Proceedings of the International Workshop on

# LIMIT STATE DESIGN IN GEOTECHNICAL ENGINEERING PRACTICE

*Massachusetts Institute of Technology, USA*
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editors

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**Proceedings of the International Workshop LSD2003**



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## PREFACE

Developments in limit state design have been gathering pace recently. The imminent introduction of Eurocode 7 as a European Norm adds impetus to this trend. Active discussions have taken place in LSD2000 (October 2000 in Melbourne, Australia) and IWS Kamakura (April 2002 in Kamakura, Japan). To attract more participation from North and South America, ISSMGE/TC23 organized a one-day International Workshop on Limit State Design in Geotechnical Engineering Practice (LSD2003) at the Massachusetts Institute of Technology, Cambridge, USA, on 26 June 2003. This workshop was held in conjunction with the 12th Pan-American Conference on Soil Mechanics and Geotechnical Engineering and the 39th U.S. Rock Mechanics Symposium (Soil and Rock America 2003) and was jointly sponsored by ISSMGE, ASCE Geo-Institute, and the Japanese Geotechnical Society. The aim of LSD2003 is to provide a forum for TC23 members, ISSMGE members, Geo-Institute members, and other interested researchers/practitioners to interact and share experiences on issues related to geotechnical limit state design (particularly those identified at IWS Kamakura). TC23 also held this event in the middle of the current term (2001–2005) so as to accelerate our activities toward ICSMGE 2005 in Osaka.

This publication contains the abstracts of 20 papers, the majority of which were presented at LSD2003. The complete contributions are available in the accompanying CD-ROM (special lecture not included). Issues covered include those identified at IWS Kamakura such as performance-based and limit state design philosophies; implementation of limit state design codes; "measured values", "derived values" versus "characteristic values"; reliability-based methodologies for analytical calibration of partial factors; and application of partial factors in FEM where highly nonlinear force-deformation behaviors may govern.

*Editors*

K. K. Phoon
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## ACKNOWLEDGMENT

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## TECHNICAL PROGRAM

**LSD2003 LIMIT STATE DESIGN IN GEOTECHNICAL ENGINEERING PRACTICE**
June 26, 2003 9:00AM – 5:10PM
Massachusetts Institute of Technology, Cambridge, Massachusetts, USA

Held in conjunction with the 12th Pan-American Conference on Soil Mechanics and Geotechnical Engineering and the 39th U.S. Rock Mechanics Symposium, *Soil and Rock America 2003*

9:00-9:10
**Opening remarks: TC23 activities and the objectives of the workshop LSD2003**
*Honjo, Y.*

9:10-10:40
**Session 1: LSD based codes developments**
Chairperson: *F.H. Kulhawy & J.L. Withiam*

Implementation of the AASHTO LRFD Bridge Design Specifications for Substructure Design
*Withiam J.L.*

Limit states foundation design code development in Canada
*Becker D.E.*

Geotechnical acceptance of limit state design methods
*Christian J.T.*

Japanese Seismic Design Specifications for Highway Bridges
*Shirato M., Fukui J., Unjoh S. & Hoshikuma J.*

The Chinese limit state design code for building pile foundations JGJ 94-94: a comparative study
*Zhang L. M., Liu J. L. & Zhang Z. M.*

10:40-11:00
Coffee Break

11:00-12:00
**Special Lecture: Eurocode 7**
*Simpson B.*

12:00-13:00
Lunch

13:00-15:00
**Session 2: Reliability-based design of geotechnical structures**
Chairperson: *R.B. Gilbert & G.B. Baecher*

Reliability-based design as a decision-making tool
*Gilbert R.B.*

Reliability analysis of anchored and cantilevered flexible retaining structures
*Cushing A.G., Withiam J.L., Szwed A. & Nowak A.S.*

Reliability-based design for rock footings
*Prakoso W.A. & Kulhawy F.H.*

New directions in LRFD for soil nailing design and specifications
*Lazarte C. A., Baecher G.B. & Withiam J.L.*

Why consider reliability analysis for geotechnical limit state design?
*Phoon K.K., Becker D.E., Kulhawy F.H., Honjo Y., Ovesen N.K. & Lo S.R.*

