Design Of Pile Foundations In Liquefiable Soils

Design Of Pile Foundations In Liquefiable Soils Design of Pile Foundations in Liquefiable Soils A Comprehensive Guide Youve got a project in mind and youre excited about the possibilities But then you hit a roadblock liquefiable soils Its enough to make any engineer sweat right These notoriously unpredictable soils can wreak havoc on your project especially when it comes to foundations But fear not This guide will equip you with the knowledge you need to design safe and effective pile foundations for liquefiable soils Understanding the Threat Liquefaction Lets start with the basics Liquefaction occurs when loose saturated sandy soils lose their strength and stiffness due to shaking like during an earthquake Imagine shaking a glass of sand and water the sand becomes like liquid In the context of construction this means your foundation could literally sink causing catastrophic damage to your structure Pile Foundations A Robust Solution Pile foundations are a triedandtrue solution for dealing with liquefiable soils These vertical structures are driven deep into the ground transferring the load of your building to a more stable soil layer below the liquefiable zone Designing for Success Key Considerations Heres where the real design work comes in You need to consider several factors to ensure your pile foundation stands the test of time Soil Investigation You need a thorough understanding of the soil profile including the depth type and liquefaction potential of the soil layers Geotechnical investigations including soil borings and laboratory testing are crucial Seismic Loading The potential for earthquake shaking is a major factor Youll need to determine the magnitude and frequency of potential earthquakes in your area

and factor this into your design Pile Type and Capacity The choice of pile type depends on your projects specific requirements Common types include Driven piles These are hammered into the ground suitable for dense soils Bored piles These are created by drilling a hole and filling it with concrete 2 Auger piles These are similar to bored piles but use an auger to excavate the soil Pile Spacing and Arrangement The spacing and arrangement of piles are crucial to distribute the load effectively and minimize settlement Pile Head Details The connection between the piles and the superstructure requires careful consideration Lateral Resistance While primarily designed for vertical loads you also need to consider how your piles will resist lateral forces like wind or earthquake shaking Beyond the Basics Advanced Techniques For challenging projects several advanced techniques can be employed to further enhance the performance of pile foundations in liquefiable soils Ground Improvement Techniques like dynamic compaction vibroreplacement and stone columns can improve the soil properties and reduce liquefaction susceptibility Pile Reinforcement Adding steel reinforcement within the piles can enhance their strength and resistance to lateral loads Geosynthetics These materials can be used to improve the drainage of the soil reducing the potential for liquefaction PileSoil Interaction Sophisticated analytical and numerical models can help predict the complex interaction between the piles and the surrounding soil improving the accuracy of your design The Importance of Collaboration Remember designing pile foundations in liquefiable soils requires a collaborative approach Close communication and cooperation between the geotechnical engineer structural engineer and architect are essential for a successful project Conclusion Designing pile foundations in liquefiable soils is a challenging but achievable task By understanding the risks considering the critical factors and utilizing advanced techniques you can ensure the safety and longevity of your structure Remember a comprehensive approach that involves a team of experts is key to creating a strong foundation for your future FAQs 1 What are the signs of liquefiable soils Loose sandy soils especially those

saturated with water are often indicative of liquefiable conditions A history of earthquakes or the presence 3 of nearby seismic activity should also raise concern 2 How can I prevent liquefaction While eliminating the risk entirely is impossible ground improvement techniques can significantly mitigate the risk of liquefaction by enhancing the soils density and strength 3 What is the difference between driven piles and bored piles Driven piles are hammered into the ground suitable for denser soils while bored piles are drilled and filled with concrete suitable for softer soils 4 How do I determine the required pile length The required pile length is determined by geotechnical analysis which considers the soil profile and the load your structure will place on the foundation 5 Are there any alternatives to pile foundations in liquefiable soils In some cases alternatives like mat foundations or shallow foundations with specialized techniques may be considered However pile foundations are generally the most reliable and robust solution for challenging soil conditions

