent need for establishing new criteria for the liquefaction susceptibility of soils to include those identified as fine-grained. The author, Professor N.Y. Chang of the University of Colorado at Denver, visited several Chinese agencies and and universities in and near Beijing, China, in the summer of 1985 in an attempt to investigate and verify reported data on the liquefaction of cohesive soils during the Tangshan earthquake of 1976 and to negotiate cooperative research into the problem. This report presents the result of supportive literature review and the findings of the China trip.

Appropriate for courses in Structural Dynamics, Earthquake Engineering or Seismology. This is the first book on the market focusing specifically on the topic of geotechnical earthquake engineering. Also covers fundamental concepts in seismology, geotechnical engineering, and structural engineering.

This book gathers selected proceedings of the annual conference of the Indian Geotechnical Society, and covers various aspects of soil dynamics and earthquake geotechnical engineering. The book includes a wide range of studies on seismic response of dams, foundation-soil system natural and man-made slopes, reinforced-earth walls, base isolation systems and so on, especially focusing on the soil dynamics and case studies from the Indian subcontinent. The book also includes chapters addressing related issues such as landslide risk assessments, liquefaction mitigation, dynamic analysis of mechanized tunneling, and advanced seismic soil-structure-interaction analysis. Given its breadth of coverage, the book offers a useful guide for researchers and practicing civil engineers alike.

Pile foundations are the most common form of deep foundations that are used both onshore and offshore to transfer large superstructural loads into competent soil strata. This book provides many case histories of failure of pile foundations due to earthquake loading and soil liquefaction. Based on the observed case histories, the possible mechanisms of failure of the pile foundations are postulated. The book also deals with the additional loading attracted by piles in liquefiable soils due to lateral spreading of sloping ground. Recent research at Cambridge forms the backbone of this book with the design methodologies being developed directly based on quantified centrifuge test results and numerical analysis.The book provides designers and practicing civil engineers with a sound knowledge of pile behaviour in liquefiable soils and easy-to-use methods to design pile foundations in seismic regions. For graduate students and researchers, it brings together the latest research findings on pile foundations in a way that is relevant to geotechnical practice.

Ground Motions and Soil Liquefaction During Earthquakes

Pearson New International Edition

Encyclopedia of Engineering Geology

Seismic Performance of Buildings Subjected to Soil Liquefaction

Living on an Active Earth

A Rigorous and Definitive Guide to Soil Liquefaction Soil liquefaction occurs when soil loses much of its strength or stiffness for a time—usually a few minutes or less—and which may then cause structural failure, financial loss, and even death. It can occur during earthquakes, from static loading, or even from traffic-induced vibration. It occurs worldwide and affects soils ranging from gravels to silts. From Basic Physical Principles to Engineering Practice Soil Liquefaction has become widely cited. It is built on the principle that liquefaction can, and must, be understood from mechanics. This second edition is developed from this premise in three respects: with the inclusion of silts and sandy silts commonly encountered as mine tailings, by an extensive treatment of cyclic mobility and the cyclic simple shear test, and through coverage from the "element" scale seen in laboratory testing to the evaluation of "boundary value problems" of civil and mining engineering. As a mechanics-based approach is necessarily numerical, detailed derivations are provided for downloadable open-code software (in both Excel/VBA and C++) including code verifications and validations. The "how-to-use" aspects have been expanded as a result of many conversations with other engineers, and these now cover the derivation of soil properties from laboratory testing through to assessing the in situ state by processing the results of cone penetration testing. Downloadable software is supplied on www.crcpress.com/product/isbn/9781482213683 Includes derivations in detail so that the origin of the equations is apparent Provides samples of source code so that the reader can see how complex-looking differentials actually have pretty simple form Offers a computable constitutive model in accordance with established plasticity theory Contains case histories of liquefaction Makes available downloads and source data on the CRC Press website Soil Liquefaction: A Critical State Approach, Second Edition continues to cater to a wide range of readers, from graduate students through to engineering practice.

This book presents comprehensive hazard analysis methods for seismic soil liquefaction, providing an update on soil liquefaction by systematically reviewing the phenomenon’s occurrence since the beginning of this century. It also puts forward a range of advanced research methods including in-situ tests, laboratory studies, physical model tests, numerical simulation, and performance-based assessment. Recent seismic liquefaction-related damage to soils and foundations demonstrate the increasing need for the comprehensive hazard analysis of seismic soil liquefaction in order to mitigate this damage and protect human lives. As such the book addresses the comprehensive hazard analysis of seismic soil liquefaction, including factors such as macroscopic characteristics, evaluating the liquefaction potential, dynamic characteristics and deformation processes, providing reliable evaluation results for liquefaction potential and deformation in the context of risk assessment. “p> Earthquake Geotechnical Engineering for Protection and Development of Environment and Constructions contains invited, keynote and theme lectures and regular papers presented at the 7th International Conference on Earthquake Geotechnical Engineering (Rome, Italy, 17-20 June 2019. The contributions deal with recent developments and *advancements as well as case histories, field monitoring, experimental characterization, physical and analytical modelling, and applications related to the variety of environmental phenomena induced by earthquakes in soils and their effects on engineered systems interacting with them. The book is divided in the sections below: Invited papers Keynote papers Theme lectures Special Session on Large Scale Testing Special Session on Liquefact Projects Special Session on Lessons learned from recent earthquakes Special Session on the Central Italy earthquake Regular papers Earthquake Geotechnical Engineering for Protection and Development of Environment and Constructions provides a significant up-to-date collection of recent experiences and developments, and aims at engineers, geologists and seismologists, consultants, public and private contractors, local national and international authorities, and to all those involved in research and practice related to Earthquake Geotechnical Engineering.*

Effects of Plasticity on Liquefaction Characteristics of Fine-grained Soils

Géotechnique Symposium in Print 2015

On the Behavior of Soils During Earthquakes, Liquefaction

Liquefaction Susceptibility of Fine-grained Soils

Effects of Soils Properties on Liquefaction Potential During Earthquakes

Proceedings of the International Conference on Seismic Design of Industrial Facilities (SeDIF-Conference)