Practical lessons learned from applying the reliability methods to LRFD for the analysis of deep foundations
*Paikowsky S.G.*

15:00-15:20
Coffee Break

15:20-16:55
**Session 3: Soil parameters, partial factors and performance-based design**
Chairperson: *D.E. Becker & K.K. Phoon*

Predictions for heterogeneous soil behavior: towards a probabilistic characterization of soil design parameters
*Rechenmacher A.L., Medina-Cetina Z. & Ghanem R.*

Use of finite element methods in geotechnical limit state design
*Simpson B. & Yazdchi M.*

LSD in geotechnics: alternative approach no.1 for slope design
*Koudelka P.*

Modification factor for pile resistance considering both number and variability
*Shirato M., Suzuki M., Matsui K. & Fukui J.*

Comprehensive design codes development in Japan: Geo-code 21 ver.3 and code PLATFORM ver.1
*Honjo Y.*

16:55 – 17:10
**Closing remarks**
*K.K. Phoon*

## CONTENTS

LSD2003: International Workshop on Limit State Design in Geotechnical Engineering Practice
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# Limit States Foundation Design Code Development in Canada

**D. E. Becker,** *PhD., P.Eng.*
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SUMMARY

Foundation design in Canada continues to undergo a transition from traditional working (allowable) stress design to design based on limit states concepts. This paper describes the history of limit states design development in Canada, identifies future research and code development work, and discusses some of the experiences and challenges encountered during the implementation of existing design codes based on limit states concepts. To date, confusion still exists as to the objectives of limit states design; it has not yet been fully accepted and embraced by the Canadian geotechnical community, even though mandatory use of limit states design is specified in existing codes.

The term limit states design has become associated with the Load and Resistance Factor Design (LRFD) format that has become the basis of most of the major codes in Canada. The development and implementation of limit states design in Canada has been driven primarily by the objectives of achieving a consistent design philosophy and approach between structural and geotechnical engineers, and obtaining a more consistent and rational framework of risk management in foundation engineering. The major Canadian design codes include: the National Building Code of Canada (NBCC), the Canadian Highway Bridge Design Code (CHBDC), and the Canadian Offshore Structures Code. These codes involve the interaction of structural and geotechnical engineers, and generally apply to the design and construction of foundations. There does not appear to be a national code document for aspects in which the geotechnical engineer does not normally interact with structural engineers, for example slope stability. The current geotechnical state-of-practice does not use limit states design concepts to design slopes, embankments, dams and other earth structures. It is expected that this practice will not change. These classes of problems will continue to be analyzed and designed using working (allowable) stress. There does not appear to be any compelling reason or impetus by the geotechnical community in Canada to adopt limit states design for purely geotechnical classes of problems.

Mandatory limit states design for geotechnical aspects of foundations was first introduced into Canadian engineering practice in the early 1980's as part of the Ontario Highway Bridge Design Code (OHBDC) that was based on a factored strength (European) approach. The initial introduction of limit states design did not get off to a good start. It was not well accepted by geotechnical engineers, and it generated a fair amount of confusion and controversy because it did not produce economy of design as promised. In 1992, in the 3rd Edition of the OHBDC, an overall factored resistance (LRFD) approach for limit states design was used. In 1995, the NBCC introduced limit states design for foundations also using a factored resistance (LRFD) approach. However, the Canadian Offshore Code (1992) is based on factored strength concepts. For the sake of limit states design harmonization for geotechnical engineers in Canada, there is merit for also incorporating a factored resistance (LRFD) approach into the Offshore Code. It is expected that the Offshore Code will soon assess whether to also adopt a factored resistance (LRFD) format.

The NBCC is currently being reassessed and revised to adopt an Objective-Based Format. The base objectives are health, safety, serviceability and not affecting neighbouring or adjacent property. Performance-based and prescriptive-based solutions will be recognized as forms of acceptable solutions. The current issue of NBCC (1995) allows geotechnical engineers to use working (allowable) stress or limit states concepts. This was done to allow for a transitional period during which geotechnical engineers could learn more about and become accustomed to limit states design concepts. However, in the next issue of NBCC in 2005, the use of limit states design for geotechnical aspects of foundation