Design of Pile Foundations in Liquefiable SoilsThe Axial Behaviour of Piled Foundations in Liquefiable SoilPiled Foundations in Liquefiable SoilsShallow Rocking Foundations in Liquefiable and Saturated Soil ConditionsSeismic Design of Buildings to Eurocode 8Seismic Performance and Simulation of Pile Foundations in Liquefied and Laterally Spreading GroundPerformance-based Earthquake Engineering Design Evaluation Procedure for Bridge Foundations Undergoing Liquefaction-induced Lateral Spreading5th International Conference on Geotechnical and Highway EngineeringSeismic Evaluation and Upgrading of Critical Tower Pile Foundations in Liquefiable SoilsRecent Trends in Civil EngineeringEffects of Liquefaction on Pile FoundationsImprovement of Liquefiable Foundation Conditions Beneath Existing StructuresImprovement of Liquefiable Foundation Conditions Beneath Existing StructuresStabilization of Potentially Liquefiable Sand Deposits Using Gravel Drain SystemsISET Journal of Earthquake TechnologySoils and FoundationsCentrifuge Modeling of Liquefaction and Soil-structure InteractionGeotechnics and Earthquake Geotechnics Towards

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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 sample chapter s foreword 85 kb chapter 1 performance of pile foundations 4 832 kb contents performance of pile foundations inertial and kinematic loading accounting for axial loading in level ground lateral spreading of sloping ground axial loading on piles in laterally spreading ground design examples readership researchers academics designers and graduate students in earthquake engineering civil engineering and ocean coastal engineering

understanding the mechanisms by which any engineering structure resists load is an essential requirement for its consistent and reliable design the axial resistance which can be mobilised by piled foundations in liquefiable soils when subjected to strong shaking remains highly uncertain and a number of piled foundations have failed in strong earthquakes as recently as 2011 the lack of visible foundation distress in many such cases indicates that failure can occur as a result of the loss of axial capacity during an earthquake as opposed to the laterally dominated failure modes which have been the focus of the research community for the last 20 to 30 years in this thesis a series of dynamic centrifuge experiments have been carried out to establish how the distribution of axial loads along the length of a pile changes during a strong earthquake in each test a 2 2

PILE GROUP WAS INSTALLED SUCH THAT ITS TIPS WERE EMBEDDED IN A DENSE SAND LAYER WHICH WAS OVERLAIN BY LIQUEFIABLE SOIL THE TESTS EXAMINE THE EFFECTS ARISING FROM THE HYDRAULIC CONDUCTIVITY IN THE BEARING LAYER THE INFLUENCE OF AXIAL PILE CAP SUPPORT AND FINALLY WHETHER THERE ARE ANY DIFFERENCES IN THE BEHAVIOUR OF NOMINALLY JACKED OR BORED PILES UNDER SEISMIC LOADING THE PILE CAP HAS BEEN SHOWN TO PLAY A SUBSTANTIAL ROLE IN SUPPORTING AXIAL LOADS DURING STRONG SHAKING IN CASES WHERE THE PILE CAP WAS UNABLE TO SUPPORT AXIAL LOAD THE MAJORITY OF THE AXIAL LOADING WAS CARRIED AS PILE END BEARING WITH SOME SHAFT FRICTION BEING MOBILISED IN BOTH THE LIQUEFIABLE AND BEARING SOIL LAYERS AS A RESULT OF RELATIVE LATERAL DISPLACEMENTS BETWEEN THE SOIL AND PILE HOWEVER WHERE THE PILE CAP IS ABLE TO SUPPORT AXIAL LOADS THE SETTLEMENT OF THE PILE CAP INTO THE SOIL LED TO A DRAMATIC TRANSFER OF AXIAL LOAD AWAY FROM THE PILES AND ONTO THE PILE CAP THESE RESULTS IMPLY THAT WHERE SUBSTANTIAL EXCESS PORE PRESSURES MAY BE GENERATED AT THE DEPTH OF THE PILE TIP THEN THE PILE CAPS MUST BE ABLE TO SUPPORT SIGNIFICANT AXIAL LOAD THE INCREASED EFFECTIVE STRESSES BELOW THE PILE CAP WERE RESPONSIBLE FOR THE MOBILISATION OF SHAFT FRICTION ON THE SECTION OF PILE WITHIN THE LIQUEFIABLE LAYER HOWEVER THESE PILES WERE UNABLE TO MOBILISE SHAFT FRICTION IN THE BEARING LAYER DUE TO THE REDUCED LATERAL LOADING ON THE PILES THE AXIAL BEHAVIOUR OF THE PILED FOUNDATIONS AFTER THE END OF STRONG SHAKING IS AFFECTED BY THE RECOVERY OF PILE END BEARING CAPACITY AND IS THEREFORE STRONGLY DEPENDENT ON THE HYDRAULIC CONDUCTIVITY OF THE BEARING LAYER THE AXIAL BEHAVIOUR OF NOMINALLY BORED AND JACKED PILE GROUPS IN LIQUEFIABLE SOIL DEPOSITS ARE VERY DIFFERENT UNDER SEISMIC EXCITATION WITH THE INSTALLATION PROCESS OF THE LATTER SUBSTANTIALLY ALTERING THE SOIL CONDITIONS AROUND THE TIPS OF THE PILE SUCH THAT IN CONTRAST TO THE BORED PILE GROUPS THE JACKED PILE GROUPS DID NOT ACCUMULATE SETTLEMENTS UNTIL SIGNIFICANTLY AFTER THE STRONG SHAKING HAD COMMENCED THESE RESULTS IMPLY THAT THE METHOD OF INSTALLATION IS AN IMPORTANT FACTOR IN THE SEISMIC RESPONSE OF A FOUNDATION AND MAY BE MORE PRONOUNCED FOR REAL EARTHQUAKES WHERE THE NUMBER OF STRONG SHAKING CYCLES MAY BE MORE LIMITED THAN THOSE SIMULATED IN THE

