

Design Of Pile Foundations In Liquefiable Soils

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A Comprehensive Guide

You've got a project in mind and you're excited about the possibilities. But then you hit a roadblock: liquefiable soils. It's 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 tried-and-true 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

Here's 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. You'll 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 project's 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.
- 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.

Pile-Soil 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 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 Soils Single Piles in Liquefiable Ground Improvement of Liquefiable Foundation Conditions Beneath Existing Structures Lateral Pile-soil Interaction in Liquefiable Soils Soil Liquefaction Soil Liquefaction Studies in Japan Improvement of Liquefiable Foundation Conditions Beneath Existing Structures Remedial Measures Against Soil Liquefaction: from Investigation and Design to Implementation Soil Liquefaction Seismic Performance and Simulation of Pile Foundations in Liquefied and Laterally Spreading Ground The Axial Behaviour of Piled Foundations in Liquefiable Soil Centrifuge Modeling of Liquefaction in Layered Soils Construction and Urban Planning Soil Dynamics and Liquefaction 2000 Flootation of Underground Structures in Liquefiable Soils Proceedings of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils Dynamic Stiffness of Piles in Liquefiable Soils Liquefaction of Silty Soils A Study of Soil-pile-structure Interaction in Liquefiable Soils During Strong Earthquakes Soil Liquefaction during Recent Large-Scale Earthquakes Gopal Madabhushi Rui Wang Richard H. Ledbetter Suresh R. Dash Michael Jefferies Toshio Iwasaki Richard Ledbetter N. Yoshida Mike Jefferies Ross W. Boulanger Mark Stringer Gregg Leland Fiegel Yong Huang Ronald Y. S. Pak Siau Chen Chian T. Leslie Youd Pedro Arduino Desmond Charles Arthur Andrews J. P. Bardet Rolando P. Orense

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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

this thesis focuses on the seismic response of piles in liquefiable ground it describes the design of a three dimensional unified plasticity model for large post liquefaction shear deformation of sand formulated and implemented for parallel computing it also presents a three dimensional dynamic finite element analysis method for piles in liquefiable ground developed on the basis of this model employing a combination of case analysis centrifuge shaking table experiments and numerical simulations using the proposed methods it demonstrates the seismic response patterns of single piles in liquefiable ground these include basic force resistance mode kinematic and inertial interaction coupling mechanism and major influence factors it also discusses a beam on the nonlinear winkler foundation bnwf solution and a modified neutral plane solution developed and validated using centrifuge experiments for piles in consolidating and reconsolidating ground lastly it studies axial pile force and settlement during post earthquake reconsolidation showing pile axial force to be irrelevant in the reconsolidation process while settlement is process dependent

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 verifiability 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

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

this text was compiled by the japanese geotechnical society it describes everything about the remedial measures against liquefaction currently used in japan following research projects after the niigata earthquake of 1964

a rigorous and definitive guide to soil liquefactionsoil 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 w

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

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

selected peer reviewed papers from the 2013 international conference on structures and building materials icsbm 2013 9 10 march 2013 guizhou china

gsp 107 contains 13 papers on soil dynamics and liquefaction presented at sessions of geo denver 2000 held in denver colorado august 5 8 2000

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