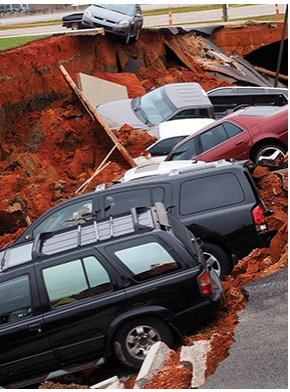
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Geo-Risk 2017

Reliability-Based Design and Code Developments





Edited by

Jinsong Huang, Ph.D.
Gordon A. Fenton, Ph.D., P.Eng.
Limin Zhang, Ph.D.
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Preface

Interest and use of probabilistic methods and risk assessment tools in geotechnical engineering has grown rapidly in recent years. The natural variability of soil and rock properties, combined with a frequent lack of high quality site data, makes a probabilistic approach to geotechnical design a logical and scientific way of managing both technical and economic risk. The burgeoning field of geotechnical risk assessment is evidenced by numerous publications, textbooks, dedicated journals and sessions at general geotechnical conferences. Risk assessments are increasingly becoming a requirement in many large engineering construction projects. Probabilistic methods are also recognized in design codes as a way of delivering reasonable load and resistance factors (LRFD) to target allowable risk levels in geotechnical design.

This Geotechnical Special Publication (GSP), coming out of the *Geo-Risk 2017* specialty conference held in Denver, Colorado from June 4-7, 2017, presents contributions in sessions: 1) Reliability- and Risk-Based Code Developments, 2) Probabilistic Methods and Reliability Analysis, 3) Performance-Based Liquefaction Assessment and Mitigation, 4) Probabilistic Performance and Resilience Assessment, and 5) Load and Resistance Factor Design (LRFD) Developments and Applications.

These contributions to the use of reliability based design methodologies and to reliability based code developments in geotechnical practice are very timely, and will provide a valuable and lasting reference for practitioners and academics alike.

The editors would like to thank all of the members of ASCE Geo Institute's Technical Committee on Risk Assessment and Management and the Engineering Practice of Risk Assessment and Management Committee (TC304) of the International Society of Soil Mechanics and Geotechnical Engineering (ISSMGE) for their ongoing support.

All the papers in this GSP went through a rigorous review process. The contributions of the reviewers are much appreciated.

The Editors

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Calculation of Equivalent Number of Uniform Cycles as Basis for Magnitude Scaling Effects in Liquefaction Risk Models

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Abstract

The seismic demand imposed by a ground motion is related to its amplitude and duration, where greater demand placed on the soil increases the probability that liquefaction is triggered and that its effects will be damaging. Historically, the seismic demand imposed by an arbitrary ground motion was quantified by describing a uniform series of shear stress cycles that caused an equivalent likelihood of liquefaction. The amplitude of the ground motion is usually represented by the Cyclic Stress Ratio (CSR), and the effects of the duration of ground shaking have usually been represented through an equivalent number of uniform amplitude cycles (N) or through the related magnitude scaling factor (MSF). We review methods used to determine N, as well as important factors known to influence the evaluation of N such as: the weight given to cycles of different amplitudes through the cycle sequence, non-zero crossings, multidirectional shaking, and soil and site conditions. Discrepancies between the current cycle counting methods and the known influential factors are identified. A cycle counting routine is proposed, and we apply it to a small suit of records in the NGA-West2 ground motion database with results presented.

INTRODUCTION

The development of seismic soil liquefaction triggering and consequence models depend on measures of seismic demand. In laboratory testing, quantifying the demand of cyclic loads placed on soils has been achieved through a measure of the amplitude of the loading, the cyclic stress ratio (CSR), and a measure of the number of loading cycles.

When evaluating the loading demands from an arbitrary ground motion, the quantification of amplitude and duration becomes necessarily more complicated. Seed et. al (1975) defined the cyclic stress ratio for an arbitrary acceleration record and developed the Cyclic Resistance Ratio (CRR), defined as the CSR required to initiate liquefaction of an earthquake with a Magnitude (M) equal to 7.5. The factor of safety against liquefaction (FS_L) is defined as:

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