EXPERIMENTS

CURRENT RESEARCH HAS SHOWN THE CAPABILITIES AND IMPROVED SEISMIC PERFORMANCE OF SHALLOW ROCKING FOUNDATIONS FOR BRIDGES AND MUCH WORK HAS BEEN DONE FOR IMPLEMENTATION OF SUCH A MECHANISM IN INDUSTRY BY PROPERLY REDUCING THE SIZE OF THE FOOTING IN DESIGN ROCKING BEHAVIOR DUE TO SEISMIC LOADING CAN OCCUR ABOUT THE FOOTING BASE ALLOWING THE FOUNDATION TO ROCK CAUSES A NATURAL RECENTERING OF THE FOUNDATION ULTIMATELY PRESERVING THE STRUCTURAL INTEGRITY OF THE COLUMN AND REDUCING RESIDUAL ROTATIONS OF THE STRUCTURE IF SOIL CONDITIONS ARE FAVORABLE IT HAS BEEN SHOWN EXPERIMENTALLY THAT ROCKING FOUNDATIONS ON COMPETENT SOILS CAN REDUCE SEISMIC DUCTILITY DEMAND ON BRIDGE COLUMNS AND IMPROVE BRIDGE PERFORMANCE THROUGH SIGNIFICANT ENERGY DISSIPATION AT THE FOUNDATION LEVEL RATHER THAN FROM A HINGING COLUMN IN CONVENTIONAL DESIGN THIS BENEFICIAL ENERGY DISSIPATION POTENTIAL IS ATTRACTIVE FOR DESIGN BUT HAS NOT BEEN VALIDATED FOR ROCKING FOUNDATIONS IN DIFFICULT SOILS THE OVERALL GOALS OF THIS RESEARCH ARE TO 1 EVALUATE THE PERFORMANCE OF ROCKING FOUNDATIONS IN LIQUEFIABLE AND SATURATED SOILS AND 2 EXPLORE THE VIABILITY OF ROCKING FOUNDATIONS IN POOR SOIL CONDITIONS IF THE FOUNDATIONS ARE SUPPORTED ON UNATTACHED PILES TWO CENTRIFUGE TESTS WERE PERFORMED WITH SIMILAR MODEL STRUCTURES REPRESENTING A DECK MASS COLUMN FOOTING SYSTEM ON FULLY SATURATED SAND WITH A LIQUEFIABLE LAYER AND SURFACE WATER THE TESTS EXPLORED THE STRUCTURE SOIL AND FLUID RESPONSES DUE TO SUCTION EROSION AND LIQUEFACTION INDUCED SETTLEMENTS UNDER THE FOOTINGS IT WAS FOUND THAT THE ROCKING FOOTING EMBEDDED IN FINE SOIL EXPERIENCED HIGH RESIDUAL ROTATIONS THROUGHOUT TESTING THIS IS DUE TO A NO BREAKAWAY CONDITION A MECHANISM WHICH EMERGES FROM A RELATIVELY LARGE DROP IN PORE WATER PRESSURE DIRECTLY UNDER THE FOOTING AS IT UPLIFTS IN LOWER PERMEABLE SOIL ULTIMATELY PULLING IN MATERIAL UNDER THE FOOTING AND INCREASING RESIDUAL ROTATIONS WITH EACH EVENT DEEP SOIL FOUNDATION IMPROVEMENT BY USE OF UNATTACHED PILES WAS ALSO TESTED IN BOTH EXPERIMENTS TO EXPLORE APPLICABILITY EFFECTIVENESS AND PRACTICALITY OF SETTLEMENT REDUCTION WHILE STILL ALLOWING ROCKING THE

RESULTS WERE USED TO EVALUATE EFFECTS OF PILE CAPACITY NUMBER OF PILES AND ARRANGEMENT OF PILES ON THE RESIDUAL SETTLEMENT AND BASE SHEAR COEFFICIENT TO INITIATE ROCKING FINALLY A NEW CENTRIFUGE TEST DATABASE WAS CREATED WHEREBY THE PERFORMANCE OF ISOLATED MAT AND ROCKING FOUNDATIONS AND ADJACENT MAT FOUNDATIONS FROM 9 DIFFERENT CENTRIFUGE EXPERIMENTS ON LIQUEFIABLE SAND ARE COMPARED RESULTS FROM THIS RESEARCH WILL HELP DEFINE THE APPROPRIATE APPLICABILITY RANGE OF ROCKING FOUNDATIONS IN SEISMIC DESIGN

PRACTICAL INFORMATION AND TRAINING HAS BECOME URGENTLY NEEDED FOR THE NEW EUROCODE 8 ON THE DESIGN OF STRUCTURES FOR EARTHQUAKE RESISTANCE ESPECIALLY IN RELATION TO THE UNDERLYING PRINCIPLES OF SEISMIC BEHAVIOUR AND THE DESIGN OF BUILDING STRUCTURES THIS BOOK COVERS SEISMIC DESIGN IN A CLEAR BUT BRIEF MANNER AND LINKS THE PRINCIPLES TO THE CODE I

PROCEEDINGS OF A WORKSHOP ON SEISMIC PERFORMANCE AND SIMULATION OF PILE FOUNDATIONS IN LIQUEFIED AND LATERALLY SPREADING GROUND HELD IN DAVIS CALIFORNIA MARCH 16 18 2005 SPONSORED BY THE PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER UNIVERSITY OF CALIFORNIA AT BERKELEY CENTER FOR URBAN EARTHQUAKE ENGINEERING TOKYO INSTITUTE OF TECHNOLOGY GEO INSTITUTE OF ASCE THIS COLLECTION CONTAINS 25 PAPERS THAT DISCUSS PHYSICAL MEASUREMENTS AND OBSERVATIONS FROM EARTHQUAKE CASE HISTORIES FIELD TESTS IN BLAST LIQUEFIED GROUND DYNAMIC CENTRIFUGE MODEL STUDIES AND LARGE SCALE SHAKING TABLE STUDIES PAPERS CONTAIN RECENT FINDINGS ON FUNDAMENTAL SOIL PILE INTERACTION MECHANISMS NUMERICAL ANALYSIS METHODS AND REVIEWS AND EVALUATIONS OF EXISTING AND EMERGING DESIGN METHODOLOGIES THIS PROCEEDING PROVIDES COMPREHENSIVE COVERAGE OF A MAJOR ISSUE IN EARTHQUAKE ENGINEERING PRACTICE AND HAZARD MITIGATION EFFORTS

THIS PROCEEDINGS CONTAINS 89 PAPERS FROM 25 COUNTRIES AND REGIONS INCLUDING 14 KEYNOTE LECTURES AND 17 INVITED LECTURES PRESENTED AT THE THIRD INTERNATIONAL CONFERENCE ON GEOTECHNICAL ENGINEERING FOR DISASTER MITIGATION AND REHABILITATION 3ICGEDMAR

2011 together with the fifth international conference on geotechnical highway engineering 5icghe which was held in semarang indonesia from 18 to 20 may 2011 this is the third conference in the gedmar conference series the first was held in singapore from 12 to 13 december 2005 and the second in nanjing china from 30 may to 2 june 2008 the proceedings is divided into three sections keynote papers invited papers and conference papers under which there are six sub sections case studies on recent disasters soil behaviours and mechanisms for hazard analysis disaster mitigation and rehabilitation techniques risk analysis and geohazard assessment innovation foundations for rail highway and embankments and slope failures and remedial measures the conference is held under the auspices of the international society for soil mechanics and geotechnical engineering issmge technical committee tc 303 coastal and river disaster mitigation and rehabilitation tc 203 earthquake geotechnical engineering and associated problems tc 302 forensic geotechnical engineering tc 304 engineering practice of risk assessment and management tc 213 geotechnics of soil erosion tc 202 transportation geotechnics tc 211 ground improvement southeast asian geotechnical society seags association of geotechnical societies in southeast asia agssea and road engineering association of asia australasia reaaa

bc hydro has been assessing and upgrading its facilities and implementing response alternatives to potential damage resulting from a major earthquake this paper reviews the utility s seismic evaluation of its overhead transmission system focusing on the lower mainland area where most of the tall critical river crossing towers are located the paper gives an overview of the geologic environment of the lower mainland and outlines the criteria used for assessing existing structures for their ability to withstand design seismic loads it then describes the investigation and analysis methods used in the assessment including geotechnical field tests ground response analysis determination of soil liquefaction potential and dynamic analysis of structures and piles options

FOR SEISMIC UPGRADES ARE DISCUSSED AND ILLUSTRATED BY THE CASE OF THE PITT RIVER CROSSING WHERE TOWER FOUNDATIONS WERE REINFORCED WITH STEEL PIPE PILES

THIS BOOK PRESENTS THE SELECTED PEER REVIEWED PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON RECENT TRENDS AND INNOVATIONS IN CIVIL ENGINEERING ICRTICE 2019 THE VOLUME FOCUSES ON LATEST RESEARCH AND ADVANCES IN THE FIELD OF CIVIL ENGINEERING AND MATERIALS SCIENCE SUCH AS DESIGN AND DEVELOPMENT OF NEW ENVIRONMENTAL MATERIALS PERFORMANCE TESTING AND VERIFICATION OF SMART MATERIALS PERFORMANCE ANALYSIS AND SIMULATION OF STEEL STRUCTURES DESIGN AND PERFORMANCE OPTIMIZATION OF CONCRETE STRUCTURES AND BUILDING MATERIALS ANALYSIS THE BOOK ALSO COVERS STUDIES IN GEOTECHNICAL ENGINEERING HYDRAULIC ENGINEERING ROAD AND BRIDGE ENGINEERING BUILDING SERVICES DESIGN ENGINEERING MANAGEMENT WATER RESOURCE ENGINEERING AND RENEWABLE ENERGY THE CONTENTS OF THIS BOOK WILL BE USEFUL FOR STUDENTS RESEARCHERS AND PROFESSIONALS WORKING IN CIVIL ENGINEERING

THE STABILIZATION AND IMPROVEMENT OF LIQUEFIABLE SOILS BENEATH EXISTING STRUCTURES IS CURRENTLY FEASIBLE WITHIN THE STATE OF KNOWLEDGE AND ASSUMPTIONS CONCERNING LIQUEFIABLE SOILS AND EARTHQUAKE EXCITATION THIS CAN BE DONE DIRECTLY OR INDIRECTLY TO MITIGATE THE EFFECTS OF LIQUEFACTION AND TO ASSURE SAFE PERFORMANCE AT THE PRESENT TIME THERE HAS BEEN ESSENTIALLY NO EXPERIENCE WITH REMEDIAL ACTIONS IN LIQUEFIABLE SOILS AT EXISTING STRUCTURES AND NO GENERAL METHOD IS APPLICABLE FOR ALL CONDITIONS EACH SITE IS UNIQUE AND WILL REQUIRE SPECIFIC ENGINEERED SOLUTIONS THIS REPORT PRESENTS AND BRIEFLY DISCUSSES METHODOLOGIES THAT HAVE BEEN DEEMED POTENTIALLY APPLICABLE FOR REMEDIATING LIQUEFIABLE SOILS BENEATH EXISTING STRUCTURES A COMPREHENSIVE BIBLIOGRAPHY IS INCLUDED ON THE FEASIBLE METHODS THE MOST IMPORTANT FACTORS FOR CONSTRUCTION IN CHOOSING REMEDIAL METHODS TECHNIQUES ARE A THE VERFIABILITY OF IMPROVEMENT AND STABILIZATION AND B THE ASSURANCE THAT THE METHOD ITSELF WILL NOT CREATE UNSAFE AND UNSTABLE

conditions under static and dynamic loading originator supplied keywords admixture stabilization compression in situ deep compaction injection and grouting liquefaction pore water pressure relief remedial treatments soils soil reinforcement and thermal stabilization

this book is part of a bold new initiative towards global sustainability and development that draws on the disciplines of geotechnical engineering and earthquake geotechnics it contains contributions from fifteen of the world s leading experts who met in kyoto in early 2010 to discuss a range of issues related to the ways geotechnics can help us face the challenges ahead from the technical to the social from geo hazards to megacities from global warming and coastal protection to the conservation of world heritage sites we hope these contributions will stimulate the debate over the role geotechnics has to play in achieving a more sustainable future for the world audience this book will be of interest to advanced levels of researchers and practicing engineers in the fields of geotechnics and earthquake geotechnics for global sustainability the greatest long term challenge of our time

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